A Remedial Action Plan to Address NAPL at Former USTs 85a/b

Alameda Commercial Properties, LLC

Alameda, California

Prepared for:

Alameda Commercial Properties, LLC

2900 Main Street
Alameda, CA 94501

Prepared by:

TRC

July 2016

A Remedial Action Plan to Address NAPL at Former USTs 85a/b

July 26, 2016

Alameda Commercial Properties, LLC
2900 Main Street
Alameda, California

TRC Project No. 232888
RWQCB Case No. 01-1060

Prepared For:

Alameda Commercial Properties, LLC
2900 Main Street
Alameda, CA 94501

By:

Jacob Zepeda
Project Geologist

Elizabeth Schwartz, PG, CHG
Senior Project Manager/Hydrogeologist

TRC
One Concord Center
2300 Clayton Road, Suite 610
Concord, California
(925) 688-1200

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

On behalf of Alameda Commercial Properties (ACP), TRC is submitting this Remedial Action Plan (RAP) for the former underground storage tank (UST) Area 85a/b on the former Alameda Gateway Limited (AGL) properties recently acquired by ACP and located at 2900 Main Street in Alameda, California (Site, Figure 1). The objective of the RAP is to evaluate and select appropriate remedial alternatives for treating non-aqueous phase liquid (NAPL) hydrocarbon-impacted soils and groundwater beneath the Site related to the San Francisco Bay Regional Water Quality Control Board (RWQCB) Case #01-1060 at former UST Area 85a/b, as referenced in the RWQCB letter, *Conditional Report Approval and Requirement for Confirmatory Groundwater Sampling and a Remedial Action Plan*, dated January 15, 2016.

This RAP includes a detailed summary and discussion of recently completed remedial investigation activities. The remedial investigation activities were completed and the RAP prepared in accordance with the provisions outlined in California Code of Regulations (CCR) Title 23, Division 3, and Article 11.

2.0 SITE DESCRIPTION

The Site is located on the northern corner of the intersection of Main Street and Singleton Avenue in a light-industrial area of Alameda, in Alameda County, California. The Site is zoned as light industrial/manufacturing and is currently owned by ACP. General activities at the Site include ship repair, storage, and office use. Within the UST Area 85a/b, two underground storage tanks 85a and 85b were historically located adjacent to the southwest corner of former Building 85. The building and USTs were located north of the drainage and railroad tracks, and located east of Building 137, the Power House, and Warehouse buildings. The USTs contained 7,000-gallons of gasoline and 600-gallons of diesel fuel and possibly associated fuel oils for refueling purposes on-Site, and were decommissioned and removed in April 1990. During the removal of the tanks, soil and groundwater were found to be contaminated with total petroleum hydrocarbons as gasoline (TPH-g), diesel (TPH-d), fuel oil (TPH-fo), benzene, toluene, ethylbenzene, and xylene (BTEX) compounds, polyaromatic hydrocarbons (PAHs), and lead. Additional environmental history and investigations of the UST Area 85a/b are summarized in Section 2.2.

2.1 Site Geology and Hydrogeology

The Site is located along the eastern San Francisco Bay and occupies a depression between two uplifted areas, the Berkeley Hills to the east, and Montara Mountain to the west, within the Coast Ranges of California. This San Francisco Bay depression and the two uplift areas were formed by two sub-parallel, active faults, the San Andreas Fault to the west, and the Hayward Fault to the east. The San Andreas Fault is approximately 12 miles to the west, and the Hayward Fault is approximately 5 miles to the east. The Site was formerly marshland and San Francisco Bay intertidal area, and is located adjoining the Oakland Inner Harbor, and has an elevation of approximately 8 feet above mean sea level (MSL) (TRC, 2015).

Surface and near-surface soils beneath the Site consist of artificial fill (sand and clay) placed during the historical filling of the tidal marshlands, which occurred from 1900 to 1940. The fill is present but variable throughout the Site and ranges from 7 to 12 feet below ground surface (fbgs) in the vicinity of the Building 61. The fill consists of brown clay with crushed stone, dark gray silty sands and sandy clays, and fat black clay with wood, asphalt, and brick debris (TRC, 2015).

A remnant tidal marsh layer of material called the "marsh crust" is an approximately 2 foot thick layer which lies beneath the fill at various depths throughout the Site, and has been reported to contain hazardous materials (including TPHs and PAHs) from former industrial discharges (former gas plant and refinery wastes) that were retained in the historic marsh prior to filling. The ‘marsh crust’ marks the top of the Bay Mud throughout the area.

The Bay Mud underlying the Site fill ranges in thickness from 25 to 100 feet in the area, and consists of recent sediment deposited in an estuarine environment. Bay Mud generally consists of gray to black, medium to high plasticity silty clay with laterally discontinuous, poorly graded silty and clayey sand layers.

The Merritt Sand Formation underlies the Bay Mud throughout the Site. The Merritt Sand Formation is composed of brown, fine to medium grained, poorly graded sand and is generally laterally continuous throughout the Site, except where bisected by a major paleo channel of thicker deposits of Bay Mud. The thickness of the Merritt Sand Formation is unknown beneath the Site, however it was encountered below the Bay Mud to a depth of at least 135 fbgs in Alameda Point (S. Figuers, 1998).

The fill material above the Bay Mud constitutes the first water bearing zone (FWBZ), with a saturated thickness of approximately 10 feet. Based on available groundwater monitoring reports for nearby sites, the depth to first groundwater varies from 1.82 to 4.62 fbgs beneath the Site. Groundwater flow in the FWBZ is variable, but generally flows north-northwest toward the Oakland Inner Harbor. The Bay Mud acts as a shallow aquitard between the fill material and the Merritt Sand Formation beneath. The Merritt Sand Formation is a deeper confined aquifer and is known as the primary aquifer beneath Alameda Point, and is referred to as the second water bearing zone (SWBZ).

The Merritt Sand Formation aquifer is underlain by the San Antonio Aquitard and Yerba Buena Mud to a depth of approximately 100 feet. The Alameda Formation water-bearing zone (AFWBZ) lies beneath the San Antonio Aquitard and Yerba Buena Mud, and is generally located deeper than 100 fbgs. The thickness of the AFWBZ aquifer ranges from 200 to 800 feet thick. The Merritt Sand and the Alameda Formation Aquifer are contained within the Oakland Upland and Alluvial Plain Groundwater Management Subarea (S. Figuers, 1998).

2.2 Previous Environmental Investigations

Historically, fuel USTs containing gasoline, diesel, and fuel oil were removed in 1990 from three different locations on the Site including the former building 85, former building 133, and adjacent to building 137, as described below.

In April 1990 four USTs and approximately 50 cubic yards of contaminated soil were removed and disposed offsite. Elevated concentrations of petroleum hydrocarbon contamination were detected in soil and groundwater during UST removals. In August 1992 a total of three groundwater monitoring wells were installed to evaluate groundwater contamination at each former UST location.

Soil and groundwater contamination was detected during Site characterization activities performed in May 2001. In 2006, during construction of the Widening of the Oakland Inner Harbor Turning Basin Project by the Army Corps of Engineers, the majority of the impacted soil and the former well MW-2 near former UST 133 were removed during the dry-dock yard construction. During this project, a deep sheet pile wall was installed into the bay mud, which provides a barrier between the former UST 133 area and the Oakland Estuary.

In January 2007, seven borings were advanced around former UST 133 where motor oil was detected in soil and in groundwater. As a result, MW-2A was installed between the former tank and the Oakland Estuary. NAPL as gasoline, diesel, and fuel oil was detected in soil borings advanced near former UST 85a/b. Well MW-3 at former UST 85a/b was replaced with a new well MW-3A. Moderate residual concentrations of gasoline, diesel, and motor oil in soil were detected in soil borings near former UST 137, and low concentrations of diesel were detected in groundwater at well MW-1 near former UST 137.

Groundwater was monitored from 2011 through 2014. In 2014, an additional investigation was conducted to support the low threat case closure recommendation proposed by AGL's consultant. During the 2014 investigation, NAPL was detected in soil from borings installed near former UST 85a/b. The RWQCB reviewed the investigation results and requested a work plan to address specific data gaps in the case for low threat case closure, including additional delineation of the extent of soil, groundwater and residual fuel impacts at the former UST 85a/b area; well abandonment, replacement and sampling at former UST 133 area; and well abandonment at former UST 137 area.

In October 2015, under the RWQCB-approved work plan (TRC, 2015), well MW-1 at former UST 137 was destroyed, and well MW-2A was destroyed and replaced with well MW-2B at former UST 133, and the extent of NAPL in former UST Area 85a/b was delineated.

A more detailed Site background and environmental investigation history is available in previous reports submitted for the three UST areas on behalf of AGL, and data summary of historical soil and groundwater concentrations from those reports in the former UST Area 85a/b is provided in Appendix A. A Site Plan showing the former UST Area 85a/b is presented as Figure 2.

3.0 CONCEPTUAL SITE MODEL

In order to address the general criteria described in the San Francisco Region RWQCB's *Low Threat UST Closure Policy* (2012), a conceptual site model (CSM) was developed to identify potential exposure pathways from contaminant sources to human and/or ecological receptors within the Former UST 85a/b area.

A CSM should address the following objectives:

1. Identify known or suspected sources of contamination.
2. Consider how and where the contaminants are likely to migrate (pathways).
3. Identify who is likely to be affected by them (receptors).

The identification of potential human and ecological receptors is based on the characteristics of the Site, the surrounding land uses, and the current and future land uses. Current conditions as they exist today and future land use is anticipated to continue to be commercial/industrial. Exposure pathways link the sources, locations, types of environmental releases, and environmental fate and transport with receptor locations and activity patterns. Generally, an exposure pathway is considered complete if it consists of the following four elements:

- A source and mechanism of release (e.g., release to the subsurface);
- A transport mechanism (e.g., wind or groundwater);
- A receptor (e.g., resident); and
- An exposure point (i.e., point of potential contact with a contaminated medium) and route (e.g., ingestion) for a specific receptor.

The CSM for exposure pathways for the former UST Area 85a/b at the Site is presented in Figure 3. The development of the CSM should be considered an iterative process, enabling refinements as additional analytical and geologic data are collected or new land uses are considered.

3.1 Transport Media

There are a number of mechanisms by which chemicals identified at the Site can migrate to other areas or to other media. Potential transport media at the Site consists of air, soil, soil vapor, and groundwater. The transport processes for soil, soil vapor, and groundwater are described below.

Air
Transport through air occurs when impacted surface soil particles are picked up and carried by the wind. Subsurface soil particles can also be released into the air during excavation or grading activities.

Soil
Transport of contaminants in soil occurs through leaching of liquid through pore spaces and volatilization of liquid into the gas phase. Contaminants that are highly soluble tend to percolate through soils quickly, such as methyl tertiary butyl ether (MTBE) and those that are less soluble, including TPH-g and BTEX compounds, tend to reside in soils for longer periods of time. In addition, impacted soil may be distributed into non-impacted areas through construction activities such as excavation and grading.

Soil Vapor
Lateral and vertical migration of soil vapor in the vadose zone follows the path of least resistance, through coarser grained soils (i.e., sand lenses), utility corridors, and fractures. Vapors flow under the processes described as advection, diffusion, and dispersion; however, dispersion in the vapor phase is generally considered negligible compared to transport through advection and diffusion processes. Transport of soil vapor is influenced by a number of factors, including density, temperature, pressure, and concentration gradients. Density gradients occur when the contaminant is several times denser than ambient air, and generally only applies to soil vapor within coarse sediment. Thermal gradients typically only influence the migration of soil vapor near the surface, with the transport occurring from warmer to cooler areas. Changes in barometric pressure may influence vapor transport in the subsurface, although the effect is generally minimal. Molecular diffusion due to concentration gradients within soil vapor is the primary mechanism for transport of contaminants in soil vapor.

Groundwater
Once in groundwater, contaminants migrate under the processes of advection and dispersion, and, to a lesser degree, molecular diffusion. The primary mode of transport is advection, which is influenced by the aquifer material properties and hydraulic gradient. Dispersion also occurs as contaminant compounds travel through various paths in the down-gradient, vertical and lateral direction, causing the contaminants to spread out. Molecular diffusion involves the movement of compounds from high to low concentrated areas.

The portion of the Site under which the plume at former USTs 85a/b lies is presently covered as a paved area. As such, biotic uptake of contaminants has been eliminated as a potential transport medium.

3.2 Potential Receptors

The identification of potential human receptors is based on the characteristics of the site, the surrounding land uses, and the hypothetical future land uses. The potential land uses and receptors include:

On-Site:

- Current ACP Land Use:
  - Current Commercial/Industrial worker (employees and subcontractors);

- Future ACP Land Use:
    - o Future Commercial/Industrial worker (employees and subcontractors);
    - o Future Construction Worker;

Off-Site:

- Current/Future Commercial/Industrial Land Use:
    - o Future Commercial/Industrial worker; and
    - o Future Construction Worker.
    - o Ecological Receptor

3.3 Exposure Points and Routes

Based on the contaminants, affected media, and migration pathways discussed above, points of potential human contact with site-related contaminants include primary environmental media (soil, soil vapor, and groundwater) and secondary media (related to one or more primary media, including ambient and indoor air).

Soil

Potential exposure routes associated with contaminants in shallow soil ($\leq$10 fbgs) include direct and indirect exposure routes. Direct exposure routes include incidental ingestion, dermal contact, and inhalation of airborne particulates. Indirect exposure routes include inhalation of volatile contaminants migrating from soil to indoor or ambient air. Site assessments have indicated that elevated petroleum hydrocarbons are present at depths less than or equal to 10 fbgs at former USTs 85a/b and 133.

Soil Vapor

Potential exposure routes associated with contaminants in soil vapor (from soil and groundwater sources) include indirect routes when contaminants volatilize to indoor or ambient air.

Groundwater

Potential exposure routes associated with contaminants in groundwater include direct and indirect exposure routes. Direct exposure routes include incidental ingestion and dermal contact. Indirect exposure routes include inhalation of volatile contaminants migrating from groundwater to indoor or ambient air.

3.4 Exposure Pathways

Given the characteristics of the contaminants and release processes, this section describes the potential exposure pathways for each receptor for on-site and off-site current and future land uses. The exposure pathways were evaluated as either:

- Incomplete –no possibility for the receptors to come into contact with contaminants via the exposure pathway;
- Complete –potentially significant mechanism of exposure; and
- Complete but insignificant –not considered to be a significant source of contaminants via the exposure pathway.

The potential receptor evaluation is shown on Figure 3.

On-Site

On-Site current and future commercial/industrial workers direct and/or indirect exposure to contaminated soil (incidental ingestion, dermal contact, and inhalation of airborne particulates) is considered complete because contaminated soil with elevated concentrations has been identified on-Site at depths less than or equal to 10 fbgs above commercial Environmental Screening Levels (ESLs) developed by the RWQCB, but insignificant because contaminated soil is covered by asphalt and is limited to the immediate vicinity of the former USTs. Future commercial/industrial workers direct and/or indirect exposure to contaminated soil is also expected to be complete but insignificant because the area is anticipated to be covered by asphalt for future Site use.

On-Site future construction worker direct and indirect exposures to contaminated groundwater (ingestion and dermal contact) are considered complete because concentrations of impacted groundwater has been identified on-Site at depths less than 10 fbgs above ESLs, although they are isolated to the immediate vicinity of the former USTs. Current and future commercial/industrial workers indirect exposure to impacted groundwater via vapor intrusion to ambient air is considered complete because elevated concentrations of benzene, TPH-g, TPH-d, and PAHs were detected in grab groundwater samples collected at former USTs 85a/b.

Off-Site

Off-site current and future commercial/industrial workers direct exposure to soil is considered incomplete because potentially impacted soil is limited to the on-Site former USTs 85a/b area. Off-site current and future commercial/industrial workers direct and indirect exposure to groundwater is considered incomplete because concentrations of impacted groundwater are isolated to the immediate vicinity of the former USTs 85a/b. Off-site current and future commercial/industrial workers direct and indirect exposure to soil vapor is considered incomplete because concentrations of impacted groundwater leading to soil vapor exposure appears limited to the immediate vicinity of the former USTs 85a/b.

Off-site construction workers direct exposure to soil is considered incomplete because potentially impacted soil is limited to the on-Site former USTs 85a/b area. Off-site construction workers direct and indirect exposure to groundwater is considered complete but insignificant because concentrations of impacted groundwater are isolated to the immediate vicinity of the former USTs 85a/b. Off-site construction workers direct and indirect exposure to soil vapor is considered incomplete because concentrations of impacted groundwater leading to soil vapor exposure appears limited to the immediate vicinity of the former USTs 85a/b.

Ecological receptors in the inner harbor (Alameda-Oakland Inner Harbor turning basin area) is considered incomplete as the impacted groundwater is isolated to the immediate vicinity of the former USTs.

4.0 REMEDIAL INVESTIGATION

To obtain additional soil and groundwater data necessary for preparation of a RAP, TRC conducted additional site assessment activities during NAPL delineation in October 2015, including the following:

- NAPL delineation at former USTs 85a/b; and
- Soil and groundwater profiling.

Details regarding this investigation can be found in TRC's 2015 *UST Investigation Report at former USTs 85a/b, 133, and 137* can be found online at the State Water Resources Control Board's Geotracker website. A summary of the investigation and findings at former USTs 85a/b are presented below.

4.1 NAPL Delineation at Former USTs 85a/b

To further investigate and delineate the extent of NAPL and elevated historical concentrations of TPH-d and TPH-fo, PAHs, and lead in soil and groundwater, TRC advanced eighteen borings (SB85-13 to SB85-30), at accessible locations in the immediate vicinity of the former UST 85a/b. The borings were advanced to 10 fbgs using a direct push drilling rig equipped with the laser induced fluorescence (LIF) ultra-violet optical screening tool (UVOST). The UVOST tool was used to delineate depth-discrete NAPL within borings SB85-13 to SB85-30, shown on Figure 2. A UVOST background boring (SB85-13) was advanced in a location outside of the NAPL impacted area to provide a baseline LIF response, followed by UVOST borings SB85-14 through SB85-30 to delineate the lateral and vertical extent of NAPL.

The UVOST data was viewed in real-time on a laptop computer inside the drilling rig, linked to the UVOST module. The colored graphical display of the log was generated electronically at the time of drilling. As indicated in the UVOST data logs in the UST Investigation Report (TRC, 2015), the UVOST waveforms indicated a heavier petroleum hydrocarbon oil present as NAPL was determined to be within the range from 2 to 5.5 fbgs in borings SB85-14, SB85-15, SB85-18, SB85-20, and SB85-22; and at 9.5 fbgs in SB85-14. The horizontal extent of NAPL appears delineated by the UVOST data from SB85-21, and SB85-23 through SB85-30, where NAPL was not observed.

Co-located confirmation borings were performed adjacent to borings SB85-14, SB85-16, and SB85-22. Two soil samples were collected per confirmation boring at depths determined from UVOST data and photoionization detector (PID) screening results. Grab groundwater samples were also collected from each confirmation boring. Confirmation soil and grab groundwater analytical results are discussed below in Sections 4.1.1 and 4.1.2, and are presented in Figures 4 and 5.

4.1.1 Soil Results

TPH-d and TPH-mo were detected in four (4) soil samples (SB85-14-3, SB85-14-9.5, SB85-16-3, and SB85-22-3) at concentrations above the RWQCB's commercial and industrial Environmental Screening Levels (ESLs; Summary Table A; RWQCB, 2013) of 100 milligrams per kilogram (mg/kg). PAHs were also detected in soil samples SB85-14-3, SB85-14-9.5, and SB85-16-3 and include acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, chrysene, fluorene, naphthalene, and phenanthrene. These results are summarized below:

- TPH-d was detected at concentrations ranging from 1,500 to 36,000 mg/kg in soil samples SB85-14-3, SB85-14-9.5, and SB85-16-3, and SB85-22-3, exceeding the screening level of 100 mg/kg;
- TPH-mo was detected at concentrations ranging from 2,000 to 15,000 mg/kg in soil samples SB85-14-3, SB85-14-9.5, and SB85-16-3, and SB85-22-3, exceeding the screening level of 100 mg/kg.
- Naphthalene was detected in sample SB85-14-3 at a concentration of 58 mg/kg, exceeding the screening level of 1.2 mg/kg.
- Benzo[a]pyrene was detected in samples SB85-14-9.5 (0.83 mg/kg) and SB85-16-3 (0.26 mg/kg), exceeding the screening level of 0.038 mg/kg.
- Benzo[a]anthracene was detected in samples SB85-14-3, SB85-14-9.5, and SB85-16-3 at concentrations ranging from 0.38 to 1.9 mg/kg, exceeding the screening level of 0.38 mg/kg.
- Benzo[b]fluoranthene was detected in sample SB85-14-9.5 at a concentration of 0.88 mg/kg, exceeding the screening level of 0.38 mg/kg.

Acenaphtene, anthracene, chrysene, fluorine, and phenanthene were also detected above their screening levels in the soil sample SB85-14-3. Lead, TPH-g, and BTEX were not detected above screening levels in the soil samples collected at former USTs 85a/b in 2015. Laboratory results of soil concentrations from this investigation are presented in Figure 4.

4.1.2 Grab Groundwater Results

Multiple PAHs, TPH-g, TPH-d, and TPH-mo were detected in the grab groundwater samples from borings SB85-14, SB85-16, and SB85-22. The following constituents exceeded commercial and industrial ESLs from grab groundwater samples collected in the former UST area 85a/b:

- TPH-d was detected at 4,500 and 79,000 micrograms per liter (μg/l) in groundwater grab samples from SB85-22 and SB85-14, respectively, exceeding the screening level of 100 μg/l.
- TPH-mo was detected at 3,200 and 40,000 μg/l in SB85-22 and SB85-14, respectively, exceeding the screening level of 100 μg/l.
- TPH-g was detected at concentrations of 280 and 430 μg/l in groundwater grab samples from SB85-14 and SB85-22, respectively, exceeding the screening level of 100 μg/l.
- Naphthalene was detected in sample SB85-14 at a concentration of 190 μg/l, exceeding the screening level of 6.1 μg/l.
- Benzo[a]pyrene was detected ranging from 1.2 to 14 μg/l in SB85-14, SB85-16, and SB85-22, exceeding the screening level of 0.014 μg/l.
- Benzo[a]anthracene was detected ranging from 0.61 to 26 μg/l in SB85-14, SB85-16, and SB85-22, exceeding screening level of 0.027 μg/l.
- Other PAHs from grab groundwater samples exceeding commercial/industrial screening levels are summarized in the UST Investigation Report (TRC, 2015).

Lead, BTEX, and MTBE were not detected above screening levels in the three grab groundwater samples collected during the investigation. Laboratory results of groundwater from this investigation are presented in Figure 5.

5.0 DISTRIBUTION AND EXTENT OF HYDROCARBON-AFFECTED SOIL AND GROUNDWATER AT AREA 85a/b

Subsurface investigations performed from 1989 to 2014 had determined that NAPL was absent in soil and groundwater from borings B85-1, B85-2, SB85-8, SB85-9, or SB85-11. The absence of NAPL in these areas was confirmed by our UVOST borings SB85-13, SB85-21, SB85-25, and SB85-29 (Figure 4) (TRC, 2015). Vertically, NAPL was apparent from 2 to 5.5 fbgs in former UST Area 85a/b. In addition to NAPL presence from historical borings SB85-3, SB85-5, SB85-6, SB85-10 and SB85-12, NAPL was again observed from 2 to 5.5 feet below ground surface (fbgs) in UVOST borings SB85-14, SB85-15, SB85-17, SB85-18, and SB85-22. The perimeter UVOST borings completed during the 2015 UVOST site assessment have sufficiently defined the extent of NAPL in the area (Figure 4) (TRC, 2015). The soil and groundwater analytical results as part of the additional site assessment activities can be found in the UST Investigation Report (TRC, 2015).

In 2007, well MW-3 was replaced with a new well MW-3A, but no other wells were installed for determining the extent of chemicals of potential concern (COPCs) in groundwater or flow direction Currently, the full extent of TPH-g, TPH-d, TPH-mo, and PAH impact to groundwater has yet to be determined around the former UST Area 85a/b, as historically only one well (MW-3) has been installed near the former UST.

6.0 CONTAMINANTS OF CONCERN AND PROPOSED CLEANUP LEVELS

Based on the operational history and analytical results of soil and groundwater samples collected at the former UST Area 85a/b, the main COPCs are TPH-d, TPH-mo, TPH-g, and PAHs including acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, chrysene, fluorene, naphthalene, and phenanthrene. These contaminants are components of gasoline, diesel, and fuel oil, which are consistent with the previous uses in former UST Area 85a/b.

6.1 Proposed Soil and Groundwater Cleanup Levels

The RWQCB has established ESLs for hazardous chemicals commonly found released to soil and groundwater. ESLs were developed to address environmental protection goals for soil, surface water, and groundwater, presented in the Water Quality Control Plan for the San Francisco Basin ("Basin Plan," RWQCB 1995) and are consistent with California Maximum Contaminant Levels (MCLs). These goals include: protection of drinking water resources, protection of terrestrial biota and aquatic habitats, protection of human health, and protection against adverse nuisance conditions.

The ESLs specify final screening levels based on a varying combination of site characteristics (i.e. general soil depth and potential drinking water resource), and land use scenarios; (i.e. residential and commercial/industrial). Each combination of soil, groundwater and land-use characteristics influences the magnitude of environmental concerns, and the ESLs that are most applicable, to a given site. Under current regulations and policies, the ESLs for residential land use provide the most conservative individual screening levels in soil and groundwater. However, the Site is zoned for commercial/industrial use only. Therefore, the Commercial/Industrial ESLs are applicable in this case as a screening guide.

Additionally, the RWQCB low-threat UST case closure policy (LTCP) (RWQCB, 2012) was enacted to increase the efficiency of the cleanup process for petroleum UST sites and to facilitate closure at UST sites that do not appear to be a long-term threat to human health, the environment, or the waters of the state. ESLs may be used at sites to screen for constituents not already addressed by the LTCP or as part of site-specific risk assessments for the media-specific criteria (e.g., groundwater; petroleum vapor intrusion to indoor air; and direct contact and outdoor air), and can be used at sites contaminated with petroleum hydrocarbons which fail one or more of the LTCP Policy's general criteria.

Until such time as the LTCP criteria appear to have been met for direct contact and outdoor air exposure for the commercial/industrial land use, the proposed soil, soil gas, and groundwater current ESLs applicable for screening at the former UST Area 85a/b are as follows:

Environmental Screening Levels Chemicals of Potential Concern	Soil[1] (mg/kg)	Soil Gas[2] ($\mu g/m^3$)	Groundwater[3] ($\mu g/L$)
TPH-g	100	2,500,000	100
TPH-d	100	570,000	100
TPH-mo	100	--	50,000
Acenaphthene	16	260,000	20
Anthracene	2.8	--	0.73
Benzo[a]anthracene	2.9	--	0.027
Benzo[a]pyrene	0.29	--	0.014
Benzo[b]fluoranthene	2.9	110	0.012

Environmental Screening Levels Chemicals of Potential Concern	Soil[1] (mg/kg)	Soil Gas[2] ($\mu g/m^3$)	Groundwater[3] ($\mu g/L$)
Chrysene	3.8	1,100	0.049
Fluorene	8.9	--	3.9
Naphthalene	0.023	360	0.12
Phenanthrene	11	28,000	4.6

Notes:
[1] Summary of Soil ESLs (RWQCB, 2016) for commercial/industrial land use where groundwater is a current or potential source of drinking water.
[2] Summary of Vapor ESLs (RWQCB, 2016) for Subslab/Soil Gas Vapor Intrusion Tier 1 ESL, or Commercial/Industrial for Human Health direct exposure.
[3] Summary of Groundwater ESLs (RWQCB, 2016), groundwater is a current or potential source of drinking water, Tier 1 ESL.
-- Indicates ESL does not exist for constituent.

The ESLs represent the conservative risk based screening criteria, which if exceeded, indicate that further site characterization may be warranted. For COPCs in Site soils, soil gas, and groundwater, the proposed remedial alternatives presented in this RAP may only result in a limited reduction in those COPCs. Additional remedial actions may be necessary, depending on the effectiveness of the implementation of this RAP. After the proposed remedial action is implemented and the effectiveness is determined, post-remedial action COPCs may be evaluated against LTCP closure scenarios.

7.0 REMEDIAL ACTION PLAN OBJECTIVES

The objectives of the RAP are consistent with those specified in applicable regulations (e.g., CCR Title 23, Division 3, Chapter 16, Article 11), as follows:

- To propose a means to reduce the toxicity, mobility, and volume of the hazardous substances (i.e. to remove NAPL to the maximum extent practicable);
- To propose a cost-effective plan to adequately protect human health and the environment; and
- To protect current and potential beneficial uses of water.

8.0 REMEDIAL ALTERNATIVE EVALUATION

Technologies are available for the recovery and/or treatment of hydrocarbon-affected soil and groundwater. The advantages and disadvantages, limitations, regulatory and economic concerns, and feasibility of application for each remediation alternative for hydrocarbon-affected soil and groundwater at former UST Area 85a/b are discussed below.

The potential remedial alternatives are evaluated considering the following three criteria: effectiveness, implementability, and cost.

- Effectiveness - The effectiveness of technically implementable remedial technologies is evaluated relative to other options within the same technology type. This evaluation focuses on: (a) the potential effectiveness of the process option to handle the estimated areas or volumes of media and meet the remedial cleanup goals; (b) the potential impacts to human health and the environment during implementation and any construction phase; and (c) the reliability and proven history of the technology with respect to the chemicals and conditions found at the Site.
- Implementability - Implementability encompasses both the technical and institutional feasibility of implementing a particular technology, including obtaining necessary permits,

the availability of treatment, storage and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the particular process.

- Cost - Cost plays a limited role in the screening of technology options, with relative capital and operation and maintenance costs being used rather than detailed cost estimates. At this stage, the cost analysis is made based on engineering assumptions and judgment. Each process option is evaluated as to whether costs are high, low, or moderate relative to other technologies. If more costly technologies within a particular technology type yield no significant advantages or are less advantageous, then these options are eliminated from further consideration.

Remedial action alternatives to be considered include:

- Alternative 1 - No action/institutional controls (30 Years)
- Alternative 2 – Excavation and Off-Site Disposal with Groundwater Monitoring (2 Years)
- Alternative 3 – Excavation, *Ex-Situ* Treatment, Groundwater Monitoring (5 years)

8.1 Alternative 1 - No action/Institutional Controls/Monitoring (30 Years)

This alternative would leave the former UST Area 85a/b “as is”. The existing Site paving and landscaping would be maintained, but not enhanced or otherwise modified. A majority of the former UST Area 85a/b is paved with asphalt, therefore potential exposure to future Site users from dust is not relevant as the Site is essentially covered/capped and impacted soils are found at a minimum of 2 fbgs. Groundwater monitoring, sampling, and analysis would continue at well MW-3A on a semi-annual to annual basis. Institutional controls (land use covenant, or LUC) would restrict Site usage to prevent access to subsurface soils or groundwater in this area or construction of structures overlying impacted soil.

This alternative could result in adverse effects to human health, as contaminants exceeding cleanup goals would remain at the former UST Area 85a/b. This alternative also does not reduce human health risk levels, except by maintaining existing paving and landscaping areas. No Action also does not achieve enforceable standards for soil. Over time, natural attenuation (e.g. biodegradation and natural source zone depletion) would decrease chemical concentrations in soil, but the time to reach ESLs or MCLs can only be estimated.

Long-term risks associated by leaving impacted soil in place at the Site could be managed by institutional controls, including deed restrictions to prevent direct contact to impacted soil and groundwater in the subsurface in this area. These controls might provide a means to minimize contaminant exposure routes. Also, the existing storm water management at the Site would serve as the surface/source control to prevent infiltration of surface water. Maintenance of Site paving and landscaping system would be required.

Although Site workers would not be exposed to risk during maintenance of paving or landscaping, this alternative is not very effective as it does not reduce the toxicity, mobility, or volume of chemicals in soil. This alternative does not achieve the statutory preference for treatment as a principal element.

This alternative is readily implementable, but has the longest life expectancy of remedial alternatives considered, though it is the easiest option to initiate, and does not require any additional administrative burden beyond what is currently in place. Costs for implementation of this alternative are provided in Table 1. The total cost estimated for this alternative 1 is approximately $592,000 over 30 years. These costs are provided as a baseline for comparison with active remediation costs.

8.2 Alternative 2 – Excavation and Off-Site Disposal, Groundwater Monitoring (2 Years)

This alternative involves excavating the known NAPL extent and transporting soil above Site cleanup goals to an off-Site disposal facility, and backfilling excavated areas with clean overburden or imported soil. This approach would provide groundwater protection from exposure to petroleum hydrocarbon impacted soils present at the Site. Assuming quarterly groundwater monitoring for 2 years after removal of NAPL to demonstrate plume stability, low threat UST closure is achievable for this area.

Implementation of this alternative would involve identification of soil excavation areas and depths based on the soil cleanup goals. Any required confirmation soil sampling during excavation would determine the final volume of soil necessary to be excavated to meet remedial objectives. Excavated soil would be temporarily held in containers or stockpiled at the Site, pending profiling and transportation to a permitted facility for disposal. Also, as groundwater is very shallow in former UST Area 85a/b, at approximately 3 fbgs, dewatering of the area would occur during excavation activities. Water pumped out of the excavation areas would be placed in holding tanks to allow the material to settle, and would then be sampled, and disposed off-site or treated on-site at the water treatment facility.

Subsequent to excavation and stockpiling, the soil would be characterized and generally segregated into three classifications: (1) clean (consisting of overburden and/or benching soils that meet Site cleanup goals); and (2) non-hazardous soils that do not meet Site cleanup goals; and possible (3) state (California, non-Resource Recovery Conservation Act (non-RCRA)) hazardous waste. The two waste classifications (non-hazardous and California hazardous) will dictate engineering controls, packaging for transport, and the disposal site. Based on environmental data collected at the Site to date, the excavated material would be anticipated as Class II non-hazardous waste.

This alternative protects human health and the environment by removing TPH-impacted soils present in the Site and disposing them at a secured landfill that will restrict both human access and contaminant mobility. Impacted groundwater in this NAPL area would also be removed and treated or disposed offsite. The workers conducting the excavation would experience a short-term exposure risk; however, this would be managed under the Site-specific health and safety plan (HASP).

Groundwater monitoring wells would then be installed surrounding the source excavation area, one up-gradient and two down-gradient of the NAPL excavation area. Groundwater monitoring and sampling will be conducted for up to 2 years following removal of the NAPL to confirm the effectiveness of the approved remedial action and to observe any rebound in dissolved-phase contaminant concentrations.

Excavation of contaminated soil and offsite disposal would eliminate the risks associated with the petroleum hydrocarbon impacted soils, through removal. The toxicity and the volume of the contaminants are not affected under this alternative, but after removal from the Site, mobility would be reduced through placement in a permitted facility with the required institutional, structural, and environmental controls.

The short-term impact on the health of the community and workers during implementation is manageable. Excavation operations would be conducted in a manner that minimizes fugitive dust emissions via dust control measures such as the application of water to the soil. Operational controls would be used to mitigate the noise and exhaust emissions from heavy equipment used during the soil excavation. These controls could include work-scheduling, the use of low emission equipment, sound barriers, and the use of low-sulfur diesel fuel during excavation.

Implementability is fairly straightforward, as it involves the anticipated excavation depth to 5.5 fbgs in an approximate area of 2,145 square feet (Figure 6), and a volume of approximately 11,800 cubic feet (450 cubic yards) of soil. Groundwater monitoring wells would be installed to a depth of

12 fbgs, and screened from 2 to 12 fbgs (Figure 7), due to the shallow nature of groundwater in this area. The excavation in this area would be laid back for safety purposes, and could impede traffic flow and operations temporarily at the Site. Costs for implementation of this alternative are provided in Table 2. The total anticipated cost for this alternative 2 is approximately $232,735 over 2 years. The excavation, transportation, and disposal work is anticipated to take approximately 3 to 4 weeks to complete, and involve approximately 32 trucks leaving the site with impacted soils, the same number entering the Site with clean fill, for a total of approximately 64 truckloads.

Approximately 450 cubic yards (11,800 cubic feet) of impacted Site soils would be excavated, transported, and disposed of off-site and the volume replaced with either clean overburden or clean imported fill. The remediation timeframe and number of trucks given above were calculated using an estimate of 14 cubic yards of soil per truckload and 15 trucks leaving the Site each day. It is anticipated, and was assumed for costing purposes, that the impacted soil would have waste profiling characteristics as non-hazardous Class II waste. Also, during this time, dewatering of the excavation pit would occur. Impacted groundwater within the excavation pit (from depths of 3 to 5.5 fbgs) would be pumped into two 20,000 gallon mobile storage tanks for storage and eventual disposal as a Class II non-hazardous waste, or treated within the Site's water treatment facility under the existing facility's National Pollution Discharge Elimination System (NPDES) permit, if appropriate treatment and disposal can be obtained.

As this alternative will meet the remedial action objectives for this Site by removal of all NAPL associated with the former USTs 85a/b in this area, it is anticipated that this alternative will be acceptable to the RWQCB, because it provides for soil source removal.

8.3 Alternative 3 – Excavation, *Ex-Situ* Treatment, Groundwater Monitoring (3 years)

This alternative involves excavating the known NAPL extent and stockpiling soil above Site cleanup goals on a non-permeable liner, followed by *ex-situ* treatment of TPH contaminated stockpile soils with chemical oxidants by soil mixing. To verify contaminant reduction, soil samples will be collected within the *ex-situ* treated soil and analyzed at a state-certified environmental laboratory. Once *ex-situ* treatment has shown to be effective and the soil has been determined to be acceptable for re-use on-Site, the *ex-situ* treated soils will be used to backfill the excavation. Any excavation remaining to be backfilled to surface grade will be backfilled with the clean overburden soil or import fill.

This approach would provide groundwater protection from exposure to petroleum hydrocarbon impacted soils present at the Site. After removal and *ex-situ* treatment of NAPL, assuming semi-annual groundwater monitoring for 5 years to demonstrate plume stability, low threat UST closure will be achievable for this area.

Subsequent to excavation and stockpiling, the soil would be characterized and generally segregated into two classifications: (1) clean (consisting of overburden soils that meet Site cleanup goals); and (2) non-hazardous soils (NAPL-impacted soils) that do not meet Site cleanup goals. Based on environmental data collected at the Site to date, the excavated material would be anticipated as Class II non-hazardous waste.

Implementation of this alternative would involve identification of soil excavation areas and depths based on the soil cleanup goals. Any required confirmation soil sampling during excavation would determine the final volume of soil necessary to be excavated to meet remedial objectives. Excavated soil (approximately 450 cubic yards) would be temporarily placed on a 12-mil liner stockpiled at the Site in which *ex-situ* treatment will occur by chemical oxidation (i.e. mixing impacted soil with a chemical oxidant). The soil mixing process ensures direct and immediate contact with the chemical oxidant and undergoes rapid oxidation reactions. Treatment of contaminated soils with chemical oxidants via *ex-situ* soil mixing involves chemical oxidation as well as biological and physical processes to transform organic contaminants in soil. The soil mixing during an *ex-situ* treatment will homogenize the soil, and dilute and volatilize the contaminants. The *ex-situ* process needs sufficient time to ensure that chemical reactions are complete, approximately 30 days per application, with 90% effective oxidation occurring within the first 7 days. Many contaminants that are partially oxidized become more readily available for biological degradation, and residual oxygen left behind will stimulate aerobic biodegradation of the TPH compounds. This process results in a continuing decline in contaminant concentrations as a result of aerobic biodegradation.

As groundwater is very shallow in former UST Area 85a/b, at approximately 3 fbgs, dewatering of the area would occur during excavation activities. Water pumped out of the excavation areas would be placed in holding tanks to allow the material to settle, and would then be sampled, and disposed off-site or treated on-site at the water treatment facility.

This alternative protects human health and the environment by removing TPH-impacted soils present in the Site and treating them to Site cleanup goals, which when re-used on-Site in excavation areas, will restrict human access and contaminant mobility. TPH-impacted groundwater in the NAPL excavation area will be removed through dewatering activities, and treated or disposed offsite. The workers conducting the excavation would experience a short-term exposure risk; however, this would be managed under the Site-specific health and safety plan (HASP).

Groundwater monitoring wells will then be installed surrounding the source excavation area, one up-gradient and two down-gradient of the NAPL excavation area. Groundwater monitoring and sampling will be conducted for up to 5 years following removal and *ex-situ* treatment of NAPL contaminated soils to confirm the effectiveness of the approved remedial action, and monitor any rebound in dissolved-phase contaminant concentrations.

Excavation of contaminated soil and *ex-situ* treatment would eliminate the risks associated with the petroleum hydrocarbon impacted soils by reducing TPH contaminant concentrations to Site cleanup leveles. The toxicity of the contaminants, as well as mobility within the environment, would be reduced.

The short-term impact on the health of the community and workers during implementation is manageable. Excavation operations would be conducted in a manner that minimizes fugitive dust emissions via dust control measures such as the application of water to the soil. Operational controls would be used to mitigate the noise and exhaust emissions from heavy equipment used during the soil excavation. These controls could include work-scheduling, the use of low emission equipment, sound barriers, and the use of low-sulfur diesel fuel during excavation.

Implementability involves the anticipated excavation depth to 5.5 feet below current grade in an approximate area of 2,145 square feet (Figure 6), and a volume of approximately 11,800 cubic feet (450 cubic yards) of soil. Anticipated e*x-situ* treatment (surface mixing/compost turning type equipment) for the low soluble and low volatile NAPL impacted soil will likely require multiple chemical oxidant treatments (at 20 pounds per cubic yard, up to 6 treatments) for the anticipated 450 cubic yard stockpile. Confirmation sampling of the treated stockpile soils will be performed (at an assumed 18 soil confirmation samples per application event) using the San Francisco Bay Regional Water Quality Control Board's *Draft Technical Reference Document, Characterization and Reuse of Petroleum Hydrocarbon Impacted Soil As Inert Waste* (October, 2006).

Also, during excavation and backfilling activities, dewatering of the excavation pit will be implemented. Impacted groundwater within the excavation pit (from depths of 3 to 5.5 feet) would be pumped into two 20,000 gallon mobile storage tanks for storage and eventual disposal as a Class II non-hazardous waste, or treated within the Site's water treatment facility under the existing facility's NPDES permit, if appropriate treatment and disposal can be obtained. Groundwater monitoring wells would be installed to a depth of 12 fbgs, and screened from 2 to 12 fbgs (Figure

7), due to the shallow nature of groundwater in this area. The excavation in this area would be laid back for safety purposes, and could impede traffic flow and operations temporarily at the Site. Costs for implementation of this alternative are provided in Table 3. The total anticipated cost for this alternative 3 is approximately $337,505 over 3 years. The excavation work is anticipated to take approximately 3 weeks to stockpile the contaminated NAPL impacted soil; the *ex-situ* chemical oxidation process is expected to take approximately 12 to 24 weeks to complete (for a minimum of 3 applications, and maximum of 6 applications); and backfilling of the excavation area is anticipated to take approximately 1 to 2 weeks to complete.

As this alternative will meet the remedial action objectives for this Site by removal, *ex-situ* treatment of NAPL impacted soils associated with the former USTs 85a/b in this area, on-site re-use, and groundwater monitoring, it is anticipated that this alternative will be acceptable to the RWQCB, because it provides for soil source removal, treatment, and upon RWQCB-approval, excavation backfill with *ex-situ* treated soil which does not exceed cleanup goals.

9.0 RECOMMENDED REMEDIAL ACTION

9.1 Remedial Actions – Excavation, Disposal, Well Installations, Monitoring

Based upon the evaluation of the remedial alternatives cited above, and on the results of the UVOST screening, soil, and groundwater confirmation testing conducted as part of the recent additional site investigation activities, TRC recommends a combined remedial approach to address both soil and groundwater impacts. TRC recommends excavation and disposal for removal of the shallow NAPL-impacted soil and groundwater from 2 to 5.5 fbgs in the delineated area at the former UST Area 85a/b, followed by installation of monitoring wells at locations shown in Figure 6. Monitoring well construction details are presented on Figure 7.

Implementing excavation and disposal of the NAPL and residual TPH-impacted soils, temporary dewatering of groundwater within the excavation and placement into holding tanks (20,000 gallon capacity), and replacement with clean fill will take approximately 3 to 4 weeks to complete. TRC will coordinate permitting and excavation activities with selected qualified contractor, and will obtain excavation and grading permits from the Alameda County Public Works Agency (ACPWA) for excavation activities and advancement of borings for monitoring well installations. Proposed excavation and monitoring well locations will be marked with white paint or the ACP facility staked according to Underground Services Alert (USA) requirements. At least 48 hours prior to commencing field work at the Site, USA will be notified. The USA ticket will be maintained as long as work continues at the site, and will be updated as necessary for drilling location adjustments that are made based upon the field data. In addition to the USA notification, TRC will contract a private utility locator to confirm the location or absence of buried utilities in and around the designated excavation area.

Removal of the NAPL and any associated deleterious materials in the area would then be completed in the former UST Area 85a/b. For Site safety purposes during excavation activities, care will be taken when excavating near the former fuel oil pipeline which reportedly connected to this area. If additional fuel oil is identified in this pipeline, we will approach the RWQCB with appropriate alternative recommendations, such as capping or filling the former fuel oil pipeline with flowable cement or suitable material.

Following NAPL removal, TRC would also initially install three groundwater monitoring wells, one up-gradient and two down-gradient of the NAPL excavation area. Groundwater monitoring and sampling will be conducted for up to 2 years following removal of the NAPL to confirm the effectiveness of the approved remedial action and to observe any rebound in dissolved-phase contaminant concentrations. If no significant rebound in groundwater TPH contaminant concentrations is observed, TRC will recommend no further action and propose the Site be considered for low threat closure. Groundwater samples from the monitoring wells will be analyzed for TPH-d, TPH-g, TPH-fo, PAHs, dissolved oxygen (DO), oxidation-reduction potential (ORP), and may include other biodegradation parameters (including manganese, nitrate, sulfate, or iron) to monitor biodegradation and confirm natural attenuation may be occurring.

The cost for excavation and disposal, installation of monitoring wells, and quarterly monitoring for approximately two years is estimated to be approximately $232,735. TRC anticipates the remedial alternative will take 2 years to demonstrate that low-threat UST closure is applicable for the area. Depending on plume stability or if migration of residual TPH contaminants in groundwater occur, additional future remedial alternatives may be needed.

A further detailed discussion of proposed excavation, stockpiling, disposal, dewatering, and well installations is presented below.

9.1.1 Excavation of Impacted Soils at Former UST 85a/b

Removal of impacted soil and debris in the source area (see Figure 6) at the former UST Area 85a/b will be accomplished via soil excavation by an appropriately licensed environmental contractor. The area will be excavated, based on field observations, until no free product or visually impacted soil is exposed on the sidewalls and base to approximately 6 fbgs, except where the excavation approaches any existing electrical or gas lines to the east (see Figure 6). The excavation boundaries will be laid back to ensure worker safety. The specific excavation plan will be subject to approval by the City and County of Alameda, where necessary. If necessary, shoring may involve the use of sheet piles to maintain sidewall stability.

Prior to excavation, the area will be cleared for subsurface structures by reviewing Site maps and drawings. If unanticipated subsurface components, such as utility lines, are found within excavation area limits, soil excavation will be immediately halted. The line or structure will be identified and evaluated. If the line or structure is no longer necessary, it will be removed and disposed of properly. If the line is active, excavation will resume carefully around it, if possible.

As the excavation will extend into groundwater, confirmation soil samples will not be collected from the excavation sidewalls or base. Barricades and/or temporary fencing will be placed around any excavation that is deeper than 4 fbgs. The excavation will be backfilled in accordance with the requirements of the geotechnical engineer with either clean, imported soil (soil that does not exceed site cleanup goals or the RWQCB's commercial ESLs) or over-excavated material that does not exceed the cleanup goals (see Section 6.1). The backfill material may be from a commercially available source, such as a quarry, or from a construction site. If the soil is derived from a construction site, the contactor will be required to provide documentation that the soil does not exceed the cleanup goals.

9.1.2 Anticipated Excavation Volume

It is estimated that approximately 450 cubic yards of soil will be excavated from the former UST Area 85a/b to a depth of approximately 5.5 fbgs. The estimated excavation area is indicated on Figure 6.

9.1.3 Permitting and Pre-Field Activities

The following work will be performed prior to initiating soil excavation activities:

- A building permit will be obtained from the City of Alameda. This permit will include approval of a grading plan.

- A traffic control plan for trucks and a noise monitoring plan will be submitted to the City of Alameda for approval, if required.
- Excavation and subsurface utility locating, will be performed, with ground penetrating radar (GPR) if applicable. In addition, Underground Service Alert (USA) will be called to complete underground clearance at least two working days before work begins.
- The proposed excavation plan and a transportation route will be presented to the City of Alameda and RWQCB for comment and approval, as appropriate.
- A Dust Mitigation Plan, including an air monitoring program, will be prepared to address soil remediation activities. Additional general dust-control measures are discussed in Section 9.1.8.
- A Storm Water Pollution Prevention Plan (SWPPP) will be prepared for soil excavation activities. The SWPPP will outline various steps to be taken in order to prevent the contamination of stormwater discharges during soil remediation.
- The site-specific Health and Safety Plan (HASP) included in Appendix B will be updated to include site activities during implementation of this RAP.
- Any power poles that are within or close to planned excavation areas will be re-located prior to the start of work. In-field mechanical support for these poles, to ensure pole stability and worker safety, will be provided.

9.1.4 Confirmation Sampling and Analysis Plan

As the excavation will extend into groundwater, only visual confirmation will be conducted, in lieu of a confirmation sampling and analysis plan. Visual confirmation will be used to verify that the NAPL has been removed from the former UST Area 85a/b. If visual observations indicate that NAPL exceeds the area estimated in Figure 6, the amount of additional soil removal will depend on subsurface obstructions and visual observations (staining and/or evidence of contamination), and potentially of field readings (e.g., photo-ionization detector [PID]).

9.1.5 Soil Segregation, Stockpiling, and Profiling

During soil excavation activities, excavated soil will be stockpiled directly adjacent to the excavation area, prior to loading and transport to the final off-site disposal facility or, if necessary, to a longer-term on-site stockpile area.

Soil will be stockpiled on a 10-mil reinforced polyethylene liner. Stockpiled soils will be managed to prevent fugitive dust emissions and contaminated stormwater runoff.

Soil will be segregated and sampled according to anticipated disposition as one of the following:

- Clean overburden or setback that can be re-used as backfill on-site. These soils will be sampled for the Site cleanup goals.
- Soil that does not meet Site cleanup goals, will need to be disposed off-site as either non-hazardous waste, non-Resources Conservation and Recovery Act (RCRA) (Federal) hazardous waste, or RCRA-hazardous waste.

Prior to off-site disposal of soils exceeding Site remedial goals, soils will be sampled to meet the profiling requirements of Waste Management's Altamont Landfill in Livermore, California (non-hazardous soils) or Chemical Waste Management's hazardous waste facility in Kettleman Hills, California (non-RCRA and RCRA hazardous soils), as appropriate. In accordance with the Department of Toxic Substances Control's (DTSC) *Information Advisory on Clean Imported Fill*

Material (October, 2001The placement of backfill will be conducted according to the requirements below.

- Place backfill materials in loose lifts no more than approximately 9-inches thick.
- Moisten each lift, as necessary, to achieve compaction requirements before compacting. Uniformly apply water to prevent free-water from appearing on the surface during or after compaction.
- Compact each lift with equipment appropriate to the soil type (e.g., vibratory plate attached to a backhoe). Minimize vibration during compaction for the first few lifts to reduce pumping of groundwater up into soils. Each successive lift should be firm and non-yielding under the weight of construction equipment.
- Field-test compaction of each lift. Soils placed deeper than 5-feet below finished grade should generally be compacted to at least 95 percent relative compaction (Modified Proctor) before placing the next lift. Soils placed less than 5-feet below finished grade should be compacted to at least 90 percent relative compaction (Modified Proctor). Field-test compaction will be verified and approved by a certified compaction testing inspector.
- Geotechnical laboratory testing (compaction, Plasticity Index, etc.) will be performed as necessary.
- A licensed geotechnical or civil engineer will approve import soils.

The excavation is intended to extend below the water table. In addition to those abovementioned, the following steps will be implemented:

- Dewater the excavation, as necessary.
- Place geotextile fabric at the base of the excavations.
- Place a 12-inch thick layer of drain rock on the geotextile.
- Densify drain rock with static compaction (no vibration), as necessary.

If stormwater has accumulated in the excavation, the excavation will be de-watered prior to backfilling. The need for geotextile fabric and/or drain rock in association with stormwater will be made in the field on a case-by-case basis, and will depend on the extent of soil moisture and compatibility.

9.1.8 Dust Monitoring and Abatement

Monitoring for airborne dust will be continuously performed during the excavation of impacted soil. Dust monitors will be placed at the up-wind and down-wind property boundaries. Air monitoring protocol will be presented in the HASP. Dust mitigation measures will be implemented during excavation, backfilling, handling of impacted soil, and grading based on field monitoring readings and visible emissions, as follows:

- Dust control will be achieved by applying a light mist of water, at least twice daily, to excavation areas and unpaved surface areas where equipment will operate, as well as any unpaved access roads, parking areas, or staging areas. The water source will be from a water truck or from an alternative metered source. Dust suppression application techniques will be performed in a manner that minimizes surface water runoff.
- All vehicles within the project Site will have a maximum speed limit of 10 miles per hour and speed limit signs will be posted at various unpaved traffic areas. The Site entrance will be graded as necessary to prevent both runoff and dust from leaving the construction site. Stabilization material will be 1- to 3-inch coarse aggregate.

- During inactive periods (such as after work hours, weekends, and holidays), excavation areas will be covered with visqueen material and sand bags.
- A cover will be provided and placed on all vehicles that will be used to transport solid bulk materials (including soil, sand, rock, fill, and other loose material) that have the potential to cause visible emissions, before the vehicles enter the public roadways. The covering will be in good condition, joined at the seams, and securely anchored to minimize headspace where vapors may accumulate.
- Trucks will be loaded at the Site with sufficient freeboard and appropriately covered using tarps or equivalent covers to minimize emissions to the atmosphere. In the event a tarp rips or comes loose, the truck will be stopped and the tarp repaired or replaced. If the tarp is not repairable, the truck will not be moved until a new tarp can be obtained and placed on the truck. Only then will the truck be permitted to continue to the disposal facility.
- All vehicles and equipment used during Site activities will be decontaminated prior to exiting the Site by brushing and scraping visible dirt or by rinsing with a high-pressure water spray to remove dirt. Vehicles will be specifically inspected for the presence of dirt caught in the tires and the undercarriage. Vehicles and equipment will be authorized to leave the Site only after decontamination has been accomplished.
- Stockpiles generated during excavation activities will be placed on top of a 10-mil plastic liner, and covered with 10-mil plastic and secured at the end of each day. Stockpiles will be watered, or dust suppressants will be applied to form a visible crust, if stockpiles remain exposed during the work day. In the event of inclement weather in the forecast, stockpiles will be covered and secured to avoid the potential for windborne dust generation and/or stormwater runoff.

9.1.9 Waste Management

9.1.9.1 Waste Classification

Waste types will be classified by the concentration of chemicals detected during the soil stockpile profiling.

9.1.9.2 Waste Storage and Loading

As described in Section 9.1.5, excavated soil will be stockpiled directly adjacent to the excavation area, prior to loading and transport to the final off-site disposal facility. In most cases, it is anticipated that after profiling, stockpiles will be loaded directly onto trucks to avoid unnecessary handling. If necessary, longer-term on-site stockpile areas will be designated.

To facilitate off-site removal of contaminated soil from the Site, the analytical results will be forwarded to an appropriate permitted facility for confirmation of acceptance for disposal. Upon approval by the disposal facility, the soil will be loaded into and transported by trucks that are fully licensed and permitted to carry the impacted soil. Prior to leaving the Site, the trucks will be decontaminated to minimize dust emissions and spillage during transportation; decontamination procedures will be discussed in the HASP. The trucking shall be conducted in compliance with California Department of Transportation (CALTRANS) regulations and in accordance with all other applicable federal and local regulations. After the waste is loaded into vehicles, it will be covered with tarps or equivalent covers to minimize emissions to the atmosphere. It is anticipated that the impacted soil from the former UST Area 85a/b would have waste profiling characteristics as non-hazardous waste and disposed at a Class II facility.

9.1.9.3 Transportation and Disposal Record-Keeping

Weight tickets, manifests, and disposal facility waste forms for each non-hazardous and hazardous truckload leaving the Site will be prepared and collected for documentation purposes. Soil classified as a non-RCRA or RCRA waste will be assigned the applicable state or federal waste codes for profiling and manifesting. All shipments of hazardous waste will be accompanied by a state-approved Uniform Hazardous Waste manifest.

9.1.9.4 Hazardous Waste Training

Each employee working at the Site will be required to have completed a hazardous waste management training program. The level of hazardous waste training required by each employee will be based on job duties as they pertain to hazardous waste management. All site personnel shall, at a minimum, meet the training requirements specified in the OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) Standard (29 CFR 1910.120(e) and CCR Title 8 Section 5192(e)). All employee training records will be kept on file with the HASP.

9.1.9.5 Transportation Training and Oversight

Site-specific waste transportation training and requirements are indicated below:

- DTSC 2007 Hazardous Waste Transporter Requirements shall be followed, pursuant to Division 20, Chapter 6.5, Article 6.5, Article 6.6 and Article 13 of the California Health and Safety Code, and regulations adopted pursuant to these statutes in Division 4.5, Chapter 13 and Chapter 29 of the California Code of Regulations, Title 22.
- All truck drivers shall have a California Department of Motor Vehicles (DMV) commercial driver's license and safe driving record.
- All drivers transporting hazardous waste shall, in addition, have a DMV endorsement to transport hazardous materials and have successfully passed a Hazardous Waste Driver Training course.
- All drivers will be required to attend site-specific orientation training. The training will describe the hazards of the materials being transported, such as asbestos and metals, and will outline site-specific transportation requirements, such as daily truck inspections prior to leaving the Site. Dedicated personnel will be assigned to truck inspections to ensure the safe transport of materials to the disposal destinations.
- All drivers will be provided with a copy of emergency procedures and emergency phone numbers to use in the event of an emergency or transportation accident.
- All drivers will be provided the approved transportation route to the disposal facility, and shall be instructed not to deviate from that route. If an emergency situation or unexpected road condition necessitates an alternate route, the drivers shall inform Site personnel.

9.1.9.6 Transportation Procedures and Routes

The proposed transportation route primarily traverses highways to minimize travel over city streets. The route does not traverse any residential areas. None of the proposed highway routes are listed with the California Highway Patrol as prohibited for hauling hazardous waste.

The proposed route for truck traffic from the Site to the nearest highway is as follows:

<u>From Site to Altamont Landfill in Livermore, California</u>: Loaded trucks will exit the Site at Main Street heading south, turn left onto Atlantic Avenue, and turn left onto Webster Street through the Webster Tube onto Highway 880 heading south to 238 and 580 east. Exit 580 West to Grant Line Road and turn right onto Grant Line Road heading north. Turn left onto Altamont Pass Road heading west, along which the disposal site is located.

9.1.9.7 Storm Water Pollution Controls

The Urban Runoff Pollution Prevention Program, also called the Non-Point Source Program, was developed in accordance with the requirements of the 1986 San Francisco Bay Basin Water Quality Control Plan to reduce water pollution associated with urban stormwater runoff. This program was also designed to fulfill the requirements of the Federal Clean Water Act, which mandated that the EPA develop National Pollution Discharge Elimination system (NPDES) Permit application requirements for various stormwater discharges, including those from municipal storm drain systems and construction sites.

For properties of 1 acre or greater, a Notice of Intent (NOI) and Storm Water Pollution Prevention Plan (SWPPP) must be prepared prior to commencement of construction.

The removal actions are not expected to occur during the winter season. However, stormwater management controls will be implemented, as needed, to reduce the potential for impacted soils to impact stormwater runoff. These stormwater controls are based on best management practices (BMPs), such as those described in the *Erosion and Sediment Control Field Manual* (CRWQCB, 1998) and the *Manual of Standards for Erosion and Sediment Control Measures, Second Edition* (ABAG, 1995). The BMPs implemented may include, but are not limited to, the following:

- Construction of berms or silt fences at the perimeter of the Site, as appropriate;
- Placement of straw bale barriers around entrances to storm drains and catch basins;
- Covering soil stockpiles with a 10 mil impermeable barrier during rain events; and
- Placement of gravel at project entrances/exits where soil can be removed from vehicles prior to leaving the Site.

9.1.10 Well Installation, Development, and Sampling

A hollow-stem auger (HSA) drill rig will be used for the installation of groundwater monitoring wells. The selected well screen length is 10-feet and will be installed at 1-foot above and 9-feet below the observed water table. After drilling has been completed to depth, a 4-inch well casing will be installed. The screen formation annulus will be filled with an appropriate filter pack to allow adequate flow of groundwater into the well. The riser formation annulus will be properly sealed with hydrated bentonite chips and cement grout. The wellhead will be sealed with a watertight, lockable well cap. A flush-mounted, watertight, traffic-rated well box will be installed over each wellhead.

Following well installation, the wells will be developed (surged and bailed) to improve hydraulic communication between the geologic formation and the well. Depth to groundwater and total depths will be gauged, wells will be purged using a standard low-flow method [see Standard Operating Procedures (SOP) in Appendix C], and samples will be collected.

9.1.10.1 Monitoring Well Locations

New monitoring wells MW-4 and MW-5 will be installed down-gradient of the TPH-impacted area as compliance monitoring wells, and new monitoring well MW-6 will be installed up-gradient (south-southeast) of the NAPL area and used as a background monitoring well, as shown on Figure 6.

9.1.10.2 Groundwater Sampling and Performance Monitoring

Quarterly groundwater samples will be collected from existing well MW-3A with newly proposed up-gradient and down-gradient wells MW-4, MW-5, and MW-6 (Figure 6). Groundwater sampled from the wells will be analyzed for the following parameters:

- TPH-g, TPH-d, and TPH-fo by Environmental Protection Agency (EPA) Method 8260B/8015B/SW846.
- Benzene, Toluene, Ethylbenzene, Xylenes, and MTBE by EPA Method 8260B.
- PAHs by EPA Method 8270C.
- General water quality parameters, including DO, ORP, specific conductivity, turbidity, temperature and pH (meter reading taken in flow-through cell).
- Other biodegradation parameters (including manganese, nitrate, sulfate, or iron) may be monitored for biodegradation and to confirm natural attenuation may be occurring.
- Visual and olfactory observations for color and smell, respectively.

9.2 Regulatory Closure

After a period of post-remediation monitoring of groundwater for approximately two years, a low-threat UST closure request will be submitted to the RWQCB, if appropriate. Following regulatory approval of low-threat UST closure by the RWQCB, the existing monitoring wells will be abandoned, after obtaining the necessary permits.

10.0 DATA QUALITY ASSURANCE

A Quality Assurance and Quality Control Procedures (QA/QC) were prepared to provide data quality assurance guidance and requirements for activities associated with field measurements, sampling, laboratory analyses, reporting, and data management during the remediation activities. The QA/QC protocols are presented in Appendix C.

11.0 REPORTING AND SCHEDULE

The schedule for remedial action will be based on availability of excavation contractors, waste disposal contractors, and drilling contractors. The excavation and removal of NAPL will tentatively be scheduled for mid-September 2016, followed by monitoring well installations for MW-4, MW-5, and MW-6 by early October 2016. Once the up-gradient and downgradient monitoring wells are installed, quarterly groundwater monitoring schedule will begin in the fourth quarter 2016, and will continue through 2 annual cycles. Following completion of the remedial action, a report of findings will be prepared for the RWQCB within 60 days, by early December 2016. The report will include excavation area maps, analytical results of groundwater samples collected following removal activities, and recommendations for additional work, if necessary. In addition, as required by RWQCB, we will electronically submit report data to the SWRCB Geotracker database.

12.0 LIMITATIONS

This Remediation Workplan was prepared for the use of Alameda Commercial Properties and the California Regional Water Quality Control Board in evaluating remedial alternatives at the ACP Site at the time of this study. We make no warranty, expressed or implied, except that our services have been performed in accordance with environmental principles generally accepted at this time and location. The chemical and other data presented in this report can change over time and are applicable only to the time this study was performed. We are not responsible for the data presented by others.

13.0 REFERENCES

DTSC, 2001. *Information Advisory on Clean Imported Fill Material.* October.

Environmental Resources Management, 2008. *Limited Site Investigation and Monitoring Well Installation Results, 2900 Main Street, Alameda, California*, July 15.

Environmental Technical Services, 2014. *A Report Documenting: Investigation for Supplemental Information to Support Low-Threat Case Closure (SF-RWQCB File #01-1060)*, February 7.

Environmental Technical Services, 2013. *A Report Documenting: March, 2013 Groundwater Monitoring Event and Assessment Case for Low-Threat Closure (SF-RWQCB File #01-1060)*, May 6.

SFRWQC), 2006. *Draft Technical Reference Document, Characterization and Reuse of Petroleum Hydrocarbon Impacted Soil As Inert Waste,* October 20.

SFRWQCB, 2012. *Low-Threat Underground Storage Tank Case Closure Policy,* August 17.

SFRWQCB, 2014. *Alameda Gateway, 2900 Main Street, Alameda, Alameda County – Comments on the Technical Report, Approval for Well Destruction, and Requirement for a Well Destruction Report and a Work Plan for Additional Site Investigation*, June 5.

SFRWQCB, 2015. *Alameda Gateway, 2900 Main Street, Alameda, Alameda County. Request for Revised Work Plan,* January 7.

SFRWQCB, 2015. *Alameda Gateway, 2900 Main Street, Alameda, Alameda County. Approval of Work Plan, and Requirement for a Technical Report,* April 30.

SFRWQCB, 2016. *Conditional Report Approval and Requirement for Confirmatory Groundwater Sampling and a Remedial Action Plan – Alameda Gateway Ltd., 2900 Main Street, Alameda, Alameda County,* January 15.

SFRWQCB, 2016. *Environmental Screening Levels* http://www.waterboards.ca.gov/rwqcb2/water_issues/programs/esl.shtml. Interim Final, February 2016.

State Water Resources Control Board (SWRCB), Geotracker website, *Alameda Gateway LTD (T0600100977), 2900 Main Street, Alameda, CA 94501, Alameda County, LUST Cleanup Site, SFRWQCB Case#10-1060;* http://geotracker.waterboards.ca.gov/profile_report.asp?global_id=T0600100977, accessed April 11, 2016

S. Figuers, 1998. *Groundwater Study and Water Supply History of the East Bay Plain, Alameda and Contra Costa Counties, CA.* June 15.

TRC, 2015. *UST Investigation Report, Former USTs 85a/b, 133, and 137, Alameda Commercial Properties, LLC, 2900 Main Street, Alameda, California*. November 23.

TABLES

TABLE 1: Alternative 1 - No Action/Institutional Controls/Monitoring (30 Years)

Item		Task Description	Unit Type	Unit Cost		Total Cost
1a		Final Risk Assessment	1 LS	$	8,500	8,500
1b		Health and Safety Plan	1 LS	$	3,500	3,500
1c		Monitoring Plan	1 LS	$	7,500	7,500
1d		California Environmental Quality Act (CEQA) Exemption Evaluation	1 LS	$	8,500	8,500
	1	Plans and Permits		**Subtotal**		**28,000**
2a		Land Use Covenant Preparation and Recording	1 LS	$	8,500	8,500
2b		Restrictive Easement for Site	1 LS	$	8,500	8,500
2c		County Well Permit Ordinance/Moratorium Area	1 LS	$	8,500	8,500
	2	Institutional Controls		**Subtotal**		**25,500**
3a		Groundwater Monitoring Well Installation	3 well	$	3,515	10,545
3b		Groundwater Monitoring (Annual)	30 Yr	$	4,250	$127,500
3c		Site Maintenance (paving, landscaping)	1 LS	$	60,000	$60,000
3d		Site Inspection/Report to Verify Institutional Controls	30 Yr	$	5,500	$165,000
3e		Reporting (Annual)	30 Yr	$	5,500	$165,000
3f		Well Replacement/Closure	3 well	$	3,515	$10,545
	3	Monitoring and Maintenance Activities (30 Years)		**Subtotal**		**$538,590**
		Total Cost				**$592,090**

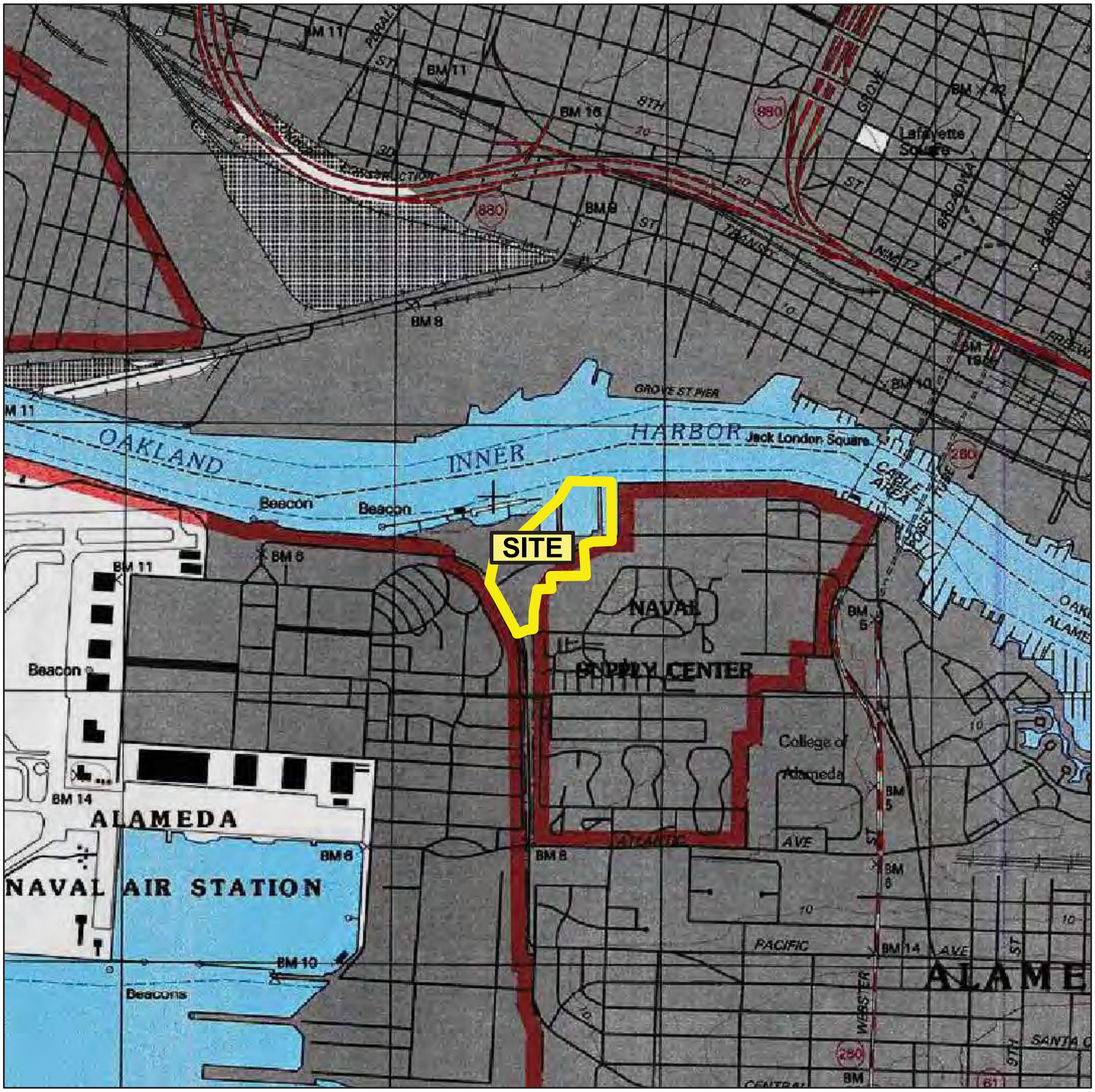
TABLE 2: Alternative 2 - Excavation and Off-Site Disposal with Groundwater Monitoring (2 Years)

Item		Task Description	Unit Type	Unit Cost		Total Cost
1a		Program Management	2 Yr	$	4,800	$12,000
1b		Site Management	2 Yr	$	15,000	$15,000
	1	Program and Site Management		**Subtotal**		**$27,000**
2a		Remedial Action Plan	1 LS	$	11,750	$11,750
2b		Health and Site Safety Plan	1 LS	$	4,500	$4,500
2c		Storm Water Pollution Prevention Plan	1 LS	$	4,500	$4,500
2d		Dust Mitigation Plan and Permit	1 LS	$	4,500	$4,500
	2	Plans and Permits		**Subtotal**		**$25,250**
	3	Mobilization	1 LS	$	6,500	**$6,500**
4a		Excavation	585 ton (450 CY)	$	11	$6,435
4b		Stockpile Sampling (Profiling)	1 LS	$	4,000	$4,000
4c		Backfill and Compact	585 ton (450 CY)	$	24	$14,040
4d		Imported Backfill	585 ton (450 CY)	$	16	$9,360
4e		Dust Control and Odor Management	1 LS	$	7,500	$7,500
	4	Remediation - Excavation		**Subtotal**		**$41,335**
5a		Dewatering	2 x 20,000 gal tanks	$	13,500	$13,500
5b		Soil Disposal (Class II)	585 ton	$	53	$31,000
5c		Water Disposal (Class II)	40,000 Gallons	$	0.54	$21,600
	5	Remediation - Dewatering and Waste Disposal		**Subtotal**		**$66,100**
6a		Groundwater Monitoring Well Installation	3 well	$	3,515	$10,545
6b		Groundwater Monitoring (Quarterly)	2 Yr	$	7,300	$14,600
6c		Reporting (Quarterly)	2 Yr	$	6,430	$12,860
6d		Well Abandonment	1 LS	$	3,515	$10,545
	6	Monitoring and Maintenance Activities		**Subtotal**		**$48,550**
7a		Low Threat Closure Report	1 LS	$	13,500	$13,500
7b		Project Close Out	1 LS	$	4,500	$4,500
	7	Regulatory Closure and Contract Completion Activities		**Subtotal**		**$18,000**
		Total Cost				$232,735

TABLE 3: Alternative 3 - Excavation and *Ex-Situ* Treatment with Groundwater Monitoring (3 Years)

Item		Task Description	Unit Type	Unit Cost		Total Cost
1a		Program Management	2 Yr	$	4,800	$12,000
1b		Site Management	2 Yr	$	15,000	$15,000
	1	Program and Site Management		**Subtotal**		**$27,000**
2a		Remedial Action Plan	1 LS	$	11,750	$11,750
2b		Health and Site Safety Plan	1 LS	$	4,500	$4,500
2c		Storm Water Pollution Prevention Plan	1 LS	$	4,500	$4,500
2d		Dust Mitigation Plan and Permit	1 LS	$	4,500	$4,500
	2	Plans and Permits		**Subtotal**		**$25,250**
	3	Mobilization	1 LS	**Subtotal**	6500	**$6,500**
4a		Excavation	585 ton (450 CY)	$	11	$6,435
4b		Dewatering	40,000 gallons	$	13,500	$13,500
4c		Water Disposal (Class II)	40,000 Gallons	$	0.54	$21,600
4d		Backfill and Compact	585 ton (450 CY)	$	24	$14,040
4e		Dust Control and Odor Management	1 LS	$	7,500	$7,500
	4	Remediation - Excavation		**Subtotal**		**$63,075**
5a		Ex-Situ Mixing (e.g. H&H Micro-enfractionator)	1 LS	$	80,000	$80,000
5b		Chemical Oxidant (for 6 applications; assume $1.90/lb)	1 LS	$	20,000	$20,000
5c		Stockpile Verification Sampling (RWQCB Testing Protocol for TPH)	1LS	$	3,000	$3,000
5d		Analytical Testing (for 6 application events)	1 LS	$	32,400	$32,400
	5	Ex-Situ Mixing and Verification		**Subtotal**		**$135,400**
6a		Groundwater Monitoring Well Installation	3 well	$	3,515	$10,545
6b		Groundwater Monitoring (Semi-Annual)	3 Yr	$	7,300	$21,900
6c		Reporting (Quarterly)	3 Yr	$	6,430	$19,290
6d		Well Abandonment	1 LS	$	3,515	$10,545
	6	Monitoring and Maintenance Activities		**Subtotal**		**$62,280**
7a		Low Threat Closure Report	1 LS		13,500	$13,500
7b		Project Close Out	1 LS		4,500	$4,500
	7	Regulatory Closure and Contract Completion Activities		**Subtotal**		**$18,000**
		Total Cost				**$337,505**

FIGURES



1 MILE 3/4 1/2 1/4 0 1 MILE

SCALE 1 : 24,000

N

SOURCE:
United States Geological Survey
7.5 Minute Topographic Maps:
Oakland East and Oakland West Quadrangles,
California

VICINITY MAP

Alameda Commercial Properties, LLC
2900 Main Street
Alameda, California

TRC | 232888.0001 | **FIGURE 1**

FILE NAME: N:\PROJECTS\CAD\Alameda Commercial Properties\Remedial Action Plan_April16\Fig1_Vicinity Map.DWG | Layout Tab: 8x11

SOURCE AERIAL PHOTO: Google Earth, May 2015.

LEGEND

Locations surveyed except as marked:*

- Monitoring well
- UVOST boring
- Co-located soil and grab groundwater boring
- Soil boring - 1989
- Soil boring - 2008
- Soil boring - 2014

NOTES:
** = Survey by Virgil Chavez Land Surveying, October 30, 2015.*
*** = Approximate location.*

N

SCALE (FEET)
0 10 20

SITE PLAN

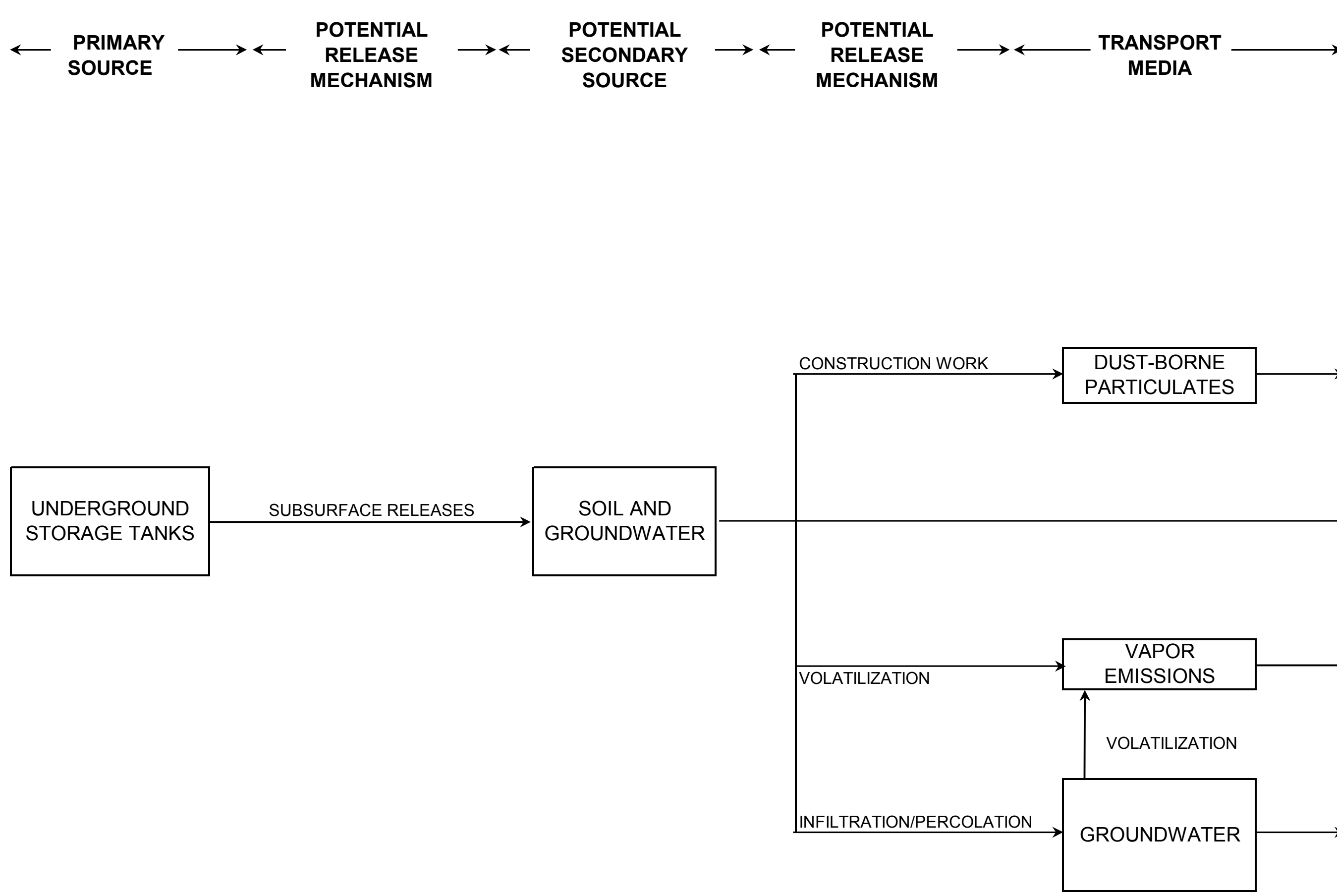
Alameda Commercial Properties, LLC
2900 Main Street
Alameda, California

TRC 232888.0001

FIGURE 2

FILE NAME: N:\PROJECTS\CAD\Alameda Commercial Properties\Remedial Action Plan_April16\Fig2_Site Plan_Former USTs 85a_b.dwg | Layout Tab: 11x17

Conceptual Site Model
Human Health Risk Analysis
Former USTs 85a/b
at 2900 Main Street
Alameda Commercial Properties
Alameda, California



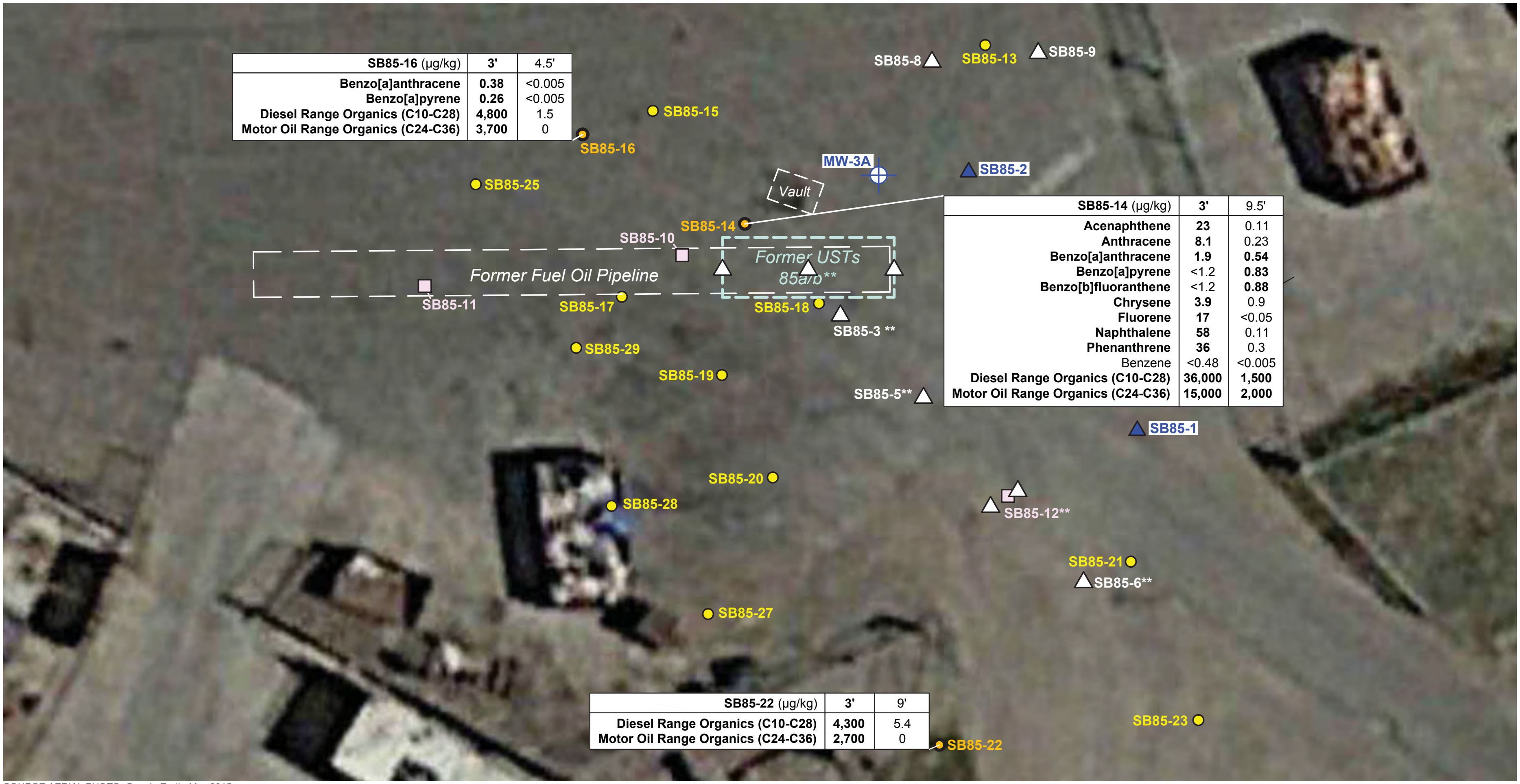
POTENTIAL RECEPTORS

	ONSITE		OFFSITE		
EXPOSURE ROUTE	COMMERICAL/INDUSTRIAL WORKER	CONSTRUCTION WORKER	COMMERCIAL/INDUSTRIAL WORKER	CONSTRUCTION WORKER	ECOLOGICAL
INHALATION	C/INS	C	INC	INC	INC
INGESTION	C/INS	C	INC	INC	INC
DERMAL CONTACT	C/INS	C	INC	INC	INC
INHALATION - AMBIENT AIR	C	C	INC	INC	INC
INGESTION	C/INS	C	INC	INC	INC
DERMAL CONTACT	C/INS	C	INC	INC	INC

NOTES:
C - COMPLETE PATHWAY
INC - INCOMPLETE PATHWAY
C/INS - COMPLETE PATHWAY, BUT INSIGNIFICANT

EXPOSURE PATHWAYS
Alameda Commercial Properties, LLC
2900 Main Street
Alameda, California

TRC | 232888.0001 | **FIGURE 3**



SB85-16 (µg/kg)	**3'**	4.5'
Benzo[a]anthracene	**0.38**	<0.005
Benzo[a]pyrene	**0.26**	<0.005
Diesel Range Organics (C10-C28)	**4,800**	1.5
Motor Oil Range Organics (C24-C36)	**3,700**	0

SB85-14 (µg/kg)	**3'**	9.5'
Acenaphthene	**23**	0.11
Anthracene	**8.1**	0.23
Benzo[a]anthracene	**1.9**	**0.54**
Benzo[a]pyrene	<1.2	**0.83**
Benzo[b]fluoranthene	<1.2	**0.88**
Chrysene	**3.9**	0.9
Fluorene	**17**	<0.05
Naphthalene	**58**	0.11
Phenanthrene	**36**	0.3
Benzene	<0.48	<0.005
Diesel Range Organics (C10-C28)	**36,000**	**1,500**
Motor Oil Range Organics (C24-C36)	**15,000**	**2,000**

SB85-22 (µg/kg)	**3'**	9'
Diesel Range Organics (C10-C28)	**4,300**	5.4
Motor Oil Range Organics (C24-C36)	**2,700**	0

SOURCE AERIAL PHOTO: Google Earth, May 2015.

LEGEND

Locations surveyed except as marked:*

- Monitoring well
- UVOST boring
- Co-located soil and grab groundwater boring
- Soil boring - 1989
- Soil boring - 2008
- Soil boring - 2014

NOTES:
** = Survey by Virgil Chavez Land Surveying, October 30, 2015.*
*** = Approximate location.*

*Analytical results in **BOLD** formatting indicate that the detected concentration exceeds the Regional Water Quality Control Board's commercial environmental screening level (ESL).*

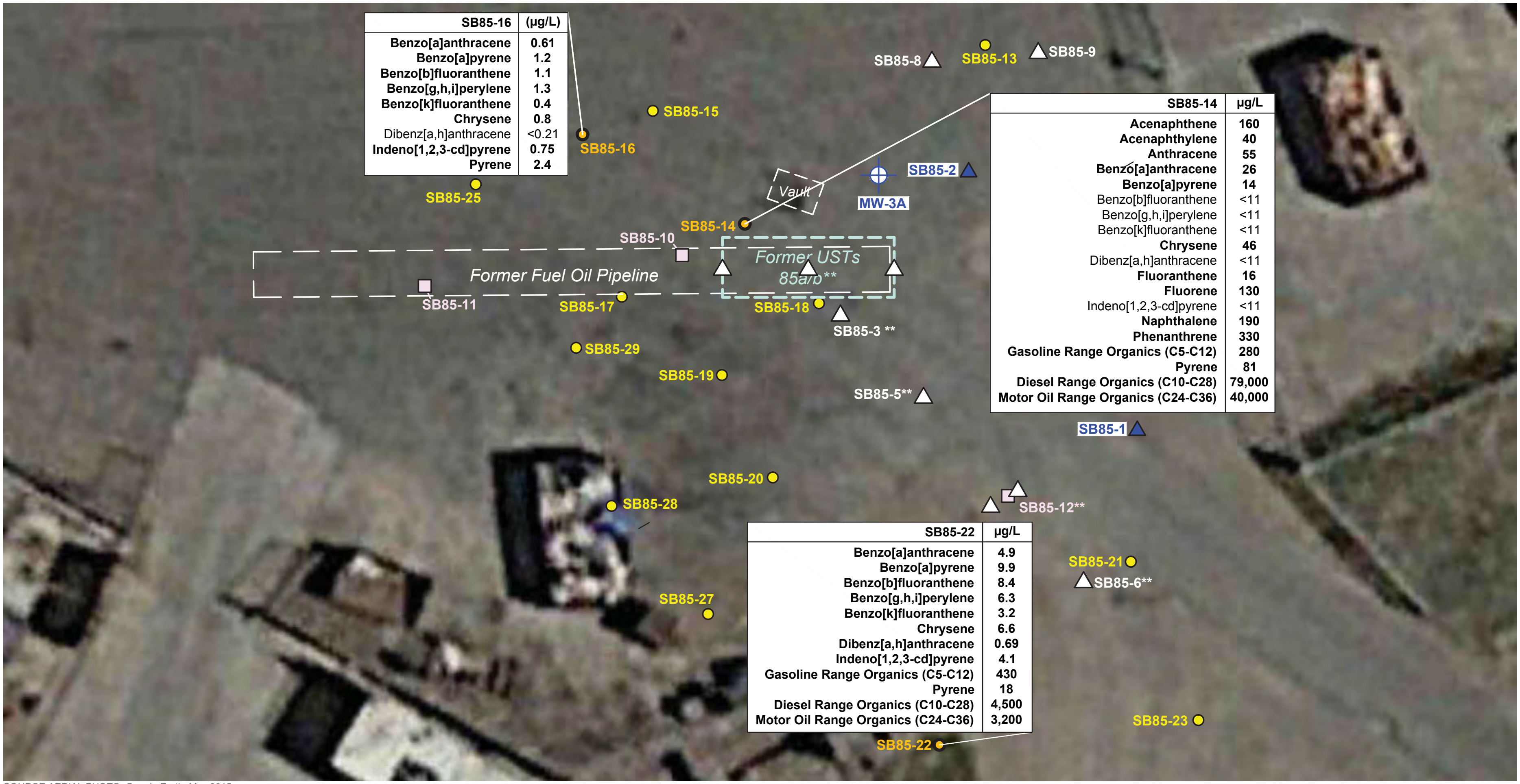
N

SCALE (FEET)
0 10 20

FORMER USTs 85a/b
SOIL ANALYTICAL RESULTS
October 13, 2015
Alameda Commercial Properties, LLC
2900 Main Street
Alameda, California

TRC 232888.0001 **FIGURE 4**

FILE NAME: N:\PROJECTS\CAD\Alameda Commercial Properties\Remedial Action Plan_April16\Fig4_Former USTs 85a-b Analytical.dwg | Layout Tab: 11x17



SB85-16	(µg/L)
Benzo[a]anthracene	**0.61**
Benzo[a]pyrene	**1.2**
Benzo[b]fluoranthene	**1.1**
Benzo[g,h,i]perylene	**1.3**
Benzo[k]fluoranthene	**0.4**
Chrysene	**0.8**
Dibenz[a,h]anthracene	<0.21
Indeno[1,2,3-cd]pyrene	**0.75**
Pyrene	**2.4**

SB85-14	µg/L
Acenaphthene	**160**
Acenaphthylene	**40**
Anthracene	**55**
Benzo[a]anthracene	**26**
Benzo[a]pyrene	**14**
Benzo[b]fluoranthene	<11
Benzo[g,h,i]perylene	<11
Benzo[k]fluoranthene	<11
Chrysene	**46**
Dibenz[a,h]anthracene	<11
Fluoranthene	**16**
Fluorene	**130**
Indeno[1,2,3-cd]pyrene	<11
Naphthalene	**190**
Phenanthrene	**330**
Gasoline Range Organics (C5-C12)	**280**
Pyrene	**81**
Diesel Range Organics (C10-C28)	**79,000**
Motor Oil Range Organics (C24-C36)	**40,000**

SB85-22	µg/L
Benzo[a]anthracene	**4.9**
Benzo[a]pyrene	**9.9**
Benzo[b]fluoranthene	**8.4**
Benzo[g,h,i]perylene	**6.3**
Benzo[k]fluoranthene	**3.2**
Chrysene	**6.6**
Dibenz[a,h]anthracene	**0.69**
Indeno[1,2,3-cd]pyrene	**4.1**
Gasoline Range Organics (C5-C12)	**430**
Pyrene	**18**
Diesel Range Organics (C10-C28)	**4,500**
Motor Oil Range Organics (C24-C36)	**3,200**

SOURCE AERIAL PHOTO: Google Earth, May 2015.

LEGEND

Locations surveyed except as marked:*

- Monitoring well
- UVOST boring
- Co-located soil and grab groundwater boring
- Soil boring - 1989
- Soil boring - 2008
- Soil boring - 2014

NOTES:
** = Survey by Virgil Chavez Land Surveying, October 30, 2015.*
*** = Approximate location.*

*Analytical results in **BOLD** formatting indicate that the detected concentration exceeds the Regional Water Quality Control Board's commercial environmental screening level (ESL).*

N

SCALE (FEET)
0 10 20

FORMER USTs 85a/b
GROUNDWATER ANALYTICAL RESULTS
October 13, 2015

Alameda Commercial Properties, LLC
2900 Main Street
Alameda, California

TRC 232888.0001

FIGURE 5

FILE NAME: N:\PROJECTS\CAD\Alameda Commercial Properties\Remedial Action Plan_April16\Fig5_USTs 85_GW Oct15.dwg | Layout Tab: 11x17

LEGEND

Locations surveyed except as marked:*

- Monitoring well
- UVOST boring
- Co-located soil and grab groundwater boring
- Soil boring - 1989
- Soil boring - 2008
- Soil boring - 2014
- Proposed monitoring well

NOTES:
** = Survey by Virgil Chavez Land Surveying, October 30, 2015.*
*** = Approximate location.*

N

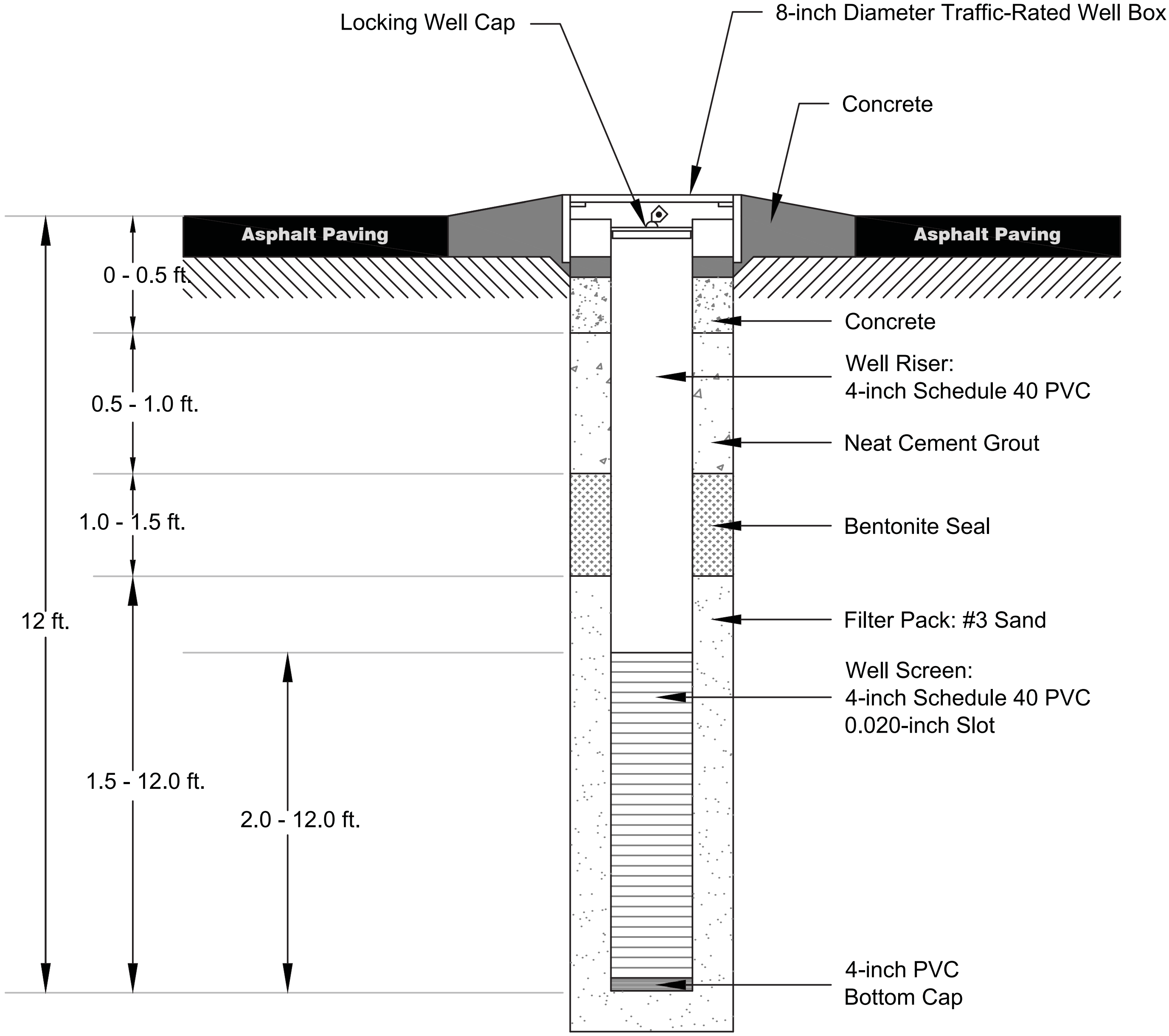
SCALE (FEET)
0 10 20

FORMER USTs 85a/b
PROPOSED REMEDIAL EXCAVATION AREA
AND WELL LOCATIONS

Alameda Commercial Properties, LLC
2900 Main Street
Alameda, California

TRC | 232888.0001 | **FIGURE 6**

FILE NAME: N:\PROJECTS\CAD\Alameda Commercial Properties\Remedial Action Plan_April16\Fig6_Prop Excav_Wells.dwg | Layout Tab: 11x17



SCALE: NOT TO SCALE

PROPOSED WELL CONSTRUCTION DETAILS AT FORMER UST AREA 85a/b

Alameda Commercial Properties, LLC
2900 Main Street
Alameda, California

TRC	232888.0001	**FIGURE 7**

APPENDIX A

HISTORICAL SOIL AND GROUNDWATER DATA
AT FORMER UST AREAS 85A/B

TRC

ENVIRONMENTAL TECHNICAL SERVICES

1548 Jacob Avenue, San Jose, CA 95118 Phone: (831) 236-9221 Fax: (408) 267-9729 hmawhinneyets@aol.com

A Report Documenting:

March, 2013 Groundwater Monitoring Event and Assessment Case for Low-Threat Closure

(SF-RWQCB FILE #01-1060)

Prepared for:

Alameda Gateway Ltd
2415 Mariner Square Drive
Alameda, California 94025

Concerning site at:

ALAMEDA GATEWAY
2900 MAIN STREET
ALAMEDA, CALIFORNIA

May 6, 2013

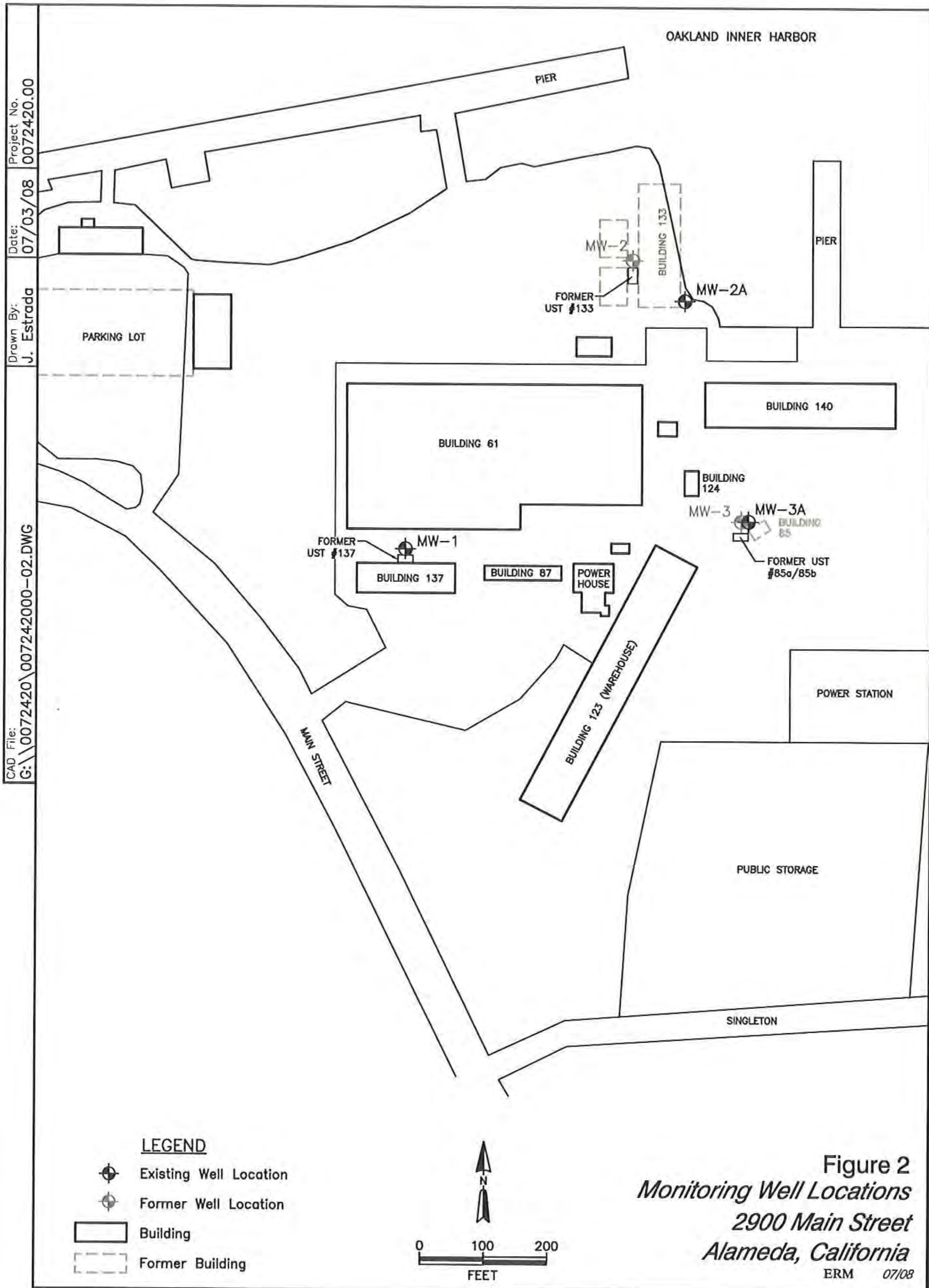


Figure 2
Monitoring Well Locations
2900 Main Street
Alameda, California
ERM 07/08

Table 2a
Underground Storage Tank Removal, April 11, 1990
Soil Samples Collected at 6" Above Groundwater
Alameda Gateway, 2900 Main Street, Alameda, CA

Tank Sample#	**TPHd** *ppm*	**TPHg** *ppm*	**B** *ppm*	**T** *ppm*	**E** *ppm*	**X** *ppm*
1,100-GAL AG-137-01	6.7	ND	ND	ND	ND	ND
1,100-GAL AG-137-02	38000.0	850.0	2.2	4.3	4.3	29.0
1,100-GAL AG-137-03	ND	2.8	0.1	ND	ND	ND
600-GAL NONE COLLECTED						
7,000-GAL AG-85-01	NA	4.8	<0.1	<0.1	<0.1	<0.1
7,000-GAL AG-85-02	NA	1.1	<0.1	<0.1	<0.1	<0.1
7,000-GAL AG-85-03	ND	4.8	<0.1	<0.1	<0.1	<0.1
600-GAL AG-133-01	1100.0	52.0	0.3	<0.1	0.4	0.7
Reporting Limit	5.0	1.0	0.1	0.1	0.1	0.1

Table 2B
Underground Storage Tank Removal, April 11, 1990
Groundwater Samples

Tank Sample#	**TPHd** *ppb*	**TPHg** *ppb*	**B** *ppb*	**T** *ppb*	**E** *ppb*	**X** *ppb*
7,000-GAL AG-85-03	NA	43,300.0	37	<0.5	<0.5	300
Reporting Limit	NA	<50.0	0.5	0.5	0.5	0.5

Table 3
Installation of Groundwater Monitoring Wells MW-1, MW-2, MW-3
Soil Samples, August 26, 1992
Alameda Gateway, 2900 Main Street, Alameda, CA

Well No. **Tank Area** **Depth**	**TOG** *ppm*	**THE** *ppm*	**TVH** *ppm*	**B** *ppm*	**T** *ppm*	**E** *ppm*	**X** *ppm*	**LEAD** *ppm*	**TVH-g** *ppm*
MW-1 #137 3.0'	140.0	4,900.0	NA	ND	ND	ND	ND	13.0	NA
MW-2 #133 2.5'	NA	NA	ND	ND	ND	ND	ND	ND	ND
MW-2 #133 3.5'	65.0	NA	ND	ND	ND	ND	ND	46.0	ND
MW-3 #85A&B 2.5'	1,600.0	12,000.0	ND	ND	ND	ND	ND	9.0	ND

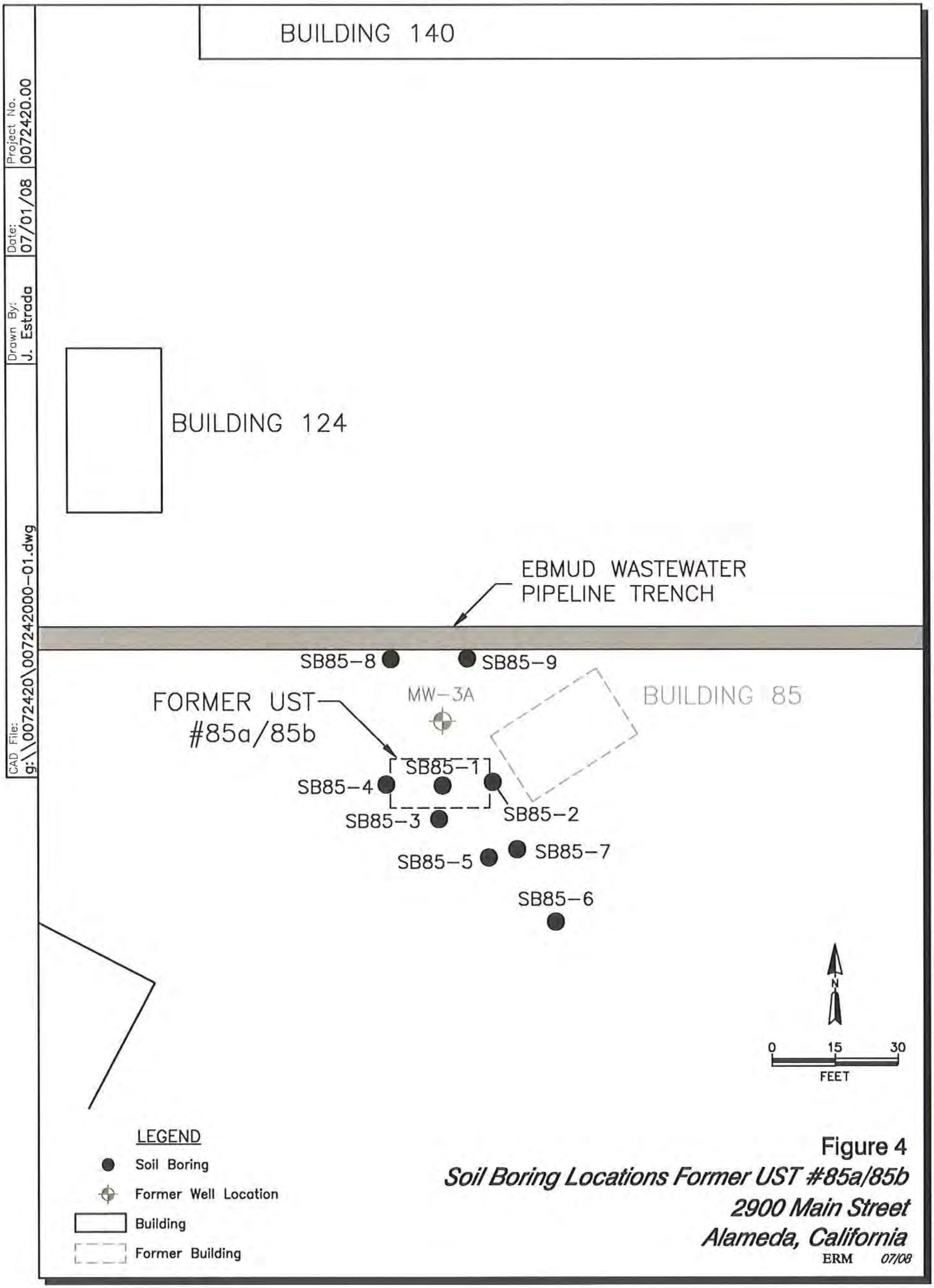


Figure 4
Soil Boring Locations Former UST #85a/85b
2900 Main Street
Alameda, California
ERM *07/08*

Table 1
Soil Analytical Results
Alameda Gateway - 2900 Main Street
Alameda, California

			Total Petroleum Hydrocarbons			*Volatile Organic Compounds*				
Sample ID	Sample Date	Sample Depth (ft bgs)	Gasoline mg/kg	Diesel mg/kg	Motor Oil mg/kg	Benzene mg/kg	Toluene mg/kg	Ethyl-benzene mg/kg	Xylenes mg/kg	MTBE mg/kg
RWQCB ESL			100	100	1,000	0.044	2.9	3.3	2.3	0.023
Former UST #85a/85b Area										
SB85-1	01/16/07	7 - 8	**3.6 a**	< 12	**97 b**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB85-2	01/16/07	6 - 7	< 0.5	< 2.5	< 10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB85-3	01/16/07	6 - 7	**4.9 a**	**2,500**	**2,300 b**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB85-4	01/16/07	3 - 4	**8.2 a**	**980**	**2,100 b**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB85-5	01/17/07	6 - 6.5	**1,700 a**	**24,000 a**	**12,000 b**	< 20	< 20	< 20	< 20	< 100
SB85-6	01/17/07	11 - 12	**11 a**	**2,500**	**1,900 b**	< 0.2	< 0.2	< 0.2	< 0.2	< 1
SB85-8	02/05/07	7.5 - 8	< 0.5	< 25	**250**	NA	NA	NA	NA	NA
SB85-9	02/05/07	5 - 5.5	< 0.5	< 12	**150**	NA	NA	NA	NA	NA
Former UST #133 Area										
SB133-2	01/16/07	7.5 - 8	< 0.5	< 50	**220**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB133-6	01/16/07	6.5 - 7	**1 a**	< 2.5	< 10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB133-7	01/16/07	9.5 - 10	< 0.5	< 2.5	**23 b**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05

Table 1
Soil Analytical Results
Alameda Gateway - 2900 Main Street
Alameda, California

			Total Petroleum Hydrocarbons			*Volatile Organic Compounds*				
Sample ID	**Sample Date**	**Sample Depth (ft bgs)**	**Gasoline** mg/kg	**Diesel** mg/kg	**Motor Oil** mg/kg	**Benzene** mg/kg	**Toluene** mg/kg	**Ethyl-benzene** mg/kg	**Xylenes** mg/kg	**MTBE** mg/kg
RWQCB ESL			100	100	1,000	0.044	2.9	3.3	2.3	0.023
Former UST #137 Area										
SB137-1	01/16/07	7.5 - 8	< 0.5	**120 a**	**150 b**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB137-2	01/16/07	5 - 5.5	**140 a**	**2,300**	< 500	< 0.2	< 0.2	< 0.2	< 0.2	< 1
SB137-3	01/16/07	6 - 6.5	**18 a**	**1,100**	< 500	< 0.04	< 0.04	< 0.04	< 0.04	< 0.2
SB137-4	01/16/07	2.5 - 3	**0.93 a**	**2,400**	**7,900 b**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB137-5	01/16/07	6 - 6.5	< 0.5	< 620	**4,500 b**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05

Notes:

Depths stated in feet below ground surface

RWQCB ESL = San Francisco Bay Regional Water Quality Control Board Environmental Screening Level, shallow industrial soil, groundwater is a potential drinking water source

mg/kg = milligrams per kilogram

< 2 = Compound not detected at or above stated Method Detection Limit (MDL)

Total petroleum hydrocarbons analyzed by United States Environmental Protection Agency (USEPA) Method 8015B/8015B(M)

Volatile organic compounds analyzed by USEPA Method 8021B

MTBE = methyl tert-butyl ether

Shading indicates exceedance of ESL

(a) Sample exhibits atypical chromatographic pattern

(b) Phthalate pattern present at 10 mg/kg in method blank; not observed in samples.

Table 2
Ground Water Analytical Results
Alameda Gateway - 2900 Main Street
Alameda, California

		Total Petroleum Hydrocarbons			*Volatile Organic Compounds*				
Sample ID	**Sample Date**	**Gasoline** µg/L	**Diesel** µg/L	**Motor Oil** µg/L	**Benzene** µg/L	**Toluene** µg/L	**Ethyl-benzene** µg/L	**Xylenes** µg/L	**MTBE** µg/L
RWQCB ESL		**100**	**100**	**100**	**1**	**40**	**30**	**20**	**5**
Former UST #85a/85b Area									
SB85-1	01/16/07	< 50	< 470	**3,000**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB85-2	01/16/07	< 50	< 480	**4,300**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB85-3	01/16/07	**150 a**	**3,900**	**3,200**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB85-4	01/16/07	< 50	< 49	**400**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB85-5[i]	01/17/07	**3,400 a**	**7,700**	**1,300**	< 5	< 5	< 5	< 5	< 10
SB85-6[ii]	01/17/07	**430 a**	**1,800**	**930**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-3A	02/15/07	<25	<50	**250 d**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-3A	09/19/07	<50	<52	NA	< 0.5	< 0.5	< 0.5	< 0.5	< 1
Former UST #133 Area									
SB133-2	01/17/07	< 50	< 56	**480**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB133-5	01/17/07	< 50	< 49	**160 c**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB133-6	01/17/07	< 50	< 50	**250 c**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB133-7	01/17/07	< 50	< 56	**170 c**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-2A	02/15/07	<25	**160**	**460**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-2A	09/19/07	<50	<52	**610**	< 0.5	< 0.5	< 0.5	< 0.5	< 1

		Total Petroleum Hydrocarbons			*Volatile Organic Compounds*				
Sample ID	Sample Date	Gasoline µg/L	Diesel µg/L	Motor Oil µg/L	Benzene µg/L	Toluene µg/L	Ethyl-benzene µg/L	Xylenes µg/L	MTBE µg/L
RWQCB ESL		100	100	100	1	40	30	20	5
Former UST #137 Area									
SB137-1	01/16/07	< 50	**160 b**	< 200	< 0.5	**0.72**	< 0.5	< 0.5	< 1
SB137-2	01/16/07	< 50	**2,000 a**	**690**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB137-3	01/16/07	88 a	**9,800**	< 4,700	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB137-4[1]	01/16/07	< 50	**320 b**	< 200	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB137-5	01/16/07	< 50	< 300	**2,700**	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-1	02/15/07	<25	**150**	NA	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-1	09/19/07	<50	<52	NA	< 0.5	< 0.5	< 0.5	< 0.5	NA

Notes:

RWQCB ESL = San Francisco Bay Regional Water Quality Control Board Environmental Screening Level, potential drinking water source area

µg/L = micrograms per liter

< 2 = Compound not detected at or above stated Method Detection Limit (MDL)

NA = not analyzed

Total petroleum hydrocarbons (TPH) analyzed by United States Environmental Protection Agency (USEPA) Method 8015B/8015B(M)

Volatile organic compounds analyzed by USEPA Method 8021B

MTBE = methyl tert-butyl ether

Shading indicates exceedance of ESL

(a) Sample exhibits atypical chromatographic pattern

(b) TPH fraction was not detected in sample; hydrocarbons detected fall in C12-C26 range, with no diesel pattern present

(c) TPH fraction was not detected in sample; hydrocarbons detected fall in C10-C36 range

(d) TPH in C9 - C32 range detected. No diesel pattern present.

[1] = TPH surrogate recovery outside QC limits due to sample dilution or matrix interference

[11] = TPH results estimated due to sample filtration; surrogate recovery outside QC limits due to matrix interference for all analytes

Environmental Technical Services Analysis Report

ID:	91	Event Date:	3/3/2013	Customer:	Alameda Gateway
Site:	2900 Main Street		Alameda		CA
Project Name:	GWM 3/3/2013				
Sample Name:	Groundwater Monitoring March 3, 2013				
Sampler:	Helen Mawhinney	Title:	Sr. Environmental Consultant		
Analytical Lab:	McCampbell Labs				
Description:	Sampling of groundwater monitoring wells MW-1, MW-2A, MW-3A on March 3, 2013				

Sample Location: AlamG MW-3A **Sample Time:** 3/3/2013

Analyte	Result	Limit	UOM	Method
Methyl Tert-Butyl Ether	ND	0.5	ppb	SW8260B
TPH-Gasoline	ND	50	ppb	SW8260B
TPH-Fuel Oil (C10-36)	120.0	100	ppb	SW8015B
Benzene	ND	0.5	ppb	SW8260B
TPH-Motor Oil (C18-C36)	ND	250	ppb	SW8015B
TPH-Diesel (C10-C23)	59.0	50	ppb	SW8015B
TPH-Diesel (C10-C23) silica gel	ND	50	ppb	SW8015B
Ethylbenzene	ND	0.5	ppb	SW8260B
TPH-Fuel Oil (C10-36) silica gel	ND	100	ppb	SW8015B
Xylenes, Total	ND	0.5	ppb	SW8260B
TPH-Motor Oil (C18-C36) silica gel	ND	250	ppb	SW8015B
Toluene	ND	0.5	ppb	SW8260B

Table 3a
Monitoring Well
Historical Groundwater Analytical Results

		TOG	TPHd	TPHg	B	T	E	X	Lead	PNAs	TDS	8260
Sample No	Date	ppm	ppm	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb
MW-1	8/17/1992	<5.0	4.8	NA	<0.5	<0.5	0.6	<0.5	9.0	NA	NA	NA
	11/25/1992	<5.0	3.9	NA	ND	ND	ND	ND	<3.0	NA	NA	NA
	2/19/1993	<5.0	1.9	NA	ND	ND	ND	ND	3	NA	NA	NA
	12/28/1995	1	3.7	0.09	ND	ND	ND	<2.0	NA	<10.0	NA	NA
	3/29/1996	0.7	1.5	<0.05	ND	ND	ND	<2.0	NA	<10.0	NA	NA
	6/14/2001	ND	0.120	ND	<0.5	<0.5	<0.5	<1.0	NA	NA	NA	NA
MW-2	8/17/1992	<5.0	0.82	NA	<0.5	<1.0	<0.5	<0.5	10	NA	NA	NA
	11/25/1992	12.00	5.6	NA	<0.5	<0.5	<0.5	<0.5	<3.0	NA	NA	NA
	2/19/1993	10.00	9.0	NA	<0.5	<0.5	<0.5	<0.5	3	NA	NA	NA
	12/28/1995	30.0	20.0	23.0	<0.5	<0.5	<0.5	<20.0	NA	24.0	NA	NA
	3/29/1996	130.00	130.0	1.8	<0.5	<0.5	<0.5	<20.0	NA	ND	NA	NA
	6/14/2001	1/4" floating product measured - not sampled.										NA
MW-3	8/17/1992	<5.0	4.0	0.7	<1.0	<1.0	<1.0	<1.0	360	NA	NA	NA
	11/25/1992	<5.0	14.0	<0.05	<0.5	<0.5	<0.5	<0.5	<3.0	NA	NA	NA
	2/19/1993	<5.0	<0.05	<0.05	<0.5	<0.5	<0.5	<0.5	10	NA	NA	NA
	12/28/1995	2	3.8	<0.05	<0.5	<0.5	<0.5	<2.0	NA	10	5000	NA
	3/29/1996	<5.0	0.4	<0.05	<0.5	<0.5	<0.5	<2.0	NA	<10.0	NA	NA
	6/14/2001	Well could not be found										NA

ND - Not detected

NA - Not Analyzed

*ND - All constituents analyzed using EPA Method 8260 were not detected

Note: March 3, 2013 presented on separate table.

Table 3d - Historical Analytical Results		TPHd	TPHd (silica)	TPH - Fuel Oil	C9 - C32	TPHg	B	T	E	X	8260
Sample ID	**Date**	**ppm**	**ppb**	**ppb**	**ppb**	**ppm**	**ppb**	**ppb**	**ppb**	**ppb**	**ppb**
MW-3A	2/15/2007	<50.0	NA	NA	***250.0	<25.0	<0.5	<0.5	<0.5	<0.5	ND*
	Reporting Limit	50.0	NA	NA	50.0	25.0	0.5	0.5	0.5	0.5	Varies
	EPA Method	3510/8015	NA	NA	3510/8015	GCMS	5030/8260B	5030/8260B	5030/8260B	5030/8260B	5030/8260B
	9/19/2007	<52.0	NA	NA	<52.0	<50.0	<0.5	<0.5	<0.5	<1.0	NA
	Reporting Limit	52.0	NA	NA	52.0	50.0	0.5	0.5	0.5	1	NA
	EPA Method	3510/8015	------	------	3510/8015	5030/8015	5030/8021	5030/8021	5030/8021	5030/8021	
	8/18/2011	120	79	ND	NA	ND	ND	ND	ND	ND	ND
	Reporting Limit	50	50	100			50	0.5	0.5	0.5	0.5
	EPA Method	SW8015B w/o Silica Gel	SW8015B w/ Silica Gel	SW8015B	SW8015B w/ Silica Gel	SW8015B	SW8260B	SW8260B	SW8260B	SW8260B	SW8260B

***C9-C32 was detected during 3510/8015, TPHd analysis

Well: MW-3A **Company:** Alameda Gateway

Address: 2900 Main Street

City: Alameda **State:** CA **Zip:** 94501-

Sample Date: 3/3/2013 **Sampler:** Helen Mawhinney

Depth To Water: 1.82 **Top of Casing:** 10.02

Depth Of Well: 17.4 **Groundwater Elevation:** 8.2

Time (PT)	Gallons	pH	Temp (F)	Conductivity (umhos/cm)
2:55 PM	1	8.36	65.3	17.16
2:59 PM	2	8.32	65.4	17.83
3:02 PM	3	8.24	65.3	17.16
3:10 PM	4	8.27	65.3	17.18
3:14 PM	5	8.27	65.5	17.25
3:19 PM	6	8.44	65.4	17.2

ENVIRONMENTAL TECHNICAL SERVICES
1548 Jacob Avenue, San Jose, CA 95118 Phone: (831) 236-9221 Fax: (831) 855-0246 hmawhinneyets@aol.com

A Report Documenting:

Investigation for Supplemental Information to Support Low-Threat Case Closure

(SF-RWQCB FILE #01-1060)

Prepared for:

Alameda Gateway Ltd
2415 Mariner Square Drive
Alameda, California

Concerning site at:

ALAMEDA GATEWAY
2900 MAIN STREET
ALAMEDA, CALIFORNIA

February 7, 2014

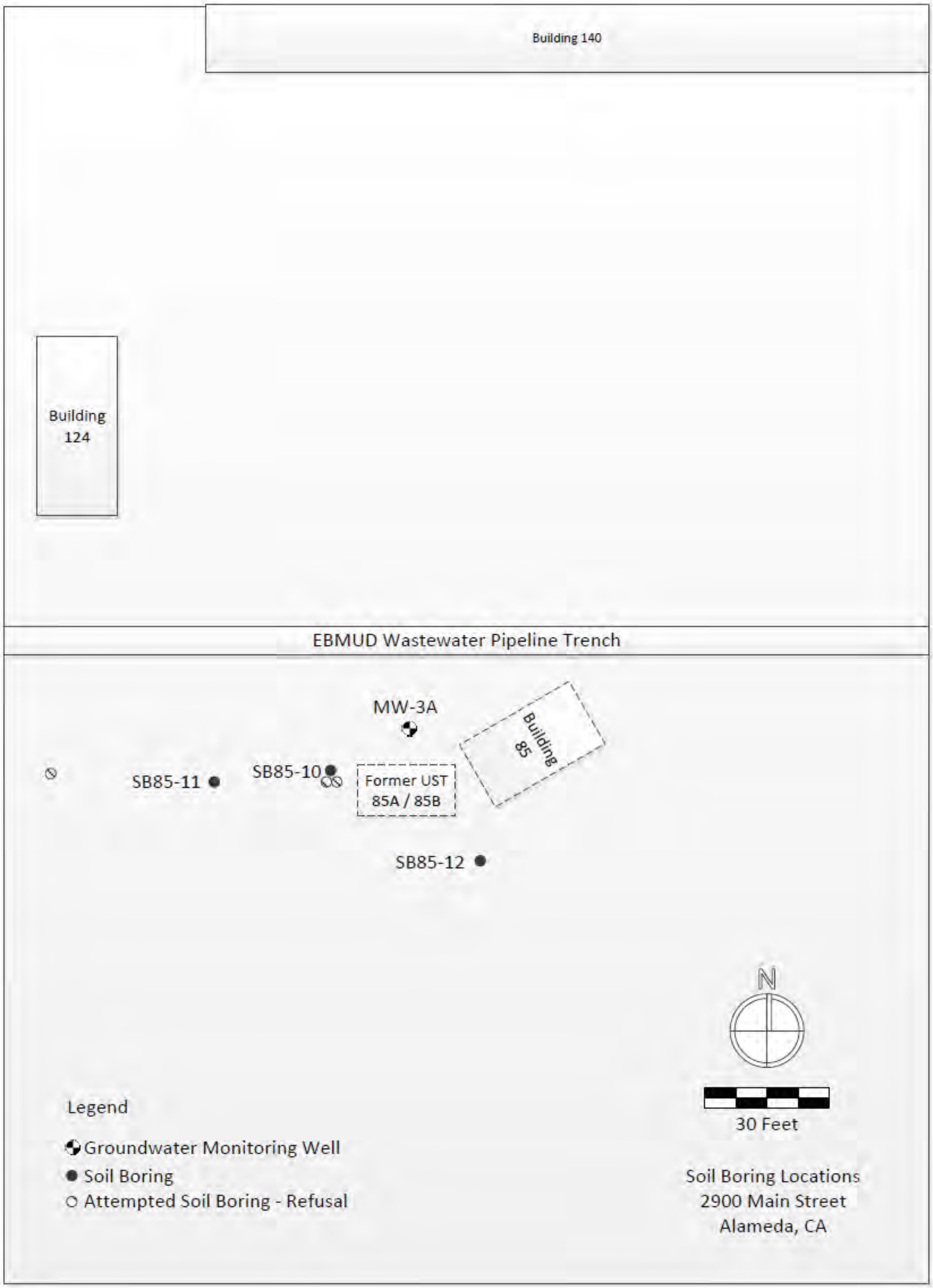


Figure 5. Site Assessment January 2014, Area #85a & b Exploratory Boring Locations

Table 1

Summary of Analytical Soil Data
Alameda Gateway
2900 Main Street, Alameda, California

Sample Designation	Depth (feet)	Date Sampled	Anthracene (mg/kg)	Pyrene (mg/kg)	Fluoranthene (mg/kg)	Benzo (g,h,i) perylene (mg/kg)	Benzo (a) pyrene (mg/kg)	Phenanthrene (mg/kg)	Naphthalene (mg/kg)	2-Methyl Naphthalene (mg/kg)	Other PAHs (mg/kg)	TPH-fo (mg/kg)	TPH-d (mg/kg)	TPH-g (mg/kg)	BTEX Compounds (mg/kg)	TBA (mg/kg)	MtBE (mg/kg)	Fuel Oxygenates (mg/kg)	1,2-DCA (mg/kg)	EDB (mg/kg)	Lead (mg/kg)
Soil Samples Collected in Area #85																					
SB85-10D3.0	3.0	01/02/14	**3.3**	3.6	<2.3	<2.3	<2.3	**16**	**3.0** / <0.17	**61**	<2.3 to 6.8	**14,000**	**10,000**	120	<0.17	<1.7	<0.17	<0.17	<0.14	<0.14	**1,200**
SB85-11D4.0	4.0	01/02/14	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012 / <0.011	<0.012	<0.012	9.5	1.4	<0.52	<0.011	<0.11	<0.011	<0.17	<0.0084	<0.0084	12
SB85-12D3.0	3.0	01/02/14	<0.24	<0.24	<0.24	0.52	**0.33**	<0.24	<0.24 / <0.21	<0.24	<0.24 to 0.54	430	130	270	<0.21	<2.1	<0.21	<0.21	<0.17	<0.17	**960**
Soil Samples Collected in Area #133																					
SB133-9D4.5	4.5	01/03/14	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57 / <0.092	<0.57	<0.57	170	33	<0.46	<0.092	--	<0.092	--	--	--	--
SB133-10D5.0	5.0	01/03/14	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22 / <0.094	<0.22	<0.22	230	27	<0.47	<0.094	--	<0.094	--	--	--	--
SB133-11D4.0	4.0	01/03/14	<0.11	0.24	0.20	0.14	0.12	0.26	<0.11 / <0.0097	<0.11	<0.11 to 0.15	**540**	110	<0.48	<0.0097	--	<0.0097	<0.0097	--	--	--
Soil Samples Collected in Area #137																					
SB137-6D2.5	2.5	01/03/14	<0.016	0.016	0.017	0.031	0.022	0.017	<0.016 / <0.021	<0.016	<0.016 - 0.020	87	38	<1.1	<0.021	--	<0.021	<0.021	--	--	--
Commercial/Industrial Land Use			2.8	85	40	27	0.13	11	1.2	0.25	Various	500	110	500	Various	0.075	0.023	--	0.0045	--	320

Notes:
TPH-g = Total Petroleum Hydrocarbons calculated as gasoline (EPA Method 8260B - 5035)
TPH-d = Total Extractable Petroleum Hydrocarbons calculated as diesel fuel (C10-C23) (EPA Method 8015B with Silica Gel Cleanup)
TPH-fo = Total Extractable Petroleum Hydrocarbons calculated as fuel oil (C10-C36) (EPA Method 8015B with Silica Gel Cleanup)
BTEX = Benzene, Toluene, Ethylbenzene and Xylenes (EPA Method 8260B - 5035)
PAHs = Polnuclear Aromatic Hydrocarbons (EPA Method 8270SIM)
mg/kg = Milligrams per Kilogram
ESL = Environmental Screening Level, California Regional Water Quality Control Board, SF Bay Region, December 2013, Table A-2 (Commercial/Industrial - groundwater is potential drinking water)
Bold = Concentration Detected above ESL
--- = Not analyzed or ESL not established
<0.57 / <0.092 = Naphthalene by both Methods 8270SIM / 8260B

Table 2

Summary of Analytical Groundwater Data
Alameda Gateway
2900 Main Street, Alameda, California

Sample Designation	Depth (feet)	Date Sampled	Anthracene (µg/L)	Pyrene (µg/L)	Fluoranthene (µg/L)	Benzo (g,h,i) perylene (µg/L)	Benzo (a) pyrene (µg/L)	Phenanthrene (µg/L)	Naphthalene (µg/L)	2-Methyl Naphthalene (µg/L)	Other PAHs (µg/L)	TPH-fo (µg/L)	TPH-d (µg/L)	TPH-g (µg/L)	BTEX Compounds (µg/L)	MtBE (µg/L)	TBA (µg/L)	Fuel Oxygenates (µg/L)	1,2-DCA (µg/L)	EDB (µg/L)	Dissolved Lead (µg/L)
Groundwater Samples Collected in Area #85																					
SB85-10		01/02/14	<100	<100	<100	<100	<100	**210**	<100 / **14**	**580**	<100 (1)	**150,000**	**110,000**	**360**	<0.5	<0.5	<2.0	<0.5	<0.5	<0.5	**15**
SB85-11		01/02/14	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5 / <0.5	<2.5	<2.5	**740**	<150	<50	<0.5	<0.5	<2.0	<0.5	<0.5	<0.5	<0.50
SB85-12		01/02/14	<140	**310**	<140	<140	**200**	<140	<140 / **6.9**	<140	<140 (1)	**390,000**	**260,000**	**3,800**	**52/13/<5/13**	<5.0	<20	<5.0	<5.0	<5.0	**2.9**
Groundwater Samples Collected in Area #133																					
SB133-9		01/03/14	<2.5	**4.8**	5.6	<2.5	<2.5	3.4	<2.5 / <0.5	<2.5	<2.5	**9,000**	**1,400**	<50	<0.50	<0.50	–	–	–	–	–
SB133-10		01/03/14	<0.5	<0.5	1.2	<0.5	<0.5	0.75	<0.50 / <0.5	<0.5	<0.5 to 1.1	**230**	**170**	<50	<0.50	<0.50	–	–	–	–	–
SB133-11		01/03/14	<10	<10	**11**	**22**	**13**	<10	<10 / <0.50	<10	<10 to 11	**6,600**	**2,100**	<50	<0.50	<0.50	–	–	–	–	–
MW-2A		01/05/14	<5	<5	<5	<5	<5	<5	<5 / <0.50	<5	<5	**2,400**	**460**	<50	<0.50	<0.50	<2.0	<0.50	<0.50	<0.50	<0.50
Groundwater Samples Collected in Area #137																					
SB137-6		01/03/14	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5 / <0.5	<2.5	<2.5	**5,700**	**4,700**	<50	<0.50	–	–	–	–	–	–
Commercial/Industrial-Vapor Intrusion Concerns			–	–	–	–	–	–	1,600	–	–	–	–	–	270/–/3100/–	100,000	–	–	1,000	–	–
Commercial/Industrial-Estuary Aquatic Habitat Goal			0.73	2	8	0.1	0.014	4.6	24	2.1	Various	640	640	500	46/130/43/100	8,000	16,000	–	2,000	–	2.5
Commercial/Industrial-Final ESL (Drinking Water)			0.73	2	8	0.1	0.014	4.6	6.1	2.1	Various	100	100	100	1.0/40/30/20	5.0	12	–	0.5	–	2.5

Notes:

TPH-g = Total Petroleum Hydrocarbons calculated as gasoline (EPA Method 8260B - 5035)
TPH-d = Total Extractable Petroleum Hydrocarbons calculated as diesel fuel (C10-C23) (EPA Method 8015B with Silica Gel Cleanup)
TPH-fo = Total Extractable Petroleum Hydrocarbons calculated as fuel oil (C10-C36) (EPA Method 8015B with Silica Gel Cleanup)
BTEX = Benzene/Toluene/Ethylbenzene/Xylenes (EPA Method 8260B - 5035)
PAHs = Polnuclear Aromatic Hydrocarbons (EPA Method 8270SIM)
µg/L = Micrograms per Liter
ESL = Environmental Screening Level, California Regional Water Quality Control Board, SF Bay Region, December 2013, Table E-1 & F-1a (Commercial/Industrical - groundwater is potential drinking water)
Bold = Concentration Detected above an ESL
— = Not analyzed or ESL not established
(1) = 1-Methylnaphthalene also detected at elevated concentrations - 1,000 µg/L in SB85-10 and 620 µg/L in SB85-12
<0.57 / <0.092 = Naphthalene by both Methods 8270SIM / 8260B

Environmental Technical Services Analysis Report

ID:	104	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway
Site:	2900 Main Street		Alameda		CA
Project Name:					
Sample Name:	Alam Gate Assess Jan 2014				
Sampler:	Helen Mawhinney	**Title:**	Sr. Environmental Consultant		
Analytical Lab:	McCampbell Labs				
Description:	Site assessment January, 2014.				

Sample Location: SB85-10 **Sample Time:** 1/3/2014 2:20:00 PM

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
TPH-Diesel (C10-C23)	110,000	5000	570	ppb	SW8015B	Water
1,2-Dichloroethane (1,2-DCA)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
1,2-Dibromoethane (EDB)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
TPH-Fuel Oil (C10-C36)	150,000	10000	570	ppb	SW8015B	Water
Petroleum Hydrocarbons - Gasoline, Total	360	50	770	ppb	SW8260B	Water
Benzene	ND	0.5	46	ug/L	SW5030/SW8260B	Water
Ethylbenzene	ND	0.5	43	ug/L	SW5030/SW8260B	Water
Xylenes, Total	ND	0.5	100	ug/L	SW5030/SW8260B	Water
Toluene	ND	0.5	130	ug/L	SW5030/SW8260B	Water
Methyl Tert-Butyl Ether	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
Ethyl tert-butyl ether (ETBE)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
t-Butyl alcohol (TBA)	ND	2	NL	ug/L	SW5030/SW8260B	Water
Diisopropyl ether (DIPE)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
Benzo (a) pyrene	ND	100	0.014	ug/L	SW8270C-SIM	Water
Chrysene	ND	100	35	ug/L	SW8270C-SIM	Water
Dibenzo (a,h) anthracene	ND	100	7.5	ug/L	SW8270C-SIM	Water
Fluoranthene	ND	100	8	ug/L	SW8270C-SIM	Water
Fluorene	ND	100	3.9	ug/L	SW8270C-SIM	Water
Fluorene	ND	100	3.9	ug/L	SW8270C-SIM	Water
Benzo (g,h,i) perylene	ND	100	10	ug/L	SW8270C-SIM	Water
Indeno (1,2,3-cd) pyrene	ND	100	560	ug/L	SW8270C-SIM	Water
2-Methylnaphthalene	580	100	2.1	ug/L	SW8270C-SIM	Water
1-Methylnaphthalene	1000	100	NL	ug/L	SW8270C-SIM	Water
2-Methylnaphthalene	580	100	2.1	ug/L	SW8270C-SIM	Water
Naphthalene	ND	100	24	ug/L	SW8270C-SIM	Water
Pyrene	ND	100	2	ug/L	SW8270C-SIM	Water
Indeno (1,2,3-cd) pyrene	ND	100	560	ug/L	SW8270C-SIM	Water
Naphthalene	14	0.5	24	ug/L	SW5030/SW8260B	Water
tert-Amyl methyl ether (TAME)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
Phenanthrene	210	100	4.6	ug/L	SW8270C-SIM	Water

Environmental Technical Services Analysis Report

ID:	**104**	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway

Site: 2900 Main Street | Alameda | CA

Project Name:

Sample Name: Alam Gate Assess Jan 2014

Sampler: Helen Mawhinney **Title:** Sr. Environmental Consultant

Analytical Lab: McCampbell Labs

Description: Site assessment January, 2014.

Sample Location: SB85-10 **Sample Time:** 1/3/2014 2:20:00 PM

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
Benzo (g,h,i) perylene	ND	100	10	ug/L	SW8270C-SIM	Water
Acenaphthene	ND	100	23	ug/L	SW8270C-SIM	Water
Acenaphthylene	ND	100	3	ug/L	SW8270C-SIM	Water
Anthracene	ND	100	73	ug/L	SW8270C-SIM	Water
Benzo (a) anthracene	ND	100	270	ug/L	SW8270C-SIM	Water
Benzo (b) fluoranthene	ND	100	560	ug/L	SW8270C-SIM	Water
Benzo (k) fluoranthene	ND	100	3.7	ug/L	SW8270C-SIM	Water
Lead	15.0	0.5	NL	ppb	E200.8	Water

Environmental Technical Services Analysis Report

ID:	104	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway
Site:	2900 Main Street		Alameda		CA
Project Name:					
Sample Name:	Alam Gate Assess Jan 2014				
Sampler:	Helen Mawhinney	**Title:**	Sr. Environmental Consultant		
Analytical Lab:	McCampbell Labs				
Description:	Site assessment January, 2014.				

Sample Location: SB85-10 D3.0' **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
% Moisture	11.4	0.1	NL	wet wt %	ASTMD2216-92	Soil/dry weight
TPH-Fuel Oil (C10-C36)	14,000	230	570	ppb	SW8015B	Soil/dry weight
TPH-Diesel (C10-C23)	10,000	110	570	ppb	SW8015B	Soil/dry weight
1,2-Dibromoethane (EDB)	ND	0.14	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
1,2-Dichloroethane (1,2-DCA)	ND	0.14	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Petroleum Hydrocarbons - Gasoline, Total	120	8.6	770	mg/Kg-dry	SW5030B/SW8260B	Soil/dry weight
Ethylbenzene	ND	0.17	3.3	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Toluene	ND	0.17	2.9	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Benzene	ND	0.17	0.044	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Xylenes, Total	ND	0.17	2.3	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Methyl Tert-Butyl Ether	ND	0.17	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Diisopropyl ether (DIPE)	ND	0.17	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
t-Butyl alcohol (TBA)	ND	1.7	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Ethyl tert-butyl ether (ETBE)	ND	0.17	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Benzo (b) fluoranthene	ND	2.3	46	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
2-Methylnaphthalene	61	2.3	25	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
1-Methylnaphthalene	68	2.3	NL	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Indeno (1,2,3-cd) pyrene	ND	2.3	15	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Indeno (1,2,3-cd) pyrene	ND	2.3	15	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Fluorene	6.8	2.3	8.9	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Fluorene	6.8	2.3	8.9	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Fluoranthene	ND	2.3	60	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Dibenzo (a,h) anthracene	ND	2.3	9.9	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Chrysene	ND	2.3	23	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (a) pyrene	ND	2.3	130	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (g,h,i) perylene	ND	2.3	130	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (k) fluoranthene	ND	2.3	5.1	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (a) anthracene	ND	2.3	12	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Anthracene	3.3	2.3	2.8	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Acenaphthylene	ND	2.3	13	mg/Kg-dry	SW8270C-SIM	Soil/dry weight

Environmental Technical Services Analysis Report

ID:	**104**	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway

Site:	2900 Main Street	Alameda	CA
Project Name:			
Sample Name:	Alam Gate Assess Jan 2014		
Sampler:	Helen Mawhinney	**Title:**	Sr. Environmental Consultant
Analytical Lab:	McCampbell Labs		
Description:	Site assessment January, 2014.		

Sample Location: SB85-10 D3.0' **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
Acenaphthene	6	2.3	16	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Naphthalene	3	2.3	1.2	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Phenanthrene	16	2.3	11	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Naphthalene	ND	0.17	1.2	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Pyrene	3.6	2.3	85	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
2-Methylnaphthalene	61	2.3	25	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
tert-Amyl methyl ether (TAME)	ND	0.17	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Benzo (g,h,i) perylene	ND	2.3	27	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Lead	1200	5.6	NL	ppm	SW6010B	Soil/dry weight

Environmental Technical Services Analysis Report

ID:	104	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway
Site:	2900 Main Street		Alameda		CA
Project Name:					
Sample Name:	Alam Gate Assess Jan 2014				
Sampler:	Helen Mawhinney	**Title:**	Sr. Environmental Consultant		
Analytical Lab:	McCampbell Labs				
Description:	Site assessment January, 2014.				

Sample Location: SB85-11 **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
TPH-Diesel (C10-C23)	ND	150	570	ppb	SW8015B	Water
TPH-Fuel Oil (C10-C36)	740	300	570	ppb	SW8015B	Water
1,2-Dichloroethane (1,2-DCA)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
1,2-Dibromoethane (EDB)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
Petroleum Hydrocarbons - Gasoline, Total	ND	50	770	ppb	SW8260B	Water
Benzene	ND	0.5	0.044	ppb	SW8260B	Water
Toluene	ND	0.5	2.9	ppb	SW8260B	Water
Xylenes, Total	ND	0.5	2.3	ppb	SW8260B	Water
Ethylbenzene	ND	0.5	3.3	ppb	SW8260B	Water
Methyl Tert-Butyl Ether	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
Diisopropyl ether (DIPE)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
t-Butyl alcohol (TBA)	ND	2	NL	ug/L	SW5030/SW8260B	Water
Ethyl tert-butyl ether (ETBE)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
Fluoranthene	ND	2.5	8	ug/L	SW8270C-SIM	Water
Naphthalene	ND	0.5	24	ug/L	SW5030/SW8260B	Water
tert-Amyl methyl ether (TAME)	ND	0.5	NL	ug/L	SW5030/SW8260B	Water
Acenaphthylene	ND	2.5	3	ug/L	SW8270C-SIM	Water
Anthracene	ND	2.5	73	ug/L	SW8270C-SIM	Water
Benzo (a) anthracene	ND	2.5	270	ug/L	SW8270C-SIM	Water
Benzo (b) fluoranthene	ND	2.5	560	ug/L	SW8270C-SIM	Water
Benzo (k) fluoranthene	ND	2.5	3.7	ug/L	SW8270C-SIM	Water
Benzo (g,h,i) perylene	ND	2.5	10	ug/L	SW8270C-SIM	Water
Benzo (g,h,i) perylene	ND	2.5	10	ug/L	SW8270C-SIM	Water
Benzo (a) pyrene	ND	2.5	0.014	ug/L	SW8270C-SIM	Water
Dibenzo (a,h) anthracene	ND	2.5	7.5	ug/L	SW8270C-SIM	Water
Fluorene	ND	2.5	3.9	ug/L	SW8270C-SIM	Water
tert-Amyl methyl ether	ND	0.5	NL	ppb	SW8260B	Water
Pyrene	ND	2.5	2	ug/L	SW8270C-SIM	Water
Chrysene	ND	2.5	35	ug/L	SW8270C-SIM	Water
Naphthalene	ND	2.5	24	ug/L	SW8270C-SIM	Water

Environmental Technical Services Analysis Report

ID:	104	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway

Site: 2900 Main Street | Alameda | CA

Project Name:

Sample Name: Alam Gate Assess Jan 2014

Sampler: Helen Mawhinney **Title:** Sr. Environmental Consultant

Analytical Lab: McCampbell Labs

Description: Site assessment January, 2014.

Sample Location: SB85-11 **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
Fluorene	ND	2.5	3.9	ug/L	SW8270C-SIM	Water
2-Methylnaphthalene	ND	2.5	2.1	ug/L	SW8270C-SIM	Water
2-Methylnaphthalene	ND	2.5	2.1	ug/L	SW8270C-SIM	Water
1-Methylnaphthalene	ND	2.5	NL	ug/L	SW8270C-SIM	Water
Indeno (1,2,3-cd) pyrene	ND	2.5	560	ug/L	SW8270C-SIM	Water
Acenaphthene	ND	2.5	23	ug/L	SW8270C-SIM	Water
Indeno (1,2,3-cd) pyrene	ND	2.5	560	ug/L	SW8270C-SIM	Water
Phenanthrene	ND	2.5	4.6	ug/L	SW8270C-SIM	Water
Lead	ND	0.5	NL	ppb	E200.8	Water

Environmental Technical Services Analysis Report

ID:	104	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway
Site:	2900 Main Street		Alameda		CA
Project Name:					
Sample Name:	Alam Gate Assess Jan 2014				
Sampler:	Helen Mawhinney	**Title:**	Sr. Environmental Consultant		
Analytical Lab:	McCampbell Labs				
Description:	Site assessment January, 2014.				

Sample Location: SB85-11 D4.0' **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
1,2-Dibromoethane (EDB)	ND	0.0084	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
1,2-Dichloroethane (1,2-DCA)	ND	0.0084	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
TPH-Diesel (C10-C23)	1.4	1.2	570	ppb	SW8015B	Soil/dry weight
TPH-Fuel Oil (C10-C36)	9.5	2.4	570	ppb	SW8015B	Soil/dry weight
% Moisture	18.1	0.1	NL	wet wt %	ASTMD2216-92	Soil/dry weight
Petroleum Hydrocarbons - Gasoline, Total	ND	0.52	770	mg/Kg-dry	SW8260B	Soil/dry weight
Ethylbenzene	ND	0.011	3.3	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Toluene	ND	0.011	2.9	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Xylenes, Total	ND	0.011	2.3	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Benzene	ND	0.011	0.044	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Methyl Tert-Butyl Ether	ND	0.011	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Diisopropyl ether (DIPE)	ND	0.011	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
t-Butyl alcohol (TBA)	ND	0.11	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Ethyl tert-butyl ether (ETBE)	ND	0.011	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Benzo (a) pyrene	ND	0.012	130	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (g,h,i) perylene	ND	0.012	130	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (g,h,i) perylene	ND	0.012	27	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (k) fluoranthene	ND	0.012	5.1	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (a) anthracene	ND	0.012	12	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Chrysene	ND	0.012	23	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Acenaphthene	ND	0.012	16	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (b) fluoranthene	ND	0.012	46	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Naphthalene	ND	0.011	1.2	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Acenaphthylene	ND	0.012	13	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Pyrene	ND	0.012	85	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Anthracene	ND	0.012	2.8	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
tert-Amyl methyl ether (TAME)	ND	0.011	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Phenanthrene	ND	0.012	11	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Naphthalene	ND	0.012	1.2	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
2-Methylnaphthalene	ND	0.012	25	mg/Kg-dry	SW8270C-SIM	Soil/dry weight

Environmental Technical Services Analysis Report

ID:	**104**
Event Date:	1/3/2014
Customer:	Alameda Gateway
Site:	2900 Main Street, Alameda, CA
Project Name:	
Sample Name:	Alam Gate Assess Jan 2014
Sampler:	Helen Mawhinney
Title:	Sr. Environmental Consultant
Analytical Lab:	McCampbell Labs
Description:	Site assessment January, 2014.

Sample Location: SB85-11 D4.0' **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
2-Methylnaphthalene	ND	0.012	25	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Fluoranthene	ND	0.012	60	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Indeno (1,2,3-cd) pyrene	ND	0.012	15	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Indeno (1,2,3-cd) pyrene	ND	0.012	15	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Fluorene	ND	0.012	8.9	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Dibenzo (a,h) anthracene	ND	0.012	9.9	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Fluorene	ND	0.012	8.9	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
1-Methylnaphthalene	ND	0.012	NL	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Lead	12	6.1	NL	ppm	SW6010B	Soil/dry weight

Environmental Technical Services Analysis Report

ID:	104	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway
Site:	2900 Main Street		Alameda		CA
Project Name:					
Sample Name:	Alam Gate Assess Jan 2014				
Sampler:	Helen Mawhinney	**Title:**	Sr. Environmental Consultant		
Analytical Lab:	McCampbell Labs				
Description:	Site assessment January, 2014.				

Sample Location: SB85-12 **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
TPH-Diesel (C10-C23)	260,000	5000	570	ppb	SW8015B	Water
1,2-Dichloroethane (1,2-DCA)	ND	5	NL	ug/L	SW5030/SW8260B	Water
1,2-Dibromoethane (EDB)	ND	5	NL	ug/L	SW5030/SW8260B	Water
TPH-Fuel Oil (C10-C36)	390,000	10000	570	ppb	SW8015B	Water
Petroleum Hydrocarbons - Gasoline, Total	3800	500	770	ppb	SW8260B	Water
Toluene	13	5	2.9	ppb	SW8260B	Water
Benzene	52	5	0.044	ppb	SW8260B	Water
Xylenes, Total	13	5	2.3	ppb	SW8260B	Water
Ethylbenzene	ND	5	3.3	ppb	SW8260B	Water
Methyl Tert-Butyl Ether	ND	5	NL	ug/L	SW5030/SW8260B	Water
t-Butyl alcohol (TBA)	ND	20	NL	ug/L	SW5030/SW8260B	Water
Diisopropyl ether (DIPE)	ND	5	NL	ug/L	SW5030/SW8260B	Water
Ethyl tert-butyl ether (ETBE)	ND	5	NL	ug/L	SW5030/SW8260B	Water
Benzo (a) pyrene	200	140	0.014	ug/L	SW8270C-SIM	Water
Fluorene	ND	140	3.9	ug/L	SW8270C-SIM	Water
Pyrene	310	140	2	ug/L	SW8270C-SIM	Water
Phenanthrene	ND	140	4.6	ug/L	SW8270C-SIM	Water
Naphthalene	ND	140	24	ug/L	SW8270C-SIM	Water
2-Methylnaphthalene	ND	140	2.1	ug/L	SW8270C-SIM	Water
2-Methylnaphthalene	ND	140	2.1	ug/L	SW8270C-SIM	Water
1-Methylnaphthalene	620	140	NL	ug/L	SW8270C-SIM	Water
Benzo (g,h,i) perylene	ND	140	10	ug/L	SW8270C-SIM	Water
Indeno (1,2,3-cd) pyrene	ND	140	560	ug/L	SW8270C-SIM	Water
Fluorene	ND	140	3.9	ug/L	SW8270C-SIM	Water
Fluoranthene	ND	140	8	ug/L	SW8270C-SIM	Water
Dibenzo (a,h) anthracene	ND	140	7.5	ug/L	SW8270C-SIM	Water
Chrysene	ND	140	35	ug/L	SW8270C-SIM	Water
Acenaphthene	ND	140	23	ug/L	SW8270C-SIM	Water
Indeno (1,2,3-cd) pyrene	ND	140	560	ug/L	SW8270C-SIM	Water
Naphthalene	6.9	5	24	ug/L	SW5030/SW8260B	Water

Environmental Technical Services Analysis Report

ID:	**104**	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway
Site:	2900 Main Street	Alameda	CA		
Project Name:					
Sample Name:	Alam Gate Assess Jan 2014				
Sampler:	Helen Mawhinney	**Title:**	Sr. Environmental Consultant		
Analytical Lab:	McCampbell Labs				
Description:	Site assessment January, 2014.				

Sample Location: SB85-12 **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
Acenaphthylene	ND	140	3	ug/L	SW8270C-SIM	Water
Anthracene	ND	140	73	ug/L	SW8270C-SIM	Water
Benzo (a) anthracene	ND	140	270	ug/L	SW8270C-SIM	Water
Benzo (b) fluoranthene	ND	140	560	ug/L	SW8270C-SIM	Water
Benzo (k) fluoranthene	ND	140	3.7	ug/L	SW8270C-SIM	Water
Benzo (g,h,i) perylene	ND	140	10	ug/L	SW8270C-SIM	Water
tert-Amyl methyl ether (TAME)	ND	5	NL	ug/L	SW5030/SW8260B	Water
Lead	2.9	0.5	NL	ppb	E200.8	Water

Environmental Technical Services Analysis Report

ID:	104	**Event Date:**	1/3/2014	**Customer:**	Alameda Gateway
Site:	2900 Main Street	Alameda	CA		
Project Name:					
Sample Name:	Alam Gate Assess Jan 2014				
Sampler:	Helen Mawhinney	**Title:**	Sr. Environmental Consultant		
Analytical Lab:	McCampbell Labs				
Description:	Site assessment January, 2014.				

Sample Location: SB85-12 D3.0' **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
TPH-Diesel (C10-C23)	130	61	570	mg/Kg-dry	SW8015B	Soil/dry weight
% Moisture	17.5	0.1	NL	wet wt %	ASTMD2216-92	Soil/dry weight
TPH-Fuel Oil (C10-C36)	140	120	570	mg/Kg-dry	SW8015B	Soil/dry weight
1,2-Dichloroethane (1,2-DCA)	ND	0.17	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
1,2-Dibromoethane (EDB)	ND	0.17	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Petroleum Hydrocarbons - Gasoline, Total	270	11	770	mg/Kg-dry	SW8260B	Soil/dry weight
Benzene	ND	0.21	0.044	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Toluene	ND	0.21	2.9	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Ethylbenzene	ND	0.21	3.3	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Xylenes, Total	ND	0.21	2.3	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Methyl Tert-Butyl Ether	ND	0.21	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
t-Butyl alcohol (TBA)	ND	2.1	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Diisopropyl ether (DIPE)	ND	0.21	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Ethyl tert-butyl ether (ETBE)	ND	0.21	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Acenaphthylene	ND	0.24	13	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Acenaphthene	ND	0.24	16	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (a) anthracene	ND	0.24	12	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Pyrene	ND	0.24	85	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
tert-Amyl methyl ether (TAME)	ND	0.21	NL	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Naphthalene	ND	0.21	1.2	mg/Kg-dry	SW5035/SW8260B	Soil/dry weight
Anthracene	ND	0.24	2.8	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (b) fluoranthene	0.32	0.24	46	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (k) fluoranthene	ND	0.24	5.1	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (g,h,i) perylene	0.52	0.24	27	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (g,h,i) perylene	0.52	0.24	130	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Benzo (a) pyrene	0.33	0.24	130	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Chrysene	ND	0.24	23	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
2-Methylnaphthalene	ND	0.24	25	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Fluoranthene	ND	0.24	60	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Fluorene	ND	0.24	8.9	mg/Kg-dry	SW8270C-SIM	Soil/dry weight

Environmental Technical Services Analysis Report

ID:	104
Event Date:	1/3/2014
Customer:	Alameda Gateway
Site:	2900 Main Street, Alameda, CA
Project Name:	
Sample Name:	Alam Gate Assess Jan 2014
Sampler:	Helen Mawhinney
Title:	Sr. Environmental Consultant
Analytical Lab:	McCampbell Labs
Description:	Site assessment January, 2014.

Sample Location: SB85-12 D3.0' **Sample Time:** 1/3/2014

Analyte	Result	Rpt. Limit	ESL Limit	UOM	Method	Type
Fluorene	ND	0.24	8.9	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Indeno (1,2,3-cd) pyrene	0.54	0.24	15	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Indeno (1,2,3-cd) pyrene	0.54	0.24	15	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
1-Methylnaphthalene	ND	0.24	NL	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Phenanthrene	ND	0.24	11	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Naphthalene	ND	0.24	1.2	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
2-Methylnaphthalene	ND	0.24	25	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Dibenzo (a,h) anthracene	ND	0.24	9.9	mg/Kg-dry	SW8270C-SIM	Soil/dry weight
Lead	960	6.1	NL	ppm	SW6010B	Soil/dry weight

MITTELHAUSER corporation

TABLE 1

SOIL SAMPLE RESULTS

SAMPLE LOCATION	TPH AS DIESEL	TPH AS GASOLINE	BENZENE	TOLUENE	XYLENES	ETHYL BENZENE
AG-85-01	--	4.8	<0.1	<0.1	<0.1	<0.1
AG-85-02	--	1.1	<0.1	<0.1	<0.1	<0.1
AG-133-01	1,100	52	0.3	<0.1	0.7	0.4
AG-137-01	6.7	<1.0	<0.1	<0.1	<0.1	<0.1
AG-137-02	38,000	850	2.2	4.3	29	4.3
AG-137-03	<5.0	2.8	0.1	<0.1	<0.1	<0.1
Detection Limit	5.0	1.0	0.1	0.1	0.1	0.1

-- Indicates analysis not performed.
Results in parts per million (ppm) unless otherwise indicated.

1332T1

MITTELHAUSER corporation

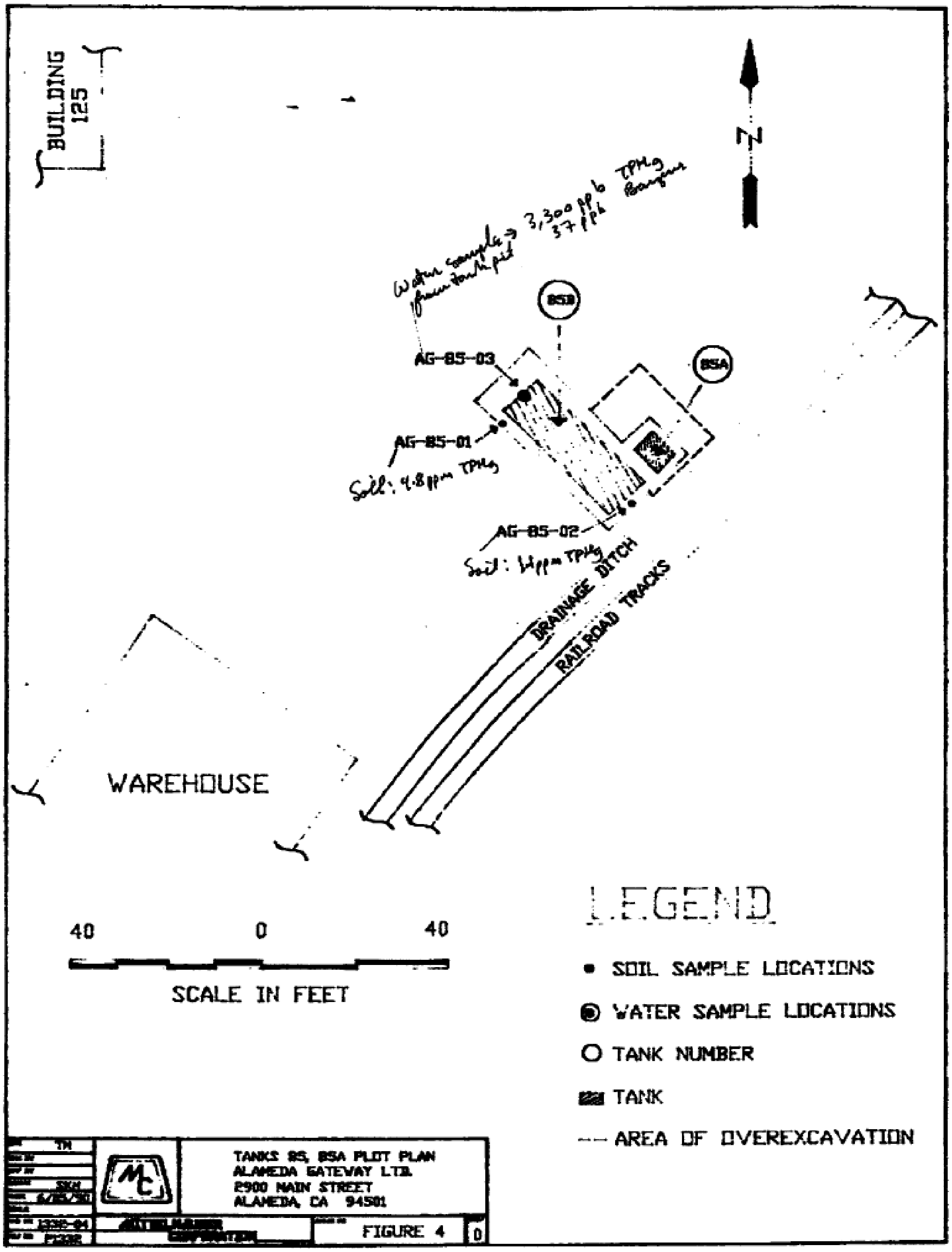
TABLE 2

WATER SAMPLE RESULTS

SAMPLE LOCATION	TPH AS DIESEL	TPH AS GASOLINE	BENZENE	TOLUENE	XYLENES	ETHYL BENZENE
AG-85-03	--	3,300	37	<0.5	300	<0.5
Detection Limit	--	50	0.5	0.5	0.5	0.5

-- Indicates analysis not performed.
Results in parts per billion (ppb), unless otherwise indicated.

1332T1


BUILDING 125
N
85B
85A
AG-85-03
AG-85-01
AG-85-02
DRAINAGE DITCH
RAILROAD TRACKS
WAREHOUSE
40
0
40
SCALE IN FEET
LEGEND
SOIL SAMPLE LOCATIONS
WATER SAMPLE LOCATIONS
TANK NUMBER
TANK
AREA OF OVEREXCAVATION
TANKS 85, 85A PLOT PLAN
ALAMEDA GATEWAY LTD.
2900 MAIN STREET
ALAMEDA, CA 94501
FIGURE 4
0

1992 MW INSTALLATIONS

Table 3.
Contaminant Concentrations in Soil

Tank Area	Sample ID	Oil and Grease mg/kg	TEH mg/kg	TVH mg/kg	B ug/kg	T ug/kg	E ug/kg	X ug/kg	Lead mg/kg
137	1 @ 7.0'	140	4,900	-	<5	<5	<5	<5	13
133	2 @ 6.0'	120	65	-	<5	<5	<5	<5	46
85A and B	3 @ 4.5'	1600	12,000	<1	<5	<5	<5	<5	9

Table 4.
Contaminant Concentrations in Groundwater

Tank Area	Sample ID	Oil and Grease mg/l	TEH ug/l	TVH ug/l	Benzene ug/l	Toluene ug/l	Ethyl-Benzene ug/l	Xylenes ug/l	Lead ug/l
137	MW-1	<5	4,800	-	<0.5	<0.5	0.6	<0.5	9
133	MW-2	<5	820	-	<0.5	<0.5	<0.5	<0.5	10
85A and B	MW-3	<5	4,000	73	<1	<1	<1	<1	360

TEH = total extractable hydrocarbons, EPA 8015/3550
TVH = total volatile hydrocarbons, EPA 8020, 3550
mg/kg = milligrams per kilogram or parts per million (ppm)
ug/kg = micrograms per kilogram or parts per billion (ppb)
mg/l = milligrams per liter or parts per million (ppm)
ug/l = micrograms per liter or parts per billion (ppb)
ND = None detected above reporting limits indicated in parentheses.

Environmental Technical Services Analysis Report

ID:	91	Event Date:	3/3/2013	Customer:	Alameda Gateway
Site:	2900 Main Street		Alameda		CA
Project Name:	GWM 3/3/2013				
Sample Name:	Groundwater Monitoring March 3, 2013				
Sampler:	Helen Mawhinney	Title:	Sr. Environmental Consultant		
Analytical Lab:	McCampbell Labs				
Description:	Sampling of groundwater monitoring wells MW-1, MW-2A, MW-3A on March 3, 2013				

Sample Location: AlamG MW-3A Sample Time: 3/3/2013

Analyte	Result	Limit	UOM	Method
Methyl Tert-Butyl Ether	ND	0.5	ppb	SW8260B
TPH-Gasoline	ND	50	ppb	SW8260B
TPH-Fuel Oil (C10-36)	120.0	100	ppb	SW8015B
Benzene	ND	0.5	ppb	SW8260B
TPH-Motor Oil (C18-C36)	ND	250	ppb	SW8015B
TPH-Diesel (C10-C23)	59.0	50	ppb	SW8015B
TPH-Diesel (C10-C23) silica gel	ND	50	ppb	SW8015B
Ethylbenzene	ND	0.5	ppb	SW8260B
TPH-Fuel Oil (C10-36) silica gel	ND	100	ppb	SW8015B
Xylenes, Total	ND	0.5	ppb	SW8260B
TPH-Motor Oil (C18-C36) silica gel	ND	250	ppb	SW8015B
Toluene	ND	0.5	ppb	SW8260B

Table 3a
Monitoring Well
Historical Groundwater Analytical Results

		TOG	TPHd	TPHg	B	T	E	X	Lead	PNAs	TDS	8260
Sample No	Date	ppm	ppm	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb
MW-1	8/17/1992	<5.0	4.8	NA	<0.5	<0.5	0.6	<0.5	9.0	NA	NA	NA
	11/25/1992	<5.0	3.9	NA	ND	ND	ND	ND	<3.0	NA	NA	NA
	2/19/1993	<5.0	1.9	NA	ND	ND	ND	ND	3	NA	NA	NA
	12/28/1995	1	3.7	0.09	ND	ND	ND	<2.0	NA	<10.0	NA	NA
	3/29/1996	0.7	1.5	<0.05	ND	ND	ND	<2.0	NA	<10.0	NA	NA
	6/14/2001	ND	0.120	ND	<0.5	<0.5	<0.5	<1.0	NA	NA	NA	NA
MW-2	8/17/1992	<5.0	0.82	NA	<0.5	<1.0	<0.5	<0.5	10	NA	NA	NA
	11/25/1992	12.00	5.6	NA	<0.5	<0.5	<0.5	<0.5	<3.0	NA	NA	NA
	2/19/1993	10.00	9.0	NA	<0.5	<0.5	<0.5	<0.5	3	NA	NA	NA
	12/28/1995	30.0	20.0	23.0	<0.5	<0.5	<0.5	<20.0	NA	24.0	NA	NA
	3/29/1996	130.00	130.0	1.8	<0.5	<0.5	<0.5	<20.0	NA	ND	NA	NA
	6/14/2001	1/4" floating product measured - not sampled.										NA
MW-3	8/17/1992	<5.0	4.0	0.7	<1.0	<1.0	<1.0	<1.0	360	NA	NA	NA
	11/25/1992	<5.0	14.0	<0.05	<0.5	<0.5	<0.5	<0.5	<3.0	NA	NA	NA
	2/19/1993	<5.0	<0.05	<0.05	<0.5	<0.5	<0.5	<0.5	10	NA	NA	NA
	12/28/1995	2	3.8	<0.05	<0.5	<0.5	<0.5	<2.0	NA	10	5000	NA
	3/29/1996	<5.0	0.4	<0.05	<0.5	<0.5	<0.5	<2.0	NA	<10.0	NA	NA
	6/14/2001	Well could not be found										NA

ND - Not detected

Table 3d - Historical Analytical Results		TPHd	TPHd (silica)	TPH - Fuel Oil	C9 - C32	TPHg	B	T	E	X	8260
Sample ID	**Date**	**ppm**	**ppb**	**ppb**	**ppb**	**ppm**	**ppb**	**ppb**	**ppb**	**ppb**	**ppb**
MW-3A	2/15/2007	<50.0	NA	NA	***250.0	<25.0	<0.5	<0.5	<0.5	<0.5	ND*
	Reporting Limit	50.0	NA	NA	50.0	25.0	0.5	0.5	0.5	0.5	Varies
	EPA Method	3510/8015	NA	NA	3510/8015	GCMS	5030/8260B	5030/8260B	5030/8260B	5030/8260B	5030/8260B
	9/19/2007	<52.0	NA	NA	<52.0	<50.0	<0.5	<0.5	<0.5	<1.0	NA
	Reporting Limit	52.0	NA	NA	52.0	50.0	0.5	0.5	0.5	1	NA
	EPA Method	3510/8015	-------	-------	3510/8015	5030/8015	5030/8021	5030/8021	5030/8021	5030/8021	
	8/18/2011	120	79	ND	NA	ND	ND	ND	ND	ND	ND
	Reporting Limit	50	50	100			50	0.5	0.5	0.5	0.5
	EPA Method	SW8015B w/o Silica Gel	SW8015B w/ Silica Gel	SW8015B	SW8015B w/ Silica Gel	SW8015B	SW8260B	SW8260B	SW8260B	SW8260B	SW8260B

***C9-C32 was detected during 3510/8015, TPHd analysis

TABLE II
Groundwater Samples
MW-1, MW-2A, MW-3A

Groundwater samples collected within MW-1, MW-2A and MW-3A were analyzed for TPH(g), BTEX, MTBE, TPH-d (with silica gel), and TPH-fo. Groundwater samples collected from MW-1 ND MW-3A were analyzed for TPHd (w/o silica gel).

Date Sampled:	3/3/2013
Site:	Alameda Gateway - 2900 Main Street, Alameda, CA
Location:	MW-1, MW-2A, MW-3A and Drum
Person Collecting Sample:	Helen Mawhinney, Environmental Technical Services (ETS)
Title:	Senior Environmental Specialist
Signature:	_I HAVE TO ADD SILICA AND NO SILICA FOR ALL…. ________________________________
Analytical Laboratory:	McCampbell Analytical Labs, Inc. DHS ELSAP Cert No 1644

Analytical Results

Analyte	MW-1	MW-2A	MW-3A	Drum	Reporting Limit	Unit	EPA Method
TPHg							
Benzene	ND	0.56	ND	ND	0.5	ug/L	SW8260B
Ethylbenzene	ND	ND	ND	ND	0.5	ug/L	SW8260B
Toluene	ND	ND	ND	ND	0.5	ug/L	SW8260B
Xylenes, Total	ND	ND	ND	ND	0.5	ug/L	SW8260B
TPH-Diesel	510	360	120	300	50	ug/L	SW8015B w/o Silica Gel
TPH-Diesel	850	NA	79	300	50	ug/L	SW8015B Silica Gel
TPH-Fuel Oil	590	1700	ND	670	100	ug/L	SW8015B
TPH(g)	ND	ND	ND	ND	50	ug/L	SW8260B

Notes:
ug/L = Micrograms per liter

TABLE DTW

Historical Depth to Groundwater Measurements at MWs			
UST Area	**Well ID**	**Date**	**DTW (ft)**
#137	MW-1	8/19/1992	3.45
		9/1/1992 am	3.48
		9/1/1992 pm	3.48
		9/16/1992	3.65
		11/25/1992	3.48
		2/19/1993	3.02
		12/28/1995	2.90
		3/29/1996	2.95
		6/14/2001	n/a
		2/15/2007	5.19
		3/7/2007	5.85
		6/9/2007	3.20
		6/11/2007	3.04
		9/19/2007	3.26
		8/18/2011	3.34
		3/3/2013	3.18
#133	MW-2/MW-2A	8/19/1992	4.36
		9/1/1992 am	5.27
		9/1/1992 pm	3.29
		9/16/1992	5.42
		11/25/1992	3.59
		2/19/1993	2.45
		12/28/1995	5.23
		3/29/1996	5.41
		8/2/2000	5.80
		6/14/2001	n/a
		2/15/2007	9.26
		3/7/2007	9.72
		6/9/2007	5.61
		6/11/2007	5.54
		9/19/2007	5.25
		8/18/2011	5.60
		3/3/2013	4.62
#85	MW-3/MW-3A	8/19/1992	2.32
		9/1/1992 am	2.16
		9/1/1992 pm	2.15
		9/16/1992	2.32
		11/25/1992	1.82
		2/19/1993	0.15
		12/28/1995	0.93
		3/29/1996	1.05
		6/14/2001	n/a
		2/15/2007	2.53
		3/7/2007	2.87
		6/9/2007	2.26
		6/11/2007	2.24
		9/19/2007	2.01
		8/18/2011	3.48
		3/3/2013	1.82

Note: MW-2A and MW-3A replacement wells installed in 2007.

TABLE IVb
Limited Site Assessment
Area of Former 1,100-gallon Fuel Oil UST - Tank #137
Groundwater Sample Analytical Results
Performed on May 18, 2001

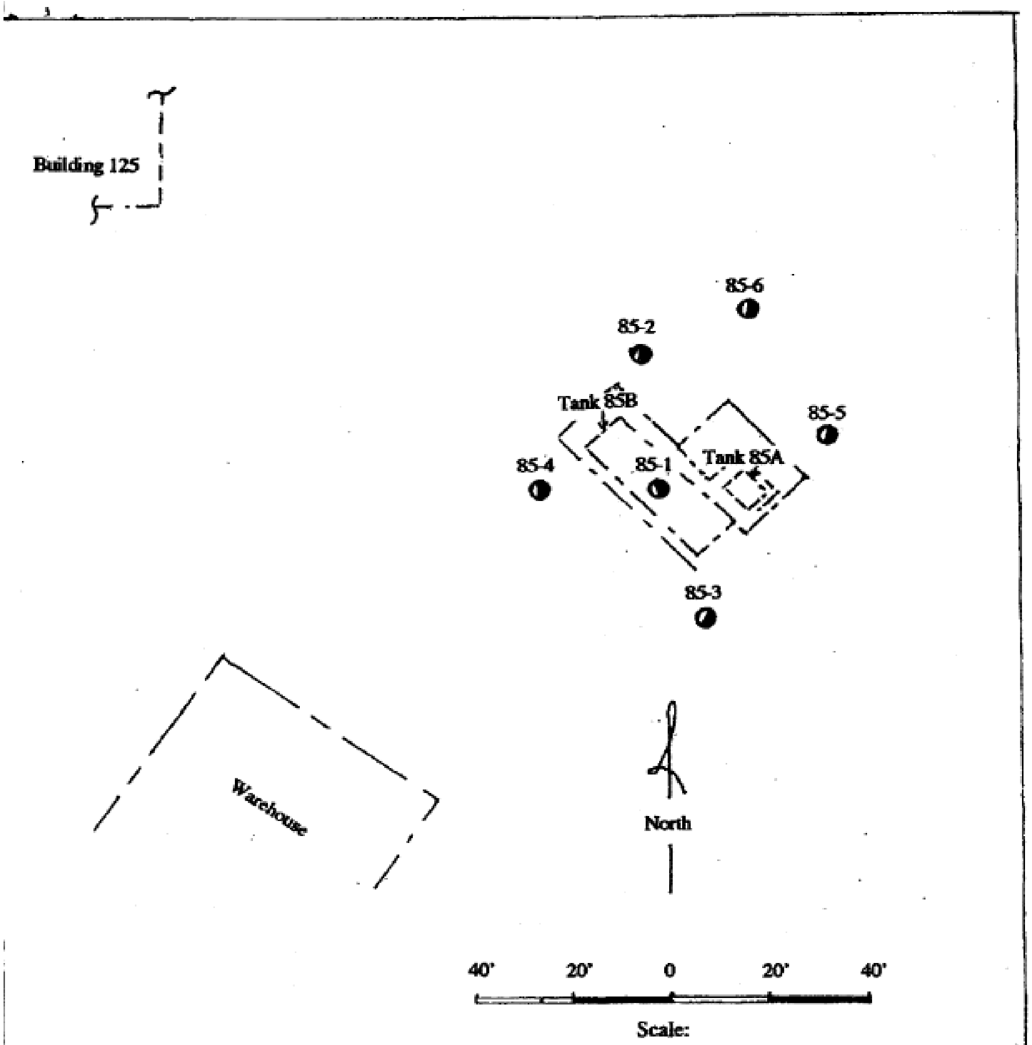
Sample# Depth	TPHmo ug/L	TPHd ug/L	TPHg ug/L	B	T	E	X	MTBE	PNAs mg/K
				-----	-----	ug/L	-----	-----	
137-1	ND	ND	ND	ND	ND	ND	ND	ND	NA
137-2	ND	65.0	ND	ND	ND	ND	ND	ND	NA
137-3	3,500.0	2,400.0	ND	ND	ND	ND	ND	ND	NA
137-4	ND	610.0	120.0	ND	ND	ND	ND	ND	NA
137-5	280.0	230.0	120.0	ND	ND	2.0	12.0	ND	NA
137-6	510.0	390.0	56.0	ND	ND	ND	ND	ND	NA

TABLE Va
Limited Site Assessment
Area of Former 7,000-gallon Gasoline UST - Tank #85a
and
Former 600-gallon Diesel - Tank #85b
Soil Sample Analytical Results
Performed on May 18, 2001

Sample# Depth	TPHmo mg/K	TPHd mg/K	TPHg mg/K	B	T	E	X	MTBE	PNAs mg/K
				-----	-----	mg/K	-----	-----	
85-1 3'-3.5'	5,900.0	5,200.0	62.0	0.53	0.12	ND	0.99	ND	ND
85-2 3'-3.5'	4,100.0	3,200.0	71.0	0.25	0.29	0.69	1.8	ND	NA
85-3 2'-2.5'	48.0	ND	ND	ND	ND	ND	ND	ND	NA
85-4 2'-2.5'	3,500.0	ND	ND	ND	ND	ND	ND	ND	NA
85-5 2'-2.5'	320.0	ND	ND	ND	ND	ND	ND	ND	NA
85-6 2'-2.5'	140.0	ND	ND	ND	ND	ND	ND	ND	NA

TABLE Vb
Limited Site Assessment
Area of Former 7,000-gallon Gasoline UST - Tank #85a
and
Former 600-gallon Diesel - Tank #85b
Groundwater Sample Analytical Results
Performed on May 18, 2001

Sample# Depth	TPHmo ug/L	TPHd ug/L	TPHg ug/L	B	T	E	X	MTBE
				ug/L				
85-1	5,900.0	4,800.0	660.0	6.4	3.4	1.1	12.0	ND
85-2	ND	100.0	ND	ND	ND	ND	ND	ND
85-3	ND	ND	ND	ND	ND	ND	1.8	ND
85-4	ND	150.0	130.0	ND	0.81	6.6	34.0	ND
85-5	ND	160.0	75.0	0.76	0.60	ND	ND	ND
85-6	ND	240.0	ND	ND	ND	ND	ND	ND



Greensfelder
&
Associates

Site:
ALAMEDA GATEWAY
2900 MAIN STREET
ALAMEDA, CA

Figure 8.
UST 85A & 85B
Location
Map

Table 1
Soil Analytical Results
Alameda Gateway - 2900 Main Street
Alameda, California

			Total Petroleum Hydrocarbons			*Volatile Organic Compounds*				
Sample ID	Sample Date	Sample Depth (ft bgs)	Gasoline mg/kg	Diesel mg/kg	Motor Oil mg/kg	Benzene mg/kg	Toluene mg/kg	Ethyl-benzene mg/kg	Xylenes mg/kg	MTBE mg/kg
RWQCB ESL			100	100	1,000	0.044	2.9	3.3	2.3	0.023
Former UST #85a/85b Area										
SB85-1	01/16/07	7 - 8	3.6 a	< 12	97 b	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB85-2	01/16/07	6 - 7	< 0.5	< 2.5	< 10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB85-3	01/16/07	6 - 7	4.9 a	2,500	2,300 b	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB85-4	01/16/07	3 - 4	8.2 a	980	2,100 b	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB85-5	01/17/07	6 - 6.5	1,700 a	24,000 a	12,000 b	< 20	< 20	< 20	< 20	< 100
SB85-6	01/17/07	11 - 12	11 a	2,500	1,900 b	< 0.2	< 0.2	< 0.2	< 0.2	< 1
SB85-8	02/05/07	7.5 - 8	< 0.5	< 25	250	NA	NA	NA	NA	NA
SB85-9	02/05/07	5 - 5.5	< 0.5	< 12	150	NA	NA	NA	NA	NA
Former UST #133 Area										
SB133-2	01/16/07	7.5 - 8	< 0.5	< 50	220	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB133-6	01/16/07	6.5 - 7	1 a	< 2.5	< 10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB133-7	01/16/07	9.5 - 10	< 0.5	< 2.5	23 b	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05

Table 1
Soil Analytical Results
Alameda Gateway - 2900 Main Street
Alameda, California

			Total Petroleum Hydrocarbons			*Volatile Organic Compounds*				
Sample ID	Sample Date	Sample Depth (ft bgs)	Gasoline mg/kg	Diesel mg/kg	Motor Oil mg/kg	Benzene mg/kg	Toluene mg/kg	Ethyl-benzene mg/kg	Xylenes mg/kg	MTBE mg/kg
RWQCB ESL			100	100	1,000	0.044	2.9	3.3	2.3	0.023
Former UST #137 Area										
SB137-1	01/16/07	7.5 - 8	< 0.5	120 a	150 b	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB137-2	01/16/07	5 - 5.5	140 a	2,300	< 500	< 0.2	< 0.2	< 0.2	< 0.2	< 1
SB137-3	01/16/07	6 - 6.5	18 a	1,100	< 500	< 0.04	< 0.04	< 0.04	< 0.04	< 0.2
SB137-4	01/16/07	2.5 - 3	0.93 a	2,400	7,900 b	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
SB137-5	01/16/07	6 - 6.5	< 0.5	< 620	4,500 b	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05

Notes:

Depths stated in feet below ground surface

RWQCB ESL = San Francisco Bay Regional Water Quality Control Board Environmental Screening Level, shallow industrial soil, groundwater is a potential drinking water source

mg/kg = milligrams per kilogram

< 2 = Compound not detected at or above stated Method Detection Limit (MDL)

Total petroleum hydrocarbons analyzed by United States Environmental Protection Agency (USEPA) Method 8015B/8015B(M)

Volatile organic compounds analyzed by USEPA Method 8021B

MTBE = methyl tert-butyl ether

Shading indicates exceedance of ESL

(a) Sample exhibits atypical chromatographic pattern

(b) Phthalate pattern present at 10 mg/kg in method blank; not observed in samples.

Table 2
Ground Water Analytical Results
Alameda Gateway - 2900 Main Street
Alameda, California

		Total Petroleum Hydrocarbons			*Volatile Organic Compounds*				
Sample ID	Sample Date	Gasoline	Diesel	Motor Oil	Benzene	Toluene	Ethyl-benzene	Xylenes	MTBE
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RWQCB ESL		100	100	100	1	40	30	20	5
Former UST #85a/85b Area									
SB85-1	01/16/07	< 50	< 470	3,000	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB85-2	01/16/07	< 50	< 480	4,300	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB85-3	01/16/07	150 a	3,900	3,200	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB85-4	01/16/07	< 50	< 49	400	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB85-5[i]	01/17/07	3,400 a	7,700	1,300	< 5	< 5	< 5	< 5	< 10
SB85-6[ii]	01/17/07	430 a	1,800	930	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-3A	02/15/07	<25	<50	250 d	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-3A	09/19/07	<50	<52	NA	< 0.5	< 0.5	< 0.5	< 0.5	< 1
Former UST #133 Area									
SB133-2	01/17/07	< 50	< 56	480	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB133-5	01/17/07	< 50	< 49	160 c	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB133-6	01/17/07	< 50	< 50	250 c	< 0.5	< 0.5	< 0.5	< 0.5	< 1
SB133-7	01/17/07	< 50	< 56	170 c	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-2A	02/15/07	<25	160	460	< 0.5	< 0.5	< 0.5	< 0.5	< 1
MW-2A	09/19/07	<50	<52	610	< 0.5	< 0.5	< 0.5	< 0.5	< 1

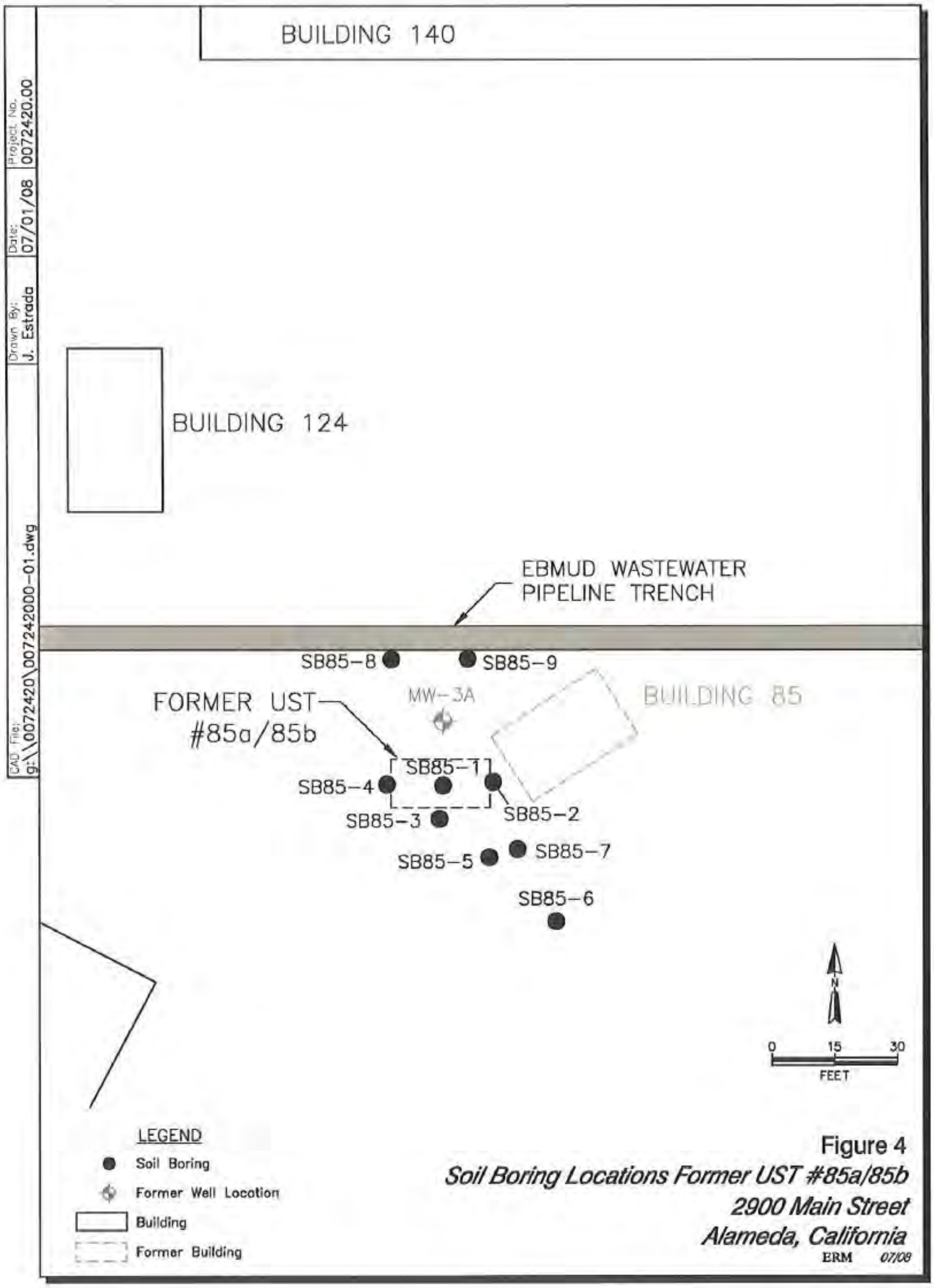
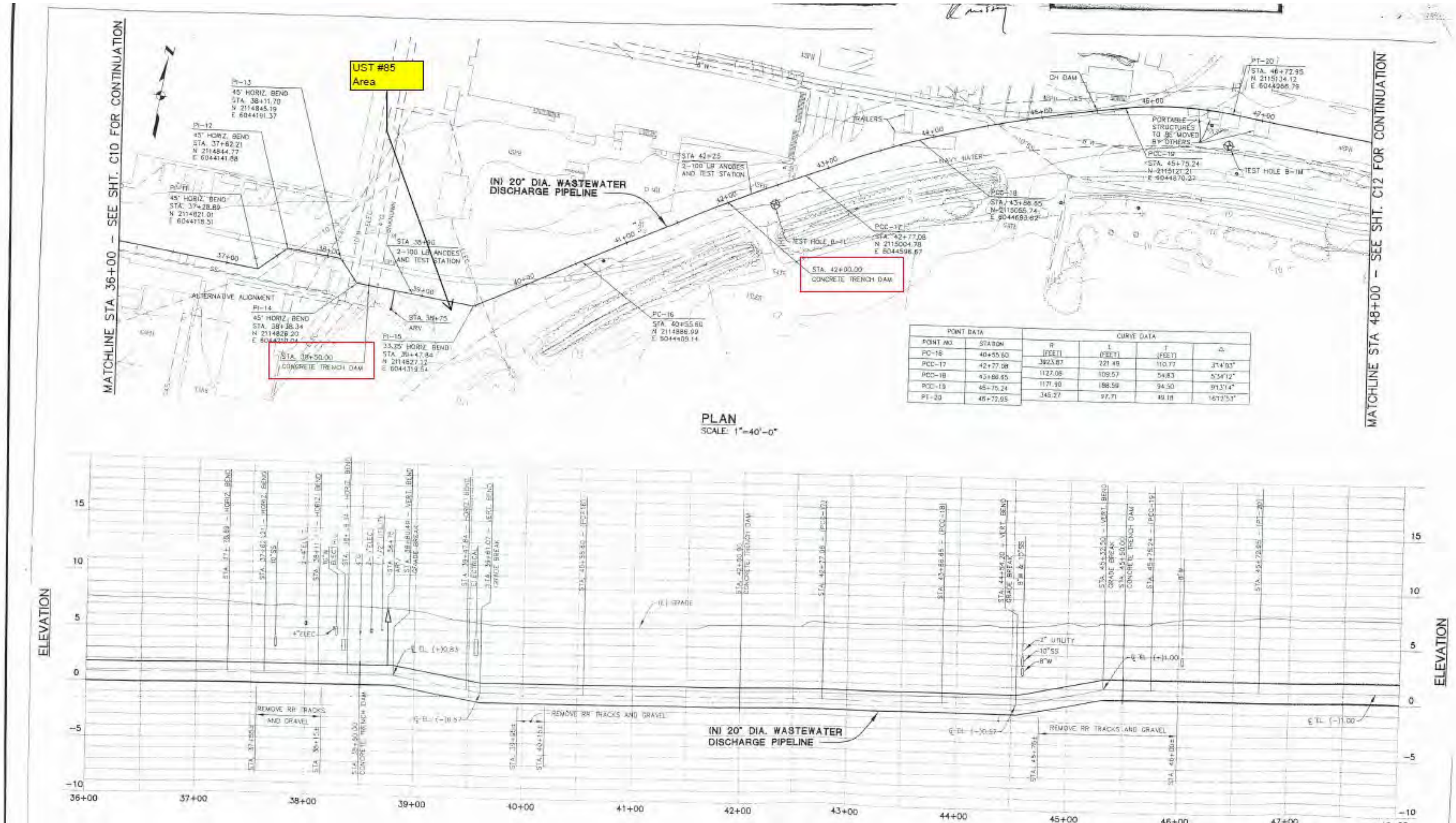


Figure 4
Soil Boring Locations Former UST #85a/85b
2900 Main Street
Alameda, California
ERM 07/08

ATTACHMENT J

EBMUD Plan Sheets for Sanitary Sewer
Through UST #137 and UST #85 Areas



POINT DATA		CURVE DATA			
POINT NO.	STATION	R (FEET)	L (FEET)	T (FEET)	Δ
PC-16	40+55.60	3923.87	221.49	110.77	3°14'03"
PCC-17	42+77.08	1127.08	109.57	54.83	5°34'12"
PCC-18	43+86.65	1171.90	188.59	94.50	9°13'14"
PCC-19	45+75.24	345.27	97.71	49.18	16°12'53"
PT-20	46+72.95				

Kennedy/Jenks Consultants

EAST BAY MUNICIPAL UTILITY DISTRICT
SPECIAL DISTRICT No. 1
OAKLAND, CALIFORNIA

ALAMEDA NAS WASTEWATER DISCHARGE PIPELINE
SD 245

PLAN AND PROFILE
STATION 36+00 TO STATION 48+00

37427

44278

C11

APPENDIX B

SITE SPECIFIC HEALTH AND SAFETY PLAN

SITE SPECIFIC
HEALTH & SAFETY PLAN

Alameda Commercial Properties LLC
2900 Main Street, Alameda, CA
Soil and Groundwater Borings and Sampling, and Monitoring Well Installation and Abandonment

TRC
2300 Clayton Road, Suite 610
Concord, California

TABLE OF CONTENTS

SECTION **PAGE**

TABLES

ATTACHMENTS

SITE SPECIFIC HEALTH AND SAFETY PLAN (HSP)

Alameda Commercial Properties, LLC – Alameda
2900 Main Street, Alameda, CA

1.0 INTRODUCTION

The purpose of this Health and Safety Plan (HSP) is to establish responsibilities, procedures and contingencies for the protection of TRC employees, contractors, visitors, and the public while performing activities at the SFPP Concord Station. This site-specific HSP is to be implemented in conjunction with TRC Solutions, Inc (TRC) Health and Safety Programs, including the Injury and Illness Prevention Program (IIPP) and Hazard Communication Program.

The use of proper health and safety procedures in accordance with applicable OSHA regulations shall be required during site work. The procedures presented in this HSP are intended to serve as guidelines. They are not a substitute for sound judgment by site personnel.

1.1 Key Companies Involved In Project

CUSTOMER OR CLIENT:	Alameda Commercial Properties, LLC
DESIGN ENGINEER:	TRC
CONTRACTOR:	TRC
SUBCONTRACTORS:	

Job Safety Analyses (JSAs) for contractor scopes of work are included in **Attachment E**.

1.2 Scope of Work

The proposed work will be performed by TRC and Gregg Drilling and will include but may not be limited to the following activities:

- Soil and groundwater borings
- Collection of soil and groundwater samples
- Destruction of monitoring well
- Construction of monitoring well

2.0 SITE INFORMATION

This HSP considers the physical, chemical, and biological hazards that may be encountered during work activities at the site. Operations associated with this HSP will be conducted in accordance with the scope of work and approved design drawings/specifications.

Summary information for this project is provided in the following table:

Table 1: Site Information

Anticipated Work Period: Site Description (see Attachment A for site map):	The approximately 16.43 -acres Site is located at 2900 Main Street, Alameda, California, in an industrial area. The Site is currently owned by Alameda Commercial Properties, LLC.
Approximate depth to groundwater:	Generally 4 feet below grade
Contaminants of Concern (see Attachment B):	TPH in Soil and Groundwater.

3.0 ROLES & RESPONSIBILITIES

Contact information and names of key project personnel are listed below. A description of their responsibilities follows.

Table 2: Key Project Personnel and Contact Information

Role	Name	Contact Information
TRC Personnel		
TRC Project Manager/Supervisor	Keith Woodburne	Office: (925) 688-2488 Cell: (415) 497-1947
TRC Site Safety Officer (SSO)	Jacob Zepeda	Office:(925) 688-2476 Cell: (925) 260-0427
TRC Assistant Site Safety Officer (Assistant SSO)		

<u>TRC Site Safety Officer or Assistant Safety Officer must report all site incidents immediately to the TRC Project Manager</u>

TRC PM/Supervisor must report all incidents INVOLVING PERSONAL INJURY immediately to:		
Sargent & Associates Contact TRC Human Resources Manager	Bill Russell Suzanne Micallef	Office:(978)256-7459 Fax :(978)256-4941 Office: (978) 656-3628
TRC PM/Supervisor must report all incidents NOT INVOLVING PERSONAL INJURY within 24 hours to:		
TRC RMD Safety Coordinator	Dave Sullivan	(978) 656-3565 – office (978) 758-2809 – cell
TRC National Safety Director	Mike Glenn	(949) 727-7347 – office (949) 697-7418 – cell

3.1 TRC Project Manager/Supervisor

- Overall responsibility for development of a complete and accurate HSP. The HSP shall account for all foreseeable hazards.
- Responsible for the management and technical direction of all aspects of the project.
- Ensure the completion of periodic site inspections.
- Conduct incident investigations.
- Delegate responsibility for field implementation of the HSP to TRC Site Safety Officer.

3.2 Site Safety Officers (SSO) – TRC & Contractor Personnel

- Responsible for the daily implementation of the HSP.
- Ensures HSP is available onsite and that the plan is understood and signed by all personnel entering the site. (See **Attachment F** "Safety Compliance Agreement").
- Conducts (or coordinates the completion of) Tailgate Safety Meetings and ensures documentation of these meeting is available for review.
- Uses JSAs to emphasize hazards and protective measures discussed in the HSP.
- Communicates any revisions to the scope of work or HSP to affected personnel and Project Manager/Supervisor.
- Implements emergency response procedures.

3.3 Assistant Site Safety Officer (Asst SSO) – TRC & Contractor Personnel

- In the event the SSO is not on site, the Assistant SSO will assume the responsibilities of the SSO.

- It is TRC's intent to have a TRC SSO or Assistant SSO available onsite during work activities. On the occasion neither person are physically onsite, they will be available by phone or pager. See "Table 2: Key Project Personnel and Contact Information".

3.4 TRC Employees

- Responsible for understanding and complying with this HSP, including the JSAs.
- Are required to participate in daily Tailgate Safety Meetings prior to commencement of site work.
- Each employee must acknowledge an understanding of the HSP by signing the "Safety Compliance Agreement" (See **Attachment F**) on a daily basis.

3.5 Contractors & Subcontractors

A copy of the HSP will be made available to each designated Contractor/Subcontractor (from now on to be referred to "Contractors") Site Health and Safety Officer (SSO) prior to coming to the site. Upon review or briefing of the HSP, each contractor and their personnel working at the site will be required to sign the "Safety Compliance Agreement" (See Attachment F) to verify their understanding and willingness to comply with the HSP.

TRC hires Contractors to apply their technical expertise to specific work tasks (i.e. construction, drilling, grading and heavy equipment operation/maintenance). Although TRC has a certain level of knowledge in these areas, the contractor is most knowledgeable of the hazards within their particular area of expertise and is in the best position to implement and monitor an effective H&S program. Contractors are required to follow and operate within their company's health and safety program and policies. TRC will exercise reasonable care to prevent and detect safety violations on the site. However, direct supervision of contractor employee safety is the responsibility of the contractor.

Contractors are to designate a company representative as their own Site Safety Officer and, if applicable, Assistant Safety Officer. This individual shall monitor the contractor's employees and ensure that safe working procedures are being followed. The Site Safety Officer and, if applicable, Assistant Safety Officer shall be identified to the TRC in writing, either by email, letter or by having the individual sign and provide contact information on "Safety Compliance Agreement" (See **Attachment F**).
Contractors are to:

- Provide a copy of their HSP to the TRC SSO or Project Manager/Supervisor before work commences, if applicable.
- Provide safety equipment and personal protective equipment for their employees.
- Ensure their equipment is in proper working order and their employees are trained and medically fit to complete the work assigned to them.
- Upon request, provide evidence that personnel working at the site have received the necessary training, certifications and, if applicable, medical surveillance.

The Contractor must inform the TRC SSO if the risks associated with a particular task exceed day-to-day safety requirements and necessitate additional safety precautions to protect the employees performing the particular task. In such cases, TRC may dictate that additional safety precautions be implemented. In the event a discrepancy arises between contractor safety procedures and those of TRC, the more stringent is to be implemented.

3.6 Visitors / Regulatory Agents

- Visitors / regulatory agents will be provided an overview of the basic site safety information. A copy of this HSP will be made available for review.
- All visitors / regulatory agents are required to sign-in on "Safety Compliance Agreement" (See **Attachment F**) each time they enter the project site.
- Visitors / regulatory agents should be escorted by a TRC or designated contractor employee and should not be allowed to move about the site alone.

4.0 COMMUNICATION

Communication is an important aspect of project safety and this HSP. There are several processes incorporated in this HSP to ensure communication of health and safety hazards.

- Pre-job project planning meetings to discuss the scope of work and potential hazards
- Site walkdowns with the TRC workgroup, subcontractors and the customer/client.
- Development of site-specific HSP and JSAs.
- Communication and acknowledgement of understanding of HSP & JSAs by signing the "Safety Compliance Agreement" (See **Attachment F**) at the start of each day. Additional communication is needed if conditions change or when changing tasks.
- Daily tailgate meetings emphasizing that hazard assessment is a continuous process, and any potentially unsafe actions or condition are to be communicated immediately to the SSO.
- Near misses are to be communicated to the onsite staff and Project Manager by the SSO. The near misses will be discussed during the next tailgate meeting to ensure all onsite staff are aware of the near miss.
- Communicating results of field observations/audits. Visual observations are to be conducted daily by the SSO. Periodic field observations will also be recorded on the TRC Site Safety

Observation Form (See **Attachment G**). Results from either observation will be communicated during Tailgate Safety Meetings.

5.0 REVISIONS TO HSP

If a situation arises where the HSP requires revision, the following options are available:

- ❑ Except in the case of emergency situations, no deviations from the HSP may be implemented without the prior notification and approval of the TRC Site Safety Officer (SSO) and the Project Manager/Supervisor.
- ❑ If HSP revisions are minor (i.e. not involving significant changes to the scope of work, associated hazards or PPE requirements), the TRC Site Safety Officer (SSO) can make hand-written revisions to the HSP in the field. HSP Revisions must then be communicated to affected personnel and the Project Manager/Supervisor.
- ❑ If HSP revisions are substantial (i.e. involving significant changes to the scope of work, associated hazards or PPE requirements), the TRC Site Safety Officer (SSO) must consult with the Project Manager/Supervisor before making revisions. The TRC Site Safety Officer (SSO) can make hand-written revisions to the HSP in the field. HSP Revisions must then be communicated to affected personnel and the Project Manager/Supervisor. It is up to the discretion of the Project Manager/Supervisor whether a revised HSP will be reissued to replace the original HSP on the work site.

6.0 HAZARD ASSESSMENT

Hazard assessment is essential for establishing hazard prevention measures. Below is a list of potential physical, chemical and biological hazards associated with various TRC project sites. Not all hazards apply to this site-specific HSP. In addition, the list is not all-inclusive and may require additional hazards associated with a particular project/site to be added.

JSAs are included in **Attachment E** of this HSP.

6.1 Physical Hazards

☐ Excavation & trenching (where personnel will be entering the excavation)
☐ Heavy equipment (not drilling related)
☒ Drilling
☒ Overhead lines
☒ Underground utilities
☐ Energy control – lock out / tag out
☐ Flammable atmospheres (> 10% LEL)
☒ Traffic - vehicular and pedestrian
☒ Trips, slips & falls
☒ Head, foot, eye, and back injuries
☐ Falling objects
☐ Working from elevated surface (greater than 6 feet); fall protection / fall arrest
☐ Ladders use
☒ Sharp objects
☐ Welding hazards
☐ Confined spaces

Equipment
☒ Electrical equipment (including powered hand tools)
☒ Hydraulic equipment
☒ Pnuematic equipment
☐ Cutting equipment (non-powered)
☐ Hammers, shovels, screwdrivers
☐ ________ (Additional equipment)

☐ Welding hazards
☐ Confined Spaces

6.2 Chemical Hazards

☐ Refined Petroleum products / waste oil
☐ Asbestos
☐ Serpentine Soils
☒ VOC's, TPH, Metals (in groundwater)
☐ Ozone
☐ Hydrogen Sulfide
☐ Heavy metals
☐ Landfill Gases
☒ Environmental samples, soil cuttings, decontamination water, dust (nuisance, silica)
☐ Industrial chemicals

6.3 Biological Hazards

☒ Noise Exposure
☐ Heat Stress
☒ Cold Stress
☒ Weather - heat, cold, rain, fog
☐ Poisonous Plants
☐ Animals/Insects
☐ Misc. Pathogens

7.0 GENERAL SAFETY RULES

This section presents general safety rules for all persons working at the project site. Failure to follow safety protocols and/or continued negligence of health and safety policies will result in expulsion of a worker or firm from the site and may result in termination of employment.

1. Horseplay, fighting, gambling or the possession of firearms are not permitted.
2. Work shall be well planned and supervised to prevent injuries. Supervisors shall assure that employees observe and obey safety rules and regulations.
3. An employee reporting for work who, in the opinion of his supervisor, is unable to perform his assigned duties in a safe and reasonable manner shall not be allowed on the job.
4. No employee shall be assigned a task without first having been instructed on proper methods, including safety training, of carrying out the task. Any employee who feels they have not received proper instruction shall notify their supervisor prior to carrying out the task.
5. Injuries and accidents shall be reported immediately to the immediate supervisor, who will then report it to the SSO.

6. There shall be no consumption of food or drink in operational areas of the site. Hands should be thoroughly cleansed prior to eating.
7. Smoking is not permitted on the site.
8. When personnel are conducting hazardous operations, there shall be at least one other person (buddy system) on duty in the immediate area as a backup in case of emergency.
9. Wear required personal protective equipment (PPE) in the workplace when appropriate and/or when specified in the site specific health & safety plan. Loose clothing and jewelry should not be worn when operating machinery.
10. Do not operate any machinery if you are not authorized or qualified to do so. If unsure how to operate a machine or perform any assigned task, ask the Project Manager/Supervisor before proceeding.
11. Do not operate motorized equipment until proper training and certification has been provided (e.g. forklifts, etc.)
12. No one shall knowingly be permitted or required to work while the employee's ability or alertness is so impaired by fatigue, illness or other causes that it might unnecessarily expose the employee or others to injury.
13. Alcohol and drugs are strictly prohibited on any TRC premises, customer property, and/or in Company vehicles. Employees shall not report to work under the influence of drugs or alcohol. Employees are prohibited from possessing, using, manufacturing, distributing, dispensing, selling or purchasing illegal drugs or other controlled substances (as defined under federal and state law).

8.0 PERSONAL PROTECTIVE EQUIPMENT

TRC and contractor personnel are required to wear PPE appropriate for the task and potential physical, chemical and biological exposures. Selection of PPE is based on hazard assessment (i.e. JSAs) and air monitoring.

PPE required by all personnel at all times on the site:

☒ Hard Hat
☒ Safety Shoes/Boots
☒ Safety Vest
☒ Eye Protection - ☒ glasses ☐ goggles ☐ face shield
☒ Hand Protection - ☒Kevlar ☐ nitrile ☐ other _______
☐ Hearing Protection
☐ Respiratory Protection - ☐ APR Particulate ☐ APR Chemical cartridge ☐ other ______
☐ Protective Clothing - ☐ Tyvex ☐ Nomex ☐ Coveralls ☐ other ______

PPE which should be available at all times on the site:

☐ Hard Hat
☐ Safety Shoes/Boots
☐ Safety Vest
☐ Eye Protection - ☐ glasses ☐ goggles ☐ face shield
☒ Hand Protection - ☐ Kevlar ☒ nitrile ☐ other _______
☒ Hearing Protection
☐ Respiratory Protection - ☐ APR Particulate ☐ APR Chemical cartridge ☐ other ______
☐ Protective Clothing - ☐ Tyvex ☐ Nomex ☐ Coveralls ☐ other ______

Please refer to the Glove Selection Guideline in **Attachment H** in order to use the appropriate Kevlar glove for the task you are about to start.

9.0 RESPIRATORY PROTECTION

For operations that require the use of a respirator, the TRC and Contractor SSOs must verify that field personnel are medically approved to use respiratory equipment, fit tested, and trained in the proper use of respirators. Only respirators that are NIOSH/MSHA approved are to be used.

Respiratory protection is mandatory if workers are required to complete tasks within a hazardous atmosphere. According to OSHA, a hazardous atmosphere is defined as:

- Flammable gas, vapor, or mist in excess of 10% of LEL.
- Atmospheric oxygen is below 19.5% or above 23.5%.
- When concentration of a known contaminant is greater than the permissible exposure limit (PEL).
- Airborne combustible dust exceeds its LEL (approximated when dust obscures vision at a distance of 5 feet or less).

If conditions warrant, air monitoring may be required to verify the presence or absence of a hazardous atmosphere. Air monitoring is to be conducted whenever a situation or condition arises that could reasonably result in a hazardous atmosphere.

9.1 Air-Purifying Particulate Respirators

Employees involved in construction and earthmoving operations that result in nuisance dust and particulates may use air-purifying respirators. These are commonly referred to as "dust masks" and do not require fit testing. Particulate respirators can to be used in situations where nuisance dust and particulates are the only contaminants posing an inhalation hazard. Particulate respirators are not to be used in oxygen deficient atmosphere or if hazardous levels of gas/vapor contaminants are also present.

A high efficiency particulate air (HEPA), P100 respirator should be used in place of commercially available "dust masks".

9.2 Air-Purifying Gas/Vapor Respirators

TRC employees and Contractors are required to wear half-face, air-purifying respirators with the appropriate chemical cartridge under the following circumstances:

- When concentration of a known contaminant continuously exceeds permissible exposure limit (PEL) time-weighted average or the threshold limit value (TLV) time-weighted average.
- When volatile organic compound (VOC) vapors in the work area continuously exceed the threshold limit value- time-weighted average (TLV-TWA) for gasoline (300 parts per million [ppm]).
- When, at any time, VOC vapors in the work area exceed the threshold limit value - short-term exposure limit (TLV-STEL) for gasoline (500 ppm).

See **ATTACHMENT B** for additional information and regulatory exposure limits for chemicals of concern at this site.

Air purifying respirators (APRs) with chemical cartridges can be used under the following conditions:

- If the oxygen concentration is between 19.5% and 23.5%.
- If chemical contaminants have been identified.

- The toxic concentrations are known and the respirator cartridges are effective in removing the contaminants.
- The respirator and cartridges are NIOSH/MSHA approved.
- The contaminants have noticeable warning qualities such as odor and visibility characteristics including color.

In the event workers are required to wear air purifying respirators (APRs) with chemical cartridges, the following requirements must be met:

- The TRC or Contractor SSO must verify that workers are:
  - Medically approved (within one year) to use respiratory protection.
  - Fit-tested for the specific respirator to be used.
  - Trained in the proper use and limitations of the respirator to be used.
- Contractors must provide proof of the above to the TRC SSO, upon request.
- If an employee or contractor has not cleared by the SSO to use a respirator, they will not be assigned tasks that may potentially expose them to contaminants.
- Personnel with interfering facial hair are not permitted to wear respirators and shall not be permitted in areas where respiratory protection is required.

9.3 Air-Supplied Respirators

Air-supplied respirators, such as SCBA or airline, full-face respiratory protection, are not anticipated to be required at the site. This level of respiratory protection is utilized in oxygen deficient atmospheres or atmospheres considered to be at or above immediately dangerous to life and health (IDLH) levels. These conditions will only occur in rare, if any, circumstances such as confined space entry or emergency situations. The use of air-supplied respiratory protection is not permitted without approval and guidance from the Project Manager.

10.0 AIR MONITORING

Air monitoring is required to verify the presence or absence of a hazardous gas/vapor atmosphere whenever a situation or condition arises that could reasonably result in a hazardous atmosphere.

Based on OSHA's definition of a hazardous atmosphere, there are 4 different hazards that require monitoring. The table below describes the type of hazard, what air monitoring equipment to use and what levels constitute a hazard. The information provided in the table does not take into consideration all the possible variations of hazardous atmosphere; however it will provide guidance when determining the presence of a hazardous atmosphere. Any questions or concerns should be directed to the SSO before work begins.

Table 3: Air Monitoring Guidance

Hazard	Appropriate Air Monitoring Equipment	Hazardous Levels	Comments
Flammability	Combustible gas indicators (CGI) are direct-reading instruments; measures % LEL and oxygen.	>25% of the LEL during cold work >10% of the LEL during hot work	Since many flammable vapors are heavier than air, be sure to take readings at ground level. Work be suspended if CGI readings exceed 10% of LEL.
Oxygen deficiency or abundance	Same as above or an Oxygen Meter	<19.5% and >23.5%	Concentrations >23.5% may present an increased flammability hazard.
Exceeding the permissible exposure limit (PEL)	Photoionization detector (PID) can detect organic and inorganic vapors/gases	Varies depending on chemical. See **Attachment B** for hazardous levels of common chemicals	It is impossible to differentiate the different chemicals using a PID meter. However, the PID will indicate whether chemicals are present and at what levels. Measurements taken within worker's breathing zone will be used to determine respiratory protection requirements.

Airborne combustible dust is not anticipated at the work site.

When conducting, air monitoring the following actions should be considered:

- Be familiar with the proper use and limitations of the air monitoring equipment to be used.
- Ensure air-monitoring equipment (TRC's or otherwise) is in working order and has been properly calibrated. The TRC SSO is to document verification of calibration (i.e. in a field log book).
- Clearly document the results of air monitoring, including:
  - Equipment name / type and calibration data
  - Date, time and site location of air monitoring (use a site map to clarify the locations of readings.
  - Indication of what is being measured (LEL, oxygen, or ppm)
  - Results of the air monitoring
- Measurements for volatile organics should be taken at low point where vapors could accumulate.
- Measurements taken to determine the need for respiratory protection should be take within the worker's "breathing zone", keeping in mind the worker's closest proximity to the hazard source.
- An individual should never enter a confined area or excavation in order to conduct initial air monitoring. Instead, actions should be taken to lower the air monitoring equipment into the area to indicate the presence (or absence) of a hazardous atmosphere. Most air monitoring equipment has audible alarms.
- In the event that CGI readings on the site exceed 10 percent of the LEL, work will be suspended until the source can be eliminated or controlled.

11.0 SITE CONTROL

The primary objective of site control is to minimize the exposure to potentially hazardous substances and/or situations. Supervision and controlling access to the work site is necessary to protect site personnel, visitors and the public.

For this site, the following areas will be designated as hot, warm and cold zones:

Hot Zones: Within 15 feet of the borehole or sampling location
Warm Zone: ☒ NA
Cold Zone: Outside the hot zone

For the purposes of this HSP, site control will be discussed under two circumstances: (1) work involving physical hazards and (2) work involving chemical hazards.

In either case, site control areas are to be clearly identified and communicated by the SSO. The hot zone must be clearly identified and should be isolated with cones, barricades, or high visibility caution tape. In addition, sufficient area also must be available to conduct operations while providing a protective buffer for persons and property outside the controlled areas.

☒ Work involving Physical Hazards

Work does *not* involve direct contact with hazardous substances. However, if the scope of work primarily involves physical hazards (i.e. vehicular traffic, heavy equipment operation, etc.), the establishment of a warm zone is not necessary. Instead, a hot zone must be established to surround all the physical hazards. The hot zone area shall provide enough room and buffer to protect both workers and the public. A cold zone is established outside the hot zone to allow "support" activities to be conducted in a safe location.

☐ Work involving Chemical Hazards

The concept of site control and the establishment of hot/warm/cold work zones are intended for work involving the exposure (or potential exposure) to hazardous chemical concentrations. Under these circumstances, the purpose of work zones is two-fold: 1) minimize the exposure to potentially hazardous substances and 2) minimize the spread of hazardous substances outside the immediate work area through decontamination procedures.

A brief overview of site control work zones is provided below:

Hot Zone

- Where personnel may be subject to chemical or physical hazards.
- Where known or suspected contamination exists and may also be where equipment operation and/or environmental sampling will take place.
- To be clearly identified and should be isolated with cones, barricades, or high visibility caution tape.
- Large enough to provide sufficient room and buffer to protect both workers and the public.

Warm Zone

- Located between the hot and cold zones; beginning at the edge of the hot zone and extends to the cold zone.
- Utilized as a control point or corridor for persons entering or exiting the hot zone.
- Where personnel and equipment are decontaminated.

Cold Zone

- Located outside the hot zone where administrative and other support functions are located.
- Where adverse exposure to contaminants and physical hazards are unlikely.

11.1 Decontamination

The purpose of decontamination is to: (1) remove chemical containments from personnel and/or equipment and (2) significantly reduce the spread of chemical contaminants beyond the hot/warm zone.

Decontamination is intended to occur within the warm zone. Depending on the project, there may be a need to decontaminate both personnel and equipment. The decontamination process should be appropriate to the chemical hazards present. For example contaminated soil on work boots/shoes may only require physical removal of the soil with a sturdy brush. However, decontamination of equipment (i.e. drilling augers) may require additional steps to ensure contaminants are not spread beyond the hot/warm zones. Heavy equipment (i.e. excavators, trucks used for waste transportation, etc.) may require a combination of steps, including the placement of gravel at the entrance/exit of the site.

Personnel Decontamination Procedures:

Remove contaminated items (i.e. gloves) in an "inside out" manner. Contaminated garments are to be placed in designated plastic bags or drums prior to disposal or transfer offsite.

Equipment Decontamination Procedures:

Follow proper procedures when the need arises to properly decontaminate onsite equipment.

11.2 Site Security

Appropriate security measures will be established in coordination with the site owner/operator and communicated to site personnel. The objective of these measures is to (1) protect the public from potential exposure to physical/chemical hazards; (2) avoid public interference with personnel and safe work practices; and (3) prevent theft or vandalism of equipment at the site.

12.0 PERSONNEL TRAINING

TRC and contractor personnel are required to acknowledge their understanding and willingness to comply with this HSP before admission to the site by signing the “Safety Compliance Agreement” (See **Attachment F**).

Site specific training requirements are indicated below:

☒ TRC Personnel shall meet the training requirements specified in the OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) Standard [29 CFR 1910.120(e) and CCR Title 8 Section 5192(e)].

☐ Kinder Morgan Contractor Safety Video.

☐ ConocoPhillips

☐ ExxonMobil

☐ Refinery Training

☐ Railroad Training:
- ☐ UPRR Contractor Orientation
- ☐ BNSF Contractor Orientation
- ☐ Cal Train Contractor Orientation
- ☐ “FRA Roadway Worker” Training (works within 25’ of track)

13.0 MEDICAL PROGRAM

TRC has established a medical surveillance program to assess, monitor, and help protect the health of employees, in particular, employees who may be exposed to potentially hazardous substances during site work. Personnel undergo medical examinations as follows:

- **Initial:** Pre-employment / prior to any assignment involving work in a hazardous or potentially hazardous environment. The initial examination is used to establish a baseline picture of health against which future changes can be measured, and to identify any underlying illnesses or conditions that might be aggravated by chemical exposures or job activities. This exam also certifies whether an employee is medically fit to wear a respirator.
- **Periodic:** At least once every 12 to 24 months (depending on the employee’s involvement in field activities) to measure changes in health status. This exam certifies whether an employee is still medically fit to wear a respirator.
- **Upon notification:** As soon as possible upon notification by an employee that they have developed signs or symptoms indicating possible overexposure to hazardous substances, or in response to an injury or exposure during an emergency situation.
- **Exit**: At termination of employment.

14.0 EMERGENCY RESPONSE PLAN

The TRC SSO (depending on which is present) will have controlling authority during an emergency. In the SSO's absence, the Alternate SSO will be in charge.

14.1 Evacuation Protocol

Evacuation protocol, routes and assembly areas from the site will be established by the SSO, and communicated to Field Personnel during the Tailgate Safety Meeting(s) prior to initiating work. In the event of an evacuation, personnel will meet at a pre-established assembly areas and the TRC SSO conduct a "head count" to see that everyone is accounted for. Contractor SSO is responsible for being able to provide an accurate head-count of contractor personnel.

14.2 First Aid & CPR

TRC employees and contractors with current First Aid and CPR certification and who are willing to provide First Aid and CPR will be asked to identify themselves at Tailgate Safety Meetings. Their names will be documented on the Tailgate Meeting Checklist (**Attachment F**).

14.3 Emergency Medical Assistance

A list of emergency medical assistance sources has been established as part of this HSP. ATTACHMENT C lists the names, locations, and telephone numbers of emergency response organizations in the vicinity of the project site, and a map to the nearest hospital(s) with an *emergency room*.

A vehicle shall be available onsite during work activities to transport injured personnel to the identified emergency medical facilities, if necessary. Company vehicles are to be equipped with a fire extinguisher and first aid kit.

14.4 Emergency Procedures

In the event of an accident, injury, or other emergency, remember to:

- ❑ **Stop work and REMAIN CALM.**
- ❑ **Move personnel to a safe location (evacuation plan).**
- ❑ **Call 911 or notify other emergency facilities, as necessary.**
- ❑ **Address medical emergencies and apply first aid, if necessary.**
  - Move injured or exposed person(s) from immediate area only if it is safe to do so.
  - If serious injury or life-threatening condition exists, call 911. Clearly describe the location, injury and conditions to the dispatcher. Designate a person to direct emergency equipment to the injured person.
- ❑ **Contain physical hazards.**
  - Act only if hazard is minimal and you are trained to deal with the situation. Otherwise evacuate and wait for emergency services to arrive.

Notify SSO and initiate incident reporting procedures.

- See page 2 of this HSP for contact information. In the event the SSO is not available, the order of notification should be 1) Assistant SSO, 2) TRC Project Manager and 3) HR Manager (if incident involves injury) or EHS Supervisor (if incident does not involves injury).
- TRC SSO is to notify TRC Project Manager/Supervisor as soon as reasonably possible.

❑ Do not resume work until the SSO has determined it is safe to do so.

15.0 INCIDENT REPORTING

In case of an accident, TRC personnel are to immediately report the incident to their Project Manager/Supervisor and follow the TRC incident reporting procedures detailed in the TRC IIPP. TRC's incident reporting forms are available through the Project Manager/Supervisor and include:

- ❑ TRC Incident Report
- ❑ Driver's Report of Accident
- ❑ TRC Potential / Near Miss Reporting Form
- ❑ TRC Employees Report of Incident
- ❑ TRC Witness Report of Incident
- ❑ Corrective Action Form

All incidents and near misses are investigated in accordance with TRC's IIPP. The TRC Incident Report Form is to be completed and submitted to the TRC National Safety Director within 24 hours following any incident. The TRC incident and near miss form can be found in **Attachment I.**

Contractor personnel are to report incidents to their SSO who is then required to report the incident to the TRC SSO, TRC Alternate SSO or TRC Project Manager immediately.

Some important information to include when reporting an incident is:

1. A description of the event (including date and time)
2. Details regarding personal injury and property damage, if any.
3. Whether emergency services were notified (i.e., medical facilities, fire department, police department) and the basis for that decision. Including time and names of persons/agencies notified, and their response.
4. Clarify the need for and type of TRC support.
5. Immediate corrective action(s) taken.

16.0 HEALTH AND SAFETY PLAN (HSP) SIGNATURE PAGE

Job Safety Analysis Author	Date:	HSP Author	Date:
________________________	______	________________________	12/16/14 ______

Review/Approvals:

Site Safety Officer Facility/Field Supervisor	Date:	Project Manager/Supervisor*	Date:
________________________	12/16/14 ______	________________________	12/16/14 ______
Local Safety Coordinator* ☐ **NA**	**Date**	**EHS Supervisor/Safety Professional (CIH, CSP, other)***	**Date**
Rochelle Clair ________________________	12/16/14 ______	________________________	______

Additional Information or Instructions:

____

____

____

____

* Note: **For most projects, the Project Manager/Supervisor will review, approve and sign the HSP.** In the event the operations are beyond the normal scope of work, additional review is available upon the request from the PM/Supervisor. The Local Safety Coordinator is the first recourse for reviewing HSPs **not** involving high-risk operations. It is recommended that for HSPs involving high-risk operations (i.e. hazardous exposures to chemicals, large scale or deep excavations, confined space entry, etc.), the EHS Supervisor and/or a Safety Professional [Certified Industrial Hygienist (CIH), Certified Safety Professional (CSP) or other professionally qualified person] be consulted for review of the HSP to ensure proper protective measures are being implemented.

ATTACHMENT A

SITE PLAN

SOURCE AERIAL PHOTO: Google Earth, May 2015.

LEGEND

Locations surveyed except as marked:*

- Monitoring well
- UVOST boring
- Co-located soil and grab groundwater boring
- Soil boring - 1989
- Soil boring - 2008
- Soil boring - 2014

NOTES:
** = Survey by Virgil Chavez Land Surveying, October 30, 2015.*
*** = Approximate location.*

N

SCALE (FEET)
0 10 20

SITE PLAN

Alameda Commercial Properties, LLC
2900 Main Street
Alameda, California

TRC 232888.0001 **FIGURE 2**

FILE NAME: N:\PROJECTS\CAD\Alameda Commercial Properties\Remedial Action Plan_April16\Fig2_Site Plan_Former USTs 85a_b.dwg | Layout Tab: 11x17

ATTACHMENT B

OCCUPATIONAL HEALTH GUIDELINES

Attachment B

OCCUPATIONAL HEALTH GUIDELINES AND TOXICOLOGICAL INFORMATION
Priority Pollutant Chemicals

Contaminant	ACGIH TLV-TWA (ppm)	NIOSH REL (ppm)	OSHA PEL (ppm)	STEL (ppm)	IDLH (ppm)	Routes of Exposure	Known or Suspected Carcinogen	Symptoms
Diesel (as Stoddard solvent)	for Diesel fuel/ Kerosene 14.4 (skin only)	Approx. 60-98	500	250-500 (NIOSH ceiling)	Approx. 3000-5600	Inhalation, Ingestion, Contact	No	Irritation to eyes, skin, mucous membrane; dermatitis, headache, fatigue, blurred vision, dizziness, slurred speech, confusion, convulsions, aspiration, weakness, restlessness, incoordination
Gasoline	300	n/a	n/a	500 (ACGIH)	n/a	Inhalation, Absorption, Ingestion, Contact	Yes	Irritation to eyes, skin, mucous membrane; dermatitis, headache, fatigue, blurred vision, dizziness, slurred speech, confusion, convulsions, aspiration
Benzene	0.5	0.1	1	1 (NIOSH)	500	Inhalation, Absorption, Ingestion, Contact	Yes	Irritation to eyes, skin, nose, resp system, giddiness, headache, nausea, staggered gait, fatigue, anorexia, weakness/exhaustion, dermatitis
Toluene	50	100	200	150 (NIOSH)	500	Inhalation, Absorption, Ingestion, Contact	No	Irritation to eyes, nose; fatigue, weakness, confusion, euphoria, dizziness, headache, dilated pupils, tears, nervousness, muscle fatigue, insomnia, dermatitis
Ethyl benzene	100	100	100	125 (NIOSH& ACGIH)	800	Inhalation, Ingestion, Contact	No	Irritation to eyes, skin, mucous membranes; headache, dermatitis, narcosis, coma
Xylenes (o,m,p,)	100	100	100	150 (NIOSH & ACGIH)	900	Inhalation, Absorption, Ingestion, Contact	No	Irritation to eyes, skin, nose, throat; dizziness, excitement, drowsiness, incoordination, staggering gait, nausea, vomiting, abdominal pain, dermatitis
Methyl tert butyl ether ((MTBE)	40	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Action levels are based on photo ionization detector readings taken in the field.

Table B-1

OCCUPATIONAL HEALTH GUIDELINES AND TOXICOLOGICAL INFORMATION

TABLE KEY

ACGIH TLV-TWA	American Conference of Governmental Industrial Hygienists, Threshold Limit Value-Time Weighted Average
NIOSH REL	National Institute of Occupational Safety & Health, Recommended Exposure Limit
STEL	Short Term Exposure Limit (BTEX STELs are by NIOSH)
OSHA PEL	Occupational Safety and Health Administration, Permissible Exposure Limit
IDLH	Immediately Dangerous to Life and Health
ppm	parts per million
CNS	Central Nervous System
n/a	not available (i.e., no value has been established)

DEFINITIONS

Threshold Limit Value: Threshold limit values (TLVs) refer to airborne concentrations of substances and represent conditions under which it is believed nearly all workers may be repeatedly exposed, day after day, without adverse health effects.

Threshold Limit Value - Time Weighted Average: The time weighted average (TWA) is a concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. TLV-TWAs are established by the ACGIH.

Recommended Exposure Limit: Unless otherwise noted, the recommended exposure limit (REL) is a TWA concentration for up to a 10-hour workday during a 40-hour workweek. RELs are established by NIOSH to reduce or eliminate adverse occupational health effects.

Short Term Exposure Limit: A short term exposure limit (STEL) is defined as a 15-minute TWA exposure that should not be exceeded at any time during a workday. When compared to the REL (or TLV-TWA for ACGIH standards), the STEL allows the worker to be exposed to a higher concentration, BUT for a shorter period of time. Exposures above the REL up to the STEL should not be longer than 15 minutes and should not occur more than four times per day.

Permissible Exposure Limit: Permissible exposure limits (PELs) are TWA concentrations that must not be exceeded during any 8-hour work shift of a 40-hour workweek. PELs are established by OSHA (29 CFR 1910.1000).

Immediately Dangerous to Life and Health: Immediately dangerous to life and health (IDLH) values are established as concentrations from which a worker can escape within 30 minutes without suffering loss of life, irreversible health effects, or other deleterious effects that could prevent him/her from escaping the hazardous environment. The purpose of establishing an IDLH exposure concentration is to ensure that workers can escape from a given contaminated environment in the event of failure of respiratory protection equipment.

Known or Suspected Carcinogen Classification: ACGIH categories for carcinogenicity classification:

A1 – Confirmed Human Carcinogen – The agent is carcinogenic to humans based on the weight of evidence from epidemiologic studies.

A2 – Suspected Human Carcinogen – Human data are accepted as adequate in quality but are conflicting or insufficient to classify the agent as a confirmed human carcinogen; OR the agent is carcinogenic in experimental animals at dose(s), by route(s) of exposure, at site(s), of histologic type(s), or by mechanism(s) considered relevant to worker exposure. The A2 is used primarily when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals with relevance to humans.

A3 – Confirmed Animal Carcinogen with Unknown Relevance to Humans – The agent is carcinogenic in experimental animals at a relatively high dose, by route(s) of administration, at site(s), of histologic type(s), or by mechanism(s) that may not be relevant to human exposure. Available epidemiologic studies do not confirm an increased risk of cancer in exposed humans. Available evidence does not suggest that the agent is likely to cause cancer in humans except under uncommon or unlikely routes or levels of exposure.

A4 – Not Classifiable as a Human Carcinogen – Agents which cause concern that they could be carcinogenic for humans but which cannot be assessed conclusively because of a lack of data. In vitro or animal studies do not provide indications of carcinogenicity which are sufficient to classify the agent into one of the other categories.

A5 – Not Suspected as a Human Carcinogen – The agent is not suspected to be a human carcinogen on the basis of properly conducted epidemiologic studies in humans. These studies have sufficiently long follow-up, reliable exposure histories, sufficiently high dose, or adequate statistical power to conclude that exposure to the agent does not convey a significant risk of cancer to humans; OR evidence suggesting a lack of carcinogenicity in experimental animals is supported by mechanistic data.

ATTACHMENT C

EMERGENCY SERVICES
PHONE NUMBERS, DIRECTIONS, AND LOCAL AREA MAP

EMERGENCY SERVICES

FACILITY / LOCATION **TELEPHONE**

Emergency Situation **911**

TRC 24 HOUR Notification Number **1-800-274-9072**

Hospital Name, Address, Phone
Alameda Hospital .... **(510) 523-4357**
2070 Clinton Avenue
Alameda, CA 94501

From 2900 Main Street
Alameda, CA 94501

1. Head southeast on **Main St** toward **Singleton Ave**
2. Slight right onto **Central Ave**
3. Turn right onto **Sherman St**
4. Take the 2nd left on to **Clinton Ave**

   Destination will be on the right

Alameda Hospital
2070 Clinton Avenue
Alameda, CA 94501

Poison Control Center: Emergency 24-Hour Hotline.................................... .... (800) 876-4766
California Poison Control System - San Francisco Division............................. (415) 502-6000
at San Francisco General Hospital
University of California San Francisco
Box 1369
San Francisco, California 94143-1369

Office of Emergency Services: Hazardous Materials Spill Notification..............(800) 852-7550

Bay Area Emergency Phone Numbers

Alameda (510) 337-2100
Alameda Co. (510) 667-7721
- Castro Valley
- San Lorenzo

Antioch (925) 757-1313
Bakersfield (661) 861-2521
Belmont (650) 592-2222
Benicia (707) 745-2424
Berkeley (510) 642-3333
Burlingame (650) 368-1421
Clovis (559) 348-1515
Contra Costa Co. (925) 933-1313
- Pittsburg
- Concord
- San Ramon

Contra Costa Co. (510) 223-4422
- Richmond
- San Pablo

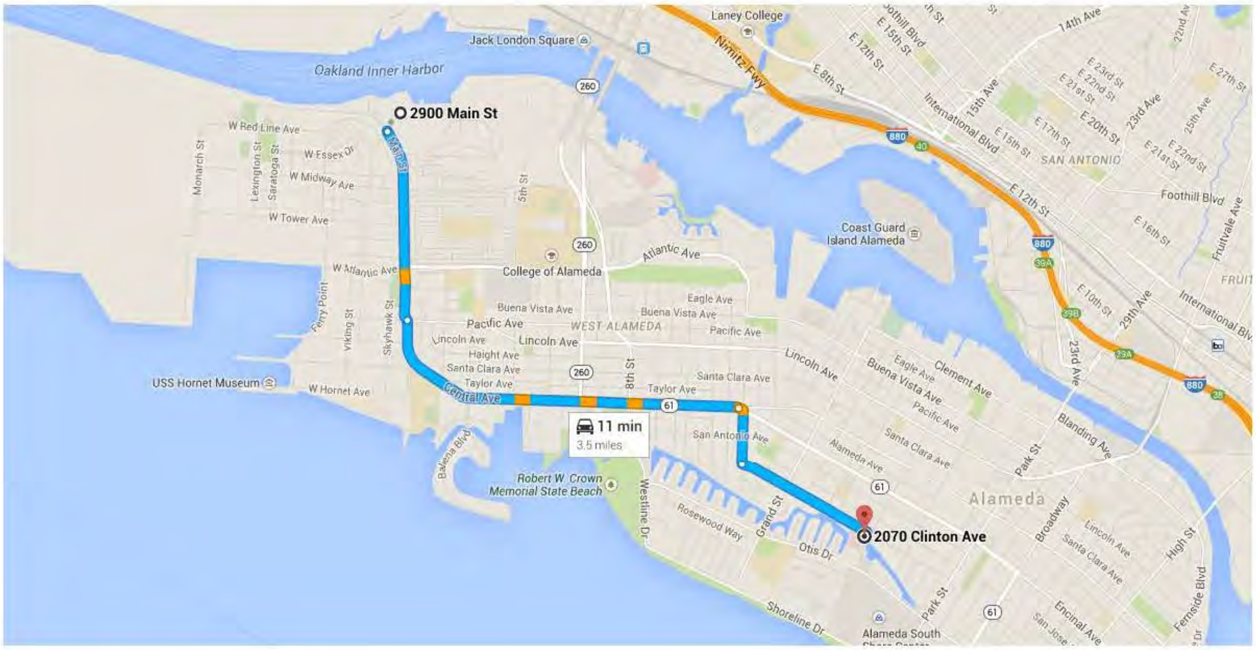
Cupertino (408) 2993144
Daly City (650) 992-2313
Danville (925) 373-5400
Dublin (925) 447-4257
Fairfield (707) 428-7300
Foster City (650) 368-1421
Fremont (510) 793-3434
Fresno (559) 294-2009
Gilroy (408) 546-0400
Hayward (510) 732-2626
Hollister (831) 636-4325
Livermore (925) 447-4257
Marin Co. (415) 472-0911
Menlo Park (650) 321-2231
Millbrae (650) 697-1212
Milpitas (408) 998-7212
Modesto (209) 552-2474
Morgan Hill (408) 299-3144
Mountain View (650) 903-6395
Napa (707) 253-0911
Newark (510) 793-3737
Oakland (510) 444-1616
Pacifica (650) 355-4151
Palo Alto (650) 321-2231
Pleasanton (925) 838-6691
Redwood City (650) 368-1421
Sacramento (916) 228-3000
San Carlos (650) 802-4255
San Francisco (415) 861-8020
San Jose (408) 277-8991
San Leandro (510) 618-3790
San Mateo (650) 368-1421
Santa Clara (408) 299-3144
Santa Cruz (831) 471-1170
Santa Rosa (707) 576-1365
South San Francisco (650) 873-3333
Stanislaus Co. (209) 552-3911
- Modesto
- Ceres
- Turlock
- Oakdale

Stockton (209) 464-4646
Sunnyvale (408) 736-6244
Tracy (209) 831-4553
Union City (510) 471-1441
Vacaville (707) 449-5452
Vallejo (707) 552-3285
Visalia (559) 734-8116

New numbers added after 11/12/2007

ATTACHMENT D
LOCAL AREA MAP with hospital route

Directions from **2900 Main St** to **2070 Clinton Ave**



2900 Main St

Alameda, CA 94501

1. Head **southeast** on **Main St** toward **Singleton Ave**

0.9 mi

2. Slight **right** onto **Central Ave**

1.7 mi

3. Turn **right** onto **Sherman St**

0.3 mi

4. Take the 2nd **left** onto **Clinton Ave**

Destination will be on the right

0.6 mi

2070 Clinton Ave

Alameda, CA 94501

ATTACHMENT E

JOB SAFETY ANALYSES

JOB SAFETY ANALYSIS

COMPANY/ PROJECT NAME or ID/ LOCATION (City, State)	DATE PREPARED FOR HSP:	
2900 Main Street, Alameda, CA	12/16/14	☐ NEW ☒ REVISED from S: Drive

JSA WORK ACTIVITY (Description):	List of Contractor(s) and key work activity:
Drilling	Vironex Drilling

SITE SPECIFIC JSA AUTHOR	POSITION / TITLE	DEPT	SIGNATURE
Jacob Zepeda	Project Geologist	Concord	

"TRC APPROVED" JSA DEVELOPMENT TEAM	POSITION / TITLE	APPROVAL
Rachelle Clair	San Francisco Bay Safety Coordinator	Rochelle Clair
Dave Sullivan	RMD Safety Director	
Mike Glenn	National Safety Director	

Required PPE (indicate with "R") vs. Must Have Available On-site (indicate "A")

R___ HARD HAT R /A_ GLOVES Specify: ☒ Kevlar ☒ Nitrile ☐ Other ________. R___SAFETY GLASSES ____GOGGLES ____FACE SHIELD	R___ REFLECTIVE VEST A___ HEARING PROTECTION R___SAFETY SHOES: Protective Toe ____ 5pt.HARNESS / LANYARD PPE CLOTHING: ____Coveralls ___Tyvek Suit ____Nomex ___Other (specify):	RESPIRATORY PROTECTION: ☒ NA _____½ face Air Purifying Respirator (APR) _____Particulate Mask: ☐ PM100 ☐ PM95 ____ Cartridge: ☐ VOC ☐ ____________ _____Full face ARP; specify cartiridge type: _____ Air Supplied Respirator ____SCBA ____Air-line	Additional PPE:

Always perform a Safety Assessment: 1) prior to starting work; 2) when changing tasks; and 3) throughout the day. Focus on each new task, procedures, and skill sets to be used.

[1] JOB TASKS	[2] POTENTIAL HAZARDS	[3] HAZARD CONTROLS (beyond wearing "Required" PPE)
1. Set up Job Site	a. Physical Injury from being struck by moving vehicles or equipment.	a. Have one person watch traffic while the other creates exclusion zone in a high-use traffic area. a. Create an exclusion zone at least 10-feet beyond the limits of the boring location; use snow fencing, barricades, delineators, cones and/or caution tape in accordance with project specifications. a. Always wear safety vest, establish eye contact with operators utilizing flag men where appropriate. a. Vehicles shall use reverse beepers or flagmen.
2. Drilling	a. Contact with subsurface water, gas, electrical, and/or fiber optic lines in the vicinity of drilling locations. b. Broken wire cable or detached drill stem c. Distracted driller	a. Clear holes to 5 feet below grade with manual tools, prior to using drill rig. a. If unknown lines or obstructions are encountered, stop drilling and notify PM. Do not undermine any utilities. b. Do not stand directly in front of the drill rig while machinery is operating. Stand off to the side by driller's platform or opposite side of drill rig. c. Always communicate with the driller before approaching the operating drill stem.
3. Well Completion	a. Opening/closing/moving drums b. Overspray and cross-contamination during auger decontamination c. Broken pump hose	a. Wear Kevlar gloves during the opening and closing of drums to protect fingers. a. Use only drum dolly to move drums with soil, grout, concrete, or decontamination water. b. Safety glasses, splash goggles, or face shield will be worn at all times when spraying/decontaminating augers. b. Do not overspray while cleaning augers. Create a "clean zone" with plastic liner for placement of decontaminated augers. c. Do not stand directly next to pump and hose when it is operating, stand to the side.
Field Changes: 4.	a. b. c. d.	a. b. c. d.

JOB SAFETY ANALYSIS

COMPANY/ PROJECT NAME or ID/ LOCATION (City, State) 2900 Main Street, Alameda, CA	DATE PREPARED FOR HSP: 12/16/14	☐ NEW ☒ REVISED from S: Drive
JSA WORK ACTIVITY (Description): Drilling	List of Contractor(s) and key work activity: Vironex Drilling	

GENERAL SAFETY HAZARDS	LOCATION(S) WHERE HAZARD IS TO BE EXPECTED	³ HAZARD CONTROLS (beyond wearing "Required" PPE)
5. Slips, trips, and falls	a. In exclusion zone	a. Clean as you work. Put equipment away when done using it. Blot up puddles of standing water and sweep work area. a. Cover or use appropriate warning to protect all unattended open holes.
6. Cut/Pinched fingers or toes	a. Throughout work area; particularly when moving materials.	a. Wear Kevlar gloves when lifting sharp or heavy equipment.
7. Strained muscles.	a. Throughout work area; particularly when moving augers	a. Use proper lifting techniques; get help when moving heavy objects (>70 lbs).
8. Unauthorized Personnel in exclusion zone	a. In exclusion zone	a. Use visitor check-in log; do not allow anyone in exclusion zone without proper PPE and training documentation. (HAZWOPER).
9. Flying debris	a. In exclusion zone	a. Wear ANSI-approved safety glasses working around operating equipment.
10. Loud Noise	a. In exclusion zone	a. Wear ANSI-approved hearing protection around operating equipment.
11. Explosion/Fire	a. In exclusion zone	a. No smoking or open flame. Periodically monitor ambient air concentrations with PID/LEL Meter. Shut down job and move personnel and equipment upwind if hydrocarbon concentrations are > **300 ppm or >10% of LEL.** a. Place 2-20lb ABC Fire extinguishers in location specified by SSO. a. Follow TRC's Cell Phone Use Guidelines.
12. Exposure to hydrocarbon impacted soil or groundwater	a. In exclusion zone	a. Wear nitrile gloves during handling of soil or groundwater.
13. Soil and groundwater cross-contamination	a. In exclusion zone	a. Identify and delineate soil stockpile area or storage area of drummed soil cuttings/decontamination water.

Field Notes:

____

____

____

____

[1] List all activities/steps which present a significant hazard, preferably in sequence. FOCUS ON POTENTIALLY HAZARDOUS ACTIVITIES; not the trivial ones. Apply common, yet knowledgeable & informed, sense to identify what could reasonably be expected to cause danger.

[2] CONCENTRATE ON SIGNIFICANT HAZARDS. What can go wrong? How can someone get hurt? Can someone be struck by or strike an object? caught on, in or between objects?; fall to ground or lower level?; experience excessive strain or stress? Be exposed to inhalation or skin hazards. Specify the hazards; be descriptive.

[3] Describe actions, procedures or limits necessary to eliminate or minimize the hazards. Be clear, concise and specific. Use objective, observable and quantified terms. Avoid subjective general statements such as, "be careful" or "use as appropriate".

LIMITATION: As part of TRC's EHS Policy, a JSA is provided by TRC for its employees. The purpose of a JSA is NOT to identify all hazards associated with a task, but to identify key potential hazards to get TRC and other onsite personnel thinking about other potential safety hazards and mitigating actions for unsafe conditions and behavior during various works. TRC recognizes that JSA's may not cover every conceivable step or hazard that emerges during a job, so we've provided a "Field Change" section below to amend a JSA if required. The JSA does not supersede or replace any local, state or federal permit, regulation, statute or other entities policies and procedures but is simply a tool for enhancing the execution of safe work at a jobsite under TRC's supervision. Similarly, all subcontractors are required to provide their own JSA(s) for their specialty prior to performing any work for TRC or its customers in accordance with TRC's EHS Policy; however, any unsafe condition or hazard not covered in any JSA is ultimately the direct responsibility of the person or entity performing the work.

JOB SAFETY ANALYSIS

COMPANY/ PROJECT NAME or ID/ LOCATION (City, State)	DATE PREPARED FOR HSP:	
2900 Main Street, Alameda, CA	3/25/15	☐ NEW ☒ REVISED from S: Drive

JSA WORK ACTIVITY (Description):	List of Contractor(s) and key work activity:
Work Area and Exclusion Zone Set-up	Gregg Drilling

SITE SPECIFIC JSA AUTHOR	POSITION / TITLE	DEPT	SIGNATURE
Jake Zepeda	Project Geologist	RMD	

JSA REVIEWERS	TITLE/ AFFILIATION	APPROVAL DATE
Rachelle Clair	Con/SF/MV Safety Coordinator	Rochelle Clair
Dave Sullivan	RMD Safety Director	
Mike Glenn	National Safety Director	

Required PPE (indicate with "R") vs. Must Have Available On-site (indicate "A")

_R_ REFLECTIVE VEST _R_ HARD HAT _R_ GLOVES Kevlar _A_ SAFETY GLASSES _____ GOGGLES _____ FACE SHIELD	____ HEARING PROTECTION _R_ SAFETY SHOES: Protective Toe ____ 5pt.HARNESS / LANYARD PPE CLOTHING: ____Coveralls ____Tyvek Suit ____Nomex ____Other (specify):	RESPIRATORY PROTECTION: ☐ NA _A_ Dust Mask _A_ ½ face Air Purifying Respirator (APR) ___X_ Particulate Mask: ☒ PM100 ☐ PM95 ___X_ Cartridge: ☒ P100-Multigas ☐ ____________ _____ Full face ARP; specify cartridge type: _____ Air Supplied Respirator ____SCBA _____Air-line	Additional PPE:

Always perform a Safety Assessment: 1) prior to starting work; 2) when changing tasks; and 3) throughout the day. Focus on each new task, procedures, and skill sets to be used.

1 JOB TASKS	2 POTENTIAL HAZARDS	3 HAZARD CONTROLS (beyond wearing "Required" PPE)
1. Pre-start Meeting and Site Safety Analysis	a. Bad organization creating confusion and hazard	a. Arrive at site prior to planned start time to evaluate vehicle and pedestrian traffic flow in the work area and in the site vicinity. a. Review site plan with traffic control set-up. a. Identify staging area with good access lateral and vertical for loading and unloading of trucks. a. Identify material and equipment laydown areas.
2. Exclusion Zone Set-up	a. Physical injury or equipment damage from onsite and offsite traffic flow.	a. Use the 'buddy system (one person watching traffic, one person working) when working in a high-use traffic area. a. Use of cones/delineators and caution signs to alert foot traffic moving about the site of potential trip hazards. a . Utilize snow fencing, barricades, delineators, cones and caution tape to provide exclusion zone around proposed work locations. Set-up exclusion zone in accordance with TRC's Exclusion Zone Set-up procedures.
3. Control of Work Area and Exclusion Zone	a. Delivery vehicles b. Personnel/vehicle entry onto site c. Fatigue	a. All vehicles moving on site shall use reverse beepers or flaggers. b. Set-up fencing around entire site with gated entry points. Limit access to staging area by keeping gate to work area closed and check documents of all vehicles entering work area. b. Use visitor check-in log and allow no-one into an exclusion area with out proper PPE as designated on this JSA. b. All personnel onsite must wear appropriate work and protective clothing including:long pants, sleeved-shirt, steel-toed boots, safety vest, safety glasses, and hard hat, Kevlar hi-flex gloves. b. Limit number of times materials, equipment and debris are handled by staging as close to work area as possible. c. Watch on-site personnel for signs of fatigue (shuffling, disorientation, small mistakes, sloppiness, etc.) and have

JOB SAFETY ANALYSIS

COMPANY/ PROJECT NAME or ID/ LOCATION (City, State)	DATE PREPARED FOR HSP:	
2900 Main Street, Alameda, CA	3/25/15	☐ NEW ☒ REVISED from S: Drive
JSA WORK ACTIVITY (Description): Work Area and Exclusion Zone Set-up	List of Contractor(s) and key work activity: Gregg Drilling	

	d. Noise and flying debris	them go to a shaded, protected area where they can rest and rehydrate. c. Set up and maintain rehydrating station. d. Always wear safety glasses and hearing protection working around operating heavy equipment.
4. Clean-up and overnight/over weekend storage	a. Slips, trips, and falls b. Bad organization creating confusion and hazard c. Run-off and soil cross-contamination d. Site Security and Anti-Thievery	a.Clean-up work area as you go. Maintain a clean, unobstructed work area by good house keeping and placing unused equipment away from work area. b. Delineate and block access to open pits/trenches with snow-fencing, delineators, and caution tape as a warning and prevent persons from falling into these items overnight. c. Place debris/detritus areas away from soil stockpile for future use. c. Cover all soil stockpiles with plastic-sheeting overnight against possible stormwater run-off and in accordance with local health regulations. d. Do not leave expensive equipment in open. d. Lock all vehicles and large equipment. Do not leave keys in vehicles.

	LOCATION(S) WHERE HAZARD IS TO BE EXPECTED	³ HAZARD CONTROLS (beyond wearing "Required" PPE)
1.	a.	a.
2.	a.	a.
3.	a.	a.

Field Notes:

____

____

[1] List all activities/steps which present a significant hazard, preferably in sequence. FOCUS ON POTENTIALLY HAZARDOUS ACTIVITIES; not the trivial ones. Apply common, yet knowleable & informed, sense to identify what could reasonably be expected to cause danger.

[2] CONCENTRATE ON SIGNIFICANT HAZARDS. What can go wrong? How can someone get hurt? Can someone be struck by or strike an object?; caught on, in or between objects?; fall to ground or lower level?; experience excessive strain or stress? Be exposed to inhalation or skin hazards. Specify the hazards; be descriptive.

[3] Describe actions, procedures or limits necessary to eliminate or minimize the hazards. Be clear, concise and specific. Use objective, observable and quantified terms. Avoid subjective general statements such as, "be careful" or "use as appropriate".

LIMITATION: The purpose of a JSA is NOT to identify all hazards associated with a task, but to identify key potential hazards to get Contractors and other onsite personnel thinking about other potential safety hazards and mitigating actions for unsafe conditions and behavior during various works. Contractors should recognize that JSA's may not cover every conceivable step or hazard that emerges during a job, so we've provided a "Field Change" section below to amend a JSA if required. The JSA does not supersede or replace any local, state or federal permit, regulation, statute or other entities policies and procedures but is simply a tool for enhancing the execution of safe work at a jobsite. Similarly, all contractors are required to provide their own JSA(s) for their specialty prior to performing any work; however, any unsafe condition or hazard not covered in any JSA is ultimately the direct responsibility of the person or entity performing the work.

TRC

JOB SAFETY ANALYSIS

COMPANY/ PROJECT NAME or ID/ LOCATION (City, State)	DATE PREPARED FOR HSP:	
2900 Main Street, Alameda, CA	12/16/14	☒ NEW ☒ REVISED
JSA WORK ACTIVITY (Description): Soil Sampling	List of Contractor(s) and key work activity: Vironex Drilling	

SITE SPECIFIC JSA AUTHOR	POSITION / TITLE	DEPT	SIGNATURE
Jake Zepada	Project Geologist	RMD/Con	

"TRC APPROVED" JSA DEVELOPMENT TEAM	POSITION / TITLE	APPROVAL DATE
Rachelle Clair	San Francisco Bay Safety Coordinator	
Dave Sullivan	RMD Safety Director	
Mike Glenn	National Safety Director	

Required PPE (indicate with "R") vs. Must Have Available On-site (indicate "A")

__R__ HARD HAT __R__ GLOVES Specify: ☒ Kevlar ☒ Nitrile ☐ Other ________. __R__ SAFETY GLASSES ____GOGGLES ____FACE SHIELD	__A__ REFLECTIVE VEST ___ HEARING PROTECTION __R__ SAFETY SHOES: Protective Toe ____ 5pt.HARNESS / LANYARD PPE CLOTHING: ____Coveralls ___Tyvek Suit ____Nomex ___Other (specify):	RESPIRATORY PROTECTION: ☒ NA _____½ face Air Purifying Respirator (APR) _____Particulate Mask: ☐ PM100 ☐ PM95 ____ Cartridge: ☐ VOC ☐ ____________ _____Full face ARP; specify cartiridge type: _____ Air Supplied Respirator ____SCBA ____Air-line	Additional PPE:

Always perform a Safety Assessment: 1) prior to starting work; 2) when changing tasks; and 3) throughout the day. Focus on each new task, procedures, and skill sets to be used.

1 JOB TASKS	2 POTENTIAL HAZARDS	3 HAZARD CONTROLS (beyond wearing "Required" PPE)
1. Soil Sampling	a. Collapse of soil stockpile. b. Broken sample jar. c. Jagged edges in sample material.	a. Look over soil stock pile prior to approaching or removing soil sample to confirm its integrity. a. Chose a sample location that will not cause the pile to collapse. a. Notify someone prior to sampling of your activites and when you expect them to be complete and that you will check in when complete. b. Wear Kevlar gloves beneath the nitriles to add a layer of protection from cuts. b. Be aware of material that is being placed in the jar and do not place jagged edged materials in the jar that may cause the jar to break. c. Wear Kevlar gloves beneath the nitriles to add a layer of protection from cuts. c. Be aware of material and watch hand placement when gathering the material. c. Use a shovel or other tool if possible to transfer the soil from the stockpile to the container.
2. Placing cooler in vehicle	a. Muscle strain from weight of the cooler	a. Be aware of how much ice and samples are in the cooler. a. Use more than one cooler if the weight will be over 50 lbs. a. Get assistance moving cooler if it is too heavy.
3.	a.	a.
Field Changes: 4.	a. b. c. d.	a. b. c. d.

GENERAL SAFETY HAZARDS	LOCATION(S) WHERE HAZARD IS TO BE EXPECTED	3 HAZARD CONTROLS (beyond wearing "Required" PPE)
5. Slips, trips, and falls	a. In exclusion zone	a. Clean as you work. Put equipment away when done using it. Blot up puddles of

JOB SAFETY ANALYSIS

		standing water and sweep work area. a. Cover or use appropriate warning to protect all unattended open holes.
6. Cut/Pinched fingers or toes	a. Throughout work area; particularly when moving materials.	a. Wear Kevlar gloves when lifting sharp or heavy equipment.
7. Strained muscles.	a. Throughout work area; particularly when moving augers	a. Use proper lifting techniques; get help when moving heavy objects (>70 lbs).
8. Unauthorized Personnel in exclusion zone	a. In exclusion zone	a. Use visitor check-in log; do not allow anyone in exclusion zone without proper PPE and training documentation. (HAZWOPER).
9. Flying debris	a. In exclusion zone	a. Wear ANSI-approved safety glasses working around operating equipment.
10. Loud Noise	a. In exclusion zone	a. Wear ANSI-approved hearing protection around operating equipment.
11. Explosion/Fire	a. In exclusion zone	a. No smoking or open flame. Periodically monitor ambient air concentrations with PID/LEL Meter. Shut down job and move personnel and equipment upwind if hydrocarbon concentrations are > **300 ppm or >10% of LEL.** a. Place 2-20lb ABC Fire extinguishers in location specified by SSO. a. Follow TRC's Cell Phone Use Guidelines.
12. Exposure to hydrocarbon impacted soil or groundwater	a. In exclusion zone	a. Wear nitrile gloves during handling of soil or groundwater.
13. Soil and groundwater cross-contamination	a. In exclusion zone	a. Identify and delineate soil stockpile area or storage area of drummed soil cuttings/decontamination water.

Field Notes:

____

[1] List all activities/steps which present a significant hazard, preferably in sequence. FOCUS ON POTENTIALLY HAZARDOUS ACTIVITIES; not the trivial ones. Apply common, yet knowledgeable & informed, sense to identify what could reasonably be expected to cause danger.

[2] CONCENTRATE ON SIGNIFICANT HAZARDS. What can go wrong? How can someone get hurt? Can someone be struck by or strike an object? caught on, in or between objects?; fall to ground or lower level?; experience excessive strain or stress? Be exposed to inhalation or skin hazards. Specify the hazards; be descriptive.

[3] Describe actions, procedures or limits necessary to eliminate or minimize the hazards. Be clear, concise and specific. Use objective, observable and quantified terms. Avoid subjective general statements such as, "be careful" or "use as appropriate".

LIMITATION: As part of TRC's EHS Policy, a JSA is provided by TRC for its employees. The purpose of a JSA is NOT to identify all hazards associated with a task, but to identify key potential hazards to get TRC and other onsite personnel thinking about other potential safety hazards and mitigating actions for unsafe conditions and behavior during various works. TRC recognizes that JSA's may not cover every conceivable step or hazard that emerges during a job, so we've provided a "Field Change" section below to amend a JSA if required. The JSA does not supersede or replace any local, state or federal permit, regulation, statute or other entities policies and procedures but is simply a tool for enhancing the execution of safe work at a jobsite under TRC's supervision. Similarly, all subcontractors are required to provide their own JSA(s) for their specialty prior to performing any work for TRC or its customers in accordance with TRC's EHS Policy; however, any unsafe condition or hazard not covered in any JSA is ultimately the direct responsibility of the person or entity performing the work.

TRC

JOB SAFETY ANALYSIS

COMPANY/ PROJECT NAME or ID/ LOCATION (City, State) **ACP, 2900 Main St, Alameda, CA**	DATE PREPARED FOR HASP: 3/30/15	☐ NEW ☒ REVISED from server
JSA WORK ACTIVITY (Description): **Driving a Company Vehicle**	List of Contractor(s) and key work activity: TRC	

SITE SPECIFIC JSA AUTHOR	POSITION / TITLE	OFFICE	SIGNATURE
Rachelle Clair	Project Geologist	Concord	

"TRC APPROVED" JSA DEVELOPMENT TEAM	POSITION / TITLE	APPROVAL
Rachelle Clair	San Francisco Bay Safety Coordinator	
Dave Sullivan	RMD Safety Director	
Mike Glenn	National Safety Director	

Required PPE (indicate with "R") vs. Must Have Available On-site (indicate "A")

____ HARD HAT ____ GLOVES Specify: ☐ Kevlar ☐ Nitrile ☐ Other ________. ____SAFETY GLASSES ____GOGGLES ____FACE SHIELD	____ REFLECTIVE VEST ____ HEARING PROTECTION ____SAFETY SHOES: Protective Toe ____ 5pt.HARNESS / LANYARD PPE CLOTHING: ____Coveralls ____Tyvek Suit ____Nomex ____Other (specify):	RESPIRATORY PROTECTION: ☒ NA _____½ face Air Purifying Respirator (APR) _____Particulate Mask: ☐ PM100 ☐ PM95 ☐ ____ _____ Cartridge: ☐ VOC ☐ _________ _____Full face ARP; specify cartiridge type: _____ Air Supplied Respirator ☐SCBA ☐Air-line	Additional PPE: • Sun Glasses

Always perform a Safety Assessment: 1) prior to starting work; 2) when changing tasks; and 3) throughout the day. Focus on each new task, procedures, and skill sets to be used.

[1] JOB TASKS	[2] POTENTIAL HAZARDS	[3] HAZARD CONTROLS (beyond wearing "Required" PPE)
1. Have correct directions and know best route of travel to make it safely to intended destination.	a Getting lost in a bad area or showing up at the wrong location. Having doubt about where you are exactly supposed to be could cause undo stress while driving.	a. Ask questions and get safest route if destination is not known, an online locator can be used to assist with travel plans. Give other people your travel plans with addresses and phone numbers so you can be contacted.
2. Knowing what TRC's driving rules and policies are before getting behind the wheel on company time.	a. Driver using excuse that they didn't know the rules or policies and following common bad practices while driving.	a. Strong driver training and driving safety stewardship prior to personnel driving company owned vehicles or driving personal vehicles on company time.
3. Vehicle walk around and perimeter check	a. Trip, slip, fall. b. Possible human contact from unknown assailants. c. Struck by other vehicle.	a. Visual verification that vehicle tires are in safe working condition and that there are no sharp objects or foreign debris under the tires. b. Check for possible unsafe human interaction in the surrounding area c. Be conscious of other vehicle activity close by.
4. Unlock and open vehicle door, enter the vehicle and secure seatbelts.	a. Pinch or crush hazard if hand or fingers are not secured inside the vehicle before shutting vehicle door.	a. Ensure driver's seatbelt is functioning properly and verify that passengers seatbelt is also in good working condition then buckle up. Lock vehicle doors once inside as added protection factor. a. Verify all body parts are in the cab prior to closing the vehicle door.
5. Traveling safely at posted speed limits and following all road rules while driving on Roadways or Freeways	a. Not obeying posted speed limits and not following road rules.	a. Driver must maintain California's DMV best Practice of following a 3 second gap. Keep good visual contact of all lanes and identifying an out in case of emergency maneuver due to other vehicle hazards and poor driving. a. Watch for slower moving and fast approaching vehicles in roadway.

JOB SAFETY ANALYSIS

COMPANY/ PROJECT NAME or ID/ LOCATION (City, State) **ACP, 2900 Main St, Alameda, CA**	DATE PREPARED FOR HASP: 3/30/15	☐ NEW ☒ REVISED from server
JSA WORK ACTIVITY (Description): **Driving a Company Vehicle**	List of Contractor(s) and key work activity: TRC	

6. Merging while entering Multilane Freeways and Making lane changes while traveling on multilane Freeways	a. Struck from side, rear contact with other vehicles, struck from behind.	a. Use vehicle signals, look over shoulder, check mirrors a. Be aware of fast approaching or slower moving vehicles and maintain speed while initiating merge a. Maintain speed and repeat same steps with all lane changes.
7. Proceeding through marked or signal controlled intersections or crosswalks after coming to a full stop	a. Struck from side, rear contact with other vehicles, struck from behind. b. Hitting pedestrians or bicyclists.	a. Driver should carefully look left and right prior to proceeding through intersection. a. Driver should allow other vehicles to proceed per the traffic rules. a. Driver should maintain lane selection through the intersection and proceed forward remaining in the same lane they stopped in. b. Driver should carefully look left and right prior to proceeding through crosswalks. b. Driver should carefully check blind spots for bicyclists prior to making a right or left turn.
8. Reaching final destination in vehicle and coming to a complete stop while parking	a. Striking other parked vehicles or striking pedestrian walking traffic b. Vehicle engine not completely stopping causing the vehicle to lunge forward.	a. Pay full attention to the new surrounding areas where you'll park. b. Ensure vehicle's engine has completely stopped and set parking break.
9. Opening vehicle door and exiting.	a. Struck by other vehicles b. Stepping onto uneven surface c. Approached by someone unwanted.	a. Take a good look at surrounding areas and make sure there are no signs of oncoming traffic. b. Take a look outside at the ground before you step out making sure surface is level and object free. c. Keep aware of unwanted approaching personnel.
Field Changes: 10.	a. b. c. d.	a. b. c. d.

Field Notes:

____

____

____

____

____

[1] List all activities/steps which present a significant hazard, preferably in sequence. FOCUS ON POTENTIALLY HAZARDOUS ACTIVITIES; not the trivial ones. Apply common, yet knowledgeable & informed, sense to identify what could reasonably be expected to cause danger.

[2] CONCENTRATE ON SIGNIFICANT HAZARDS. What can go wrong? How can someone get hurt? Can someone be struck by or strike an object? caught on, in or between objects?; fall to ground or lower level?; experience excessive strain or stress? Be exposed to inhalation or skin hazards. Specify the hazards; be descriptive.

[3] Describe actions, procedures or limits necessary to eliminate or minimize the hazards. Be clear, concise and specific. Use objective, observable and quantified terms. Avoid subjective general statements such as, "be careful" or "use as appropriate".

LIMITATION: As part of TRC's EHS Policy, a JSA is provided by TRC for its employees. The purpose of a JSA is NOT to identify all hazards associated with a task, but to identify key potential hazards to get TRC and other onsite personnel thinking about other potential safety hazards and mitigating actions for unsafe conditions and behavior during various works. TRC recognizes that JSA's may not cover every conceivable step or hazard that emerges during a job, so we've provided a "Field Change" section below to amend a JSA if required. The JSA does not supersede or replace any local, state or federal permit, regulation, statute or other entities policies and procedures but is simply a tool for enhancing the execution of safe work at a jobsite under TRC's supervision. Similarly, all subcontractors are required to provide their own JSA(s) for their specialty prior to performing any work for TRC or its customers in accordance with TRC's EHS Policy; however, any unsafe condition or hazard not covered in any JSA is ultimately the direct responsibility of the person or entity performing the work.

ATTACHMENT F

TAILGATE SAFETY MEETING CHECKLIST

Date / Time of Tailgate Meeting: ______________________________

- ☐ **Vehicle Inspection:** Driver will perform Driver's Daily Vehicle Inspection Checklist before leaving the yard or if changing drivers during the day.
- ☐ **Personnel training/qualifications:** Check cards for OSHA HAZWOPER 40-hour certification/8-hour-refresher training (or any other specialized training to perform the task if appropriate). TRC personnel have been trained on the Company's Drug and Alcohol Policy and will inform all site personnel.
- ☐ **Supplies:** Indicate location of first aid kit, fire extinguisher, clean water supply (drinking, eye wash), and Site Health and Safety Plan (HSP).
- ☐ **Emergency services:** Discuss location of nearest telephone and directions to hospital. Map, directions, phone numbers are provided in the HSP (Attachment C).

  First-Aid/CPR volunteers: ______________________________

- ☐ **Site background:** Discuss types, locations, and concentrations of chemicals found onsite, presence of free product, depth to groundwater, etc.
- ☐ **Offsite Permits/Access Permits:** Discuss any permitting requirements for the site.
- ☐ **Work activities:** Discuss scope of work for the day and activities to be performed.
- ☐ **Potential hazards: Review JSAs.** Discuss physical, chemical and biological hazards Discuss the prohibiting of any eating, drinking, and/or smoking in the work zone
- ☐ **Personal protective equipment (PPE):** Discuss required level of protection; review additional PPE requirements in JSAs, as needed.

  ☐ Hard Hat ☐ Safety Shoes/Boots ☐ Safety Vest ☐ Eye Protection - ☐ glasses ☐ goggles ☐ face shield

  ☐ Hand Protection - ☐ Kevlar ☐ nitrile ☐ other _______

  ☐ Hearing Protection

  ☐ Respiratory Protection - ☐ APR Particulate ☐ APR Chemical cartridge

  ☐ other ______

  ☐ Protective Clothing - ☐ Tyvex ☐ Nomex ☐ Coveralls ☐ other ______

- ☐ **Utilities:** Utilities have been cleared/marked by appropriate divisions.
- ☐ **Traffic control** (vehicular and pedestrian): Work area is properly delineated and cordoned off from traffic. Technician will put a traffic cone at all four corners of his parked vehicle. Upon completion of work, walk around vehicle to pick up cones and check all four sides and underneath vehicle for obstacles prior to moving truck.
- ☐ **Emergency Shut-off Switch:** Location has been identified/communicated with field personnel.

By signing below, I have completed the Tailgate Safety Meeting Checklist, reviewed this Site Health and Safety Plan and the Job Safety Analysis (JSA) and understand their contents. I hereby agree to comply with all safety requirements outlined herein:

TRC

Signature: ________________________________ Site Safety Officer (SSO)

Print Name: _________________________________ Date: ______________________

Signature: __________________________________ Asst. Site Safety Officer (Asst. SSO)

Print Name: _____________________________________ Date:

Contractor:

Signature: ______________________________________, Site Safety Officer (SSO)

Print Name: _____________________________________ Date:

Signature: _______________________________________, Asst. Site Safety Officer (Asst. SSO)
Print Name: _____________________________________Date:

Contractor:

Signature: _______________________________________, Site Safety Officer (SSO)
Print Name: _____________________________________ Date:

Signature: _______________________________________, Asst. Site Safety Officer (Asst. SSO)
Print Name: _____________________________________ Date:

By signing below, I have completed the Tailgate Safety Meeting Checklist, reviewed this Site Health and Safety Plan and the Job Safety Analysis (JSA) and understand their contents. I hereby agree to comply with all safety requirements outlined herein:

TRC Employees / Contractor Personnel / Visitors (cont.)

Signature: ________________________ Print Name: ______________________________
Date: ____________________________ Company: ________________________________

Signature: ________________________ Print Name: ______________________________
Date: ____________________________ Company: ________________________________

Signature: ________________________ Print Name: ______________________________
Date: ____________________________ Company: ________________________________

Signature: ________________________ Print Name: ______________________________
Date: ____________________________ Company: ________________________________

Signature: ________________________ Print Name: ______________________________
Date: ____________________________ Company: ________________________________

Signature: ________________________ Print Name: ______________________________
Date: ____________________________ Company: ________________________________

Signature: ________________________ Print Name: ______________________________
Date: ____________________________ Company: ________________________________

Signature: ________________________ Print Name: ______________________________
Date: ____________________________ Company: ________________________________

ATTACHMENT G

Site Safety Observation Form

TRC SAFETY OBSERVATION FORM

Revised January 2014

Location/Project Name: ______________________ **Date:** ____________

Observer Name: ______________________

Observee Name: ______________________ **Time:** ____________

Task Observed

Description of Task Observed and Background Information

Positive Comments

Conclusions / Why the Questionable Items Occurred?

Feedback Session Conducted By: ______________________ **Date:** ____________

Name of Observee's Supervisor: ______________________ **Time:** ____________

Questionable Observations/Root Cause Analysis

Personal Factor:

(1) Lack of skill or knowledge
(2) Correct way takes more time/requires more effort
(3) Shortcutting standard procedures is rewarded or appreciated
(4) In past, did not follow procedures or acceptable practices and no incident occurred

Job Factor:

(5) Lack of or inadequate operational procedures or work standards
(6) Inadequate communication of expectations or work standards
(7) Inadequate tools or equipment

Questionable Observation #	Root Cause Analysis #	Solution(s) To Prevent Potential Incident from Occurring	Person Responsible	Agreed Due Date	Date Completed

Results of Verification (were solutions done?) and Validation (were solutions effective?)

Reviewed by (Supervisor): ______________________ **Date:** ____________

Approved by (Practice Safety Leader): ______________________ **Date:** ____________

ATTACHMENT H

TRC Glove Selection Policy

RMD PRACTICE
HAND PROTECTION POLICY

PURPOSE

This Hand Protection Policy provides RMD staff with the guidance and understanding to identify the correct glove to use for the work they are performing. This policy applies to all RMD Practice employees, and should also be utilized by subcontractors performing work for TRC's RMD Practice.

POLICY GOALS AND OBJECTIVES

The primary objective of the Hand Protection Policy is to eliminate or minimize the potential injury to employee's hands exposed to hazards such as sharp edges, pinch points, crush points, and impacts. Gloves made of protective material, such as kevlar, must be worn at all times when there is potential for exposure to chemicals, hot/cold materials or surfaces, and for added protection against cuts, punctures and abrasions. TRC's goal is to prevent all hand injuries.

MINIMUM STANDARDS

Gloves are required to be worn at all times while performing tasks that have the potential for hand injuries. TRC personnel and subcontractors must wear hand protection appropriate to the job task or potential hazard. Many of TRC's job sites have work activities that present cut, abrasion, and puncture hazards and therefore a glove that protects against these hazards is the primary choice for use. To assist our employees in selecting the proper glove, a glove selection guideline is presented in Table 1 below. Employees should note that Table 1 is not intended to address all chemical hazards. Gloves used for chemical protection, such as nitrile gloves, shall provide cut/puncture resistance, or be used in tandem with cut/puncture protection. It is expected that through the application of this guideline, appropriate gloves will be selected and worn for all work tasks. If necessary, employees should consult with project managers and/or office safety coordinators to ensure the proper selection of gloves.

Workers are not authorized to use unapproved or inadequate gloves based on the listed ANSI cut and abrasion rating or the BS EN 388 standard listed in Table 1 for each task.

PROJECT MANAGER RESPONSIBILITIES

It is the responsibility of the Project Manager in developing the site-specific Health and Safety Plan to identify the potential physical and chemical hazards and utilize the glove selection guideline. For potential chemical hazards, consult the applicable Material Safety Data sheets to determine the appropriate glove material and type. In Addition, the Project Manager must identify in the Job Safety Analysis (JSA) the appropriate glove for every task.

TRAINING AND COMMUNICATION REQUIREMENTS

Training shall be provided to each employee who is required to wear personal protective equipment including gloves. At a minimum, the training shall include the following:

- When PPE is necessary
- What PPE is necessary
- Limitations of PPE
- Proper care, maintenance, useful life, and disposal of PPE
- What glove is required for each subcontractor used on a TRC job

GLOVE SELECTION GUIDELINE

The Glove Selection Guideline provides guidance to TRC employees regarding the expectation for glove usage. Gloves being used on TRC projects MUST be inspected prior to use to ensure their integrity meets the specifications in the guideline.

Basic Requirements

1. Jobs MUST be evaluated to determine the hazards and the appropriate hand protection that is required. Appropriate gloves (i.e., impact resistant, cut resistant, etc.) for the specific job task shall be worn at all times while the task is being performed.
2. Site-specific health and safety plan and job safety analysis MUST identify the hazards associated with the task and the appropriate gloves to use. In some cases, multiple glove types may be necessary for an entire job or project. Analysis and selection prior to starting a job or project will help ensure the hand protection of workers.

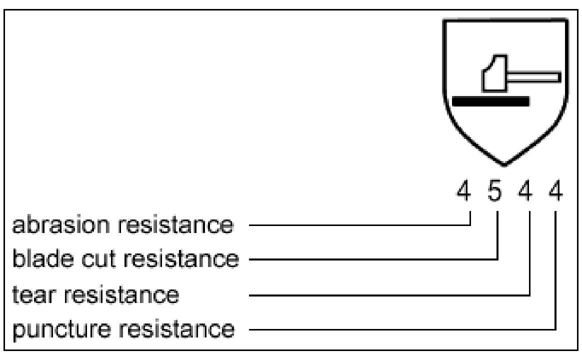
BACKGROUND ON ANSI/ BS EN 388 STANDARDS

The American National Standards Institute and the International Safety Equipment Association created the ANSI/ISEA 105-2000. This standard provides information about choosing appropriate gloves from the perspectives of cut resistance, abrasion, puncture, heat, cold, chemical permeation and flame resistance. For cut resistance, ANSI/ISEA 105-2005 ranks gloves from 0-5. The test determines how much weight is required for a straight blade to cut through a material traveling 25 millimeters (1 inch). As the weight required increases, the glove's rating increases.

ANSI/ISEA 105-2005 Mechanical Ratings:							
Rating	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**
Abrasion Resistance* (Cycles)	< 100	≥ 100	≥ 500	≥ 1000	≥ 3000	≥ 10000	≥ 20000
Cut Resistance (Grams)**	< 200	≥ 200	≥ 500	≥ 1000	≥ 1500	≥ 3500	-
Puncture Resistance (Newtons)	< 10	≥ 10	≥ 20	≥ 60	≥ 100	≥ 150	-
* Abrasion ratings 0 through 3 are based on measurements with a 500-gram load. Levels 4 through 6 are measured with a 1,000-gram load. **Weight needed to cut through material with 25mm of blade travel.							

The EN 388 is a European standard that was designed to assess the performance on abrasion resistance, tear resistance, puncture resistance and cut resistance. These standards were set using specific scientific methods. For cut resistance, the numerical ratings of 1 through 5 are decided by the number of cycles a rotating blade applied to the tested fabric needed to cut through the material. More rotations needed means a higher numerical cut resistance rating is given to the glove. Though not required in the United States, some gloves are starting to carry the same EN 388 shield and rating.

Each glove listed in Table 1 has an ANSI and BS EN 388 rating and either or both can be found on the gloves themselves. Presented below is an example of the BS EN 388 rating on a glove and what each number represents.



Note: Remember to compare "apples to apples" when considering cut resistance ratings. Although EN 388 and ANSI/ISEA reach similar conclusions, they are based on different test methods resulting in different test ratings.

EN 388 Mechanical Ratings:							
Number	**Rating**	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**
1	Abrasion Resistance (Cycles)	< 100	≥ 100	≥ 500	≥ 2000	≥ 8000	-
2	Cut Resistance (Cycles)	< 1.2	≥ 1.2	≥ 2.5	≥ 5.0	≥ 10.0	≥ 20.0
3	Tear Resistance (Newtons)	< 10	≥ 10	≥ 25	≥ 50	≥ 75	-
4	Puncture Resistance	< 20	≥ 20	≥ 60	≥ 100	≥ 150	-

TABLE 1

GLOVE SELECTION GUIDELINE

HAZARD	EXAMPLE TASKS	ANSI CUT/ABRASION RATING*	REPRESENTATIVE GLOVE
Impact Hazards, Med/Heavy Duty Puncture Cut	Drilling/direct push activities. Construction. Heavy materials handling. Power tools. Air knifing. Excavation.	ANSI Cut and Abrasion Resistance **Level 5** **EN 388 4521**	Hexarmor® Chrome Hexarmor® GGT5 Hexarmor® L5 Hexarmor® SteelLeather III Ironclad® Kong Glove
Med/Heavy Duty Puncture Cut Oil/Solvent Resistant	Tasks where materials are treated with oil or solvents.	ANSI Cut and Abrasion Resistance **Level 3 - 4** **EN 388 4522**	Ansell Alpha-Tec ® Memphis® Ultra Tech Nitrile Cut & Splash Best® Neoprene 6780 Hexarmor™ TenX Threesixty
Medium Duty Cut/Puncture Gloves with Oily Surface Grip	Light materials handling, wet service	ANSI Cut and Abrasion Resistance **Level 3** **EN 388 44xx**	Best® Zorb-It Ultimate HV 4567 Ansell® Cut Protective Glove 97-505 Ansell HyFlex® 11-511 Ansell HyFlex® 11-624
Med/Heavy Duty Cut/Puncture	Light Materials Handling. System O&M. Use of Hand Tools. Hand Augering. Heavy Equipment Operator.	ANSI Cut and Abrasion Resistance **Level 2** **EN 388 33xx**	Perfect Fit® PF570 Hexarmor® Level Six 9010/9012 Ironclad® Cut Resistant Glove Ansell HyFlex® 11-511 Ansell HyFlex® 11-624 Ansell® Cut Protective Glove 97-505
Light Duty Cut/Puncture Abrasion Only	Handling soil and Groundwater Samples. Opening spoons. Well construction.	ANSI Cut and Abrasion Resistance **Level 2 - 4** **EN 388 21xx**	Memphis® Ninja Max N9676GL Memphis® UltraTech Dyneema 9676 Memphis® Ninja Ice (Cold Weather) Ansell HyFlex® 11-511 Ansell® Cut Protective Glove 97-505 Ansell® Powerflex 80-813 Ironclad™ Workforce
Light Duty Glove Cut/Abrasion (used under nitrile gloves)	Groundwater Sampling.	ANSI Cut and Abrasion Resistance **Level 2** **EN 388 21xx**	Ansell HyFlex® 11-500 Ansell HyFlex® 11-624 Ansell GoldKnit ®
* Reference to ANSI and EN 388 glove testing standards. Listed gloves meet the standards in the table, but are not the only gloves that meet the standard.			
This selection chart is not intended to address all chemical hazards. Gloves used for chemical protection shall provide cut/puncture resistance, or be used in tandem with cut/puncture protection. Nitrile gloves used for environmental sampling must be used in tandem with a cut/puncture resistant glove.			
Gloves available in high visibility colors have shown to be effective and are preferred.			

ATTACHMENT I

TRC Incident and Near Miss Form

TRC Incident Report Form

(To be completed immediately after an Injury, Illness, Incident, Accident or Significant Near Miss by Employee's Supervisor and Employee involved)

Incident Category		
☐ Employee Injury/Illness ☐ Near Miss/Loss ☐ Property Damage ☐ Vehicle Accident ☐ Fire ☐ Other: Specify		
1	Incident Location:	
2	Site Identification/Project No.:	
3	Site Address:	
4	Date Incident Occurred:	
5	Time Incident Occurred:	
6	Date Incident Reported to Supervisor:	
7	Date Report Completed:	
8	Was WorkCare Contacted? ☐ Yes ☐ No	
9	Client:	

TRC Employee Information			
10	Name:		
11	Address:		
12	Employee Phone:		
13	Title or Occupation:		
14	Sector/Practice:		
15	Supervisor Name/Phone:		
TRC Employee Information (to be completed by Worker's Compensation Claims Administrator)			
16	Employee Date of Birth:		
17	Employee Social Security Number:		
18	Employee Marital Status:	☐ Married	☐ Single
19	Number of Dependant under the age of 18:		
20	Date of Hire:		
21	Rate of Pay:		Hours per week:

Type of Employee Injury or Illness (To be determined by Safety Director)			
22	☐ First Aid Only	20	☐ Extended Time Away From Work (3 days or more)
23	☐ Medical Treatment Only	21	☐ Fatality
24	☐ Restricted Work-case	22	☐ Other (specify):
25	☐ Lost Workday		
26	Estimated Number of Days on Restricted Work:		
27	Estimated Number of Days Away from Work:		

Employee Injury or Illness Description	
28	Describe the Injury or Illness:
29	First Aid/Medical Treatment Administered:
30	Name of Doctor's Office, Clinic, or Hospital: Concentra
31	Address and Phone Number:

TRC Incident Report Form

(To be completed immediately after an Injury, Illness, Incident, Accident or Significant Near Miss by Employee's Supervisor and Employee involved)

	Incident Description	
32	Equipment Involved:	
33	Site Description:	
34	What task was being performed at time of incident?	
35	Describe Incident in Detail :	
36	Conditions at time of Incident: (weather, lighting, etc.):	
37	Motor Vehicle Accident:	
38	TRC Vehicle ID:	
39	Year/Make/Model:	
	☐ DOT Regulated Vehicle ☐ Towed From Scene ☐ Airbag Deployed ☐ Seatbelt in Use ☐ TRC Fleet ☐ Rental ☐ Personal Vehicle	
40	Other Vehicle License Plate	
41	Other Vehicle Year/Make/Model	
42	Other Vehicle Driver Name	
43	Other Vehicle Year/Make/Model	
44	Other Injured Parties ☐ Yes ☐ No	
43	Description of other injuries:	

	Subcontractor Involvement / Description of Incident	
44	Subcontractor Involved: ☐ Yes ☐ No	
45	Name of Company:	
46	Address:	
47	Contact Name and Phone Number:	
48	Subcontractor Description of Incident:	

TRC Incident Report Form

(To be completed immediately after an Injury, Illness, Incident, Accident or Significant Near Miss by Employee's Supervisor and Employee involved)

Witness Involvement / Description of Incident		
49	Witnesses to Incident: ☐ Yes ☐ No	
50	Name(s) and Address(s):	
51	Phone Number(s):	
52	Witness Description of Incident:	

Personal Protective Equipment (PPE)	
53	List PPE required to complete the task: (glasses, gloves, shoes, hard hat, respirator, hearing protection, etc.)
54	Was the employee using the proper PPE at the time of the Incident?

Immediate Corrective Actions			
55	Describe the immediate corrective actions taken:		
56	Immediate Supervisor:	Signature:	Date:
57	Employee:	Signature:	Date:

Supervisor's Post-Incident Review and Recommendations	
Safety Violation ☐ Yes ☐ No	
58	State the company safety rule, OSHA regulation, or specific training that was violated:
59	Describe the training the employee received to prevent this violation:

TRC Incident Report Form

(To be completed immediately after an Injury, Illness, Incident, Accident or Significant Near Miss by Employee's Supervisor and Employee involved)

#	Root Cause Factors (RCF)
1	Lack of skill or knowledge
2	In the past, did not follow procedures or acceptable practices and no incident occurred (injury, product quality incident, equipment damage, regulatory assessment or production delay)
3	Doing the job according to procedures or acceptable practices takes more time/effort
4	Short-cutting procedures or acceptable practices are positively reinforced or tolerated
5	Lack of or inadequate operational procedures
6	Inadequate communication of expectations regarding procedures or acceptable practices
7	Inadequate tools or equipment (available, operable and safely maintained, proper task and workplace design)
8	External factors

60	Root Cause(s)	Identified Root Cause(s):							
		#1	#2	#3	#4	#5	#6	#7	#8
A		☐	☐	☐	☐	☐	☐	☐	☐
B		☐	☐	☐	☐	☐	☐	☐	☐
C		☐	☐	☐	☐	☐	☐	☐	☐
D		☐	☐	☐	☐	☐	☐	☐	☐
E		☐	☐	☐	☐	☐	☐	☐	☐
F		☐	☐	☐	☐	☐	☐	☐	☐
G		☐	☐	☐	☐	☐	☐	☐	☐
H		☐	☐	☐	☐	☐	☐	☐	☐

61	Conclusion: Why did the Incident Occur?

62	Item No.	RCF No.	Recommended Corrective Action(s) How to Prevent Incident from Reoccurring	Responsible Person	Due Date	Completed (date)	Verified/ Validated (date)

TRC Incident Report Form

(To be completed immediately after an Injury, Illness, Incident, Accident or Significant Near Miss by Employee's Supervisor and Employee involved)

Supervisor: ____________________________ Signature: _______________________________ Date: __________
TRC Safety Director: ________________________ Signature: _______________________________ Date:__________

TRC NEAR MISS REPORT

3/30/2015

Near Miss Description:				
Date	**Employee Name**	**Office**	**Project**	**Incident Location**

What task was being performed at time of incident?

Describe Incident in detail:

Contributing Factors (Environment, Behaviors, Training, Procedures):

Describe the immediate corrective actions or changes to procedures taken (if any) as a result of the incident:

Lessons Learned:

APPENDIX C

QUALITY ASSURANCE AND QUALITY CONTROL PROCEDURES (QA/QC)
STANDARD OPERATING PROCEDURES FOR FIELD ACTIVITIES

TRC

APPENDIX C-1

SOIL SAMPLING SOP

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the logistics, collection techniques, and documentation requirements for collecting representative soil samples. These are standard (i.e., typically applicable) operating procedures that may be changed, as required, dependent upon site conditions, equipment limitations, or limitations imposed by the procedure. In addition, other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. In all instances, the actual procedures used should be documented and described in the field notes. Portions of this SOP may be applicable to soil sample collection for geotechnical analysis. However, specific instructions for collection of geotechnical samples are not provided; these samples should be collected in accordance with ASTM methods or other applicable standards.

1.2 Summary of Method

The objective of soil sampling is to obtain a representative sample of soil for laboratory analysis of constituents of interest at a given site. This objective requires that the sample be of sufficient quantity and quality for analysis by the selected analytical method. Soil samples may be collected using a variety of methods and equipment depending on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type. Near-surface soils may be sampled using a spade, trowel, and/or scoop. Sampling at greater depths typically is performed using a hand auger, continuous flight auger, a split-spoon, direct-push methods (i.e., Geoprobe®), sonic drilling, a backhoe or an excavator. The following reference may be used as a guide to aid in selecting an appropriate method or sampling device for the collection of subsurface soil samples with a drill rig: ASTM D6169–98 Standard Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigation

1.3 Equipment

The following equipment may be utilized when collecting soil samples. Project-specific conditions or laboratory requirements may warrant the addition or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP).
- Sample containers (may be supplied by the laboratory, depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project.

  For non-volatile organic compound (VOC) parameters, glass containers with Teflon®-lined caps are typically utilized. Typical containers used for VOC parameters are provided in Attachment A. Brass liners, steel liners, or soil core acetate liners with Teflon® tape and plastic end caps may also be used.
- En-Core® samplers.
- Disposable plastic syringes or Terra Core™ samplers.

- Stainless steel mixing bowl.
- Stainless steel spoon or spatula.
- Hand auger, mud auger, sand auger, bucket auger and T-handle.
- Post hole auger.
- Extension rods.
- Stainless steel trowel.
- Shovel.
- Tape measure, folding ruler.
- Wooden stakes and spray paint, plastic flagging (highly visible), or steel pin flags.
- Field book and/or boring log.
- Sample container labels.
- Chain-of-custody (COC) forms (TRC or laboratory, as appropriate).
- Camera.
- Maps/site plan.
- Survey equipment and/or global positioning system (GPS) and/or other means of measuring sample locations.
- Indelible marking pens or markers.
- Organic absorbent (e.g., Slickwick, ground corn cob, sawdust).
- Sample coolers.
- Bubble wrap.
- Ice (for sample storage/preservation).
- Zip-loc® plastic bags (for ice and COCs).
- Equipment decontamination supplies.

1.4 Definitions

Composite sample	Composed of a number of grab samples collected over a period of time or space during a single sampling event and mixed together.
En-Core® sampler	A disposable volumetric sampling device with an airtight sealing cap.
Grab sample	Individual discrete sample collected at a particular time.
High-level VOC analysis	VOC soil analysis that yields high reporting limits (approximately 50-200 µg/kg, depending on the laboratory). Samples are typically preserved in methanol and cooled to 4°C.

	High-level VOC analyses are used for samples that are expected to contain elevated concentrations of VOCs (>200 µg/kg).
Low-level VOC analysis	VOC soil analysis that yields low reporting limits (approximately 5 µg/kg, depending on the laboratory). Samples are typically preserved in water, cooled to 4°C, and frozen within 48 hours of collection. Low-level VOC analyses are used for samples that are expected to contain lower concentrations of VOCs (≤200 µg/kg).
Terra Core™ sampler	A disposable volumetric sampling device used to transfer soil samples to the appropriate sample containers.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE, as defined in the HASP.

Soil samples containing chemical contaminants may be handled during implementation of this SOP. Additionally, sample preservatives including caustics and/or acids may be considered hazardous materials and TRC employees will appropriately handle and store them at all times Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. Hazardous substances may be incompatible or may react to produce heat, chemical reactions, or toxic products. Hazardous substances may be incompatible with clothing or equipment; some substances can permeate or degrade protective clothing or equipment. Also, hazardous substances may pose a direct health hazard to workers through inhalation or skin contact or if exposed to heat/flame and they combust. Material safety data sheets for chemicals handled by TRC should be maintained in the field.

1.6 Cautions and Potential Problems

- Cross contamination: Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary.

- Improper sample collection: Improper sample collection can involve using contaminated equipment, disturbance of the matrix resulting in compaction of the sample, or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

- Special considerations for the different soil sampling techniques are provided below in the applicable sections. Cautions and potential problems associated with soil sampling for VOCs are provided in Attachment A.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained.

Project and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Always review the site-specific work plan and/or scope of work for any site-specific sampling procedures.

2.1 Pre-Sampling Activities

Pre-sampling activities that the sampling team should consider include the following: preparing a sampling strategy; reviewing the work plan approved by the regulatory agency; selecting a laboratory, and determining laboratory-specific procedures related to bottle orders, holding times, work orders, methods of analysis, COC procedures, data deliverables, schedule, and cost. Additional activities include determining shipping logistics, utility clearance, and handling of investigation-derived waste disposal. Pre-labeling bottles can help to reduce sampling and labeling errors.

The following steps should also be employed.

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies required.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or clean equipment, and ensure that it is in working order.

4. Prepare schedules and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific HASP.

6. Use stakes, flagging, or buoys to identify and mark all sampling locations. Specific site factors, including extent and nature of contaminants, should be considered when selecting sample locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.
   NOTE: If spray paint is used to mark stakes, the spray paint should be carefully isolated from the space used to hold sample bottles, sampling equipment, etc.

7. Prior to any subsurface soil sampling, especially that completed with a drill rig or backhoe, it is important to ensure that all sampling locations are clear of overhead and buried utilities by conducting a utility survey/markout.

2.2 General Soil Sampling Procedures

1. Refer to other TRC SOPs for the proper procedures for classifying soil samples and for screening of samples for VOCs.

2. **<u>For sampling in the state of California only:</u>** When the sampling interval is predetermined and soil samples are collected by direct-push methods into an acetate liner, the section of the liner corresponding to the predetermined depth interval may be cut off and submitted to the laboratory for analysis with the exception of samples for VOC, volatile petroleum hydrocarbon (VPH), or gasoline-range organics (GRO) analysis. If VOC, VPH, or GRO analysis is required, then these samples can be collected from either open end of the acetate liner section according to the procedures outlined in Attachment A prior to packaging and submitting it to the laboratory. The laboratory should be consulted for the required length of liner tube (i.e., sample volume) depending on the analytical suite and to ensure that the use of acetate liners is appropriate for the analytical method(s). After collecting material for the VOC, VPH, or GRO analysis samples (if required), seal each end of the acetate liner section with Teflon tape and plastic end caps. Wrap the ends with non-volatile tape and label the acetate liner with the sample identification (ID) and date and time of collection. Ensure that the laboratory will perform homogenization of the soil sample within the acetate liner and proceed to Step #9.

3. Prior to the collection of soil samples from a particular location or depth, the soil is typically screened for organic vapors with a portable meter equipped with a flame ionization detector (FID) and/or photoionization detector (PID) depending upon the suspected contaminants of concern and site-specific work plan requirements. Such organic vapor screening may be used to determine appropriate soil sample locations or depths for laboratory VOC analysis depending upon established site-specific work plan requirements. Soil should be screened *in situ* or immediately upon retrieval of the soil sample from the subsurface.

4. Samples for VOC, VPH or GRO analysis are then collected as soon as possible after the soil has been exposed to the atmosphere and prior to sample collection for other analyses.

    - **These samples are NOT homogenized.**
    - These samples are generally collected using an open-barrel disposable syringe, a Terra Core™ sampler, or an En-Core® sampler, or equivalent. Note that En-Core® samplers are not recommended for non-cohesive soils (see Attachment A).
    - Refer to the site-specific work plan or governing regulatory authority for preservation requirements for VOC, VPH or GRO analysis. Attachment A of this SOP includes typical procedures on the collection and preservation of soil samples for VOC, VPH and GRO analysis.

5. After collecting the sample for VOC analysis, the sample portion for the remaining analysis should be well homogenized, *in situ* (if possible, such as with surface soil sampling), or in a decontaminated stainless steel bowl or disposable new aluminum pie pan. These soil samples must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. Soil can be homogenized and transferred to sample containers using soil sampling devices that have been decontaminated prior to use or individually wrapped, sterile, new polystyrene devices. Such sterile, polystyrene devices are generally for one-time use. Stainless steel devices may be decontaminated and individually foil wrapped, plastic bagged,

or field decontaminated and foil wrapped between uses. Decontamination of sampling equipment shall be conducted in accordance with TRC's SOP on equipment decontamination.

6. Stones, gravel, or vegetation should be removed from the soil sample as much as practical prior to placement in sample containers, since these materials will not be analyzed. Visible asphalt, concrete, ash, slag, and coal debris should also be removed from the sample as much as possible to ensure sufficient soil quantity for laboratory analyses, unless these matrices are part of the overall characterization program. The soil sample must be representative of what the end user is trying to characterize. In addition, if such debris is to be tested, further sample preparation (e.g., pulverizing) will likely be necessary in the field or laboratory. In any case, the presence of any such materials in the soil at the sample location must be documented in the field book.

7. Filling of the sample bottles should be completed immediately after sample collection to minimize losses due to volatilization and biodegradation. Soil classification can be completed following sample collection.

8. Place the sample into an appropriate, labeled container(s) by using the alternate shoveling method and secure the cap(s) tightly. The alternate shoveling method involves placing a spoonful of soil in each container in sequence and repeating until the containers are full or the sample volume has been exhausted. Threads on the container and lid should be cleaned to ensure a tight seal when closed.

9. Restore the sampling location to grade in accordance with applicable state or federal guidelines and/or the site-specific work plan. Options include backfilling the sample location with the remaining removed soil, bentonite pellets or, cement/bentonite grout depending on site conditions and patching the surface to match the surrounding area (e.g., topsoil with grass seed, asphalt or concrete patch), as necessary. Boreholes must be abandoned or backfilled after the completion of sampling. In general, shallow boreholes (e.g., less than 10 feet deep) that remain open and do not approach the water table may be abandoned by pouring a cement/bentonite grout mixture from the surface or pouring bentonite pellets from the surface and hydrating the pellets in lifts. The grout mixture should be based on site-specific conditions (e.g., boring depth, groundwater depth, and formation permeability), site-specific work plan procedures, and local regulatory requirements. Boreholes where bridging of the bentonite may be an issue, such as boreholes that intercept groundwater or are greater than approximately 10 feet in depth, should be backfilled by pressure grouting with a cement/bentonite grout mixture, either through a re-entry tool string or through a tremie pipe introduced to within several feet of the borehole bottom.

10. Record locations of soil borings/samples in the field book by sketching a map and/or providing a description of the location. Always measure and record distances to fixed landmarks, such as buildings, fences, curbs, existing surveyed wells, etc. Additionally, a GPS unit with real-time sub-meter accuracy (not applicable for interior samples or other site conditions such as heavy tree/brush cover and thick cloud cover that limit unit connection with satellites) could be used to document sample locations. Note observations about elevation changes between sample locations.

2.2.1 Surface Soil Sampling Methods

The depth of surface soil samples will be determined on a site-specific basis and may be influenced by site-specific conditions and/or applicable local, state, or federal regulatory programs and potential exposure pathways. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface (bgs). The most common interval is 0 to 6 inches; however, the data quality objectives of the investigation may dictate another interval, such as 0 to 3 inches for risk assessment purposes.

The following procedure should be used for surface soil sampling:

1. If a thick, matted root zone, leaf layer, gravel, surface debris, concrete, etc. is present at or near the surface, it should be carefully removed using clean decontaminated tools or clean nitrile gloves before the soil sample is collected. The presence and thickness of any such material should be recorded in the field book for each location. The depth measurement for the soil sample begins at the top of the soil horizon, immediately following any such removed materials.

2. A decontaminated stainless steel spoon, scoop or trowel is typically used for surface soil sampling depths from 0 to 12 inches bgs where conditions are generally soft, and there is no problematic vegetative layer to penetrate. A hand auger or shovel may also be used to dig down to the desired depth and then after careful removal of the dug soils from the hole, a decontaminated stainless steel spoon, scoop or trowel is used to collect the soil sample from the bottom of the hole for laboratory chemical analysis. Plated trowels typically available from garden supply centers should not be used due to potential heavy metal impacts from the trowel plating.

3. When using stainless steel spoons or trowels, consideration must be given to the procedure used to collect a soil sample for VOC analysis. Samples for VOC, VPH or GRO analysis must be collected first and never homogenized or composited. These samples are collected using an open-barrel disposable syringe, a Terra Core™ sampler, or an En-Core® sampler, or equivalent. If the soil being sampled is cohesive and holds its *in situ* texture in the spoon or trowel, the En-Core® sampler or disposable syringe used to collect the sub-sample should be plugged directly from the spoon or trowel. However, if the soil is not cohesive and crumbles when removed from the ground surface for sampling, the sub-sample should be plugged directly from the surface of the appropriate sample depth. Additionally, note that En-Core® samplers are not recommended for non-cohesive soils (see Attachment A). Generally, the sample portion for VOC analysis is collected from several inches below grade to minimize volatilization from the *in situ* soil.

4. Continue by following the General Soil Sampling Procedures in Section 2.2.

2.2.2 Hand Auger Sampling Methods

The shallow subsurface interval may be considered to extend from approximately 12 inches bgs to a site-specific depth at which sample collection using manual collection with a spoon or trowel becomes difficult or impractical. Hand augers may be used to advance boreholes and collect soil samples in shallow subsurface intervals. Often, 4-inch diameter stainless steel auger buckets with cutting heads are used. The auger is advanced by simultaneously pushing and turning using an attached T-handle with extensions (if needed).

Auger holes are advanced one bucket at a time until the appropriate sample depth is achieved. When the sample depth is reached, the bucket used to advance the hole is removed and decontaminated or a clean bucket is attached. The clean auger bucket is then placed in the hole and filled with soil to make up the sample and then carefully removed. The practical depth of investigation using a hand auger largely depends upon the soil properties and depth of investigation. In sand, augering is typically easy to perform, but the depth of collection is limited to the depth at which the sand begins to flow or collapse. The use of hand augers may be of limited use in soils containing large amounts of unnatural fill (e.g., brick, slag, concrete), coarse gravel and cobbles (or larger grain size), and in tight clays or cemented sands. In these soil types, it becomes more difficult to recover a sample due to increased friction and torqueing of the hand auger extensions as the depth increases. At some point, these problems become so severe that alternate methods (i.e., power equipment) must be used.

The following procedure is used for collecting soil samples with the hand auger:

1. Attach the auger head to a drill rod extension and attach the T-handle to the rod.

2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter). It may be advisable to remove the first several inches of surface soil and any root layer for an area approximately 6 inches in radius around the borehole location.

3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the borehole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding rod extensions. It also facilitates refilling the borehole and avoids possible contamination of the surrounding area.

4. When the sample depth is reached, remove the bucket used to advance the borehole and attach a decontaminated or clean bucket. Place the clean auger bucket in the borehole, advance the clean auger bucket to fill it with the soil sample and then carefully remove the clean auger bucket.

5. If VOC analysis is to be performed, collect a sample directly at the bottom of the boring, if within reach, and not from the auger bucket. If not within reach, collect the sample directly from the auger bucket or from minimally disturbed material immediately after the auger bucket is emptied. Use an En-Core® sampler or other coring device (i.e., syringe, Terra Core™) to collect the sub-sample as described in Attachment A. Note: some regulatory agencies do not allow for subsurface VOC sample collection directly with a hand auger; refer to the site-specific work plan and regulatory requirements to ensure the collection of VOC samples with a hand auger is appropriate.

6. Continue by following the General Soil Sampling Procedures in Section 2.2. Note that if another sample is to be collected in the same borehole, but at a greater depth, reattach the auger bucket to the rod assembly, and follow steps 1 through 5 above, making sure to decontaminate the sampling device between samples.

Special Considerations for Hand Auger Sampling

- *Utility Clearance* - Prior to any subsurface soil sampling, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- *Slough* - Because of the tendency for the auger bucket to scrape material from the sides of the auger hole while being extracted, the top several inches of soil in the auger bucket should be discarded prior to placing the bucket contents in the homogenization container for processing.
- *VOC Sample Collection* - Observe precautions for VOC sample collection found in Attachment A and/or the site-specific work plan.
- *Decontamination* - If sampling equipment is to be reused at a new sampling location or at a deeper depth in the same location, proper decontamination of sampling equipment is required.

2.2.3 Direct-Push Sampling Methods

Direct-push sampling methods are used primarily to collect shallow and deep subsurface soil samples. Soil sampling probes may range from simple hand tools to truck-mounted or track-mounted hydraulically operated rigs. The basic concept is the same for all of these samplers: the tool is hydraulically driven into the soil, filling the tube, and then the tool is withdrawn. All of the sampling tools involve the collection and retrieval of the soil sample within a thin-walled liner. The following sections describe two specific sampling methods using direct-push techniques, along with details specific to each method.

- *Macro-Core® Sampler (Direct-push)* - The Macro-Core® (MC®) sampler is a solid barrel, direct-push sampler equipped with a piston-rod point assembly used primarily for collection of either continuous or depth-discrete subsurface soil samples. Although other lengths are available, the standard MC® sampler has an assembled length of approximately 52 inches (1321 mm) with an outside diameter (OD) of 2.2 inches (56 mm). The MC® sampler is capable of recovering a discrete sample core 45 inches x 1.5 inches (1143 mm x 38 mm) contained inside a removable liner. The resultant sample volume is a maximum of 1300 mL. The MC® sampler may be used in either an open-tube or closed-point configuration.

- *Dual-tube Soil Sampling System (Direct-push)* - The Dual-tube 21 soil sampling system is a direct-push system for collecting continuous core samples of unconsolidated materials from within a sealed outer casing of 2.125-inch (54 mm) OD probe rod. The samples are collected within a liner that is threaded onto the leading end of a string of 1.0-inch diameter probe rod. Collected samples have a volume of up to 800 mL in the form of a 1.125-inch x 48-inch (29 mm x 1219 mm) core. Use of this method allows for collection of a continuous core inside a cased hole, minimizing or preventing cross contamination between different intervals during sample collection. The outer casing is advanced, one core length at a time, with only the inner probe rod and core being removed and replaced between samples. If the sampling zone of interest begins at some depth below ground surface, a solid drive tip must be used to drive the dual-tube assembly and core to its initial sample depth.

The following procedure is used for collecting soil samples from direct-push soil cores:

1. The driller will advance and extract the soil sampler liner which will then be given to the field sampler - confirm with the driller which end is top and which end is bottom. Record the time of core collection (military time), the soil boring ID and the depth interval in feet bgs in the field book.

2. Measurement of vertical depth should start from the top of soil; surface asphalt, surficial concrete slabs, or gravel sub-base should be excluded from the depth measurement unless otherwise specified in the site-specific work plan. However, the presence and thickness of these items should be noted in the field book.

3. Measure the length of recovered soil in inches and record in the field book.

4. Continue by following the General Soil Sampling Procedures in Section 2.2.

   If a specific depth interval is targeted for sampling, be sure to give consideration to the percent recovery of soil when selecting the sample interval. For example, if the targeted sample interval was from 2.0 to 2.5-ft, and the core barrel was advanced from 0 to 4 ft bgs, and 30 inches (2.5 ft) of soil was recovered, the sample should be collected immediately below the mid-point of the recovered soil, or 15- inches below the top of the recovered soil (not including slough). The sample designation will indicate that the depth was 2.0 to 2.5 ft bgs.

<u>Special Considerations for Direct-push Sampling</u>

- *Utility Clearance* - Prior to any subsurface soil sampling, especially that completed with a drill rig, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- *Liner Use and Material Selection* - Direct-push soil samples are collected within a dedicated new or decontaminated liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool, although overall, liners are available in brass, stainless steel, cellulose acetate butyrate (CAB), polyethylene terephthalate glycol (PETG), polyvinyl chloride (PVC) and Teflon®. For most investigations, the standard disposable new polymer liner material for a sampling tool will be acceptable. When the study objectives require very low reporting levels or unusual contaminants of concern, the use of more inert liner materials such as Teflon® or stainless steel may be necessary. However, such costly liner materials typically are not disposable and therefore require decontamination between each use.
- *Sample Orientation* - When the liners and associated sample are removed from the sample tubes, it is important to confirm and maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of the liner and black caps on the bottom to maintain proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.

- *Core Catchers* - Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In such cases, the use of core catchers on the leading end of the sampler may help retain the soil until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability. However, given the limited sample contact that core catchers have with the sample material, most standard core catchers available for a tool system will be acceptable.
- *VOC Sample Collection* - Observe precautions for VOC sample collection found in Attachment A and/or the site-specific work plan.
- *Decontamination* - The cutting shoe and piston rod point are to be decontaminated between each sample. Within a borehole, the sample barrel, rods, and drive head may be subjected to an abbreviated cleaning to remove obvious and loose material, but must be cleaned between boreholes, such as with high-pressure water or steam.

2.2.4 Split-spoon Sampling Methods

All split-spoon samplers, regardless of size, are basically split cylindrical barrels that are threaded on each end. The leading end is held together with a beveled threaded collar that functions as a cutting shoe. The other end is held together with a threaded collar that serves as the stub used to attach the spoon to a string of drill rod.

- Standard Split Spoon - A drill rig auger is used to advance a borehole to the target depth. The drill auger string is then removed and a standard split spoon is attached to a string of drill rod. Split spoons used for soil sampling must be constructed of stainless steel and are typically 2.0- inches OD (1.5-inches inside diameter) and 18- inches to 24- inches in length. Other diameters and lengths are common and may be used if constructed of the proper material. After the spoon is attached to the string of drill rod, it is lowered into the borehole. The safety hammer is then used to drive the split spoon into the soil at the bottom of the borehole. After the split spoon has been driven into the soil, filling the spoon, it is retrieved to the surface, where it is removed from the drill rod string and opened for sample acquisition. Split-spoon soil sampling for geotechnical purposes should be conducted in accordance with ASTM Method D1586 *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soil*.

The following procedure is used for collecting soil samples from split-spoon soil cores:

1. Record the blow count per 6-inch interval when advancing split-spoon samplers with the hollow stem auger rig. Record the hammer weight (e.g., 140 pounds [lb] is standard, but 300 lb may also be used to advance the spoon). Blow counts are an indication of soil density and are a measure of the number of blows it takes for a 140 lb slide hammer falling over a distance of 30- inches to penetrate 6- inches of soil. The drillers will keep the count and will repeat them to the field sampler (e.g., 11, 13, 16 – means the number of blows the hammer advanced the spoon every 6 inches over a total depth interval of the split-spoon sampler, in this case over 18 inches). If refusal is encountered, the count is recorded in the book as “# of hammer blows / depth in inches the spoon is driven” (e.g., 50/3 – means 50 blows of the hammer advanced the spoon 3 inches).

2. The driller will advance, extract, and open the split spoon, which will then be given to the field sampler - confirm with the driller which end is top and which end is bottom, if a soil

sampler liner is used and removed from the spoon. Record the time of core collection (military time), the soil boring ID and the depth interval in feet bgs in the field book.

3. Measurement of vertical depth should start from the top of soil; surface asphalt, surficial concrete slabs or gravel sub-base should be excluded from the depth measurement unless otherwise specified in the site-specific work plan. However, the presence and thickness of these items should be noted in the field book.

4. Measure the length of recovered soil in inches and record in the field book.

5. Continue by following the General Soil Sampling Procedures in Section 2.2.

Special Considerations for Split-spoon Sampling

- *Utility Clearance* - Prior to any subsurface soil sampling, especially that completed with a drill rig, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- *Slough* - Generally discard the top several inches of material in the spoon before removing any portion for sampling. This material normally consists of borehole wall material that has sloughed off of the borehole wall after removal of the drill string prior to and during insertion of the split spoon.
- *VOC Sample Collection* - Observe precautions for VOC sample collection found in Attachment A and/or the site-specific work plan.
- *Decontamination* - The split-spoon sampler(s) is to be decontaminated between each sample. Within a borehole, the split spoon sample barrels must be cleaned between each sample - the driller typically has multiple barrels and can alternate between clean and dirty barrels so drilling progress is not affected by decontamination of the barrels. The augers should be decontaminated between boreholes (such as with high-pressure steam).

2.2.5 Shelby Tube/Thin-walled Sampling Methods

Shelby tubes, also referred to generically as thin-walled push tubes or Acker thin-walled samplers, are used to collect subsurface soil samples in cohesive soils and clays during drilling activities. In addition to samples for chemical analyses, Shelby tubes are also used to collect relatively undisturbed soil samples for geotechnical analyses of physical properties such as shear strength, grain size distribution, density, hydraulic conductivity and permeability, to support engineering design, construction, and hydrogeologic characterizations at hazardous waste and other sites.

A typical Shelby tube is 30 inches in length, has a 3.0-inch OD (2.875-inch inside diameter) and may be constructed of steel, stainless steel, galvanized steel, or brass. They are typically attached to push heads constructed with a ball check to aid in holding the sample in the tube during retrieval. If used for collecting samples for chemical analyses, it must be constructed of stainless steel. If used for collecting samples for standard geotechnical parameters, any material is acceptable. To collect a sample, the tube is attached to a string of drill rod and is lowered into the borehole, where the sampler is then pressed into the undisturbed material by hydraulic force from the drill rig. Shelby tube or thin-walled soil sampling should be conducted in accordance with

ASTM Method D1587 *Practice for Thin-walled Tube Sampling of Soils for Geotechnical Purposes*.

After retrieval to the surface, the tube containing the sample is then removed from the sampler head. If samples for chemical analyses are needed, the soil contained inside the tube is then removed for sample acquisition by following the direct-push sampling procedures in Section 2.2.3. If the sample is collected for geotechnical parameters, the tube is typically sealed, to maintain the sample in its relatively undisturbed state, capped, labeled appropriately (including sample ID, top end of sample, inches of recovery, etc.), and shipped to the appropriate geotechnical laboratory. The tube is typically stored in an upright position to maintain the integrity of the undisturbed sample. For geotechnical use, check with the laboratory prior to sampling to understand sample volume recoveries needed to perform the actual tests.

2.2.6 Sonic Drilling Sampling Methods

Sonic drilling/rotary vibratory drilling employs the use of high-frequency, resonant energy to advance a core barrel or casing into subsurface formations. Although sonic drilling is not technically a direct-push method of soil sampling, it is similar because soil sample collection from cores of recovered unconsolidated soil would follow the same procedures as described for direct-push methodologies. The soil core is extruded from the core barrel or casing into a plastic sleeve.

Sonic drilling is different than conventional drilling, as sonic drilling minimizes the friction between the borehole wall and the drilling tool by maintaining the resonance of the drill string with a sonic drill head. Typically the drilling method utilizes dual casings that independently resonate into the subsurface with an inner core barrel that is overrun by an outer casing.

Typically core runs are 10- feet. The core barrel is removed from the borehole and the core is extruded into a plastic sleeve. The plastic sleeve is placed on dedicated plastic sheeting. The plastic sleeve is then slit with a razor knife (or similar) vertically along the core run, exposing the soil inside.

The procedures for collecting soil samples from sonic cores are the same as the procedures presented for collecting soil samples from direct-push sampling methods in Section 2.2.3.

Special Considerations for Sonic Drilling Sampling

- *Utility Clearance* - Prior to any subsurface soil sampling, especially that completed with a drill rig, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- Sonic-generated soils are not undisturbed. The resonation of the core barrel during advancement energizes the skin of the sample immediately adjacent to the barrel, approximately ⅛ to ¼ inch around the OD of the sample. Heating of the soils is possible.
- Coring is always accomplished without air or fluids. Depending on site conditions, the outer casing may require adding some water to the borehole if heaving or flowing sands/sand and gravel are present.
- Resistance is not measured during core barrel advancement, as in split-spoon sampling where blow counts are measured. To collect conventional split-spoon samples and obtain blow

counts, the sonic drill rigs can be outfitted with automatic hammers to advance split spoons or thin-walled push tubes, although the advantage of drilling speed with the sonic drilling technique is diminished.

2.2.7 Excavator Sampling Methods

A backhoe or excavator can be used to assist with soil sampling. This method is typically used during remedial excavation activities (to collect floor and sidewall samples within the excavation), test pit installation, or trenching operations. Test pit excavations are commonly completed to allow for greater observation of physical soil characteristics (e.g., stockpiles) and/or to further investigate buried suspect areas of concern (e.g., petroleum tanks, drums, waste, fill).

The following procedures are used for collecting soil samples excavated with a backhoe or excavator:

1. Prior to any excavation, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout.

2. For test pits or trench excavation, excavate in accordance with the site-specific work plan. Typically, this will be approximately 3 feet wide and approximately 1 foot deep below the cleared sampling location with the backhoe. Remedial excavations may be much wider and deeper. The work plan may also require that excavated soils be placed on plastic sheets or another impervious surface and protected from rain.

3. Refer to the site-specific work plan for the number of floor and/or sidewall samples, which is typically driven by the surface area and can vary depending on the governing regulatory agency.

4. Samples can be collected using a trowel, spoon, or coring device at the desired intervals. A clean shovel may be used to remove a 1 to 2- inch layer of soil from the vertical face of the pit that contacted the backhoe bucket and where soil sampling is planned. Scrape the vertical face at the point of sampling to remove any soil that may have fallen from above and to expose fresh soil for sampling. In many instances, soil sample locations within the excavation area are inaccessible (do not physically enter backhoe excavations to collect a sample). In these cases, soil samples can be collected directly from the backhoe bucket – use caution not to collect a soil sample from edges that may have come into contact with the backhoe bucket.

5. If VOC analyses are required, collect the sample in accordance with the procedures in Attachment A and/or the site-specific work plan. With a dedicated decontaminated spoon, or equivalent, place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

6. Abandon the pit or excavation according to applicable state regulations and the site-specific work plan. Generally, shallow excavations can simply be backfilled with the removed soil material.

Special Considerations for Excavator Sampling

- *Utility Clearance* - Prior to any subsurface soil sampling, it is important to ensure that all sampling locations are clear of overhead and buried utilities through the conduct of a utility survey/markout. Locations on private properties should also be reviewed with the owner prior to installation.
- *VOC Sample Collection* - Observe precautions for VOC sample collection found in Attachment A and/or the site-specific work plan.
- Do not physically enter backhoe excavations to collect a sample if the excavations are unstable or not sloped and protected with shoring. A trench with non-cohesive soils (i.e., sand, saturated/wet muds, or flowing water at the base) is particularly susceptible to collapsing suddenly. Never enter a trench without a confined space entry permit, as required by OSHA regulations.
- Smearing is an important issue when sampling with a backhoe or excavator. Any time a vertical or near vertical surface is sampled, such as achieved when shovels or similar devices are used for subsurface sampling, the surface should be dressed (scraped) to remove smeared soil. This is necessary to minimize the effects of contaminant migration interferences due to smearing of material from other levels.
- Loose paint, grease and rust should be removed and the backhoe bucket decontaminated prior to use for sample collection if the bucket will come in direct contact with the material to be sampled. Care should be taken to collect the soil sample from the center of the excavated material within the bucket (i.e., material that has not touched the bucket walls).

2.2.8 Stockpile Soil Sampling Methods

Stockpiled soils are typically sampled to characterize the soils for reuse or disposal. The stockpile sampling strategy used must consider the source of the soil and all available data, field observations, shape/dimensions and volume of the pile, and sampling frequency requirements established by oversight regulatory agencies or potential soil disposal facilities.

If the stockpile is known to be a representative mixture of soil with no known or suspected significant variability of contamination with depth in the pile, the stockpile sampling may be conducted according to the surface soil sampling method described in Section 2.2.1. However, if the soil characteristics are not known or are known or suspected to vary with depth in the pile, both surface soil and deeper subsurface soil samples will be required to properly characterize the soil pile.

A backhoe or excavator equipped with a bucket can be used to collect subsurface soil samples from stockpiles. This method is often preferred for collecting subsurface soil samples from a stockpile, since it allows the sampler greater opportunity to inspect the physical characteristics of the pile for any potential signs of variability for determining appropriate sample depths and locations.

Typically, based on the minimum required number of samples for the estimated stockpile volume, the stockpile is divided into the appropriate number of estimated volumes equal to that sample number. For example, if the specified sample frequency is 1 sample per 1,000 cubic yards (cy) and the estimated stockpile size is 4,000 cy, the stockpile would be broken down into approximately four equal volumes or quadrants. Grab VOC samples and composite non-VOC samples, as required, would then be collected from each of the areas for characterization of the stockpile.

2.3 Post-sampling Activities

1. After the samples have been collected, the sampling location may be marked with wooden stakes colored with highly visible spray paint and/or flagging in order to identify the sample location for surveying purposes. The sample and/or location identification should be written on the stake in indelible ink or marking pen. The sample location should be surveyed in the field with a GPS unit if not surveyed later by some other means. A sketch of the sampling locations should also be included in the field book.

2. Package the samples with bubble wrap and/or organic absorbent, as necessary.

3. Place the samples into a shipping container and cool to 4ºC. If wet ice is used to cool the samples, place the ice in double-bags to prevent water from the melting ice from damaging the samples during shipment.

4. Complete the COC form.

5. Decontaminate non-disposable sampling equipment.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of specific field quality control (QC) samples will be specified in the project-specific planning documents and may include one or more of the following: field blank, equipment blank, trip blank, field duplicate, and matrix spike/matrix spike duplicates.

4.1 Duplicate Soil Sample Collection

The following procedures should be used for collecting duplicate soil samples:

1. For QC purposes, each duplicate sample will be submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for soil sampling will be employed. However, a sample collection time will not be included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book.

2. Each duplicate sample will be collected simultaneously with the actual sample. At the coincident step in the sampling procedures that the VOC, VPH and/or GRO containers are filled and sealed, the duplicate sample VOC, VPH and/or GRO containers will also be filled and sealed. Duplicates for all parameters other than VOCs, VPH and GRO should be filled from the homogenized sample to ensure consistency between the sample and the duplicate. Following the order of collection specified for each set of containers (i.e., VOCs, VPH, GRO, semivolatile organic compounds [SVOCs], other organics and then inorganic compounds), the duplicate sample containers will be filled simultaneously with each parameter.

3. All collection and preservation procedures outlined for soil sampling will be followed for each duplicate sample.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the general sample collection information such as location, identification, and date/time in the field book or on a field data sheet. Typical field documentation recorded in a field book includes the following information:

- Sample identification number
- Sample location (description or sketch of the sample point)
- Sample depth interval
- GPS coordinates and coordinate system
- Time and date sample was collected
- Personnel performing the task
- Visual or sensory description of the sample (e.g., odors, staining)
- Brief soil descriptions (e.g., color, texture, appearance)
- Presence of any fill materials (e.g., concrete, asphalt, ash)
- Readings from field screening equipment (e.g., PID)
- Weather conditions during sampling
- Other pertinent observations including whether photographs were taken
- Sample collection equipment used
- Decontamination procedure
- Analytical parameters

Affix a properly completed label to each sample container.

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the record management procedures specified in the site-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

ASTM Methods D1586 *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soil*, D1587 *Practice for Thin-walled Tube Sampling of Soils for Geotechnical Purposes*, ASTM D6169 *Standard Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigation*, ASTM International, Most Current Version.

MassDEP, *Method for the Determination of Volatile Petroleum Hydrocarbons (VPH)*, May 2004.

U.S, EPA, SW-846 Method 5035A, *Closed System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples*, Draft Revision 1, July 2002.

U.S. EPA Environmental Response Team, Soil Sampling SOP #2012, February 18, 2000.

U.S. EPA Science and Ecosystem Support Division, Soil Sampling Operating Procedure (SESDPROC-300-R2), December 20, 2011.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	SEPTEMBER 2013	NOT APPLICABLE

APPENDIX C-2

WELL INSTALLATION SOP

TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the construction and installation of groundwater monitoring wells. TRC typically employs a drilling subcontractor to perform the actual construction and installation. The SOP conforms to *A Compendium of Superfund Field Operations Methods* (EPA/540/P-87/001) and American Society for Testing and Materials (ASTM) standard D5092, *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers* (ASTM 2004). A thorough discussion of well design, installation, materials, and potential problems is found in *Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring*, Chapter 10: Design and Installation of Ground-Water Monitoring Wells (Nielsen and Schalla 2006). In general, this SOP conforms to typical practices utilized in the field; project-specific and local or state regulatory requirements should be applied, as needed.

1.1 Scope and Applicability

The objective of a groundwater monitoring well is to provide for the collection of representative groundwater samples and hydrologic data on the target saturated zone. These objectives require that the well be installed and developed (well development is presented in RMD SOP 006) using suitable materials, equipment, and procedures that will best represent the actual hydraulic conditions. Specific monitoring well design and installation procedures depend on project-specific objectives and subsurface conditions. The well construction activity should include consideration of the potential impact on the groundwater quality and measures to rectify that impact to the extent practicable. The following aspects should to be considered prior to well installation:

- Borehole drilling method
- Well construction materials
- Well depth
- Screen length
- Location, thickness, and composition of annular seals
- Well completion and protection requirements

Monitoring well installation will be performed in accordance with the applicable regulatory agency standards and the project-specific work plan. Drilling methods used to pilot the borehole for monitoring well installation will be dependent on the physical nature of the subsurface materials (unconsolidated materials and/or consolidated materials) at the project site.

1.2 Summary of Method

The most common type of monitoring well installations are single-screen, single casing wells designed to monitor one specific interval within the groundwater. Monitoring wells are typically 2 inches (inside) diameter, but may be larger or smaller depending on the project requirements. With direct push technology being used more frequently, 1-inch diameter wells are also frequently used. Monitoring wells most commonly consist of 5 or 10 feet of well screen with an interconnected length of blank well casing that extends to the surface. The annulus between the screen and the formation is filled with a filter pack of appropriately-sized sand depending on the formation material. The annulus between the blank casing and the borehole is filled with an annular seal to the ground surface. A surface completion usually consisting of a traffic-rated well vault or monument that protects the well from damage or unauthorized use is installed at or above the surface.

For more complicated monitoring well installations, such as situations requiring very small screen intervals (such as with fractured rock), open boreholes, or multiple zones of interest, the well design can be modified to suit the application. See Nielsen and Schalla (2006) for additional information on less conventional well installations.

In general, all well materials (other than filter sand, seals, and grout) are typically provided by the manufacturer and are individually plastic-wrapped. If required by the project-specific work plan or at the discretion of the TRC inspector, well materials (other than filter sand, seals, and grout) may be steam-cleaned, rinsed with deionized water, and covered in plastic prior to installation of the well to prevent the introduction of foreign contaminants into the aquifer. Decontamination and bagging can be conducted by the manufacturer, prior to delivery to the site. Furthermore, well construction materials shall be properly stored until use to ensure their good condition and cleanliness.

1.3 Equipment

The following list of equipment may be used during the installation of groundwater monitoring wells. Many of these materials may be supplied by the drilling subcontractor. Specific details on these materials are described in Section 2.2. Site-specific conditions may warrant the use of additional items or deletion of items from the list.

- Appropriate level of personal protection equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator
- Weighted tape measure appropriate to the depth of well
- Well screens with appropriately sized slot openings
- Well casings/risers
- Well end caps
- Centralizers
- Graded sand for filter pack (appropriate for formation and screen slot size)
- Fine-grained sand (for use between filter pack and annular seal)
- Bentonite pellets or granules/chips
- Powdered bentonite
- Type I Portland cement
- Redi-Mix concrete
- Protective surface casing (for aboveground or “stick-up” wells)
- Lockable well cover
- Steel manhole/curb box (for flush-mounted wells)
- Equipment decontamination supplies

1.4 Definitions

Annulus/annular space	The space between the well casing/screen and the borehole wall.
Annular seal	An interval of low-permeability material placed above the filter pack designed to inhibit the flow of water into or through the annulus.
Bentonite	A naturally occurring deposit of volcanic ash that has partially weathered to form an absorbent swelling clay, consisting mostly of montmorillonite.
Bridge(-ing)	An obstruction within the annulus that may prevent circulation or complete installation of annular materials.
Casing – pipe (well casing)	Rigid pipe constructed in threaded or welded sections installed to temporarily or permanently counteract caving of the borehole or to isolate an interval to be monitored.
Casing - protective	A section of larger diameter pipe placed over the uppermost end of a monitoring well riser or casing to provide structural protection to the well and restrict unauthorized access.
Caving (sloughing)	The inflow or collapse of unconsolidated material into a borehole that occurs when the borehole walls lose their cohesive strength, or a detached section of consolidated material is dislodged into the borehole.
Cement (Portland cement)	A mixture of calcareous, argillaceous, or other silica-, alumina-, and iron-oxide-bearing materials that is manufactured and formulated to produce a hardened material when mixed with water. Type I Portland cement as classified by ASTM C150 Standard Specification for Portland Cement is a general purpose cement most commonly used for monitoring wells when the special properties (e.g., sulfate resistance, high early strength, low heat of hydration) specified for other types are not required.
Centralizer	A device that assists in centering the riser pipe and screen in the borehole or casing.
Filter pack (gravel pack; sand pack)	An annular material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.

Flush-threaded	Casing or riser that is threaded and sized in such a manner that the inside and outside diameters are maintained between sections and joints.
Grout	A low-permeability material placed in the annulus between the well casing or riser and the borehole wall (typical well construction), or between the riser and casing, to maintain the alignment of the casing and riser and to prevent movement of groundwater or surface water into the annular space.
Riser	Sections of blank pipe that connect to the well screen and extend to or above the ground surface.
Tamping device	A heavy object attached to a measuring tape, rope or wire used to slip inside the annular space to ensure annular materials are properly placed per the designed depth criteria and to prevent bridging.
Tremie pipe	A tube or string of piping used to convey filter pack and annular seal materials from the ground surface to fill the annulus.
Vented end cap	A covering device that slips over or into the top of the well riser with a hole drilled in it to allow continuous equilibration of the potentiometric surface with the atmospheric pressure.
Well screen	Pipe (typically polyvinyl chloride [PVC] or stainless steel) used to retain the formation or filter pack materials outside of the well. The pipe has openings/slots of a uniform width, orientation, and spacing.

1.5 Health & Safety Considerations

Drilling operations can create a hazardous environment. The potential for injury is fairly high around a drill rig. Level D PPE, including a hardhat, gloves, steel-toed safety shoes, and safety glasses, must be worn at a minimum. Hearing protection is also standard for drilling personnel. Tyvek clothing is recommended when mixing grout. Most well installations are performed with the assistance of the hoist on the drill rig mast as the downhole drill pipe or augers are removed when the well materials are placed. Therefore, TRC personnel must be mindful of the same hazards that apply during drilling. TRC staff should only approach the drill rig if necessary to monitor the breathing zone, confirm depths of materials, or confer with the driller. Before approaching the drill rig, direct eye contact should be made with the driller so they are aware of your presence. The following safety requirements should be adhered to while performing drilling activities:

- The drill rig should not be operated within a minimum distance of 20 feet of overhead electrical power lines and/or buried utilities that might cause a safety hazard. In addition, the drill rig should not be operated while there is lightening in the area of the drilling site. If an electrical storm moves in during drilling activities, the area will be vacated until it is safe to return.

- Serious injuries have occurred while the driller removes casing using a cable and winch. The winch should only be used to move augers or piping – NOT to pull casing, piping or augers from the ground. Use of the drill string is the safest means to pull casing, auger, or piping as the well materials are placed.

- Exposure to potential contaminants can occur from vapors coming from the open boring and from contaminated groundwater being forced out of the boring when grouting.

- While the exposure duration is very low, the dusts from well sand, bentonite, and cement can harm the lungs. Workers should avoid the dust produced when placing the well materials.

- Cement is highly caustic and can irritate the skin. Chemical-resistant gloves should be worn if contact with cement is necessary.

- The bags of sand, cement, and bentonite typically do not require a knife to cut them open. A dull instrument, such as a screwdriver, is sufficient.

- Cutting PVC well casing or screen should be conducted using a PVC cutting tool or hacksaw.

1.6 Cautions and Potential Problems

Well installation is typically conducted by the drilling subcontractor. TRC personnel serve to observe and document the installation and to serve as quality control that the well is installed according to the project specifications. The following cautions or problems may be associated with well installation

- Wells are often specified to be installed as "water table" wells with the screen designed to intersect the top of the water table. The difficulty arises in being able to determine if the water surface as measured in the open borehole will remain the same once the well is installed.

- It is also common that "water table" conditions do not exist due to a confining layer or fractured rock environments. In such cases, the well screen is placed in the producing formation or fracture, and the screen may not intersect the potentiometric surface.

- A well screen should never be placed such that the screen straddles a confining unit, thus connecting two separate aquifer units.

- Flush-mount well constructions require appropriate design to account for vehicular traffic and potential water infiltration into the surface completion among other things. In general, wells with flush-mount completions should not be located in low-lying areas or drainage paths where water influx can be a recurring problem. Appropriate design should consider a drainage layer of sand or gravel with a weep hole so water that accumulates in the vault can drain.

- Aquifer or other pressure conditions at some locations may warrant consideration of a vent hole in the well cap. For flush-mount well completions, a vent hole can provide a means for ambient surface water to enter the well if the if the completion is not designed properly.

Careful consideration should be given to well completion design, including vented well caps, depending on the circumstances at the location.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Monitoring well installation is typically conducted by a subcontractor experienced in such installations following completion of a soil boring. A qualified TRC representative provides oversight and documentation that the well is properly installed. Subcontractor personnel should not be on the site without a TRC representative being present unless specific prior approval has been given by TRC. The TRC representative should prepare a Monitoring Well Installation Form (Attachment A) that documents the well completion details.

2.1 Preparation

Prior to the initiation of field work, the Project Manager or field technical lead (site manager) will secure the services of a qualified drilling contractor. A contract between TRC and the drilling contractor should be executed before mobilization. At a minimum, the drilling contractor must meet the following requirements:

- have the appropriate licenses, registrations and/or certifications for drilling and monitoring well installation in the state in which the work is being conducted,
- have the proper equipment in good operating condition and free of leaks (fuel, hydraulic fluid, lubricants, and similar compounds) available to perform the type of well installation required, and
- have experienced personnel who are OSHA-trained to work on hazardous waste sites.

Before the start of field tasks, the TRC field representative is responsible for coordinating the following items with the drilling subcontractor personnel:

- familiarizing the subcontractor with the objectives of the investigation,
- providing and reviewing a copy of the project-specific work plan with the subcontractor,
- providing and reviewing a copy of the project HASP with the subcontractor,
- determining overhead hazards including power lines, buildings, trees and verifying local/city regulatory requirements if tree roots will be damaged, and
- performing a daily health and safety review with the subcontractor.

Compliance with state and federal requirements is required prior to the installation of monitoring wells. TRC is responsible for ensuring that all required permits have been obtained prior to the start of work. If state regulations require the driller to obtain drilling permits and/or utility clearance approvals, TRC personnel must review the documentation prior to the start of work. This documentation may include, but is not limited to, the following:

- notification and approval to drill/install a monitoring well (access agreement),
- registration or notification of the well installation,
- permit for water withdrawals,
- well abandonment when the project is completed, and
- applicable dig-safe permits or approvals (utility clearance).

Copies of any permits and notification forms must be provided to TRC.

2.2 Materials

Unless approved in writing by TRC, no lubricants or glue shall be used in any manner that could possibly contaminate samples, boreholes, or monitoring wells. The following provides a detailed description of the key features of well installation and how their proper selection and use is necessary to complete an effective groundwater monitoring well.

2.2.1 Well Screens

Monitoring well screens most commonly consist of two-inch diameter, flush-threaded, Schedule 40, PVC, machine-cut, slotted, wire wrap and/or V-wire screen. Up to two-inch or smaller diameter PVC is often used for wells installed using direct-push drilling methods. Four-inch diameter (and larger) wells are most typically used to accommodate larger pumps for groundwater and/or non-aqueous phase liquid (NAPL) recovery – but may also be used for groundwater monitoring. The screen slot size should be selected to retain a minimum of 90% of the filter pack material (see below). The most commonly used slot size is 0.010-inch (0.25 mm) slot openings.

In wells installed at depths greater than 100 feet, Schedule 80 PVC well screens can be used to minimize narrowing of the slots from the increased weight of the riser string. Note that the inside diameter of Schedule 80 riser pipe is slightly smaller than Schedule 40. That difference may cause difficulty when inserting some downhole monitoring equipment or instrumentation.

PVC screens can be adversely affected (typically by weakening or swelling) by concentrations of organic solvents that exceed 25% of the solubility limit. If such subsurface contaminant conditions are possible, the type and concentration of solvent should be researched in more detail prior to well installation. Stainless steel is also a common choice for well screens, but under certain conditions, metals (including iron, nickel, lead, and chromium) have been known to leach from stainless steel screens; in addition, stainless steel screens are costly. Other materials or sizes may be specified in the project-specific work plan as required by site conditions or local regulations.

Manufactured prepacked well screens are commercially available and generally consist of a standard, slotted Schedule 40 PVC well screen pipe (typically 0.5 to 2.0 inch diameter) wrapped in a stainless steel mesh filled with filter sand (typically 20-40 grade silica sand). Additional finer sand pack is commonly added directly above the installed prepack as a grout barrier. Since the sand is packed around the slotted PVC before the well screen is installed, using prepacked screens guarantees that sand will be located directly adjacent to and uniformly around the well screen. Prepacked well screens are typically installed by direct push drilling techniques. The use of prepacked well screens generally makes well installation quicker and more efficient than traditional methods. However, their use for permanent groundwater wells for chemical groundwater quality monitoring should first be verified to determine consistency with project-specific and state regulatory requirements.

2.2.2 Riser and End Caps

Monitoring well riser and end caps will consist of appropriately sized, flush-threaded material compatible with the well screen. Other materials or sizes may be specified in the project-specific work plan as required by site conditions or local regulations. The top cap should be vented to allow the passage of air, unless the well is to be installed at or below the ground surface (i.e., "flush mount well"). In that case, the top of the well should be sealed with an expansion cap/plug or a protective watertight manhole provided to prevent the inflow of storm water runoff into the well.

2.2.3 Filter Pack

A filter pack (also known as "sand pack" or "gravel pack") will be required in any formation other than coarse sand and gravels containing less than 10% fines (silts and clays) by weight. In such formations (i.e. well-to-moderately sorted sands and gravels), a filter pack may not be necessary and the formation can be allowed to collapse around the screen; however, most regulatory guidance requires a filter pack be constructed. The purpose of the filter pack is to inhibit transport of fine-grained formation material into the well screen and stabilize the formation so as to avoid excessive caving/sloughing during installation and development. The introduction of coarser material than the natural formation also results in increasing the effective diameter of the well.

The filter pack material shall be composed of washed, graded, commercially-produced silica sand. Based upon field estimates of grain size distribution of the screened aquifer materials, a sand pack should be selected. A detailed discussion of filter pack determination is found in Nielsen and Schalla (2006). ASTM Standard D5092, *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers* (ASTM 2004), may also be consulted for further guidance on specifications for sand packs for various conditions. If grain size information is not known for the formation, several sand packs should be available during well construction based upon known or presumed geological information for the site. The most common choice of filter pack sand is 20-40 mesh for 0.010-inch screen slots.

One to two feet of clean, fine sand can be used (required in some states) as a buffer between the annular seal and the filter pack to provide added protection that grout invasion into the filter pack and/or the well screen will not occur. This layer is sometimes referred to as the "secondary filter pack." The sand should be well sorted quartz sand; 40-60 mesh sand is typically used for this purpose.

2.2.4 Annular Seal

An annular seal, typically a minimum of 2 feet thick, is placed above the filter pack and screen to inhibit the boring from serving as a pathway for the vertical movement of water. Without an annular seal, the wellbore annulus can serve to transport contaminants between geologic units (for example, from unconfined to confined aquifer or from the vadose zone to the groundwater). The annular seal will consist of bentonite pellets, chips, granules, or slurry (produced from powdered bentonite). Bentonite swells rapidly when in contact with water. Coated bentonite pellets are preferable in situations where the bentonite must travel through a water column greater than 30 feet, because uncoated pellets may expand and bridge the annulus above the desired depth. Larger bentonite chips may also be used since they also swell at a slower rate than pellets and granules. The selection of the form of bentonite will depend upon the location of the top of the filter pack relative to the water table. If the seal is placed in the vadose zone, the seal will be hydrated with potable water. The volume of water necessary to hydrate the bentonite chips or pellets is dependent on the pellet size, volume of pellets used, and manufacturer's requirements. Granular bentonite is the best choice in situations where the seal is placed in the vadose zone – particularly in arid climates. Other forms of bentonite require longer contact times with water to form an adequate seal. Note that if the seal may be exposed to NAPL, it can shrink and crack. In addition, in situations with total dissolved solids (TDS) concentrations >5,000 parts per million (ppm) or chloride concentrations >8,000 ppm, bentonite will not swell; in these situations, neat cement should be considered as an alternative seal.

2.2.5 Grout

In certain wells, the annular space above the bentonite seal to the ground surface may be grouted with a mixture of 95% Portland cement or equivalent, and 5% bentonite grout, mixed with potable water to the specifications of the concrete manufacturer. This equates to 6 gallons of water added to each 94-pound sack of Type I Portland cement with 3- to 8% powdered bentonite added to improve the workability of the slurry. Bentonite should be prehydrated before adding to the cement to limit clumping. Note that bentonite does not swell considerably when mixed with cement. Grout is generally mixed in a container or barrel using pumps and may include an electric paddle or rotating vane blender.

Note: Grout mixtures may vary based on applicable regulatory requirements or site-specific subsurface conditions.

2.2.6 Surface Protective Casing

The primary purpose of a protective surface completion is to prevent surface water runoff from entering the well, and to prevent unauthorized access to the well. There are two types of protective casings used for surface completions of monitoring wells: (1) the above ground completion and (2) the below ground or flush-mount manhole-type completion, which is typically used in high traffic or public areas where the well could be damaged by equipment or is deemed unsightly.

<u>Above-Ground Completion</u>

An above-grade surface completion (i.e., a well monument) consists of rigid surface casing (typically galvanized or steel coated with rust-proofing or anodized aluminum). The inside diameter of the casing should be at least 2 inches larger than the well casing and be long enough to extend 2.5 to 3 feet above and below the ground surface. The casing is set in the annular seal and/or the surface seal that consists of either concrete (in warm to moderate climates) or bentonite (in cold climates). Bollards are often used around the aboveground surface casing to prevent vehicular damage.

The surface casing shall have a cap with provision for a lock that cannot be easily removed and leave at least 3 to 6 inches of clearance between the top of the well casing and the cap. The base of the casing, at the point where it shall extend above the concrete pad, should have a small weep hole drilled through the casing to prevent the build-up of precipitation or ice between the steel casing and well riser.

Flush-Mount Completion

Flush-mount well completions are generally selected or may be required in areas where vehicular traffic or equipment operation is an important consideration and an above-ground completion may not be a viable option. Depending on the expected activity in the area of the flush-mount completion and the existing surface conditions, the strength and durability of the completion will need to be designed appropriately. An appropriate completion may not be noticed, but a poor completion will generate negative comments with increasing wear and tear. In general, flush-mount completions should be located away from local low areas that drain or accumulate water, if at all possible.

Well completions flush with the pavement or ground surface may be accomplished by various means including the use of well can cylinders or elaborate vaults, and sufficient concrete to stabilize the structure within its surroundings. Regardless of the surface completion, the interior of the flush-mount completion should include the following characteristics: 1) rubber gasket to provide a cover seal; 2) locking capability for well security; 3) drainage management; and 4) sufficient interior space to accommodate any equipment (e.g., dedicated pump) that may be placed in the well.

Flush-mount well completions should provide a minimum of 2 inches of annular space around the outside of the well (i.e., a 6-inch diameter vault for a 2-inch well). The protective steel “skirt” should extent at least 1 foot below the top of the well vault. As most flush-mount wells are installed in paved areas, the concrete used to set the well vault should be compatible with the bearing capacity of the existing pavement. Depending on location considerations, the well completion may be sloped slightly away from the well or completed truly flush with the surroundings. The inside of the manhole annulus should be filled with a drainage layer of sand or gravel with a weep hole so water that accumulates in the vault will drain.

2.3 Monitoring Well Installation

Boreholes to be completed as monitoring wells will be advanced and logged in accordance with RMD SOP 005 (Visual-Manual Procedure for Soil Description and Identification). Equipment used to advance the boring and install the monitoring well will be decontaminated prior to the start of the boring.

All downhole well construction materials (with the exception of the protective casing) should be clean prior to use at the site. In general, all well materials (other than filter sand, seals, and grout) are typically provided individually plastic-wrapped by the manufacturer. If required by the project-specific work plan or at the discretion of the TRC inspector, well materials (other than filter sand, seals, and grout) may be steam-cleaned, rinsed with deionized water, and covered in plastic prior to installation of the well to prevent the introduction of foreign contaminants into the aquifer. Decontamination and bagging can also be conducted by the manufacturer, prior to delivery to the site. Furthermore, well construction materials shall be properly stored until use to ensure their good condition and cleanliness.

2.3.1 Procedures

Monitoring wells will be installed by the drilling subcontractor under the direction of a qualified TRC geologist, environmental scientist, or engineer. Monitoring wells will be installed using the following general procedures which may be dependent on the site-specific requirements.

1. Prior to mobilizing to the site, the construction details of the well to be installed will be provided to the driller, including well identifiers, locations of wells, boring diameter, well materials, screen slot size, screen lengths/depths, riser length, well depths, filter pack materials and depths, annular seal, grouting requirements, and well surface completion requirements.

2. All well materials shall be inspected to ensure that they are new and clean prior to installation.

3. Sections of screen and riser will be threaded together and lowered into the borehole to the predetermined depth. It is preferable to keep the drilling string or temporary casing in the hole while well materials are placed and slowly remove them as the well materials are installed. Centralizers may be used on the well riser in deeper wells to ensure proper well placement within the center of the borehole. Centralizers should not be placed within the location of the annular seal. Once the well is completed, the well cap should have a hole drilled in the top for venting, if possible.

4. The selected well packing materials will be introduced into the annulus in a manner so as to ensure an adequate well pack and seal. Approximately 0.5 to 1.0 foot of filter pack may be placed at the base of the boring to establish a stable base for the well materials. The thickness of each layer of well materials placed in the annulus will be measured with a weighted measurement tape and recorded to the nearest 0.10 foot. The weighted tape may also act as a tamping device to reduce bridging. Augers or casing will be removed sequentially during sand pack installation and the well will remain at the desired depth during auger or casing withdrawal.

   The primary filter pack may be placed using a rigid tremie pipe to minimize the potential for sand bridging in the annulus. The primary filter pack should extend at least 2 feet above the top of the well screened interval. One to 2 feet of fine sand as the secondary filter pack can then be placed above the primary filter pack (if required). However, the height of the filter pack may differ from that specified here due to shallow well depth limitations and project-specific work plan requirements. The secondary filter pack should not extend into a different aquifer unit as the primary filter pack. The depth of each interval of filter pack and volume of material used must be recorded on the Monitoring Well Installation Form and/or the field book.

5. The annular bentonite seal installation technique will vary with the depth of the water table. The appropriate type of bentonite will be selected to suit the objectives of the installation program. The bentonite should be poured slowly into the annular space to minimize

bridging, with periodic tamping. The volume of the annular space should be calculated and compared to the volume of bentonite used as a check to make sure bridging in the annular space has not occurred. If a tremie pipe is used for installation of the annular seal, either coated pellets or slurry should be used because bridging may occur as the bentonite swells. The preferred method of annular seal placement is by using the drilling rods or augers as a conductor casing, except in deep or difficult wells. The annular seal typically ranges from 1 to 5 feet in thickness. Annular seals in wells installed above the water table will be hydrated typically with 10 to 20 gallons (added in 5-gallon increments) of water and allowed to swell prior to the emplacement of a cement-bentonite grout mixture (if the well is to be grouted). In arid or highly permeable formations, the bentonite pellets should be allowed to swell for 1 hour. The high TDS concentration of cement grout does not act to hydrate bentonite, so it is important to allow the bentonite to hydrate fully in water. The level and volume of material(s) used for the annular seal are then recorded on the Monitoring Well Installation Form and/or the field book.

6. Once the annular seal is sufficiently hydrated, a cement-bentonite grout (or other type depending on local regulation) is placed to fill the remaining annulus of the boring. Depending on the depth of the well and water table, the grout may be tremied into the desired location from the bottom up. A side-discharge tremie is preferred so as to not disturb the annular seal. The tremie can remain near the bottom until grouting is completed. Grout requires 8 to 48 hours to set, but it does not become rigid like cement. The grout mixture (percentage of cement to bentonite) will be recorded and will be in accordance with the project-specific work plan or recommended guidance and Section 2.2.5 of this SOP. The grout will be pumped into the boring around the well materials to the surface. If necessary, after solidification of the grout and settling occurs, the grout may need to be topped off with additional grout mixture. The need for additional grout will be based on the intended surface completion for the well. The composition and volume of material(s) used for the grout are then recorded on the Monitoring Well Installation Form and/or the field book.

7. For wells finished above-grade, the protective casing may be cemented in place as described in Section 2.2.6 or completed with grout and bentonite in areas subject to frost heave. The protective casing should be in a plumb position and installed with at least half of the casing below ground and below the frost line (3- to 5 feet below ground surface). The protective casing should have a granular material placed in the base and a weep hole drilled through the casing to allow drainage of water that accumulates in the protective casing. Once completed, the well will be locked and typically allowed to settle for a minimum of 24 hours prior to well development. After well installation, development of a well should occur as soon as reasonably possible to enable representative sampling within the parameters of the project schedule. Some regulatory agencies require minimum timeframes for the newly-installed well materials, such as the bentonite seal or grout column, to cure before initiating well development (e.g., 24 or 48 hours).

   In some instances, a concrete pad is often constructed around wells to provide a working surface and more significant protective surface seal; this concrete pad is required by law in some states. These pads should be a minimum of 4 inches in thickness and are typically a minimum of 2 feet by 2 feet. It is recommended that the concrete pad extend 4 to 6 inches below the ground surface within six inches of the borehole. In areas of traffic or periodic mowing, three or four guard posts ("bumper guards" or bollards) may be positioned around the well to protect the well from equipment. The ground or pad around the well head should be sloped away from the well to promote drainage away from the surface completion. The guard posts consist of 3- to 4-inch diameter steel pipes set 3 to 4 feet outside the concrete pad. The pipes are set at least 3 feet in the ground and are filled with concrete. The well "stickup" and the guard posts should be painted a bright color (typically "safety yellow") for visibility. The type and details of the surface completion should be sketched, photographed or otherwise recorded on the Monitoring Well Installation Form and/or the field book.

8. Depending on the location of the well, flush-mounted utility boxes (i.e., well vaults or manholes) or above-ground, steel, protective casings with locking caps will be used to complete the well. Flush-mount wells should be located outside of areas that accumulate ponded water or areas of runoff, if at all possible, to minimize the potential for well damage by freeze/thaw conditions or for surface water to flow into the completed well.

   The well top should extend a minimum of 4 inches from the bottom of the cement or grout base with sufficient distance to the vault cover to accommodate any equipment (e.g., dedicated pump) that may be placed in the well. The well vault should also include a rubber gasket to make it water tight and is typically tightened with lug bolts.

   Flush-mount well vaults should provide a minimum of 2 inches of free space around the outside of the well (i.e., a 6-inch diameter vault for a 2-inch well). The protective, steel "skirt" should extent at least 1 foot below the top of the well vault. The vault will be sealed in concrete or cement grout that extends 4 to 6 inches away from the vault and extends a minimum of 1 foot below the frost depth. As most flush-mount wells are installed in paved areas, the concrete used to set the well vault should be compatible with the bearing capacity of the existing pavement. The vault should be set slightly higher than the existing grade and the concrete sloped (1- to 2% slope) away from the manhole to promote drainage away from the well. In cold-weather areas where snow removal occurs, the well may have to be set flush with the pavement to avoid damage. The inside of the manhole annulus should be filled with a drainage layer of sand or gravel with a weep hole, so water that accumulates in the vault will drain. Below-grade wells should be fitted with a locking, water-tight friction cap or expandable plug because below-grade wells often fill with water.

9. The wells should be permanently marked with the well identification number either on the cover or an appropriate place (i.e., in concrete pad) that will not be easily damaged and/or vandalized. Keyed-alike weatherproof brass padlocks should be installed on each well casing.

10. The manufacturer, type, weight, and number of bags or other containers of each type of well sand, cement, bentonite, and any other grout materials should be counted and documented on the Monitoring Well Installation Form and/or the field book as a means of determining if the amount used is consistent with the information obtained by the drilling subcontractor.

11. All information concerning well installation details will be recorded on a Monitoring Well Installation Form (examples provided in Attachment A).

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

There are minimal wastes other than general refuse and PPE that is generated during well installation. Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following quality assurance/quality control procedures apply:

- Check well construction materials to ensure these materials conform with the project-specific work plan and project specifications.
- Operate field instruments according to the manufacturers' manuals.
- Calibrate field instruments at the proper frequency, if utilized.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record well installation measurements on field forms or in a field book. See Attachment A for an example of a Monitoring Well Installation Form.

The following additional information should be recorded in the field book and/or Monitoring Well Installation Form:

- Well/piezometer or monitoring point identification number
- Well permit number (if applicable)
- Date of well installation
- Type of drilling method used and model number of rig
- Ground surface elevation (if known)
- Diameter and depth of borehole
- Depth of well bottom
- Depth of top and bottom of screened interval
- Depth of top and bottom of filter pack
- Depth of top and bottom of secondary filter pack (if used)
- Depth of top and bottom of annular seal
- Depth of top and bottom of grout seal
- Type, diameter, length, and screen slot size of well screen
- Type, diameter and length of riser
- Type, diameter, and length of casing (if used)
- Type, gradation, and volume/mass of filter pack
- Type and volume/mass of secondary filter pack (if used)
- Method used for filter pack placement

- Well lock type (i.e., padlock) and key number
- Type and volume of bentonite or other material used for annular seal
- Method used for annular seal placement
- Type, volume, and mix percentages of grout used
- Method used for grout placement
- Source of water used
- Type and length of protective casing
- Type and dimensions of well vault
- Type, number and array of protective posts (if used)
- Type and dimensions of surface completion/seal
- Measurement of "stickup" above or below ground
- Initial depth to groundwater
- Other pertinent observations
- Measurement equipment used
- Decontamination procedures used

6.0 REFERENCES

ASTM. 2004. *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers*, ASTM Standard D 5092, ASTM, West Conshohocken, PA 2004, pp. 20.

EPA. 1987. *A Compendium of Superfund Field Operations Methods,* EPA/540/P-87/001, US EPA. August 1987.

Nielsen, D.M. and Ronald Schalla. 2006. *Design and Installation of Ground-Water Monitoring Wells.* In Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring. Second Edition. David M. Nielsen ed. CRC Press. Boca Raton, FL. pp. 339 – 805.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	JANUARY 2014	NOT APPLICABLE

APPENDIX C-3

WELL DEVELOPMENT SOP

TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for the development of wells. Well development is completed to (1) evacuate any water added during the drilling of wells, (2) establish a good hydraulic connection between the well and the surrounding water-bearing zone, (3) settle the sand pack and formation following the disruptive drilling and installation activities, (4) alleviate clogging, smearing or compaction of formation materials at the borehole wall due to the drilling process, and (5) remove fine particles (e.g., silt or clay) from the water column and sand pack in order to obtain groundwater samples that are representative of the water-bearing zone in which the well is installed and/or enhance groundwater extraction and injection rates. Well development typically occurs for all newly installed wells and can also be implemented to refurbish an older well where significant silt/sediment build-up has occurred, as may be observed when the measured depth to bottom of a well is notably shallower than the recorded constructed depth to bottom.

1.2 Summary of Method

Proper well development includes initial and ongoing water-level and water quality measurements, implementation of the development method, management of the development wastes, equipment decontamination, and documentation. First, the well should be opened and initial measurements (e.g., headspace air monitoring readings, depth to water, total depth of the well) are collected and recorded. The well is developed using the method selected for each project based on the lithology, site conditions, and objectives and requirements of the project. Development of the well continues until the water is visually clear and free of sediments (e.g., turbidity <10 nephelometric turbidity units [NTU]), until a minimum number of well volumes has been evacuated (depending on regulatory requirements) or until water quality parameters such as pH, temperature, and specific conductivity stabilize, depending on project requirements. All purge water is containerized for proper characterization and disposal at an appropriate facility unless prior approval to discharge to land surface has been obtained from appropriate sources (e.g., governing regulatory agency). Final measurements (e.g., depth to water, total depth of the well, total water removed) are recorded in the field book or on the Well Development Form (Attachment A). Equipment is decontaminated, as appropriate, prior to use in the next well.

After well installation, development of a well should occur as soon as reasonably possible to enable representative sampling within the parameters of the project schedule. Some regulatory agencies require minimum timeframes for the newly-installed well materials, such as the bentonite seal or grout column, to cure before initiating well development (e.g., 24 or 48 hours). In addition, more vigorous well development methods (e.g., surging) may require a relatively longer setup time before development. If a less vigorous method (e.g., bailing) is being used, development may be initiated shortly after installation when grout is not used in well installation or if the sealant is above the water table. Regardless, the method used for development should not interfere with the setting of the well seal, which should be considered in preparing the work plan.

Well development also provides an opportunity to collect data that can be used to estimate the hydraulic conductivity (permeability) of the screened water-bearing formation. These estimates can be used to estimate groundwater flow velocities, and are often needed to project the extent of plume migration, estimate monitored natural attenuation rates, and other investigative tasks. Estimates of hydraulic conductivity and aquifer transmissivity can be derived from a measure of a well's specific capacity; i.e., flow rate divided by water-level drawdown (expressed in gallons per minute per foot [gpm/ft] of drawdown). The data needed to estimate specific capacity are the flow rate (purge rate during development, measured with a flow meter or a 5-gallon bucket and stopwatch), the static (pre-pumping) depth to water, and the pumping depth to water. The duration of pumping when the pumping depth to water is measured should also be noted.

Several development methods may be used depending on site conditions and project requirements. There are several regulatory agency guidance documents (e.g., USGS, 1997) as well as ASTM standards available for reference. If possible, select a development method that avoids introduction of air, foreign water, or chemicals to the aquifer during development. A few development methods are outlined in Section 2.0.

1.3 Equipment

The following list of equipment may be utilized during the development of wells. Site-specific conditions may warrant the use of additional items or deletion of items from this list.

- Appropriate level of personal protection equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Field book and forms
- Well keys
- Socket wrench
- Centrifugal or submersible pump and tubing/hosing
- Water quality meter (including parameters such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP) and dissolved oxygen (DO))
- Flow-through cell
- Turbidity meter
- Plastic beaker, jar, or disposable plastic cups
- Bailer and cord
- Large-capacity DOT-approved containers (if required)
- Five-gallon buckets
- Surge block
- Bulk supply of deionized/organic-free water
- Well construction diagrams and previous well development data (if available)
- Equipment decontamination supplies

1.4 Definitions

Bailer	A cylindrical device suspended from a rope or cable, which is used to remove water, non-aqueous phase liquid (NAPL), sediment or other materials from a well or open borehole. Usually equipped with some type of check valve at the base to allow water, NAPL, and/or sediment to enter the bailer and be retained as it is lifted to the surface.
Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and, therefore, floats on the surface of the water.
Monitoring Well	A well made from a polyvinyl chloride (PVC) pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
Non-aqueous Phase Liquid (NAPL)	Petroleum or other fluid that is immiscible in water and tends to remain as a separate liquid in the subsurface.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Separate-phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Low-permeability Formation	A geologic formation that has very slow recharge and discharge rates due to small pore spaces in the formation material. A clay formation is considered to have low permeability and a very slow recharge rate compared to a more permeable formation, such as sand or gravel.
Surge Block	A disc-shaped or cylindrical device that closely fits the well casing interior and is operated like a plunger below the water table to force water in and out of the well as a well development tool.

Total Depth of Well Distance from the measuring point to the bottom of the well.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

When present, special care should be taken to avoid contact with contaminated groundwater, LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

1.6 Cautions and Potential Problems

The following cautions or problems may be associated with well development:

- The observed presence of NAPL may warrant alternative goals and objectives for the well other than immediate development. The Project Manager should be contacted for direction on how to proceed.
- Low-yielding wells (e.g., at clay-bedrock interface, tight bedrock formations, etc.) may produce insufficient water to achieve optimal development including parameter stabilization.
- High-yielding wells (e.g., in coarse sand and gravel aquifers) may require the removal of large quantities of water to approach optimal development.
- Long well screens and/or larger diameter wells may require more time and effort to ensure adequate development of the entire interval depending on the development method employed.
- Development of wells should occur from the least-contaminated well to the most-contaminated well, if known.
- Overpumping is not as vigorous as surging and jetting and is probably the most desirable method for the development of new wells. The possibility of disturbing the filter pack is greatest with jetting well development methods, which are generally reserved for redevelopment of clogged extraction or injection wells. Surging or jetting may be preferred methods for supply, recovery, or injection wells (if constructed with metal screens) to achieve higher well efficiencies.
- The introduction of external water or air by jetting may alter the chemistry of the aquifer.
- Surging with compressed air may produce “air locking” in the water-bearing zone, preventing water from flowing into the well.
- Exercise caution with the use of surge blocks in PVC screen and pipe as the well could be damaged.
- Small (2-inch nominal diameter) submersible pumps that will fit in 2-inch diameter well casings are especially susceptible to becoming lodged (stuck) if used in well development applications.
- Prior to sampling a well, sufficient time should be allowed for equilibration with the formation after development. Refer to the governing regulatory agency for guidance regarding the required/recommended time interval between well development and sampling.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained.

Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Well development will be completed on wells after the grout, annular seals, and protective casings are deemed sufficiently stable (i.e., 24 to 48 hours after installation) for the development method being utilized and/or after required regulatory agency timeframe requirements. Development may be performed immediately after well installation if grout is not used during well installation or if the sealant (i.e., bentonite seal) is above the water table, in accordance with the regulatory requirements. Various well development methods, including surging, pumping, hand bailing, and jetting, are summarized below, followed by step-by-step well development procedures.

2.1 Well Development Methods

Surging Method

Surge and Pump: To increase the effectiveness of well development, the well can be surged and then pumped. Surging may be accomplished in several ways, but essentially water is rapidly forced into and out of a well in a wash and backwash action. One method of surging is to simply turn the pump on for a few minutes and then turn it off for a few minutes. Surging can also be accomplished with a surge block, which is a piston-like device attached to the end of a drill rod or pipe. The block is plunged up and down along the screened interval, similar to a piston in a cylinder, to flush water in and out of the well. Periods of surging are typically followed by a period of water extraction to remove the sediment brought into the well. Surge blocks are best utilized for wells screened in lithologies of medium to high porosities and hydraulic conductivities. Exercise caution with the use of surge blocks in PVC screens which can be damaged by tight-fitting surge blocks.

A surge block method is used alternately with either a bailer or pump, so that materials that have been agitated and loosened by the surging action are removed. The cycle of surging-pumping/bailing is repeated until satisfactory development is achieved.

The surge block, usually attached and operated by a drill rig, is lowered to the top of the well screen and then operated in a surging action with a typical stroke of about three feet. The surging action is usually initiated at the top of the well screen and gradually worked downward through the screened interval so that sand or silt loosened by the surging action cannot cascade down on top of the surge block and prevent removal from the well. The surge block is removed at regular intervals and the fine material that has been loosened is removed by a bailer or pump.

Surging is initially gentle and the energy of the action is gradually increased during the development process. By controlling the speed, length and stroke of the surge block, the surging activity can range from very rigorous to very gentle.

Pumping Method

Pumping develops a well by creating a surging action as a result of variable flow rates. An electric submersible pump or compressed air-operated air displacement pump is installed into the well. The rate of flow is varied at levels adjacent to the well screen.

Overpumping: A simple method of well development is overpumping, where water is simply pumped from the well at a high rate.

Many pumps can also be used to surge a well, employing a similar method as with the surge block. While either off or running, the pump may be plunged up and down along the screened interval, in effect flushing water and sediment in and out of the well and adjacent filter pack.

Hand Bailing Method

Surge and Bail: Instead of a surge block, a bailer can be used in a similar manner since the diameter of the bailer is commonly slightly smaller than the diameter of the well. A water-filled bailer can be plunged up and down, followed by periods of bailing out sediment suspended in the water column. The impact of the bailer as it strikes the surface of the water produces an outward surge of water through the well construction and into the formation. This action tends to break sediment bridges that may have formed during well installation. Movement of water back into the well suspends fine sediments into the water column, which are removed with the bailer.

Bailers are good well development tools for wells screened in low-permeable formations. Deep wells or large purge volume wells should not be developed with bailers, as development with a bailer would be very labor intensive.

Jetting Method

Another method of development is high-velocity hydraulic jetting. Using a specialized jetting tool, jets of water are directed horizontally at the sides of the well from inside the well to loosen fine-grained material and drilling mud residue from the formation. The loosened material is flushed into the well and can be removed through concurrent pumping or by bailing. Caution should be used when using a jetting method of development as there is the possibility of disturbing the well filter pack. For product recovery, a jetting method of development can push product away from the well and can delay or completely prevent product from coming back into the well.

2.2 General Procedures for Well Development

1. The project plan will be consulted regarding any project-specific well development requirements.

2. Consult the well completion diagram and boring log to determine the well construction (well diameter, depth and length of screen), soil core vapor screening results, lithology of the screened interval, and depth to water.

3. If potable water was introduced into the water-bearing zone during well installation, the estimated amount of water lost to the formation during the drilling process should be removed during well development to ensure connection with formation water during the development process.

4. Select the appropriate method and equipment to implement development of the well. Ensure any non-dedicated equipment is clean and decontaminated prior to use and also in between wells. The development equipment should be the appropriate length to reach the entire length of the well screen. The method should be capable of evacuating the development water to the surface and into containers if required.

5. Measure the static DTW and total depth of the well using RMD SOP 004, and determine the amount of standing water in the well (well volume). Record the DTW and calculate the water column volume of the well.

   To calculate the volume of water in the well, the following equation (Equation 1) is used:

   Well Volume (V) = πr^2 h (cf)
   where:
   π = pi (3.14)
   r = radius of well in feet (ft)
   h = height of the water column in ft. [This may be determined by subtracting the DTW from the total depth of the well as measured from the same reference point.]
   cf = conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3.

   The volume in gallons/linear foot (gal/ft) for common size wells are as follows:

Well Diameter (inches)	Volume (gal/ft)
2	0.1631
3	0.3670
4	0.6524
6	1.4680

   If the volumes for the common size wells above are utilized, Equation 1 is modified as follows:

   Well volume = (h)(f)
   where:
   h = height of the water column (feet)
   f = the volume in gal/ft

6. Using the appropriate length of dedicated or decontaminated hosing/tubing and the selected pumping apparatus, insert the equipment into the well.

7. Initiate water removal from the well and record the initial water quality measurements including pH, temperature, specific conductivity, DO, ORP and turbidity (as required by project specifications) in the field book or on the Well Development Form. Record any odors, water color/clarity, changes in air monitoring results or other observations in the field book or on the Well Development Form.

8. Optional step to estimate the permeability of the formation: Estimate flow rate of extracted water, in gallons per minute (gpm). The flow rate can be measured with a 5-gallon bucket and stop watch, or timed transfer to any vessel which can be measured. Measure DTW in the well during pumping to derive an estimate of water-level drawdown. Calculate the approximate specific capacity (gpm/ft of drawdown). Tracking the improvement of specific capacity can provide a

direct measure of the effectiveness of well development and can determine when development is no longer providing improvement.

9. In general, well development should proceed until the following criteria are met (note: certain regulatory agencies may have more stringent well development requirements):

   a. Water can enter as readily as hydraulic conditions allow.

   b. A representative sample can be collected.

      - In general, representative conditions can be assumed when the water is visibly clear of sediments (e.g., turbidity <10 NTU).
      - In addition to clear water, a further criterion for completed well development is that the other water quality parameters mentioned above stabilize to within 10 percent between readings over one well volume. During well development, pH, specific conductivity, DO, ORP, temperature and turbidity can additionally be monitored to establish natural conditions and evaluate whether the well has been completely developed.

   c. The duration, along with any measured water quality parameters (e.g. pH, temperature, specific conductivity, DO, ORP and turbidity) should be recorded on the Well Development Form.

      In some instances, collection of a sample with a turbidity of 10 NTU or less is difficult or unattainable. If a well does not provide a sediment-free sample, development can stop when all of the following conditions are met:

      - Several procedures have been tried,
      - Proper well construction has been verified,
      - Turbidity has stabilized within 10 percent over three successive well volumes, and
      - Specific conductivity and pH have stabilized over at least three successive well volumes.
        (It should be noted that pH, temperature, and specific conductivity may not stabilize if water quality has been degraded).

   d. The sediment thickness remaining in the well is less than 1 percent of the screen length or less than 0.1 foot for screens equal to or less than 10 feet.

   e. A minimum of three times the standing water volume in the well (to include the well screen, casing, plus saturated annulus, assuming 30 percent annular porosity) should be removed. If water was added as part of the well installation and development, attempts should be made to recover the volume of water added, plus the three well volumes.

10. Measure the total depth of the well, to determine the amount, if any, of sand/silt removed during development of the well.

11. Note the final water quality parameters in the field book or on the Well Development Form. The time between well development and sampling will depend on project objectives and regulatory requirements.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following Quality Assurance/Quality Control procedures apply:

- Operate field instruments according to the manufacturers' manuals.
- Calibrate field instruments at the proper frequency.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

- Record well development measurements on field forms or in a field book. See Attachment A for an example of a Well Development Form.
- The following additional information should be recorded on the field form or in a field book:
  - Well/piezometer or monitoring point identification number
  - Well/piezometer or monitoring point location (sketch of the sample point or reference to a location figure)
  - Date of well installation
  - Date(s) and time of well development
  - Static DTW before and after development
  - Quantity of water removed and initial and completion times
  - Quantity and source of water added to well to facilitate development, if applicable
  - Type and capacity of pump or bailer used
  - Description of well development techniques
  - Visual or sensory description (e.g., odors, product, etc.)
  - Time and date measurements were taken
  - Personnel performing the task
  - Weather conditions during task
  - Other pertinent observations
  - Measurement equipment used
  - Calibration procedures used
  - Decontamination procedures used

6.0 REFERENCES

U.S. EPA *A Compendium of Superfund Field Operations Methods*. EPA/540/P-87/001. December 1987.

U.S. EPA Environmental Response Team, Standard Operating Procedures, *Monitor Well Development*, SOP 2044. October 23, 2001.

U.S. Geological Survey, Guidelines and Standard Procedures for Studies of Ground-Water Quality: *Selection and Installation of Wells, and Supporting Documentation*. Water-Resources Investigations Report 96-4233. 1997.

Ohio EPA, Division of Drinking and Ground Waters, *Chapter 8: Monitoring Well Development, Maintenance, and Redevelopment*. Technical Guidance Manual for Ground Water Investigations. February 2009 (Rev 2).

Sanders, Laura L. *A Manual of Field Hydrogeology*. New Jersey: Prentice-Hall, 1998. pp. 260-261.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	OCTOBER 2013	NOT APPLICABLE

APPENDIX C-4

GROUNDWATER SAMPLING SOP

TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to provide TRC personnel with general guidance in performing groundwater sampling activities. This SOP details equipment and sampling procedures for low-flow sampling, multi-volume purge sampling and passive diffusion bag sampling from monitoring wells. Various regulatory agencies and project-specific work plans may have specific requirements (e.g., equipment/instrument, flow rate, etc.) that may be applicable and take precedence, depending on the program.

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

1.2 Summary of Method

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling.

For low-flow and multiple well volume removal, there are various types of equipment available to perform groundwater sampling. The most common of these are the submersible pump, peristaltic pump, and bailer. However, the equipment selected and the purge method used, if any, will depend on project goals, data quality objectives (DQOs), hydrogeologic conditions, and regulatory requirements. Care should be taken when choosing the sampling procedures and device(s), as some procedures have the potential to affect the representativeness of the sample more than others. For repeated monitoring events, the sampling methodology and operating equipment employed should be consistent to minimize potential variability due to sampling procedures. The type of sampling method utilized is dependent upon site-specific conditions and it is not within the scope of this document to recommend a specific methodology. Information on applicability of sampling methods can be found on Interstate Technology & Regulatory Council (ITRC) and United States Environmental Protection Agency (EPA) websites.

1.3 Equipment

The following equipment is commonly used to collect groundwater samples from a monitoring well. Site-specific conditions may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator capable of measuring to 0.01 foot accuracy
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Submersible pump with low-flow capabilities (less than 1 liter/min) constructed of inert materials (e.g., stainless steel and Teflon®), such as a bladder pump (with sufficient quantity of bladders, o-rings, grab plates, etc.)
- Peristaltic pump
- Source of power for use with submersible or peristaltic pump (e.g., 12-volt battery, compressor, generator, compressed gas tanks, etc.)
- Flow controller for use with submersible pump (varies depending on type of pump used)
- Bottom-filling bailer constructed of inert materials (i.e., polyethylene, polyvinyl chloride [PVC], stainless steel or Teflon®)
- Bailer cord or wire (recommended Teflon®-coated, stainless steel cable; bailer wire; or contaminant-free rope with a Teflon®-coated stainless steel leader to connect bailer and rope)
- Tubing (Teflon®, Teflon®–lined polyethylene, or high density polyethylene [HDPE], type dependent upon project objectives)
- Silicone tubing (only used for peristaltic pump head and/or flow-through cell connections)
- Water quality meter(s) capable of measuring parameters, such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO)
- Flow-through cell
- T-connector
- Turbidity meter
- Passive sampling device (and any device-specific accessories)
  - Passive diffusion bags (PDBs)
  - Tether (stainless steel cable or marine-grade polyethylene rope), well cap, and weights, unless already installed
  - Funnel (Fill kit)
  - PVC cable ties
  - Tool to cut cable ties
  - PVC discharge tubes
  - Tether reel
- Well lock keys
- Bolt cutters

- Appropriate tools for equipment and to open well box (e.g., socket wrench, pry bar, etc.)
- Containers with lids for purge water (i.e., 5-gallon buckets, drums, etc.)
- Stopwatch or timer
- Graduated measuring container appropriately sized to measure flow rate
- Sample bottle labels
- Laboratory-grade water (can request from lab – for equipment blanks)
- Chain-of-custody (COC) forms
- Sample cooler(s)
- Photoionization detector (PID) or flame ionization detector (FID) for well head monitoring
- Sample containers (may be supplied by the laboratory depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project. If not included in sample containers provided by laboratory, sample preservatives will need to be kept with sample containers, and added to sample containers prior to sample collection.
- Field book and/or Groundwater Field Data Record (multiple copies)
- Filtration equipment
- In-line filter (0.45 micron [μm]) or as otherwise required by the project-specific work plan.
- Bubble wrap/Bubble wrap bags
- Lint-free, non-abrasive, disposable towels (e.g., Kimwipes®)
- Indelible marking pens
- Plastic bags (e.g., Ziploc®)
- Ice
- Teflon® tape
- Plastic sheeting or large trash bags which can be cut open
- Umbrella, tent, or equivalent for shading equipment (particularly the flow-through cell) from sunlight or blocking rain
- Equipment decontamination supplies
- Container for bailing water out of water-logged road boxes or well vaults
- Map of well locations and well construction data
- Copy of field notes from previous sampling event for reference
- Project-specific work plan

1.4 Definitions

Bailer	A cylindrical device suspended from a rope or cable, which is used to remove water, non-aqueous phase liquid (NAPL), sediment or other materials from a well or open borehole. Usually equipped with some type of check valve at the base to allow water, NAPL, and/or sediment to enter the bailer and be retained as it is lifted to the surface. A bailer may be made in varying diameters; however a bailer that fits in a two-inch well is the most common. In some instances a < 1-inch diameter bailer (a.k.a. pencil bailer) is used for small diameter wells.
Borehole	A hole drilled into the soil or bedrock using a drill rig or similar equipment.
Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Drawdown	The response to purging/pumping a well resulting in the lowering of groundwater within the water column in the well or in a water-bearing zone.
FID	An instrument that uses a flame to break down volatile organic compounds (VOCs) into ions that can be measured.
Flow-Through Cell	The container used to immerse the multi-parameter probes in well purge water during pre-sampling well purging. The flow-through cell is usually made of transparent acrylic and is connected to the end of the discharge tubing creating an in-line, sealed container in which purge water circulates around the measurement probes. The discharge from the pump prior to the flow-through cell may be fitted with a check valve or T-connector for collection of water for turbidity measurement.
Flush Mount	The type of well completion where the riser terminates at or below grade. Flush-mounted wells are typically completed with a "curb box" which is an "at-grade" enclosure designed to protect the well riser.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and therefore floats on the surface of the water.

Monitoring Well	A well made from a PVC pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
PID	An instrument that uses an ultraviolet light source to break down VOCs into ions that can be measured.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Potentiometric Surface	A surface representing the hydraulic head of groundwater.
Protective Casing	The pipe installed around the well riser that sticks up from the ground (above-grade completions) or is flush with the ground (at-grade completions, e.g., curb box) in order to protect the well integrity. Protective casings are typically constructed of steel or aluminum and usually closeable with a locking cover/hasp to maintain well integrity between sampling events.
Recharge Rate	The rate at which groundwater returns to the water column in the well.
Separate-Phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Static Water Level	Level at which water resides in a well when the water level is at equilibrium with atmospheric pressure.
Well Cover	The cap or lid constructed at the end of the protective casing (above-grade completions) or flush-mounted curb box (ground surface completions) to secure access to the well. Well covers for stick-up wells are often equipped with a hasp to accommodate a padlock. Well covers for flush-mounted road boxes or vaults are opened and closed using a threaded bolt.
Well Filter Pack	A material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.
Well Plug/Expansion Plug	The plug fashioned into a cap placed into the top of the well riser (e.g., J-Plug). Well plugs are usually designed with an expandable gasket that is activated by turning a locking wing nut or removable key latch, closing a snap cap or engaging a magnetic clutch cap to seal the well riser.

Well Riser	Sections of blank (non-slotted) pipe that extend from the well screen to or above the ground surface.
Well Screen	Pipe (typically PVC or stainless steel) used to retain the formation or filter pack materials outside of the well. The pipe has openings/slots of a uniform width, orientation, and spacing. The openings/slots can vary based on formation and filter pack material specifications.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

The well head should be pre-screened using a PID/FID to avoid inhalation of contaminants venting from the well. If monitoring results indicate sustained elevated concentrations of organic contaminants, the level of PPE may need to be increased in accordance with the HASP or work could be conducted upwind of the well.

When present, special care should be taken to avoid contact with LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

Implementing this SOP may require the use of reagents and/or compressed gases for the calibration and operation of field equipment. These substances may be hazardous and TRC personnel must appropriately handle, store, and dispose of them at all times. Skin contact with liquid from preserved sample bottles must be avoided as they may contain strong acids or bases. When filling bottles pre-preserved with acid (e.g., hydrochloric acid, nitric acid, sulfuric acid), vapors may be released and should not be inhaled. Do not allow bottles with acid to be exposed to elevated atmospheric temperatures or sunlight as this will facilitate fumes from the acids.

1.6 Cautions and Potential Problems

The following sections highlight issues that may be encountered and should be discussed with the Project Manager prior to mobilization into the field.

1.6.1 Pre-Sampling Issues

(a) Selection of equipment for groundwater sampling should consider multiple factors, including: DTW, well specifications (e.g., depth and length of well screen intervals), desired flow rate, possible weather conditions, type and concentration of contaminant(s), and remoteness/accessibility to the site. The benefits and limits of each type of groundwater sampling equipment should be fully reviewed during project planning or prior to mobilization if the project-specific work plan does not identify the required equipment. For example, peristaltic pumps are incapable of withdrawing water in wells in which the depth to water is greater than approximately 20-25 feet below ground surface (bgs).

(b) If the screen or open borehole is greater than 10 feet in length, consult the project-specific work plans for the target sampling interval. Generally, pumps are either placed in the middle of the saturated zone if the water level is below the top of the screen or in the middle of the screen interval if the water level is above the top of the screen.

(c) The need for redevelopment of the monitoring wells should be evaluated periodically in accordance with the project-specific requirements. This is assessed by comparing the measured total depth of the well with the constructed depth. If the measured depth is less than the constructed depth, this may indicate siltation of the well and/or the presence of an obstruction in the well. If it is determined that redevelopment is necessary, it should be performed in accordance with RMD SOP 006, *Well Development*. The time necessary for a well to restabilize after redevelopment will be determined on a project-specific basis and may depend on regulatory requirements.

(d) During the total well depth measurement, there is the potential for sediment, if present at the bottom of the well, to be disturbed, thereby increasing the turbidity of the groundwater. Therefore, the total well depth measurement should be collected the day prior to collecting groundwater samples, if possible.

(e) Use caution if using compressed gas cylinders (e.g., nitrogen, carbon dioxide) for purging/sampling of groundwater. Check for leaks around regulator connections by spraying soapy water on the connections. If a leak is discovered, the connection to the regulator should be disassembled, wrapped with Teflon® tape, and reconnected to the cylinder. If the leak continues, the regulator should be replaced. It should be noted that Department of Transportation (DOT) regulations apply to the transportation and handling of compressed gas cylinders (see 49 Code of Federal Regulations [CFR] 171). Never transport cylinders with the regulator attached. Replace the cylinder valve cover on the compressed gas cylinder before transport.

(f) All field personnel must be made aware of the water level measurement reference point being used for each well at a site (i.e., must be clearly marked) in order to ensure collection of comparable data between events.

(g) Bolt cutters may be necessary to remove rusted locks. Dipping rusted locks in a soapy solution may help with opening difficult locks. Oils and other products containing VOCs (e.g., WD-40) should not be used on locks as these compounds may cause contamination of water samples collected at the well. Replace cut locks and note in the field book.

(h) Prior to accessing the well, physical conditions around the well head should be assessed for situations that might result in cross-contamination or the introduction of foreign material/debris into the well. For example, flush-mounted wells may have water or road sand/salt/debris inside the curb box. Rodents and insects (e.g., bees, wasps) have been known to construct nests within the protective casing of a well. If bees, wasps, or other insects are encountered, insecticides should be used with caution as the chemicals may cause contamination of water samples collected at the well. If water or foreign material is introduced into the well, the Project Manager should be immediately notified.

1.6.2 General Purging and Sampling Issues

(a) Prior to installation of a submersible pump into a well, ensure that the tubing is properly sealed to the pump to avoid losing the pump down the well and to prevent escape of air or water from the pump, which could result in poor pump performance and the aeration of the well water. Do not do this by tugging on tubing. Never lower pumps into the well using only tubing; instead a security line attached to the pump is required to prevent potentially losing the pump down the well.

(b) A submersible pump should not be lowered to the bottom of the well to avoid stirring up any sediment at the bottom of the well and prevent getting the pump stuck (fine sediment accumulation in the bottom of the well can create a strong suction with a flat bottom pump such as a bladder pump, which may require jetting to retrieve the pump).

(c) Start with the lowest pumping rate possible and increase until a sustainable rate is reached. Avoid high pumping rates (> 1 liter/min), as this could lead to damage of the well filter pack, if present. Where practical and/or possible, refer to previous sampling events to establish consistent flow rates.

(d) Some regulatory agencies may have concern about the use of peristaltic pumps when sampling for VOCs due to the potential for loss of VOCs during sampling and alteration of other water quality parameters such as pH and alkalinity. Samplers should review the requirements in the project-specific work plan and/or regulatory guidelines prior to performing the work. Explicit approval to use a peristaltic pump for the collection of VOCs may be required by the governing regulatory agency. An option may be to use the "soda straw" method to collect the VOC sample which does not allow the water to go through the pump head:

(1) After purging the well with the peristaltic pump, collect all fractions <u>except VOCs</u> from the outlet side of the pump (i.e., VOCs will be collected last instead of first).
(2) Turn the pump off.
(3) Change into clean gloves.
(4) Disconnect the tubing coming out of the well from the inlet side of the pump and <u>immediately</u> put a finger over the end of this tubing to prevent water from draining out of the tubing.
(5) Retrieve tubing from the well, coiling it in one hand as it is being retrieved (maintain finger over end of tubing).
(6) Open VOC vials. Briefly remove finger from end of tubing to allow water to flow into vial. Replace finger on end of tubing to stop flow. Do this for remaining VOC vials.

(e) In the event that a well cannot be purged and sampled with a pump, the alternative to pumping may be the use of a bottom-filling bailer. The applicable regulatory agency requirements and the Project Manager should be consulted if in doubt about the appropriateness of using a bailer at a site or during a particular sampling event.

(f) During purging and sampling, the tubing should remain filled with water to minimize possible changes in water chemistry due to contact with the atmosphere. All flow-through cells should be shaded from direct sunlight to minimize the potential for off-gassing and temperature fluctuations.

(g) Ensure monitoring instruments (i.e., multi-parameter water quality instrument, turbidity meter, water level measuring device) are maintained in good condition and properly calibrated to ensure accurate readings. Be sure to have appropriate-sized extra batteries on hand.

(h) Adverse weather conditions may present challenges that need to be dealt with on a case-by-case basis. For example, air temperatures below 32°F may cause ice formation in the tubing, flow-through cell, and on the sampling equipment, or heavy rain could cause standing water issues with flush-mounted wells. Heavy rain can also impact electronic sampling equipment; preventative measures should be taken to keep electronic equipment dry.

(i) Observe and avoid any uncontrolled ambient/surrounding air conditions that could affect analytical results (e.g., truck/vehicle exhaust nearby, industrial building vents). Always ensure that vehicles are turned off during sampling to avoid introducing vehicle exhaust into the sample. If uncontrolled ambient/surrounding air conditions cannot be avoided, contact the Project Manager for further instruction; collection of a field blank sample may be warranted in this situation.

(j) Procedures should be established to minimize potential cross-contamination. For example:

- Wrap monitoring and sampling equipment with protective material (e.g., aluminum foil, polyethylene sheeting, Ziploc® bags) after decontamination and between sampling locations to minimize the potential for cross-contamination between well purging events at different locations.
- Use dedicated or disposable sampling equipment or new tubing at each sampling point when appropriate to minimize the need for decontamination.
- Protect sampling equipment and/or the open well head from blowing soil and dust by covering with plastic sheeting as needed.
- If a bailer and rope are used to purge and/or sample the well, then there is the possibility of contamination from the rope used to lower the bailer. New or dedicated rope should be used when appropriate. Alternatively, a decontaminated, Teflon®-coated stainless steel leader can be attached between the rope and the bailer. The leader acts as an extension to the rope and allows for the top of the bailer to enter the water column without immediately placing the rope into the water. It is important to keep the rope clean and not allow contact with the ground surface during bailing.

(k) Disposal of the groundwater collected during purging must be performed in accordance with all applicable regulations and the project-specific work plan.

(l) Clear tape should not be used to cover labels on containers used for certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

(m) In cases where it is difficult to obtain sufficient sample volume for multiple analytical fractions as well as required quality control (QC) analyses (*e.g.*, field duplicates, matrix spike/matrix spike duplicate [MS/MSD] analyses), discuss this situation with the Project Manager and laboratory prior to sample collection. Laboratories can often "make do" with less volume, especially for inorganic parameters, or increase the reporting limit proportional to the sample volume obtained.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Procedures for collecting groundwater samples from monitoring wells are described below. The project-specific work plan should also be consulted for specific details regarding sampling.

Sampling should always begin at the monitoring well with the least contaminated groundwater and systematically proceed to the well with the most contaminated groundwater, if possible.

2.1 Pre-sampling Activities

(a) It should be determined if there is the requirement to determine static water level measurements on all wells at the site prior to sampling, regardless if the well is being sampled.

(b) Prior to field activities, review historical groundwater sampling logs (if available) to maintain consistency for the current sampling event (e.g., equipment type, pump intake depth setting, flow rate, etc.)

(c) Organize monitoring, purging, and sampling equipment taking care not to allow cross-contamination. This can be accomplished by laying new polyethylene sheeting near the well or using new buckets, etc.

(d) Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to TRC SOPs and manufacturer’s equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

(e) Unlock the well cover on the well.

(f) Record the sample location, time, and date in the field book and/or on the Groundwater Field Data Record.

(g) On the Groundwater Field Data Record, note the physical condition of the well, including damage, deterioration, and signs of tampering, if any. Collect photographic documentation of serious damage to present to the Project Manager.

(h) Open the well cap and expansion plug, and stay upwind of and not directly over the well. Note any unusual odors, sounds, or difficulties in opening the well and, if required, measure the organic vapor reading at the rim of the well with a suitable organic vapor screening device (e.g., PID or FID), and record the reading in the field book and/or on the Groundwater Field Data Record. If pressure or vacuum is noted or suspected in the well, allow sufficient time for the water level elevation in the well to equilibrate.

(i) Gently lower a clean, decontaminated water level measuring device into the well to determine the static water level. If appropriate for site conditions, check for the presence of LNAPL or DNAPL using an oil/water interface probe (refer to RMD SOP 004, *Water Level and Product Measurements*). If LNAPL or DNAPL is detected, contact the Project Manager before proceeding with purging and sampling activities. Record the information on depth to groundwater to the nearest 0.01 feet, depth to LNAPL or DNAPL, and/or thickness of NAPL in the field book and/or the Groundwater Field Data Record. Refer to RMD SOP 004, *Water Level and Product Measurements*, for proper procedures in performing these measurements.

(j) If required in the project-specific work plan, measure the depth to the bottom of the well to assist in calculating the well volume of the well. If possible, avoid making total well depth measurements on the same day as sampling due to the tendency to disturb sediment during this measurement. If NAPL is suspected, use a decontaminated oil/water interface probe. If the measured depth is less than the constructed depth, this may indicate that the well needs to be redeveloped (see RMD SOP 006, *Well Development*). Consult the project-specific work plan or Project Manager for further instructions.

2.2 Groundwater Purging Activities

Purging is conducted to ensure that representative groundwater is obtained from the water-bearing unit for analysis. The multiple-volume or low-flow purging approach may be used to remove water from the well and monitor the water in order to determine when a well has been adequately purged (i.e., stabilized); at a minimum, the pH, specific conductance and temperature of the groundwater removed during purging should be monitored and recorded in the field notes. Other parameters may be required in some regulatory jurisdictions (e.g., turbidity). Additionally, the purge volume should be monitored and recorded. In some instances, such as when monitoring at solid waste disposal facilities, simply removing an adequate volume of water (e.g., three well volumes) may be suitable for adequate purging, and sampling can commence. Check with the project-specific work plan and appropriate regulatory guidance to determine any specific purging requirements.

If the well has been previously sampled consistent with this SOP, then the prior purging strategy (e.g., method, pump intake depth and the flow rates) should be followed during subsequent sampling events to maintain consistency and minimize potential variability due to the sampling procedure.

2.2.1 Multiple-Volume Purging Approach

The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization. The field parameters should be recorded at regular volumetric intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough (e.g., every 3 to 5 minutes) to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes may be sufficient.

Purge Volume

Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. The specific methodology for obtaining these measurements is included in SOP 004 *Water Level and Product Measurements*.

Once this information is known, the well volume can be calculated using Equation 1:

Well Volume (V) = $\pi r^2 h$ (cf) **Equation 1**

where:
π = pi (3.14)
r = radius of well in feet (ft)
h = height of the water column in ft. [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
cf = conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3.

The volume in gallons/linear foot (gal/ft) and liters/linear foot (L/ft) for common-size wells are as follows:

Well Inside Diameter (inches)	Volume (gal/ft)	Volume (L/ft)
1	0.0408	0.1529
2	0.1631	0.6174
3	0.3670	1.3892
4	0.6524	2.4696
6	1.4680	5.5570

If the volumes for the common-size wells above are utilized, Equation 1 is modified as follows:

Well volume = (h)(f) **Equation 2**

where:
h = height of water column (feet)
f = the volume in gal/ft or L/ft

For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed. The field notes should reflect the single-well volume calculations or determinations according to one of the above methods and a reference to the appropriate multiplication of that volume, (i.e., a minimum of 3 well volumes) clearly identified as a purge volume goal.

For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.

If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. If, after 3 well volumes have been removed, the field parameters have not stabilized (see discussion in Section 2.2.3), additional well volumes (up to a total of 5 well volumes), should be removed. If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging. If, after 5 well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible with respect to turbidity. The conditions of sampling should be noted in the field book.

2.2.2 Low-flow Purging Approach

The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample. The term low-flow refers to the low velocity with which water enters the pump intake during purging and sampling. The objective is to draw representative saturated zone water through the well screen to the pump intake while avoiding disturbance of the stagnant water above the well screen through minimizing drawdown of the water column in the well. To achieve this, the flow rate should be adjusted to less than 1 L/min (usually, this will be a rate less than 500 ml/min and may be as low as 100 ml/min). Once drawdown stabilizes, the sampled water is isolated from the stagnant water in the well casing, thus eliminating the need for its removal. This sampling method is based on the principle that water within the screened zone passes through continuously and does not mix with water above the screen. Water entering the pump can be considered representative of water in the formation after drawdown and indicator parameters have stabilized.

When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval (or center of the water column within the well screen if the water level is below the top of the well screen) to help prevent disturbance of any sediment at the bottom of the well. If known, the pump can be placed adjacent to the areas with the highest hydraulic conductivity or highest level of contaminants. Dedicated pumps can be utilized to minimize disturbance of the water column. Subsequent sampling events should duplicate as closely as possible the pump intake depth and the stabilized flow rate from the previous events.

To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.

The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings. Note any flow rate adjustments on the Groundwater Field Data Record. Once an appropriate purge rate has been achieved, record this information, continue purging until water quality indicator parameters have stabilized (see Section 2.2.3), and then sample the well.

Attempts should be made to avoid pumping a well dry. If drawdown cannot be maintained at less than 0.3 feet and the falling water level is approaching the top of the screened interval (or the top of the pump for sampling that began with the water level below the top of the screen), perform the following steps:

1. Reduce the flow rate, or turn the pump off and allow for recovery. (The pump must have a check valve to prevent backflow if it is shut off).
2. Begin pumping again at a lower flow rate.
3. If water draws down to the top of the screened interval again (or the top of the pump for sampling that began with the water level below the top of the screen), turn the pump off and allow for recovery.
4. If two tubing volumes (including volume of water in the pump and flow-through cell) have been removed during purging, sampling can proceed the next time the pump is turned on without waiting for indicator field parameters to stabilize. The project-specific work plan or Project Manager should be consulted for guidance.
5. If this procedure is used, this should be recorded in the field book and/or on the Groundwater Field Data Record.

2.2.3 Field Parameter Stabilization During Purging

Stabilization criteria may depend on project objectives or regulatory-specific requirements. Refer to Appendix A for some of the regulatory-specific requirements for field parameter stabilization. Generally, an adequate purge with respect to the ground water chemistry is achieved when, stability for at least three consecutive measurements is as follows:

- pH ± 0.1 standard unit (SU)
- specific conductance within 3%
- turbidity within 10% for values greater than 5 nephelometric turbidity units (NTUs). If three turbidity readings are less than 5 NTUs, the values are considered as stabilized

Other parameters, such as DO, may also be used as a stabilization parameter. Typical stabilization goals for DO are within 0.2 mg/L or 10% saturation, whichever is greater. DO measurements should be conducted using either a flow-through cell or an over-topping cell to minimize or reduce potential oxygenation of the sample.

Because groundwater temperature is generally not very sensitive in distinguishing between stagnant casing water and formation water and is subject to rapid changes during purging, its usefulness is subject to question for the purpose of determining parameter stability. Even if temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters, during well purging, as it may be needed to interpret other parameter results.

ORP is not always used as a stabilization parameter since it may also be subject to rapid changes during the purging process; however, it may be measured and recorded during well purging.

2.2.4 Special Considerations During Purging

Wells Purged Dry/Purge Adequacy

For wells with slow groundwater recovery, attempts should be made to avoid purging the well dry. This may be accomplished by slowing the purge rate. As water enters a well that has been purged dry, the water may cascade down the sand pack and/or the well screen, potentially stripping VOCs that may be present and/or potentially mobilizing soil fines into the re-accumulating water column.

However, even with slower purge rates, in some situations, a well may be pumped or bailed dry (evacuated) during the purging process. In these situations, evacuation generally constitutes an adequate purge and the well may be sampled following sufficient recovery (enough volume to allow filling of all sample containers). **It is not necessary that the well be evacuated three times before it is sampled.** Purging parameters should be measured and recorded during sample collection to serve as the measurements of record for the sampling event.

It is particularly important that wells be sampled as soon as possible after purging to maintain sample representativeness. If adequate volume is available upon completion of purging, the well should be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells that have a slow recovery should be scheduled so that they can be purged and sampled in the same day after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

Temporary Monitoring Wells

Procedures used to purge temporary groundwater monitoring wells may differ from permanent wells, because temporary wells are installed with different DQOs for immediate sample acquisition. Wells of this type may include standard well screens and risers placed in boreholes created by hand augering, power augering, or by drilling. Alternatively, they may consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler, or a Hydropunch® sampler.

Purging to address stagnant water may not necessarily apply to temporary wells, because stagnant water is not typically present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column may become, and the more appropriate it may be to apply, to the extent possible, standard permanent monitoring well purging criteria.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing saturated conditions, resulting primarily in increased turbidity. Therefore, the goal of purging, if conducted, may be to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low-stress purging techniques using variable-speed peristaltic pumps.

2.2.5 Equipment Considerations for Purging

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The pump of choice is usually a function of the purging approach (e.g., multiple-volume vs. low-flow), well diameter, the DTW, the total depth of the well, the amount of water that is to be removed during purging, the specific analytical testing program for the well, and the equipment previously used during purging and sampling of the well. A peristaltic pump is appropriate for purging whenever the head difference between the sampling location and the water level is less than the limit of suction (approximately 25' to 30') and the volume to be removed is reasonably small. For wells where the water level is below the limit of suction, and/or where there is a large volume of water to be purged, the variable-speed electric submersible pump or adjustable-rate bladder pumps would be appropriate. Bailers may also be used for purging in appropriate situations (e.g., shallow wells with small purge volumes); bailers are not suitable for low-flow purging.

The following subsections describe well evacuation devices that are most commonly used. Other devices are available but are not discussed in this SOP due to their limited use. Site-specific operating procedures should be developed in the case that an uncommon purge device is used.

2.2.5.1 Purging with a Suction Pump

There are many different types of suction pumps. They commonly include: centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low-volume pump that incorporates a roller to squeeze flexible tubing, thereby creating suction. This tubing can be dedicated to a well for re-use or discarded. It is recommended that 1/4 inch or 3/8 inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2 (applicable to peristaltic pumps only).
(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.
(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications.
(d) Ensure that the pump tubing is set at the pre-determined pump intake depth.
(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, adjust the rate accordingly or, if consistent with the purging and sampling objectives, lower the tubing further into the well and continue pumping.

(g) Using the water quality meter, take an initial reading of the required indicator parameters. All measurements, except turbidity, must be obtained using a transparent flow-through cell unless an unforeseen situation makes this impractical or inadvisable. Initially, turbidity may be elevated. Once turbidity has decreased to a measurable range, begin monitoring indicator parameters at approximately every 3-5 minutes, or as appropriate. Please note that flow-through cell size should be taken into account in conjunction with the flow rate to determine the length of time between water quality parameter readings. At least one flow-through cell volume should be turned over between readings. For example, if the flow through cell size is 500 mL and the flow rate is 100 mL/min, then it would be appropriate to measure water quality parameters every 5 minutes.

(h) Record the readings on the Groundwater Field Data Record. The monitoring probes must be submerged in water at all times. Record the indicator parameters, along with the water level, as described in Step (g) above. If removing a specified volume of water (e.g., 3-5 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. Stabilization criteria are discussed in Section 2.2.3.

Particulate build-up in the flow-through cell may impact indicator parameters. If the cell must be cleaned during pumping operations, continue pumping and disconnect the cell for cleaning, then reconnect and continue monitoring. Record the start and stop times, and describe the cleaning steps in the field book.

If indicator parameter stabilization is required and parameters have not stabilized after 2-hours of purging (or other pre-determined length of time), one of three options may be taken after consultation with the Project Manager:

1) continue purging until stabilization is achieved;
2) discontinue purging, do not collect any samples, and record in the field book and/or on the Groundwater Field Data Record the stabilization conditions and steps taken to attempt to achieve stabilization; or,
3) discontinue purging, collect samples and document attempts to achieve stabilization.

NOTE: If parameters do not stabilize, or turbidity remains greater than 5 NTU within the project-determined time range (EPA recommends up to 2 hours), contact the Project Manager to develop a modified sampling approach.

(i) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(j) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.2.5.2 Purging with a Submersible Pump

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110-

or 220-volt AC power supply. Those units powered by compressed gas (e.g., bladder pump) normally use a small electric controller that also needs a 12-volt DC battery or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells and the height of the potentiometric surface/water table (e.g., pressure head). It is recommended that 1/4-inch or 3/8-inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.

(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications. If the pump itself is being lowered into the well, ensure a safety line is attached.

(d) Non-dedicated purge/sampling vs. dedicated purge/sampling systems.

<u>Dedicated systems:</u> Pump has already been installed. Refer to historical monitoring well information, and record the depth of the pump intake in the field book and/or on the Groundwater Field Data Record.

<u>Non-dedicated systems:</u> Determine the target depth of the pump intake. Note that this may be a historical intake depth; see well construction data or the project-specific work plan. If there is not an established intake depth, the center of the screened interval should be targeted. If the measured water level is lower than the top of the well screen, position the pump intake at the midpoint of the water column. The intake should be generally 1 to 2 feet above the bottom of the well to minimize potential mobilization of any settled sediment, the risk of the pumping suction being broken, or the entrainment of air in the pump tubing and resulting sample. Slowly lower the pump, safety line, and tubing into the well to the pre-determined pump intake depth. The tubing should be cut to the desired length to assist in installing the pump. Measure the depth of the pump intake while lowering the tubing/pump into location. Record the pump intake depth in the field book and/or on the Groundwater Field Data Record. For deeper wells and large diameter wells, two staff members may be necessary to accomplish this task.

(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Measure the flow rate of the pump with a graduated container and stop watch. The pump pressure may need to be increased for discharge to occur. Record the volume of water collected for a period of 1 minute and calculate the flow rate as follows.

$$Flowrate\ (mL/min) = \frac{volume\ collected\ \ (mL)}{1\ minute}$$

(g) Measure the water level and record the flow rate and the water level. This should be performed every 3 to 5 minutes during purging. For low-flow purging, the flow rate should be adjusted to result in a rate between 100 to 500 mL/min; however, if drawdown of the well is observed, a slower flow rate may be necessary. If using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL volatile organic analysis (VOA) vial, if possible.

(h) Prior to recording the water quality indicator parameters, a minimum of one tubing volume should be purged. Note that this includes the volume of the flow-through cell.

(i) Proceed to steps (g) through (j) in Section 2.2.5.1.

2.2.5.3 Purging with a Bailer

(a) Determine the volume of water to be purged as described in Section 2.2.1.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of tubing or other purging/sampling equipment with foreign materials.

(c) Use a well-dedicated bailer (i.e., used exclusively for that well only), a decontaminated bailer or an unused, disposable bailer.

(d) Attach an appropriate length of (a) bailing line, (b) Teflon®-coated bailing wire or (c) rope with Teflon®-coated stainless steel leader to reach the bottom of the well. Secure a knot or series of knots to the top of the bailer. Be sure to have additional length of line to facilitate handling of the bailer at the surface (typically 10 ft).

(e) Lower the bailer gently into the well until it reaches the water column and fills with water from the bottom. Note: It is recommended that the bailer be lowered into the water to a depth that prevents the water from entering the top of the bailer. This is done to prevent excess turbulence caused by filling from the bottom and the top simultaneously. Controlling the line attached to the bailer as it is lowered into the well is also important to prevent degassing of the water as the bailer impacts the water. In shallow wells, controlling the line is not too difficult; however, for wells of greater depths it is common to utilize a hand-over-hand (windmill) approach using both hands to control longer lengths of line and prevent the loops in the line from tangling with one another. This procedure is simple to learn and saves a good deal of time by preventing tangles. Do not allow the bailing line or rope to become contaminated by surface soil.

(f) Once the bailer is full of water, gently withdraw the bailer from the well until it comes out of the top of the well. Be sure to control excess line in your hands to prevent the rope and bailer from touching the ground, and then grasp the bailer as it appears at the top of the well.

(g) Immediately pour the water into a vessel for water quality measurements, and record the measurements in the field book or on the Groundwater Field Data Record (at the project-required frequency). Otherwise, pour water into a 5-gallon bucket or other vessel to track the volume purged. As a general rule, standard 2-inch bailers are able to hold about 1 liter of water when full. This process will have to be repeated several times to complete adequate purging of the well (e.g., three to five well volumes).

(h) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(i) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.3 Post-purging Groundwater Sample Collection

(a) New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.

(b) If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell or sample from the T-connector, if used. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.

(c) If using bottom-filling bailers,

- Slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling).
- Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.

2.3.1 Sample Collection Order

Fractions of the groundwater sample should be collected in the following order (i.e., decreasing volatility) unless otherwise specified in the project-specific work plan:

1. VOCs;
2. Semivolatile organic compounds (SVOCs);
3. Other organic parameters;
4. Unfiltered inorganic constituents (e.g., total metals);
5. Filtered inorganic constituents (e.g., dissolved metals); and
6. Other constituents.

During sample collection, allow the water to flow directly down the side of the sample container without allowing the tubing to touch the inside of the sample container or lid in order to minimize aeration and turbulence and maintain sample integrity. The tubing should remain filled with water.

2.3.2 VOC Sample Collection

Collection of VOCs/Volatile Petroleum Hydrocarbons (VPH): Samples for VOCs will be collected first unless they are being collected by the "straw" method described in Section 1.6.2 (d), and the sample vial must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken to not flush any preservative out of the vial when topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. Note: Extra VOC vials should be obtained prior to the sampling event in case this situation occurs.

Note: When using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 ml VOA vial, if possible.

When acid preservation is used for the collection of VOCs, the acid must be added to the vials before sample collection. However, in most cases 40-ml VOA vials come pre-preserved. If a pre-preserved vial effervesces upon the addition of sample, the acid preservative can be rinsed out of the vial with sample water and then used to collect the sample. The laboratory should be made aware that the affected sample will not be acid-preserved as this may affect the sample holding time. Note effervescence in the field book for future reference.

2.3.3 Non-VOC Sample Collection

Completely fill the remaining sample containers for all non-VOC analyses.

Preserve the non-VOC samples in accordance with method and project-specific requirements following sample collection if the sample containers are not pre-preserved. (**NOTE:** Pre-preserved vials may be supplied by the laboratory, depending on the program).

2.3.4 Field Filtering

Depending upon project requirements, field filtering may be performed for non-VOC analyses. An in-line filter should be fitted at the end of the discharge tubing and the sample should be collected after the filter. Pre-rinse the in-line filter by allowing a minimum of 0.5 to 1 liter of groundwater from the well to pass through the filter prior to sampling. Ensure the filter is free of air bubbles prior to collecting samples. Preserve the filtered water sample immediately or directly fill pre-preserved containers (if provided). Clearly note "filtered" or "dissolved" on sample label and COC document.

2.4 Groundwater Sample Collection Without Purging (Passive Sampling)

Passive sampling can be defined as the free flow of contaminants from the media being sampled to a receiving phase in a sampling device. Depending upon the sampler, the receiving phase can be a solvent (e.g., water), chemical reagent, or porous adsorbent (e.g., activated carbon). While there are many different types of passive samplers, most have a barrier between the medium being sampled and the receiving phase. The barrier determines the sampling rate that contaminants are collected at a given concentration and can be used to selectively permit or restrict various classes of chemicals from entering the receiving phase.

There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers.

Passive samplers are deployed down a well to the desired depth within the screened interval or open borehole to obtain a discrete sample without using pumping or a purging technique. Most samplers are able to be stacked to obtain samples at multiple depths. Some samplers can also be used to measure contaminants in groundwater as it enters a surface water body.

Diffusion, or equilibrium, samplers are devices that rely on diffusion of the analytes to reach equilibrium between the sampler fluid and the well water. Samples are time-weighted toward conditions at the sampling point during the latter portion of the deployment period. The degree of weighting depends on analyte and device-specific diffusion rates. Typically, conditions during only the last few days of sampler deployment are represented. Depending upon the contaminant of concern, equilibration times range from a few days to several weeks. Diffusion samplers are less versatile than grab samplers as they are not generally effective for all chemical classes.

Both the diffusion and integrating samplers depend upon permeation or diffusion through barriers that hold the receiving phase. This diffusion process is chemical and barrier specific. Diffusion samplers are commonly known as PDBs or rigid porous polyethylene (RPP) samplers. PDBs may be used to sample for VOCs, and RPPs may be used to sample for various organic and inorganic constituents. PDBs must be allowed to remain in the well for a sufficient period of time to allow the deionized water in the sampler to come into equilibrium with the constituents in the ambient groundwater.

Some regulatory agencies allow groundwater samples to be collected without purging the well. This may be accomplished by suspending a passive sampler in the well for a period of time appropriate for the type of passive sampler being used. It is important to confirm that the chosen sampler is compatible with the contaminants of concern including all VOCs of interest at the site.

Diffusion passive samplers are used most commonly and the procedure for their use is as follows:

(a) Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.

(b) New passive samplers are attached via PVC cable ties to a tether (a pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well. There should be sufficient well screen saturation within the well to completely cover the passive sampler. For VOCs, it is recommended that there should be several feet of groundwater above the top of the PDB.

(c) The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers). Longer equilibration times may be necessary in lower permeability formations. Once sufficient time for equilibration has passed, the PDB samplers can be retrieved when convenient.

(d) Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.

(e) Detach the passive sampler from the tether.

(f) Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

(g) Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. Tilting the passive sampler will control the flow rate. The VOA vials must be filled within the first several minutes of passive sampler retrieval. (Note that sample vials should be prepared and opened on a stable surface or holding device such as a foam pack. Decanting sample from passive samplers into containers requires techniques that may require some practice and patience.) Refer to Section 2.3.2 for special circumstances regarding the filling of VOA vials.

(h) A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.

(i) Dispose of the passive sampler after use.

2.5 Post-sampling Activities

(a) Cease pumping and, if system is non-dedicated, disassemble and decontaminate the purging and sampling equipment. Verify the end of the tubing is not submerged in the purge bucket prior to turning off the pump.

(b) Dispose of the bailer (if disposable) and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the bailer in a plastic bag for transport to the site decontamination area.

(c) Dispose of the empty passive sampler and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the empty passive sampler in a plastic bag for transport to the site decontamination area

(d) Replace the well cap and well cover on the well and lock the outer casing (if present).

(e) Label each sample. If the labels are covered with clear tape, ensure this is not performed for VOA vials.

(f) Place all samples in a cooler with ice.

(g) Ensure samples are delivered to the laboratory well before the required holding time expires.

(h) Consult the project-specific work plan to determine if a calibration check is required at the end of the day for the water quality parameters.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of QC samples is dependent upon the DQOs. Project-specific work plans should be consulted to determine the required frequency of QC sample collection.

4.1 Field Duplicates

The following procedures should be used for collecting field duplicates of groundwater samples:

(a) For QC purposes, each duplicate sample will be typically submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for groundwater sampling will be employed. However, a sample collection time will not be included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book and/or on the Groundwater Field Data Record.

(b) Each duplicate sample will be collected simultaneously with the actual sample by alternately filling sample and duplicate bottles. Following the order of collection specified for each set of containers (VOCs, SVOCs, other organic parameters, unfiltered inorganic constituents, and filtered inorganic constituents), the duplicate sample containers will be alternately filled with groundwater for each parameter.

(c) All collection and preservation procedures outlined for groundwater sampling will be followed for each duplicate sample.

4.2 Equipment Blanks

Equipment blanks include reagent water that is run through the bailer (if not disposable), rope, leader line, decontaminated pump, a representative section of the pump's tubing, or any other piece of sampling equipment that may have come in contact with the sample. The equipment blanks are collected and preserved in the same sample containers as field samples. If dedicated or disposable systems are used, equipment blanks are not required, although an initial blank could be performed to demonstrate that the dedicated equipment is clean prior to use. If only dedicated tubing is used, the equipment blank will include only the pump in subsequent sampling events. A passive sampler is considered a dedicated device and no equipment blank is required.

Ideally, the reagent water should come from the laboratory and be certified clean. If not certified and/or if not from the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should be sent to the laboratory for analysis.

4.3 Trip Blanks

Trip blanks will be used to check for potential contamination of VOCs via migration during storage and shipping. Trip blanks typically consist of two to three 40 mL VOA vials filled with analyte-free water and preserved with hydrochloric acid (HCl) to pH <2 SU. Trip blank containers are usually supplied pre-filled by the laboratory. Trip blanks are typically submitted to the laboratory at a frequency of one per cooler for coolers that contain samples for VOC and/or VPH analysis. Trip blanks are analyzed by the laboratory for VOCs and/or VPH, depending on field sample analyses.

4.4 MS/MSDs and MS/Duplicates

MSs are an additional analysis of a sample spiked by the laboratory with a subset or all of the target analytes and are used to demonstrate the accuracy of analytical methods for a given matrix. MSDs are an additional analysis of a sample spiked with a subset or all of the target analytes and are also used to demonstrate the accuracy of analytical methods for a given matrix. MS/MSDs also provide a measure of analytical precision for a given matrix. Duplicates are an additional analysis of a sample and are used to demonstrate the precision of analytical methods for a given matrix.

Triplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform the MS/MSD analyses for organic parameters. Duplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform MS/Duplicate analyses for inorganic parameters. The sample designated for MS/MSD or MS/Duplicate analyses should be noted in the Comments column of the COC document.

4.5 Temperature Blanks

Temperature blanks consist of a sample container filled with non-preserved water (potable or distilled) and typically are included in all coolers that contain samples that require temperature preservation. These may be added to the coolers by the field team if not provided by the laboratory. Temperature blanks must remain inside the coolers on ice during the sampling process.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the sample location, sample identification, and date and time of collection in the field book and/or the Groundwater Field Data Record. The Groundwater Field Data Record (Attachment B) should be used to record the following information:

- Volume of each sample
- Sample identification number
- Sample location (sketch of the sample point)
- Time and date sample was collected
- Personnel performing the task
- Volume of water removed
- Purging time
- Flow rate during purging and sampling
- Weather conditions during sampling
- Field parameters such as water level, pH, temperature, conductivity, turbidity, ORP, and DO
- Sample collection equipment and method used
- Decontamination procedures
- Analytical parameters
- Preservation method and amount of preservative

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the records management procedures specified in the project-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

Interstate Technology Regulatory Council (ITRC). March 2006. *Technology Overview of Passive Sampler Technologies.*

USEPA. November 1992. *RCRA Ground-Water Monitoring: Draft Technical Guidance*. EPA/530-R-93-001. USEPA Office of Solid Waste.

USEPA. April 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA Ground Water Issue. EPA/540-S-95-504. USEPA Office of Solid Waste and Emergency Response.

USEPA. May 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. EPA/542-S-02-001. USEPA Office of Solid Waste and Emergency Response.

USEPA. September 2004. Field Sampling Guidance Document #1220: Groundwater Well Sampling. USEPA Region 9 Laboratory Richmond, California.

USEPA, January 19, 2010. *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*. USEPA Region 1, Rev. 3.

USEPA. March 6, 2013. *Groundwater Sampling.* SESDPROC-301-R3. USEPA Region 4, Science and Ecosystem Support Division. Athens, Georgia.

USEPA. April 22, 2014. Passive (No Purge) Samples.
http://www.clu-in.org/characterization/technologies/default.focus/sec/Passive_%28no%20purge%29_Samplers/cat/Overview/

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	AUGUST 2014	NOT APPLICABLE