DRAFT

Removal Action Workplan
Research, Education, and Support Area and Groundwater

Five-Year Review

Richmond Field Station Site
University of California, Berkeley

Prepared for

Office of Environment, Health and Safety
University of California, Berkeley
317 University Hall, No. 1150
Berkeley, California 94720

December 31, 2019

Prepared by

TETRA TECH, INC.
1999 Harrison Street, Suite 500
Oakland, California 94612

Jason Brodersen, P.G., No 6262 [Professional stamp to be included in final version]

CONTENTS

Figures

Tables

Appendices

ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per liter
BAP (EQ)	Benzo(a)pyrene Equivalency Factor
CAG	Community Advisor Group
CFR	Code of Federal Regulations
DTSC	Department of Toxic Substances Control
EIR	Environmental Impact Report
EPA	U.S. Environmental Protection Agency
FS/RAP	Feasibility Study/Remedial Action Plan
LRDP	Long Range Development Plan
MCL	Maximum contaminant level for drinking water
MFA	Mercury Fulminate Area
mg/kg	Milligrams per kilogram
NOS	Natural Open Space
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated Biphenyl
RAW	Removal Action Workplan
RBC	Risk-based concentration
RES	Research, Education, and Support
RFS	Richmond Field Station
SMP	Soil Management Plan
TCE	Trichloroethene
TCRA	Time-Critical Removal Action
TSCA	Toxic Substances Control Act
UC	University of California
VOC	Volatile organic compound

1.0 INTRODUCTION

University of California (UC) Berkeley has been conducting investigation and cleanup actions at the Richmond Field Station (RFS) under the oversight of the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC), in compliance with the Site Investigation and Remediation Order for the former RFS Site, Docket No. IS/E-RAO 06/07-004, dated September 15, 2006 (RFS Site Investigation and Remediation Order). The RFS Site Investigation and Remediation Order provides for the investigation and cleanup of 96 acres of upland and 13 acres of tidal marsh and transition habitat within RFS.

The purpose of a Five-Year Review is to evaluate the implementation and performance of a remedy to determine if the remedy is, and will continue to be protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in this five-year review report. The report also identifies any issues found during the review and makes recommendations to address them. This document is prepared consistent with U.S. Environmental Protection Agency (EPA) Comprehensive Five-Year Review Guidance (EPA 2001) and EPA Five-Year Review Recommended Template (EPA 2016).

This is the first Five-Year Review for RFS. UC Berkeley published the Final Removal Action Workplan (RAW) (Tetra Tech 2014), which presents soil cleanup actions to be conducted within the Research, Education, and Support Areas (RES), and for groundwater throughout RFS. The 2014 publication year of the RAW is the triggering action for this Five-Year Review. This report has been prepared because hazardous substances, pollutants, or contaminants remain at RFS above levels that allow for unrestricted use and unrestricted exposure.

The scope of the Five-Year Review is based on the RAW, and consists implementation of (1) three specific soil removal actions, (2) a cinder management plan, (3) land use controls for soils, (4) a soil management plan (SMP), (5) three specific groundwater monitoring actions, and (6) land use controls for groundwater. Other portions of RFS designated as Natural Open Space (NOS) are not included in the scope of this Five-Year Review, since a decision document has not been prepared for the NOS.

The RFS Five-Year Review was authorized and directed by UC Berkeley and prepared by Tetra Tech, Inc. DTSC participated in the scoping and site inspection, and will complete the review, and approval processes. Respondents of the RFS Site Investigation and Remediation Order were notified of this review which was initiated in April 2019.

2.0 BACKGROUND

This section provides a brief summary of site characteristics and land uses relevant to the five-year review process. Specific details for these topics are presented in the Final Current Conditions Report (Tetra Tech 2008), Final Site Characterization Report (Tetra Tech 2013), and RAW (Tetra Tech 2014).

2.1 PHYSICAL CHARACTERISTICS

The site is located at 1301 South 46th Street in Richmond, California, along the eastern shoreline of the Richmond Inner Harbor of the San Francisco Bay and northwest of Point Isabel. The site is bounded to the north by Meade Street and Hoffman Boulevard, east by South 46th street, south by the East Bay Regional Park District Bay Trail and the San Francisco Bay, and west by Meeker Slough and Regatta Boulevard. The site is located immediately to the west of the former Zeneca/Campus Bay site. The site map is presented as Figure 1.

The site consists of: (1) Upland Areas developed for academic teaching and research activities, upland remnant coastal terrace prairie; (2) a tidal salt marsh (Western Stege Marsh); and (3) a transition zone between the academic teaching and research activity areas and the marsh. The 96-acre Upland Areas consist of native soils and small areas of imported fill material. The 7.5-acre Western Stege Marsh includes a small isolated area of artificial fill, known as the “Island,” that occupies 0.425 acre and is surrounded by tidal marsh. The 5.5-acre Transition Area consists entirely of artificial fill placed on historical mudflats. The Upland Areas, Transition Areas, and Western Stege Marsh are shown on Figure 2.

2.2 LAND USE

RFS is owned by the Regents of the University of California (UC Regents). In October 1950, the UC Regents purchased the eastern portion of the property from the California Cap Company. From 1950 through 1963, UC acquired the adjacent undeveloped property between Avocet Way and Regatta Boulevard in the western portion of the property.

In May 2014, the UC Regents approved the Long Range Development Plan (LRDP) and Environmental Impact Report (EIR) which identify two land use designations for current and future land uses at RFS: (1) Research, Education, and Support (RES), and (2) Natural Open Space (NOS). The LRDP and EIR will guide growth and development of the campus through year 2050, unless otherwise amended prior. RES and NOS areas are shown on Figure 1.

The RES land use applies to areas that are either currently developed with facilities that would remain in their present form or be expanded, or that would be developed with new facilities. Specific land uses within the RES include: college-level classrooms and laboratories, office, and administration buildings for researchers, faculty, postdocs, students, and non-UC public and private entities. The RES also includes storage areas for UC and non-UC tenants, and RFS facility maintenance activities.

The NOS land use applies to areas that UC plans to protect from development and maintain in their natural condition. The NOS includes natural areas such as the Western Stege Marsh and coastal grasslands. Human engagement and disruption to these spaces is limited, with the intent to protect, restore, and maintain these resources in their natural condition.

3.0 RESPONSE ACTION SUMMARY

This section provides a summary of (1) the rationale for the response actions identified in the RAW, presented as the basis for action; (2) a review of response actions completed to date and those identified in the RAW; and, (3) the status of actions identified in the RAW. Details regarding the actions presented in each section are presented in the respective reference documents.

3.1 BASIS FOR ACTION

The basis for action is a summary of the chemicals of potential concern and receptors that have been or could be affected by those chemicals (EPA 2016).

The chemicals of potential concern are defined as chemicals exceeding screening criteria listed in the RAW, as updated in this Five-Year Review and presented in Section 4. Table 1 presents the list of chemicals of potential concern.

The chemicals of potential concern and receptors comprise the remedial action objectives presented in the RAW, as summarized below. Response action areas are shown on Figure 2.

- Mercury Fulminate Area (MFA) and Corporation Yard: prevent exposure of (a) current and future maintenance and construction workers and future commercial workers via dermal contact with, and incidental ingestion and inhalation of, soil containing mercury, arsenic, lead, benzo(a)pyrene equivalent (BAP [EQ]), and dioxin concentrations above the RAW remedial goals, and (b) current and future off-site receptors via inhalation of soil containing mercury, arsenic, lead, BAP (EQ), and dioxin concentrations greater than the RAW remedial goals.

- Transformer Areas: prevent exposure of (a) current and future maintenance and construction workers and future commercial workers via dermal contact with, and incidental ingestion and inhalation of, soil containing total polychlorinated biphenyl (PCB) concentrations above the remedial goals; and (b) off-site receptors via inhalation of soil containing chemical concentrations above the remedial goals.

- Future projects within the RES: prevent exposure of (a) commercial workers, maintenance workers, and construction workers via dermal contact with, and incidental ingestion and inhalation of, soil containing chemical concentrations above the receptor-appropriate remedial goals, and (b) off-site receptors via inhalation of soil containing chemical concentrations above the remedial goal for off-site receptors.

- Groundwater: prevent exposure of current and future maintenance workers, construction workers, and off-site receptors, and future commercial workers via inhalation of unsafe vapors from groundwater containing carbon tetrachloride or trichloroethene (TCE).

3.2 RESPONSE ACTIONS

Previous remediation activities at the RFS occurred from 2002 through 2003 in three phases under the oversight of the California Regional Water Quality Control Board, until DTSC provided lead agency authority in 2005. Two Time-Critical Removal Actions (TCRA) were implemented under DTSC's authority prior to issuance of the RAW. The RAW presents response actions to be implemented throughout the RES and for groundwater.

Response Actions Under RWQCB Authority

Remediation Phases 1 through 3 were completed in 2002, 2003, and 2004 and detailed in the Final Current Conditions Report (Tetra Tech 2008):

- Phase 1 consisted of excavation and subsequent stabilization of cinder- and mercury-contaminated soil and sediment in the eastern portions of the Transition Area and Western Stege Marsh, designated as Subunit 2, Areas 1 and 4. Excavations were backfilled with clean upland soil and imported clean Bay Mud, as appropriate, and a biologically-active barrier was installed on the eastern portion of Western Stege Marsh to treat any residual metals contamination in groundwater prior to discharge into Western Stege Marsh.

- Phase 2 consisted of continued excavation and stabilization of cinder- and mercury-contaminated soil and sediment from Subunit 2, Areas 1 and 4, and two areas in the central and western portions of Western Stege Marsh, designated as Areas M3 and M1a. Excavations were backfilled with clean upland soil and imported clean Bay Mud. Invasive, non-native vegetative species were also removed and native vegetative materials were planted pursuant to the marsh restoration plan.

- Phase 3 consisted of excavation of cinder materials from upland Remediation Areas 1 through 6 and sediment to widen the existing channel in the north-central portion of Western Stege Marsh at marsh area M3. Phase 3 also included the installation of permanent fencing and signage along the East Bay Regional Park Bay Trail.

Response Actions Under DTSC Authority, Prior to RAW

Two TCRAs were conducted under the oversight of DTSC prior to the issuance of the RAW.

- The first TCRA consisted of the removal of arsenic-contaminated soil at the Former Forest Product Laboratory in October 2007, located near Building 478. The contaminated soil was excavated and disposed of off-site, and backfilled with clean import material. Details are included in the Implementation Summary Report (Tetra Tech 2008a).

- The second TCRA consisted of the removal of PCB-contaminated soil within two subareas at the Western Transition Area in October 2008. The contaminated soil was excavated and disposed of off-site, and backfilled with clean import material. Details are included in the Implementation Summary Report (Tetra Tech 2009).

Response Actions Identified in RAW

The RAW identifies specific response actions for soil within the RES, and groundwater throughout the site.

Soil Remedy

1. Excavation of PCB–impacted soils at Building 112 and Building 150 Transformer Areas and three areas within the Corporation Yard with total PCB concentrations exceeding the Toxic Substances Control Act (TSCA) high occupancy without further conditions threshold of 1 milligram per kilogram (mg/kg).

2. Excavation of mercury-impacted soil at the MFA exceeding the remedial goal of 275 mg/kg.

3. Excavation of BAP (EQ)-impacted soil exceeding the remedial goal of 0.4 mg/kg, and dioxin-impacted soil exceeding the remedial goal of 1.64 x 10-05 mg/kg.

4. Management of cinders encountered during soil excavations.

5. Implementation of site-wide land use controls, consisting of deed restrictions identifying the future use of the site as commercial only, and mandating that future site soil disturbance or soil movement be conducted under the SMP.

6. Implementation of the SMP which provides a framework for excavation and soil management, in conjunction with redevelopment or construction projects for chemicals in soil exceeding Category I or II screening level remedial goals within the RES.

Groundwater Remedy

1. Monitoring natural attenuation of groundwater with carbon tetrachloride exceeding the remedial goal of 2.63 micrograms per liter (µg/L) at the western edge of the Coastal Terrace Prairie.

2. Continuing groundwater monitoring throughout the site.

3. Treatment and monitoring of contaminants in groundwater originating from the former Zeneca/Campus Bay Site, including TCE and its breakdown components, under the Zeneca Order.

4. Implementation of site-wide land use controls consisting of deed restrictions prohibiting groundwater extraction for purposes other than groundwater monitoring/treatment or construction dewatering.

3.3 STATUS OF IMPLEMENTATION

A summary of the actions completed and the current status of each response action identified in the RAW are presented below.

Soil Response Action	Actions Completed/Current Status
1. PCB soil removal at Building 112, Building 150, and Corporation Yard	PCB-contaminated soil was removed from Building 150 and the Corporation yard in October 2017. Contaminated soil was successfully removed at Building 150. Contaminated soil was removed at the Corporation Yard; however, the extent of contamination was much larger than the estimates provided in the RAW and residual contamination was left in place. The excavations were backfilled with clean soil and the areas were secured with fencing to eliminate possible exposure. UC Berkeley is working with DTSC and EPA to develop a strategy for completing the removal of PCB-contaminated soil at the Corporation Yard. Following completion of the response action, all data from Building 150 and the Corporation Yard will be presented in a summary report for agency review and approval, and the response will be considered complete. PCB-contaminated soil at Building 112 is scheduled for removal in the first quarter of 2020. All data will be presented in a summary report for agency review and approval, and the response will be considered complete.
2. Mercury soil removal at MFA	A pilot study was completed in June 2018 which further defined the extent of contamination to enable a more efficient and effective response action. A second pilot study was completed in December 2018 to evaluate mercury vapor controls and waste profiling. Subsequently, 79 cubic yards of mercury-contaminated soil were removed, and the excavations were backfilled with clean soil. The soil removal is scheduled to be completed in January 2020. All data will be presented in a summary report for agency review and approval, and the response will be considered complete.
3. BAP (EQ) and dioxin soil removal at Corporation Yard	BAP (EQ)- and dioxin-contaminated soil was removed from the Corporation yard in October 2017. Completion of the response action will be confirmed following discussions with the agencies regarding additional PCB-contaminated soil removal at the Corporation Yard, as there are comingled contaminants. Following completion of the response action, all data from the Corporation Yard will be presented in a summary report for agency review and approval, and the response will be considered complete.
4. Cinder management	UC Berkeley Environmental Health and Safety Department has successfully implemented cinder management protocols consistent with the RAW at all soil excavation projects at RFS.
5. Land use controls	Land use controls identified in the RAW will be implemented following the completion of soil response actions 1, 2, and 3 above.

Soil Response Action	Actions Completed/Current Status
6. Implement SMP	UC Berkeley Environmental Health and Safety Department has successfully implemented SMP protocols consistent with the RAW at all soil excavation projects at RFS. Ongoing reviews of the SMP have resulted in SMP Revision 1 published in April 2017, and Revision 2 in December 2019. SMP Revision 2 is included as Appendix A to this report. A summary of SMP activities is included as Table 2 of this report. All SMP activities are documented at the RFS website (https://rfs-env.berkeley.edu/current-activities/smp-forms).

Groundwater Response Action	Actions Completed/Current Status
1. MNA Coastal Terrace Prairie	UC Berkeley has conducted groundwater monitoring in the Coastal Terrace Prairie since the issuance of the RAW in April 2015 through April 2019. Results at piezometer CTP indicate carbon tetrachloride has decreased in concentrations from a high of 25 µg/L in 2011 to 5.8 µg/L in 2019. UC Berkeley will continue to monitor carbon tetrachloride in the Coastal Terrace Prairie through the groundwater monitoring program.
2. Continued groundwater monitoring	UC Berkeley has conducted groundwater monitoring since the issuance of the RAW in July 2014. Site-wide water level measurements have been conducted in Wet and Dry seasons from 2014 through 2019. Groundwater sampling has been conducted in April 2015 through April 2019. UC Berkeley will continue to implement the groundwater monitoring program.
3. TCE remedy under the Zeneca Order	The TCE remedy is presented in the Campus Bay Final Feasibility Study/Remedial Action Plan (FS/RAP) (Terra Phase 2019). Under this response action, UC Berkeley monitors implementation of the remedy presented in the FS/RAP as approved. The implementation plan is scheduled for submittal by the Zeneca respondents on December 24, 2019.
4. Land use controls	Land use controls for groundwater will be implemented with the land use controls for soil, following the completion of soil response actions 1, 2, and 3 presented above.

4.0 FIVE-YEAR REVIEW PROCESS

The Five-Year Review process consists of community notification, data review, and site inspection, as presented below.

4.1 COMMUNITY INVOLVEMENT AND NOTIFICATION

UC Berkeley and DTSC have implemented several community involvement mechanisms throughout the site investigation and remediation process at RFS. As there are several hundred UC and non-UC tenants at RFS, UC Berkeley conducts Town Hall meetings for all tenants to discuss current status and progress of all environmental activities; the Town Hall meetings are generally held on a biannual basis. UC Berkeley provides monthly updates to DTSC for status updates to the Richmond Southeast Shoreline Area Community Advisory Group (CAG). UC Berkeley meets monthly with the RFS representative to the CAG to provide environmental updates and answer questions regarding ongoing or upcoming activities.

UC Berkeley provides environmental updates and posts technical documents at the RFS website (https://rfs-env.berkeley.edu). All final major documents are provided to the City of Richmond Public Library and a public reading space with all final documents is provided at RFS Building 478. All incoming students, faculty, staff, tenants, and workers potentially exposed to on-site contaminants are required to complete the "Working at the Richmond Field Station Awareness Training" (https://rfs-env.berkeley.edu/working-rfs-training-module). The training presents a brief history of RFS, information about the current remediation and restoration project, and safe work practices required to be followed by all members of the RFS community.

DTSC prepared a public notice in August 2019 regarding the Five-Year review for RFS. The notice was sent to the email list-serve distribution for RFS as well as posted in the Marketplace section of the West County Times on August 30, 2019. The Public notice provided an overview of the process, site history and remedy, link to DTSC's EnviroStor website which includes all previous RFS documents submitted to DTSC, and individual DTSC contacts.

4.2 DATA REVIEW

The data review task consists of evaluating existing data or trends which have occurred primarily in the previous 5 years since the publication of the RAW, including a review of cleanup goals.

Environmental activities at RFS, including response actions, status, and data trends, are evaluated on a monthly basis by UC Berkeley, DTSC, and EPA, as a part of monthly technical management meetings at RFS. Specifically, all soil response actions are included within the monthly agenda, and groundwater evaluation and trends are addressed within the yearly monitoring reports.

Soil Response Actions

Soil response actions include the removal of approximately 50 cubic yards of PCB-, BAP (EQ)-, and dioxin-contaminated soil at Buildings 112, 150, and at the Corporation Yard, and removal of 71 cubic yards of mercury-contaminated soil at the MFA.

PCBs at Building 112. No response actions have been conducted and no data generated since the publication of the RAW. The response action is scheduled for the first quarter of 2020.

PCBs at Building 150. PCB-contaminated soil was removed from Building 150 in November 2017. Confirmation samples collected from three of the four sidewalls had PCB concentrations of 0.185 mg/kg, 1.26 mg/kg, and 1.48 mg/kg. The fourth sidewall consisted of concrete from the adjacent transformer and no sample was collected. The confirmation sample result collected from the bottom of the excavation was 2.57 mg/kg. The excavation was backfilled with clean fill and finished to grade.

PCBs at Corporation Yard. PCB-contaminated soil was removed from the Corporation at seven excavations. Several iterations of step-out excavations were completed due to elevated confirmation sampling results, particularly adjacent to Building 120. UC Berkeley excavated approximately twice the volume of PCB-contaminated soil identified in the RAW. Confirmation sample results ranged from below the 1 mg/kg to 494 mg/kg at a bottom location, and 8,240 mg/kg at a sidewall location. Both elevated concentrations were adjacent to Building 120. All other confirmation samples were below 20 mg/kg. All excavations were backfilled with clean fill and finished to grade.

Surface samples were collected in December 2017 adjacent to the excavations to characterize soil from the surface to 2 inches below ground surface (bgs). Results ranged from 0.72 mg/kg to 5.48 mg/kg. All areas above the cleanup goal of 1 mg/kg were fenced and secured.

Concrete samples were collected from the floor of Building 120 in September 2018 to ensure no PCB source remained at Building 120. Samples were analyzed for PCBs and dioxins; all results were below the cleanup goals.

Additional surface samples were collected in September 2019 to characterize all surface soils within the Corporation Yard for PCBs from 0 to 2 inches bgs. Total PCB results from the area adjacent to the fenced area were 2.76 mg/kg and all other areas were below 1 mg/kg.

Mercury at MFA. Two pilot studies conducted in 2018 provided additional characterization data necessary to prepare the scope of work for the excavation of mercury-contaminated soils. The pilot studies resulted in larger excavation boundaries than identified in the RAW. No other changes to the RAW are anticipated. The removal of mercury-contaminated soil is scheduled to begin January 6, 2020.

BAP (EQ) and Dioxins at Corporation Yard. BAP (EQ)-contaminated soil was removed from seven excavations at the Corporation Yard in November 2017. Confirmation sample results were above the cleanup goal at four of the excavations ranging from 0.52 mg/kg to 108 mg/kg. Dioxin-contaminated soils were excavated from the Corporation Yard in November 2017. Dioxins were sampled at two of the seven excavations; both exceeding the cleanup goals ranging from to 0.65 x 10-05 mg/kg to 9.1 x 10-05 mg/kg.

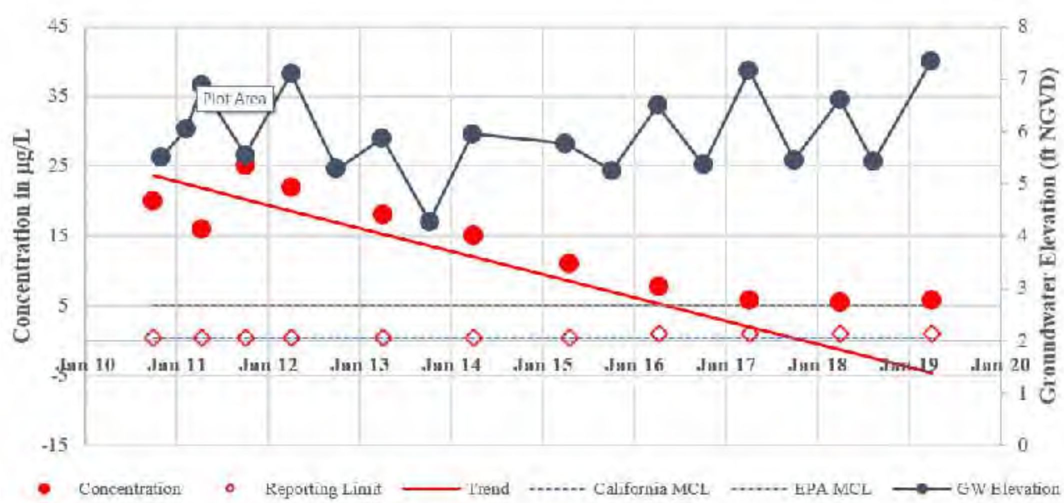
As discussed in Section 3.0, these soil response actions have not been completed and residual soil remains on site above the cleanup goals. As discussed in the Updated Cleanup Goals section below, completion of the soil removal actions will be based on the updated cleanup goals and based on continued discussions with DTSC and EPA.

Groundwater Response Actions

Groundwater monitoring consists of yearly collection of groundwater samples for volatile organic compounds (VOC) and metals analyses. Details regarding groundwater trends since the publication of the RAW are provided in the most recent groundwater monitoring report (Tetra Tech 2019). A summary is presented below.

- Concentrations of VOCs detected at RFS since the first sampling event in November 2010 demonstrate a noted overall decreasing trend, specifically for carbon tetrachloride and TCE. Trend graphs presented in the groundwater monitoring reports show decreasing concentrations of TCE at piezometers B120, B175S, B178, B185, and B197/197R. The trend graph for CTP demonstrates decreases in carbon tetrachloride concentrations. While some VOCs continue to be detected above California and federal maximum contaminant levels for drinking water (MCL), the overall trend across the RFS since sampling began in 2010 is a reduction in VOC concentrations. Most VOCs detected at concentrations exceeding the California or federal MCLs were detected within the eastern and southeastern portion of the property boundary, adjacent to the Campus Bay site. Carbon tetrachloride continues to be detected exceeding the MCL at location CTP on the northwestern portion of the site; the trend is decreasing from a historic high of 25 µg/L in 2011 to 5.8 µg/L in 2019. Vinyl chloride at PZ11 demonstrated an increasing trend in concentrations with a significant increase noted from 2017 to 2018; however, the 2019 sampling event also yielded nondetected results for vinyl chloride at PZ11.

  Trend graphs for concentrations of carbon tetrachloride, TCE, and mercury at 25 representative piezometers are included in Appendix C. Results for carbon tetrachloride at piezometer CTP are presented below.



- Metals have been detected in the same general areas as in previous sampling events. No trends have been observed in any metals since 2010.

- UC Berkeley completed a passive soil gas study at the piezometer CTP area under the NOS Phase IV data gaps study (Tetra Tech 2016). Results of the soil gas study show that no source area for the carbon tetrachloride contamination exists, and additional piezometers identified in the RAW are not warranted.

Updated Cleanup Levels

The cleanup goals established in the RAW were presented in the Final Site Characterization Report (Tetra Tech 2013), and have not been updated since the SCR. The cleanup goals are based on risk-based concentrations (RBC).

The RBCs were calculated using the standard default exposure parameters and toxicity values available at that time from the U.S. EPA and DTSC. Exposure parameters used in the 2013 RBCs were primarily derived from U.S EPA's *Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part A)* (EPA 1989) and *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors* (EPA 1991) and DTSC's *HERD Note Number 1: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Hazardous Waste Sites and Permitted Facilities* (DTSC 2019a).

Significant updates were made to the EPA's default exposure factors in 2014 (EPA 2014) and to subsequently to DTSC's default exposure factors (DTSC 2019a). The most significant change was the default adult weight increased which increased the risk-based concentrations for adults from the ingestion and dermal pathways (became less stringent) by approximately 14 percent. Other exposure factors also changed, including decrease of the adult resident exposure duration which also results in a less stringent screening value than the previous exposure assumptions.

Numerous toxicity values have changed since 2013, with some chemicals now considered more toxic while others are less toxic than previously (DTSC 2019b, EPA 2019). Consistent with California's *Toxicity Criteria for Human Health Risk Assessments, Screening Levels, and Remediation Goals* rule (DTSC 2018), DTSC toxicity values were used in this update. If there was no toxicity value from DTSC, then the EPA toxicity values were used.

Chemicals 1,2-dichloropropane, arsenic, benzene, and tetrachloroethene all have cancer slope factor updates that result in these chemicals being more toxic via the ingestion and dermal pathways. The PAHs exhibit similar toxicological properties (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene) and those included the benzo(a)pyrene equivalent [BAP (EQ)] calculation all have a decreased cancer toxicity factor, as do carbazole, and delta-BHC. Benzene, cadmium, methylene chloride, tetrachloroethene, and vinyl chloride have greater inhalation toxicity for cancer risk.

The RAW identifies the cleanup goal for PCBs as 1 mg/kg, based on the Toxic Substances Control Act (TSCA) 40 Code of Federal Regulations (CFR) Section 761.61.(a) Self-Implementing On-Site Cleanup and Disposal of PCB Remediation Waste, threshold for high occupancy areas without further conditions. Since the issuance of the RAW, EPA has determined that 40 CFR Section 761.61(c) Risk-Based Disposal Approval is the more relevant and appropriate TSCA program. As such, risk-based thresholds and cleanup goals must be determined, and the default threshold value of 1 mg/kg under 40 CFR Section 761.61(a) is no longer appropriate. The revised risk-based values will be protective of human health and the environment.

Table 1 provides a summary of the changes to the RBCs identified in the RAW and specifically the SMP, and toxicological factors responsible for the changes. Complete supporting tables are provided as Appendix B. Impacts from the updated cleanup goals are summarized below.

> **PCB Soil Response Actions.** The default threshold value of 1 mg/kg under 40 CFR Section 761.61(a) is no longer appropriate, as directed by EPA. UC Berkeley will work with DTSC and EPA to establish the appropriate and relevant cleanup goals to be applied under 40 CFR Section 761.61(c).
>
> **MFA Soil Response Action.** The RAW identifies the cleanup goal for mercury as 275 mg/kg, based on the commercial use exposure scenario. The application of current toxicity values and updates of exposure parameters resulted in the cleanup level decreasing from 275 to 187 mg/kg. The scheduled removal action for mercury-contaminated soils will use 187 mg/kg as the cleanup goal.
>
> **BAP (EQ) and Dioxin Soil Response Actions.** The BAP (EQ) and dioxin cleanup levels in the RAW will be replaced with the levels identified in Table 1 as the updated cleanup goals. The BAP (EQ) cleanup level of 0.4 mg/kg in the RAW was based on the ambient level in surface soils in Northern California, since the original RBCs were below the ambient level. The revised BAP (EQ) level can now be based on the most stringent of the RBCs of 1.27 mg/kg, which is more appropriate for RFS-specific activities. The dioxin level of 1.64 x 10-05 mg/kg in the RAW will be updated to 1.79 x 10-05 mg/kg. These goals will be incorporated into the final soil removal actions in the affected areas.
>
> **Groundwater Response Actions.** The RBC for carbon tetrachloride in the RAW was 2.63 µg/L based on the commercial worker exposure. The updated RBCs for carbon tetrachloride are 280 µg/L for the commercial worker scenario, and 18.1 µg/L for the construction and maintenance worker scenarios. The TCE remedial goals identified in the RAW were based on site-specific goals established by DTSC for the adjacent Campus Bay site, which have not changed since the publication of the RAW.

4.3 SITE INSPECTION

The site inspection was conducted on August 15, 2019. In attendance were Lynn Nakashima, DTSC Senior Environmental Scientist, Allan Fone, PhD, DTSC Senior Environmental Scientist, Greg Haet, PE, UC Berkeley EH&S Associate Director, Alicia Bihler, UC Berkeley Environmental Health and Safety Representative, and Jason Brodersen, PG, Tetra Tech, UC Berkeley environmental consultant.

The purpose of the inspection was to evaluate if any conditions have changed which would impact the protectiveness of the response actions. The inspection consisted of a review of the status of all ongoing environmental actions, and a site-walk conducted in various RFS areas specific to the response actions.

No issues were identified which impact current or future protectiveness. A summary of the findings of the DTSC Environmental Risk Assessor are presented in Exhibit 1. Habitat areas noted in the exhibit are shown on Figure 1.

Exhibit 1. Site Inspection Review, Habitat Assessment

From: Fone, Allan@DTSC <Allan.Fone@dtsc.ca.gov>
Sent: Monday, August 26, 2019 3:55 PM
To: Nakashima, Lynn@DTSC <Lynn.Nakashima@dtsc.ca.gov>
Subject: UC Richmond Field Station - Site Visit, August 15, 2019

Hi, Lynn,

On August 15, 2019, I was part of the DTSC team that visited UC Richmond Field Station (RFS). UC is conducting a five-year review to evaluate the remedy that was implemented in accordance with the 2014 Removal Action Workplan (RAW). My role during the site visit was to evaluate the distribution and extent of the various habitat areas at RFS and to determine if there had been changes since implementation of the 2014 RAW. During the site visit, I observed current habitat areas and compared these with what had been reported in 2014. My observations indicate that there have been no significant changes in the distribution and extent of habitat areas at RFS.

Allan

Allan Fone, PhD, Project Manager

Department of Toxic Substances Control

700 Heinz Avenue

Berkeley, California 94710

5.0 TECHNICAL ASSESSMENT

This section presents the technical assessment of the current response items at RFS based on the Five-Year Review. This assessment for soil and groundwater response actions answers three questions outlined in the guidance documents:

Question A: Is the remedy functioning as intended by the RAW?

Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

5.1 Soil Response Actions

The response to each of the three questions and associated technical assessment for soil response actions are provided below.

1. PCB soil removal at Building 112, Building 150, and Corporation Yard	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** Completion of the PCB soil removal actions to cleanup goals will meet the protectiveness of the remedy intended by the RAW.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. **No:** The PCB cleanup standards presented in the RAW are no longer valid. UC Berkeley will work with DTSC and EPA to develop acceptable risk-based cleanup goals consistent with 40 CFR 761.61(c). **Yes:** Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the soil response action.
2. Mercury Soil Removal at MFA	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** Completion of the mercury soil removal actions to cleanup goals will meet the remedy intended by the RAW.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. **No:** Toxicity data and cleanup standards presented in the RAW are no longer valid. The 275 mg/kg mercury cleanup goal in the RAW will be replaced with 187 mg/kg as the revised cleanup goal. **Yes:** Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the soil response action.

3. BAP (EQ) and Dioxin Soil Removal at Corporation Yard	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** Completion of the BAP (EQ) and dioxin soil removal actions to cleanup goals will meet the remedy intended by the RAW.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. **No:** Toxicity data and cleanup standards presented in the RAW are no longer valid. The cleanup goals in the RAW will be replaced with the revised cleanup goals presented in Table 1. **Yes:** Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the soil response action.
4. Cinder Management	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** Ongoing UC Berkeley implementation of the cinder management plan is functioning as intended by the RAW.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. **No:** Toxicity data and cleanup standards presented in the RAW are no longer valid and are updated in Table 1; however, the cinder management plan does not specify toxicity data or cleanup standards. **Yes:** Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the cinder management plan.
5. Land Use Controls	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** Following completion of the soil response actions, UC Berkeley will implement the land use controls as intended by the RAW.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. **No:** Toxicity data and cleanup standards presented in the RAW are no longer valid and are updated in Table 1; however, the land use controls will not specify toxicity data or cleanup standards. **Yes:** Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the land use controls.

6. Implement SMP	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** Ongoing UC Berkeley implementation of the SMP is functioning as intended by the RAW.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. **No:** Toxicity data and cleanup standards presented in the RAW are no longer valid and are updated in Table 1. SMP Revision 2, included as Appendix A provides the updated cleanup standards. **Yes:** Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the SMP.

5.2 GROUNDWATER RESPONSE ACTIONS

The response to each of the three questions and associated technical assessment for groundwater response actions are provided below.

1. MNA Coastal Terrace Prairie	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** Ongoing groundwater monitoring is providing data supporting the natural attenuation of carbon tetrachloride in the Coastal Terrace Prairie, and continues to meet the protectiveness of the remedy intended by the RAW.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. Groundwater cleanup goals will be updated based on the updated toxicity data and exposure parameters. Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the groundwater monitoring response action.
2. Continued Groundwater Monitoring	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** Ongoing groundwater monitoring is providing data supporting minimal changes in groundwater conditions site-wide, and continues to meet the protectiveness of the remedy intended by the RAW.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. Groundwater cleanup goals will be updated based on the updated toxicity data and exposure parameters. Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the groundwater monitoring response action.

3. TCE Remedy under the Zeneca Order	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** The RAW mandates that the response action for TCE in groundwater at the adjacent Campus Bay site be protective of RFS exposure scenarios. The TCE groundwater response action identified in the Final FS/RAP is protective.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. **No:** Toxicity data and cleanup standards relevant to TCE at the adjacent Campus Bay site have not changed. **Yes:** Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the groundwater response action.
4. Land Use Controls	
Question A: Is the remedy functioning as intended by the RAW?	**Yes:** Following completion of the soil response actions, UC Berkeley will implement the land use controls as intended by the RAW.
Question B: Are the exposure assumptions, toxicity data, cleanup standards, and remedial action objectives used at the time of the remedy selection still valid?	**Yes:** All exposure assumptions are still valid. **No:** Toxicity data and cleanup standards presented in the RAW are no longer valid and are updated in Table 1; however, the land use controls will not specify toxicity data or cleanup standards. **Yes:** Remedial action objectives are still valid.
Question C: Has any other information come to light that could call into question the protectiveness of the remedy?	**No:** Site conditions, current and future land uses, exposure assumptions, and regulatory requirements have not changed or called into question the protectiveness of the land use controls.

6.0 ISSUES AND RECOMMENDATIONS

This section provides any issues and corresponding recommendations identified during the Five-Year review process.

6.1 PCB CLEANUP GOAL

The RAW identifies the cleanup goal for PCBs as 1 mg/kg, based 40 CFR Section 761.61.(a) Self-Implementing On-Site Cleanup and Disposal of PCB Remediation Waste. Since the issuance of the RAW, EPA has determined that 40 CFR Section 761.61(c) Risk-Based Disposal Approval is the more relevant and appropriate TSCA program. As such, risk-based thresholds and cleanup goals for human health and the environment must be determined, and the default threshold value of 1 mg/kg under 40 CFR Section 761.61(a) is no longer appropriate.

UC Berkeley will work with DTSC and EPA to establish the appropriate and relevant cleanup goals to be applied under 40 CFR Section 761.61(c), and possible impacts to the information presented in the RAW. The change in TSCA cleanup programs will not alter the remedial action objectives or the overall protectiveness of the RAW. Final decisions regarding further soil excavations will also determine the strategy to address any BAP (EQ) and dioxin residual contamination. The updated cleanup goals may necessitate the RAW be recirculated for public review.

6.2 COASTAL TERRACE PRAIRIE MONITORED NATURAL ATTENUATION

UC Berkeley completed a passive soil gas study at the piezometer CTP area under the NOS Phase IV data gaps study (Tetra Tech 2016). Results of the soil gas study shows no source area for the carbon tetrachloride contamination exists, and installation of additional piezometers identified in the RAW are not recommended. This recommendation is further supported through measured decreases in carbon tetrachloride within the current piezometer network. The trend is decreasing with concentrations from a historic high of 25 µg/L in 2011 to 5.8 µg/L in 2019 at piezometer CTP. A graphic depiction of the carbon tetrachloride decreasing trend is provided in Section 4.2.

6.3 ONGOING GROUNDWATER MONITORING

UC Berkeley has completed annual groundwater monitoring at RFS since November 2010, including four events during the first year. During the span of nine consecutive years of groundwater monitoring, there have been no noted changes in chemical concentrations other than the decreasing trends described in Section 4.2. As a result, UC Berkeley recommends annual monitoring conducted on a biennial basis beginning with the April 2021 event. The April 2021 event would include the same piezometers and analyses as implemented in April 2019.

Semiannual groundwater elevation monitoring will continue consistent with the current groundwater monitoring plan.

7.0 PROTECTIVENESS STATEMENT

The U.S. Environmental Protection Agency's Comprehensive Five-Year Review Guidance (EPA 2016) and Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews (EPA 2012) define five protectiveness categories below.

Category	Description
1. Protective	Appropriate when responses are complete and operating, or when remedial action objectives have been met, and continued operation and maintenance activities are occurring.
2. Short-Term Protective	Appropriate in same application as "Protective," wherein all responses are considered currently protective; however, the five-year review has raised issues or concerns which could impact future protectiveness. Examples include no current exposure, but institutional controls have not been implemented, future land use assumptions may have changed, or monitoring data indicates the remedy will not achieve goals within the anticipated time frame.
3. Will be Protective	Appropriate when responses are ongoing and that no issues or concerns were raised during the five-year review indicate changes to the protectiveness of the current responses.
4. Protectiveness Deferred	Appropriate for ongoing or completed responses; however, the five-year review has raised issues or concerns that the remedial action objectives have not been met, and there are concerns regarding protectiveness of the response actions. Examples include a new exposure pathway has been identified, an emerging contaminant not previously addressed is present, or a toxicity value has changed and it is unclear if the current response is protective or can meet the new cleanup level.
5. Not Protective	Appropriate for ongoing or completed responses; however, the five-year review has raised issues or concerns that risks to human health or the environment are not currently under control. Examples include an immediate threat is present, migration of contaminants are uncontrolled and pose unacceptable risks, or that exposure is clearly present and there is evidence of exposure.

The categories have been applied to the responses listed in Section 3 based on the technical content and evaluation provided in Sections 4, 5, and 6.

Soil Response Actions	Protectiveness Statement
1. PCB soil removal at Building 112, Building 150, and Corporation Yard.	**Will be Protective.** Removal of residual soil to cleanup goals is expected to be protective of human health and the environment. In the interim, there are no current or ongoing exposures which are not acceptable.
2. Mercury soil removal at MFA	**Will be Protective.** Removal of contaminated soil to cleanup goals is expected to be protective of human health and the environment. In the interim, there are no current or ongoing exposures which are not acceptable.
3. BAP EQ and dioxin soil removal at Corporation Yard	**Will be Protective.** Removal of residual soil to cleanup goals is expected to be protective of human health and the environment. In the interim, there are no current or ongoing exposures which are not acceptable.
4. Cinder management	**Protective.** Ongoing implementation of cinder management protocols is protective of human health and the environment.
5. Land use controls	**Will be Protective.** Implementation of land use controls are expected to be protective of human health and the environment.
6. Implement SMP	**Protective.** Ongoing implementation of the SMP is protective of human health and the environment.

Groundwater Response Actions	Protectiveness Statement
1. MNA Coastal Terrace Prairie	**Protective.** Ongoing implementation of groundwater monitoring is protective of human health and the environment.
2. Continued groundwater monitoring	**Protective.** Ongoing implementation of groundwater monitoring is protective of human health and the environment.
3. TCE remedy under the Zeneca Order	**Will be Protective.** Implementation of the TCE remedy under the Zeneca Order is expected to protective of human health and the environment. In the interim, there are no current or ongoing exposures which are not acceptable.
4. Land use controls	**Will be Protective.** Implementation of land use controls are expected to be protective of human health and the environment.

8.0 NEXT REVIEW

The next five-year review report for RFS site will be conducted in 5 years after the completion date of this review.

9.0 REFERENCES

California Department of Toxic Substances Control (DTSC). 2018. Final Statement of Reasons. Toxicity Criteria for Human Health Risk Assessments, Screening Levels, and Remediation Goals. September 4.

DTSC. 2019a. HERD Note Number 1: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Hazardous Waste Sites and Permitted Facilities. Office of Human and Ecological Risk.

DTSC. 2019b. Human Health Risk Assessment Note 3 – DTSC-Modified Screening Levels (DTSC-SLs). Available on-line: https://dtsc.ca.gov/human-health-risk-hero.

Tetra Tech EM Inc. (Tetra Tech EM Inc. 1996-2012; Currently Tetra Tech, Inc. [Tetra Tech]). 2008a. Implementation Summary Report for a Time-Critical Removal Action at the Forest Products Laboratory, Wood Treatment Laboratory. March 14.

Tetra Tech. 2008b. Final Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond, California. November 21.

Tetra Tech. 2009. Final Summary Report for a Time-Critical Removal Action at Two Subareas in the Western Stege Marsh. May 26.

Tetra Tech. 2013. Final Site Characterization Report. Proposed Richmond Bay Campus, Research, Education, and Support Area and Groundwater within the Richmond Field Station Site. May 28.

Tetra Tech. 2014. Final Removal Action Workplan. Proposed Richmond Bay Campus, Research, Education, and Support Area and Groundwater within the Richmond Field Station Site. July 18.

Tetra Tech. 2016. Final Phase IV Sampling Results Technical Memorandum. May 16.

Tetra Tech. 2019. Final 2019 Groundwater Sampling Results Technical Memorandum. August 2, Finalized via transmittal of amendment from UC Berkeley, November 7.

Terraphase Engineering, Inc. 2019. Feasibility Study and Remedial Action Plan for Lot 1, Lot 2, and the Uplands Portion of Lot 3, Campus Bay, Richmond, California, Volumes I, II, and III. November 1.

U.S. Environmental Protection Agency (EPA). 1989. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual, Part A. Interim Final. Office of Emergency and Remedial Response. EPA/540.1-89/002. December.

EPA. 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03. March.

EPA 2001. Comprehensive Five-Year Review Guidance. OSWER Directive 9355.7-03B-P. June.

EPA. 2012. Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews. September 13.

EPA. 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6.

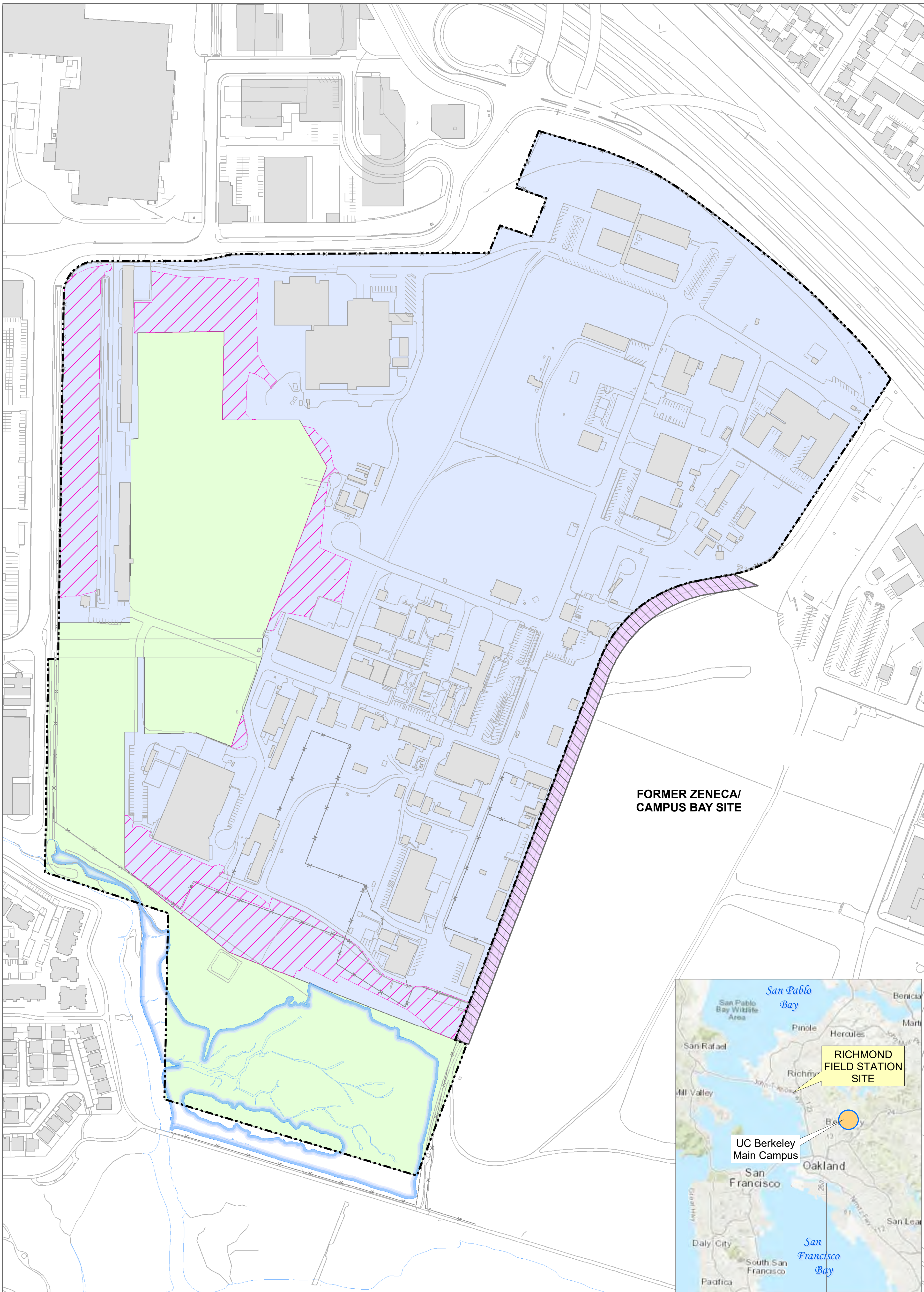
EPA. 2016. Five-Year Review Recommended Template. OLEM 9200.0-89. January 20.

EPA. 2018. Johnson and Ettinger Model Spreadsheet Tool, Version 6.0. https://www.epa.gov/vaporintrusion/epa-spreadsheet-modeling-subsurface-vapor-intrusion.

EPA. 2019. Regional Screening Levels for Chemical Contaminants at Superfund Sites. https://www.epa.gov/risk/regional-screening-levels-rsls. December.

Virginia Department of Environmental Quality. 2007. Voluntary Remediations Program. Table 3.8. Exposure-point concentrations (inhalation) for construction/utility workers in a trench: Groundwater less than 15 feet deep. October 5.

FIGURES



- Research, Education & Support Area
- Natural Open Space
- The portion of South 46th Street owned by UC and Zeneca under a 1/3 and 2/3 shared interest is subject to the RAW
- Habitat within RES Area
- Richmond Field Station Boundary
- Roads and Other Landscape Features
- Marsh Boundary

N

300 0 300

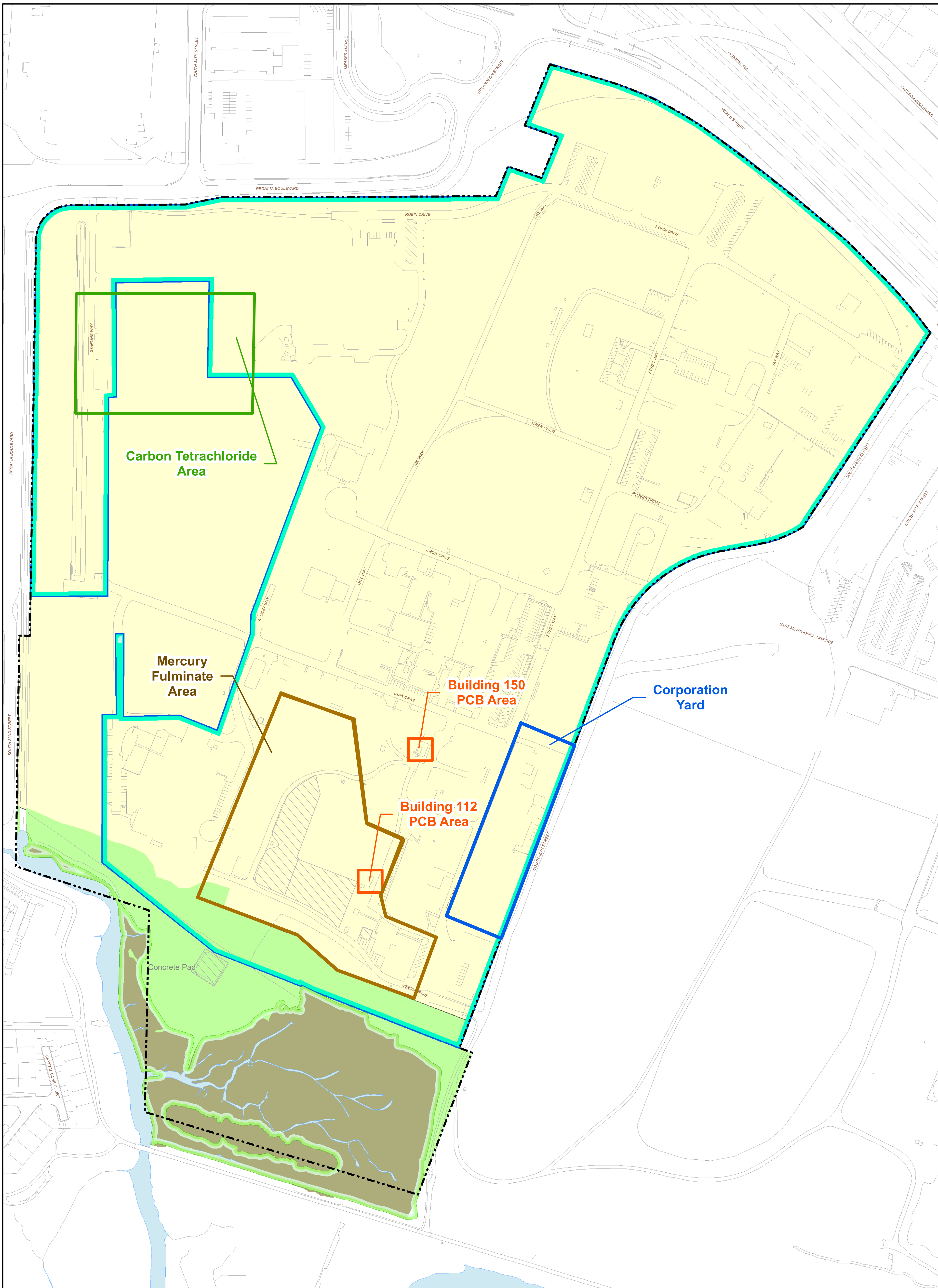
Feet

TETRA TECH

Richmond Field Station

FIGURE 1
SITE MAP

Five-Year Review



Area Boundaries

- Mercury Fulminate Area
- Corporation Yard
- PCB Areas
- Carbon Tetrachloride Area
- Marsh
- Transition
- Upland
- Marsh Boundary
- RES Area
- Asphalt/Concrete Pads
- Surface Water
- Richmond Field Station Boundary
- Roads and other Landscape Features

N

0 250 500

Feet

TETRA TECH

Richmond Field Station

FIGURE 2
RESPONSE ACTION AREAS

Five-Year Review

12/31/2019 C:\misc_GIS\Richmond_Field_Station\Projects\RAW\5-yr_Review\Figure2_RES Soil Sampling RBC and PCB Exceedances.mxd TtEMI-OAK michelle.handley

TABLES

Table 1
Comparison of Risk-Based Concentrations

Chemical	2013 Risk-Based Concentrations [1]				2019 Risk-Based Concentrations [1]				Comments
	Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	
SOIL									
Metals									
Aluminum	100,000	**20,300**	100,000	6,860,000	--	--	--	--	Eliminated as chemical of potential concern
Antimony	367	**109**	2,720	--	467	**142**	3,540	--	Exposure parameter updates.
Arsenic [2, 3]	**0.224**	1.58	1.58	745	**0.253**	0.850	1.77	--	Exposure parameter updates, toxicity update.
Barium	100,000	**2,110**	52,600	686,000	100,000	**2,120**	53,100	709,000	Exposure parameter updates.
Beryllium	1,760	**29.0**	128	1,330	232	**21**	128	1,590	Updated toxicity (more toxic) and exposure parameter updates.
Boron	100,000	**33,600**	100,000	27,400,000	100,000	**39,200**	100,000	28,400,000	Exposure parameter updates.
Cadmium	1,000	**68.1**	73.0	762	778	**36.6**	73.0	909	Updated toxicity (more toxic) and exposure parameter updates.
Chromium	**100,000**	100,000	100,000	--	**100,000**	100,000	100,000	--	No change; saturation limit.
Cobalt [2]	273	**19.9**	34.1	356	347	**21.1**	34.1	--	Exposure parameter updates.
Copper	36,700	**10,900**	100,000	--	46,700	**14,200**	354,000	--	Exposure parameter updates.
Iron	**100,000**	100,000	100,000	--	**100,000**	100,000	100,000	--	No change; saturation limit.
Lead [3, 4]	**320**	320	320	--	**320**	320	320	--	No change; based on California value.
Manganese [2]	20,500	**212**	5,300	68,600	25,600	**213**	5,340	--	Exposure parameter updates; updated dermal absorption factor.
Mercury [5]	275	**77.0**	1,920	412,000	187	**39.6**	989	--	Updated toxicity, use of mercuric chloride and updated volatilization factor for mercuric chloride. Exposure parameter updates.
Molybdenum	4,590	**1,360**	34,000	--	5,840	**1,770**	44,200	--	Exposure parameter updates.
Nickel [2]	14,900	**60.6**	1,180	12,300	11,100	**60.4**	1,180	--	Updated toxicity (more toxic) and exposure parameter updates.
Selenium	4,590	**1,340**	33,500	27,400,000	5,840	**1,730**	43,400	28,400,000	Exposure parameter updates.
Silver	4,590	**1,360**	34,000	--	5,840	**1,770**	44,200	--	Exposure parameter updates.
Thallium	9.17	**2.72**	68.0	--	11.7	**3.54**	88.5	--	Exposure parameter updates.
Vanadium	4,590	**1,360**	34,000	--	5,780	**351**	8,780	142,000	Updated toxicity (more toxic) and exposure parameter updates.
Zinc	100,000	**81,600**	100,000	--	100,000	**100,000**	100,000	--	Exposure parameter updates.
VOCs									
1,2-Dichloropropane	4.41	71.0	83.7	**0.993**	11.0	65.8	213	**2.88**	Updated toxicity (inhalation less toxic, ingestion more toxic) and exposure parameter updates.
Acetone	**100,000**	100,000	100,000	475,000	**100,000**	100,000	100,000	441,000	No change; saturation limit.
Benzene	1.44	27.9	27.9	**0.320**	1.43	32	32	**0.343**	Updated toxicity (inhalation more toxic) and exposure parameter updates.
Ethylbenzene	24	393	393	**5.94**	25	529	529	**6.37**	Exposure parameter updates.
m,p-Xylene	2,510	2,350	58,700	**614**	2,370	2,310	57,600	**570**	Updated volatilization factor and exposure parameter updates.
o-Xylene	2,950	2,730	68,100	**725**	2,800	2,700	67,600	**674**	Updated volatilization factor and exposure parameter updates.
Toluene	5,230	3,830	95,700	**1,440**	5,320	4,680	100,000	**1,340**	Updated volatilization factor and exposure parameter updates.
Trichloroethene	5.72	15.8	93.7	**1.03**	6.05	17.4	126	**1.06**	Updated volatilization factor and exposure parameter updates.

Table 1
Comparison of Risk-Based Concentrations

Chemical	2013 Risk-Based Concentrations [1]				2019 Risk-Based Concentrations [1]				Comments
	Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	
SVOCs									
BAP (EQ) [6, 7]	**0.145**	0.963	0.963	1,150	**1.27**	7.07	8.29	--	Updated toxicity (less toxic for cancer risk, more toxic for noncancer hazards) and exposure parameter updates.
1-Methylnaphthalene	**36.4**	243	243	--	**43.9**	294	294	17,100	Updated toxicity (reference concentration added) and exposure parameter updates.
2-Methylnaphthalene	1,510	**403**	10,100	--	1,260	**433**	10,800	968	Updated toxicity (reference concentration added) and exposure parameter updates.
4-Methylphenol	47,800	**13,000**	100,000	823,000,000	52,900	**14,300**	100,000	851,000,000	Exposure parameter updates.
Acenaphthene	22,600	**6,050**	100,000	--	23,000	**6,930**	100,000	35,300	Updated toxicity (more toxic) and exposure parameter updates.
Acenaphthylene	22,600	**6,050**	100,000	--	23,000	**6,930**	100,000	35,300	Updated toxicity (more toxic) and exposure parameter updates.
Anthracene	100,000	**30,200**	100,000	--	100,000	**35,900**	100,000	654,000	Updated toxicity (more toxic) and exposure parameter updates.
Benzo(a)anthracene	**0.880**	5.87	5.87	11,500	**12.4**	82.3	82.3	40.5	Updated toxicity (less toxic for cancer risk) and exposure parameter updates.
Benzo(a)pyrene	**0.145**	0.963	0.963	1,150	**1.27**	7.07	8.29	1,250	Updated toxicity (less toxic for cancer risk, more toxic for noncancer hazards) and exposure parameter updates.
Benzo(b)fluoranthene	**0.88**	5.87	5.87	11,500	**12.7**	82.9	82.9	12,500	Updated toxicity (less toxic for cancer risk) and exposure parameter updates.
Benzo(g,h,i)perylene	11,300	**3,020**	75,600	--	13,500	**3,620**	90,600	297,000	Updated toxicity (more toxic) and exposure parameter updates.
Benzo(k)fluoranthene	**0.880**	5.87	5.87	11,500	**127**	654	654	12,500	Updated toxicity (less toxic for cancer risk) and exposure parameter updates.
bis(2-Ethylhexyl)phthalate	**95.5**	647	647	1,330,000	**106**	715	715	1,590,000	Exposure parameter updates.
Chrysene	**8.80**	58.7	58.7	115,000	**1,270**	6,540	6,540	125,000	Updated toxicity (less toxic for cancer risk) and exposure parameter updates.
Dibenz(a,h)anthracene	**0.145**	0.963	0.963	2,670	**0.311**	2.07	2.07	1,150	Updated toxicity (less toxic for cancer risk) and exposure parameter updates.
di-n-Butylphthalate	47,800	**13,000**	100,000	--	52,900	**14,400**	100,000	--	Exposure parameter updates.
Fluoranthene	15,100	**4,030**	100,000	--	18,200	**4,880**	100,000	--	Exposure parameter updates.
Fluorene	15,100	**4,030**	100,000	--	16,700	**4,730**	100,000	46,900	Updated toxicity (more toxic) and exposure parameter updates.
Indeno(1,2,3-cd)pyrene	**0.880**	5.87	5.87	11,500	**12.7**	82.9	82.9	12,500	Updated toxicity (less toxic for cancer risk) and exposure parameter updates.
Naphthalene	18.0	450	450	**3.57**	16.7	399	399	**3.82**	Updated volatilization factor and exposure parameter updates.
Phenanthrene	15,100	**4,030**	100,000	--	18,200	**4,880**	100,000	227,000,000	Updated toxicity (reference concentration added) and exposure parameter updates.
Pyrene	11,300	**3,020**	75,600	--	13,500	**3,620**	90,600	297,000	Updated toxicity (reference concentration added) and exposure parameter updates.
PCBs									
Aroclor-1242	**0.528**	3.50	3.50	5,620	**0.580**	3.98	3.98	2.90	Updated toxicity (more toxic) and exposure parameter updates.
Aroclor-1248	**0.528**	3.50	3.50	5,620	**0.582**	3.99	3.99	3.07	Updated toxicity (more toxic) and exposure parameter updates.
Aroclor-1254	**0.528**	2.02	3.50	5,620	**0.588**	2.29	4.00	4.15	Updated toxicity (referencece concentration added) and exposure parameter updates.
Aroclor-1260	**0.528**	3.50	3.50	5,620	**0.595**	4.01	4.01	6.44	Updated toxicity (more toxic) and exposure parameter updates.
Total PCBs	--	--	--	--	**0.577**	3.98	3.98	2.61	Toxicity values for "Polychlorinated Biphenyls (high risk)" used for 2019 values.

Table 1
Comparison of Risk-Based Concentrations

Chemical	2013 Risk-Based Concentrations [1]				2019 Risk-Based Concentrations [1]				Comments
	Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	
Pesticides									
4,4'-DDD	**7.59**	52.8	52.8	46,400	**6.18**	4.31	41.5	55,300	Updated toxicity (more toxic) and exposure parameter updates.
4,4'-DDE	**5.36**	37.3	37.3	33,000	**9.28**	70.5	70.5	60.7	Updated toxicity (more toxic) and exposure parameter updates.
4,4'-DDT	**5.36**	37.3	37.3	33,000	**7.06**	49.9	49.9	39,400	Exposure parameter updates.
Aldrin	**0.107**	0.745	0.745	654	**0.184**	1.41	1.41	0.984	Updated toxicity (more toxic) and exposure parameter updates.
alpha-BHC	**0.289**	2.01	2.01	1,780	**0.235**	1.58	1.58	2,120	Updated dermal absorption factor and exposure parameter updates.
alpha-Chlordane	**1.40**	9.76	9.76	9,420	**6.10**	43.6	43.6	42.9	Updated toxicity (less toxic) and exposure parameter updates.
beta-BHC	**1.01**	7.04	7.04	6,040	**0.823**	5.54	5.54	7,200	Updated dermal absorption factor and exposure parameter updates.
Carbazole	**145**	934	934	291,000	**1,270**	6,540	6,540	125,000	Updated toxicity (less toxic) and exposure parameter updates.
Chlordane	**1.40**	9.76	9.76	9,420	**6.10**	43.6	43.6	42.9	Updated toxicity (less toxic) and exposure parameter updates.
delta-BHC	**0.289**	2.01	2.01	1,780	**0.823**	5.54	5.54	7,200	Updated toxicity (less toxic) and exposure parameter updates.
Dieldrin	**0.114**	0.792	0.792	696	**0.093**	0.623	0.623	830	Updated toxicity (more toxic) and exposure parameter updates.
Endosulfan I	3,910	**1,100**	27,500	--	6,030	**1,990**	49,600	10,300	Updated toxicity (reference concentration added) and exposure parameter updates.
Endosulfan II	3,910	**1,100**	27,500	--	6,030	**1,990**	49,600	10,300	Updated toxicity (reference concentration added) and exposure parameter updates.
Endosulfan sulfate	3,910	**1,100**	27,500	--	3,180	**855**	21,400	34,000,000	Updated toxicity (reference concentration added) and exposure parameter updates.
Endrin	195	**54.9**	1,370	--	159	**43.1**	1,080	--	Updated permeability coefficient and exposure parameter updates.
Endrin aldehyde	195	**54.9**	1,370	--	159	**43.1**	1,080	--	Updated permeability coefficient and exposure parameter updates.
gamma-BHC (Lindane)	**1.66**	11.5	11.5	10,300	**2.01**	14.0	14.0	12,300	Exposure parameter updates.
gamma-Chlordane	**1.40**	9.76	9.76	9,420	**6.10**	43.6	43.6	42.9	Updated toxicity (less toxic) and exposure parameter updates.
Heptachlor	**0.405**	2.82	2.82	2,460	**0.626**	5.14	5.14	1.03	Updated toxicity (reference concentration added) and exposure parameter updates.
Heptachlor epoxide	**0.200**	1.39	1.39	1,230	**0.330**	2.59	2.59	0.910	Updated toxicity (reference concentration added) and exposure parameter updates.
Mirex	**0.101**	0.704	0.704	628	**0.167**	1.31	1.31	0.472	Updated toxicity (reference concentration added) and exposure parameter updates.
Pentachlorophenol	**1.86**	12.2	12.2	628,000	**2.04**	13.3	13.3	749,000	Exposure parameter updates.
Dioxin					--	--	--	--	
Dioxin TEQ [8]	**0.0000160**	0.000116	0.000116	0.0843	**0.0000179**	0.000129	0.000129	--	Updated volatilization factor and exposure parameter updates.
Explosives									
HMX	23,900	**6,500**	100,000	--	54,500	**16,300**	100,000	--	Updated dermal absorption and exposure parameter updates.
TPH									
Diesel range organics	**500**	--	--	--	**880**	--	--	--	Updated Environmental Screening Levels, California Regional Water Quality Control Board
Gasoline range organics	**500**	--	--	--	**2,800**	--	--	--	Updated Environmental Screening Levels, California Regional Water Quality Control Board
Motor oil range organics	**2,500**	--	--	--	**32,000**	--	--	--	Updated Environmental Screening Levels, California Regional Water Quality Control Board

Table 1
Comparison of Risk-Based Concentrations

Chemical	2013 Risk-Based Concentrations [1]				2019 Risk-Based Concentrations [1]				Comments
	Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	
GROUNDWATER									
Carbon Tetrachloride	**2.63**	2.63	2.68	--	280 [9]	**18** [10]	18 [10]	--	Updated vapor intrusion models and toxicity values
Trichloroethylene	**270**	890	890	--	**270**	890	890	--	Risk-based values established for the former Zeneca/Campus Site

Notes:

All soil values are in mg/kg.

All groundwater values are in µg/L.

Bold values indicate the lowest of the risk-based concentrations for all potential future receptors.

1 Risk-based concentrations are calculated in Appendix C of the Site Characterization Report (Tetra Tech 2013). Risk-based concentrations are shown with 3 significant figures, except where the default value of 100,000 mg/kg applies (where calculated value exceeds 100,000 mg/kg). Risk-based concentrations shown are the minimum values between the cancer and noncancer multi-pathway risk-based concentrations. For the off-site receptor, the values shown are the minimum values between the

2 Background levels for arsenic (16 mg/kg), cobalt (73 mg/kg), manganese (5,900 mg/kg), and nickel (280 mg/kg) were established for the RFS per the Appendix A, Soil Management Plan, Revision 2. Background levels are a not-to-exceed value, except in cases where arsenic is associated with cinders in soil (see note 3).

3 If lead or arsenic is associated with cinders, manage on site per Section 5.2.3 of the SMP. If not associated with cinders, investigate further, determine if source is present, and dispose of off-site.

4 A risk-based concentration was not calculated for lead. The California industrial screening level of 320 mg/kg (DTSC 2019) was used for the commercial, construction, and maintenance worker scenarios.

5 The toxicity criteria and chemical parameters for mercuric chloride was used as a surrogate for mercury to calculate the risk-based concentration.

6 The toxicity criteria for benzo(a)pyrene was used for BAP (EQ) to calculate the risk-based concentration.

7 The ambient level for BAP (EQ) (0.4 mg/kg) is based on the 95 UCL concentration of the ambient dataset for BaP (EQ) in surface soils in Northern California (DTSC 2009; Environ Corporation and others 2002).

8 The toxicity criteria for 2,3,7,8-TCDD was used as a surrogate for Dioxin TEQ to calculate the risk-based concentration.

9 The vapor intrusion screening levels were calculated using the EPA's version of the Johnson and Ettinger Model update version 6 (EPA 2018) with updated toxicity values (DTSC 2019, EPA 2019).

10 The construction and maintenance worker groundwater screening levels were calculated using the volatilization factor calculated in the VDEQ trench model (VDEQ 2007) for inhalation exposure and dermal equations from the RSL calculator (EPA 2019) for dermal exposure. Incidental ingestion of groundwater was considered to be *de minimus* and was not included in the risk-based concentrations.

BHC	Hexachlorocyclohexane	OEHHA	Office of Environmental Health Hazard Assessment
Cal/EPA	California Environmental Protection Agency	PCB	Polychlorinated biphenyl
DDD	Dichlorodiphenyldichloroethane	TCDD	Tetrachlorodibenzo-p-dioxin
DDE	Dichlorodiphenyldichloroethylene	TPH	Total Petroleum Hydrocarbons
DDT	Dichlorodiphenyltrichloroethane	VDEQ	Virginia Department of Environmental Quality
DTSC	California Department of Toxic Substances Control	VOC	Volatile organic compound

Table 2
Soil Management Plan Activity Summary
Updated: December 13, 2019

Project Name	Description	Reporting Status	Summary
PEER Pipe Valve	Removal of oily soil beneath drip pad of hydraulic fuel line; identified in FSP Phase II at Building 420.	*De minimis* Form A: Issued to DTSC 10/13/14	Collection of one soil sample at completed excavation depth. Results submitted to DTSC 10/31/14 Follow-up Actions: None. Project complete.
SEISMIC	LBNL Fiber Optic cable temporary trenches at Building 400.	Form A: Issued to DTSC 11/5/14 Form B, Part 1: Issued to DTSC 11/12/14 Form B, Part 2: Issued to DTSC 12/8/14	Collection of five samples at two depths. Results submitted to DTSC 12/8/14 Followup Actions: Form C to be submitted at project closure.
PEER Footings	Installation of eight new footers to support above ground lines at Building 420.	*De minimis* Form A: Issued to DTSC 11/7/14	Collection of one ISM sample for worker safety as described in 7/18/14 letter report. Results sent to DTSC 11/7/14. Followup Actions: None. Project complete
Phytoremediation Project Building 163	Establishment of a field study location to assess uptake of arsenic and other metals by a fern. Project to last approximately 2 years.	Forms A and B: Issued to DTSC 3/28/16 Summary Report: Issued to DTSC 4/01/16	One soil sample collected to address SMP COPCs not part of the research chemical suite. Followup Actions: None. Project complete
Utility Trenching Building 445	Utility trenching and soil leveling (grading) to install an educational 24 sq ft. kiosk at the Building 445 Conference Building parking lot.	Forms A and B: Issued to DTSC 6/09/16	No sampling recommended based on existing sampling results. Followup Actions: None. Project complete

Project Name	Description	Reporting Status	Summary
Utility Trenching Building 180	Utility trenching to install subsurface fiber optic cable	*De minimis*	Collected one ISM sample for worker safety as described in 8/21/18 letter report. Results sent to DTSC 9/13/18. Addendum to sampling report submitted 10/22/18. <u>Followup Actions:</u> None. Project complete.
NRLF Phase 4 Construction	Excavation associated with construction of Phase 4 of Northern Regional Library Complex.	Forms A and B Part 1: Issued to DTSC 7/19/2018 Sampling Report: Issued to DTSC 9/20/2018 Updated Sampling Report: Issued to DTSC 6/10/2019 Updated Sampling Report: Issued to DTSC 11/25/2019	<u>Followup Actions:</u> Form C following completion of construction phases.
NRLF Phase 4 Retention Pond	Excavation of stormwater retention area associated with construction of Phase 4 NRLF	Form A: Issued to DTSC 10/28/19. Form B and Sampling Approach: Issued to DTSC 11/22/19. Revised Sampling Approach: Issued to DTSC 12/3/19	<u>Followup Actions:</u> Collect two soil samples from single location; provide results summary. Form C following completion of construction phases.

APPENDIX A
SOIL MANAGEMENT PLAN, REVISION 2

Final

Soil Management Plan, Revision 2
Removal Action Workplan
Five-Year Review, Attachment C

Research, Education, and Support Area within the Richmond Field Station

Prepared for:

University of California, Berkeley

December 31, 2019

Prepared by

TETRA TECH, INC.
1999 Harrison Street, Suite 500
Oakland, California 94612

Jason Brodersen, PG.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

Figures

Tables

Exhibits

Attachments

ACRONYMS AND ABBREVIATIONS

AST	Above ground storage tank
BAP(EQ)	Benzo(a)pyrene equivalent
Bgs	Below ground surface
Cal/EPA	California Environmental Protection Agency
CCC	California Cap Company
CCR	Current Conditions Report
CFR	Code of Federal Regulations
COC	Chemical of concern
CY	Cubic yard
DTSC	Department of Toxic Substances Control
EH&S	Office of Environment, Health & Safety
EPA	U.S. Environmental Protection Agency
FPL WTL	Forest Products Laboratory Wood Treatment Lab
FSW	Field Sampling Workplan
GIS	Geographic information system
HMX	Octahydor-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HSP	Health and Safety Plan
IDW	Investigation-derived waste
LBNL	Ernest Orlando Lawrence Berkeley National Laboratory
LBP	Lead-based paint
LRDP	Long Range Development Plan
LUC	Land use control
MCL	Maximum contaminant level
MFA	Mercury Fulminate Area
mg/kg	Milligrams per kilogram
NOI	Notice of Intent
NOS	Land use designation identified in the LRDP as Natural Open Space, which applies to areas that UC plans to protect from development and maintain in their natural condition
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyl
PPE	Personal protective equipment
QSD	Qualified SWPPP Developer
QSP	Qualified SWPPP Preparer

ACRONYMS AND ABBREVIATIONS (Continued)

RAW	Removal Action Workplan
RBC	Risk-based concentration
RES	Land use designation identified in the LRDP as Research, Education, and Support, which applies to areas that are either currently developed with facilities that would remain in their present form or be expanded, or that would be developed with new facilities
RFS	Richmond Field Station
RFS Site Investigation and Remediation Order	DTSC Site Investigation and Remediation Order. Docket No. IS/E-RAO 06/07-004 for the Richmond Field Station
RWQCB	San Francisco Bay Regional Water Quality Control Board
SAP	Sampling and analysis plan
SCR	Site Characterization Report
SMP	Soil Management Plan
SOP	Standard operating procedure
SVOC	Semivolatile organic compounds
SWPPP	Stormwater pollution prevention plan
TCE	Trichloroethene
TCRA	Time-critical removal action
TPH	Total petroleum hydrocarbons
TSCA	Toxic Substance Control Act
UC	University of California
UCL	Upper confidence limit
URS	URS Corporation
UST	Underground storage tank
VOC	Volatile organic compound
Zeneca Order	DTSC Site Investigation and Remediation Order. Docket No. IS/E-RAO 06/07-005 for the former Zeneca Site

EXECUTIVE SUMMARY

The Soil Management Plan (SMP) supports the implementation of land use controls established in the Removal Action Workplan (RAW) for the Richmond Field Station (RFS) (Figure C-1). Revision 2 is the second of the as needed SMP updates: it incorporates updates and clarifications to SMP protocols and provides additional supporting maps.

UC Berkeley has been conducting investigation and cleanup actions at the Richmond Field Station under the oversight of the California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC), in compliance with the Site Investigation and Remediation Order, Docket No. IS/E-RAO 06/07-004, dated September 15, 2006 (RFS Site Investigation and Remediation Order). The RFS Site Investigation and Remediation Order provides for the investigation and cleanup of 96 acres of upland and 13 acres of tidal marsh and transition habitat within the Richmond Field Station. In July 2014, UC Berkeley published the RAW and SMP under Health and Safety Code Section 25356.1(h)(1) and in compliance with the RFS Site Investigation and Remediation Order.

The SMP provides a framework to prohibit uncontrolled soil excavation or disturbance activities which may expose workers or visitors to unsafe exposures to environmental contaminants. The objective of the SMP is to ensure that soil disturbance activities do not adversely impact human health or the environment and that the soils are handled, stored and disposed of, or reused onsite in accordance with applicable laws, regulations, and UC policies. The SMP ensures that soils disturbed during future construction, redevelopment, or maintenance projects will be sampled and managed to ensure that no uncontrolled exposures to, or releases of contaminants occur within the areas of the Richmond Field Station planned for Research, Education, and Support (RES) land uses.

SMP Revision 2 supersedes the original version of the SMP and SMP Revision 1 and should be used in its place, per the changes identified in the respective draft document transmittal letters. The final version addresses comments received from DTSC on the Draft SMP Revision 2, as documented in Attachment C1, DTSC Comments.

The SMP will be reviewed annually or more frequently if necessary, and an updated version of the SMP will be published if warranted due to significant content changes.

1.0 INTRODUCTION AND PURPOSE

The Soil Management Plan (SMP) supports the implementation of land use controls established in the Removal Action Workplan (RAW) for the Richmond Field Station (RFS (Figure C-1). Revision 2 is the second SMP update and replaces the original SMP published in July 2014 and SMP Revision 1 dated April 12, 2017. SMP Revision 2 incorporates updates and clarifications to SMP protocols, and provides additional supporting maps, as detailed in its transmittal letter. The SMP is applicable to all activities conducted within the Research, Education, and Support (RES) land uses identified within the RAW; the SMP is not strictly applicable to the Natural Open Space (NOS) land uses identified within the RAW; however, its principals and management strategies may be applied if appropriate.

UC Berkeley has been conducting investigation and cleanup actions at the Richmond Field Station under the oversight of the California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC), in compliance with the Site Investigation and Remediation Order, Docket No. IS/E-RAO 06/07-004, dated September 15, 2006 (RFS Site Investigation and Remediation Order). The RFS Site Investigation and Remediation Order provides for the investigation and cleanup of 96 acres of upland and 13 acres of tidal marsh and transition habitat within the Richmond Field Station. In July 2014, UC Berkeley prepared a RAW and an accompanying SMP under Health and Safety Code Section 25356.1(h)(1) and in compliance with the RFS Site Investigation and Remediation Order. The RAW was published for the Richmond Bay Campus, which was later renamed the Berkeley Global Campus at Richmond Bay. The Berkeley Global Campus was comprised of the Former Richmond Field Station and the adjacent Regatta Property, which is also owned by UC Berkeley. The term Berkeley Global Campus is no longer in use, and the scope of this SMP only addresses the Richmond Field Station. UC Berkeley also owns two outboard parcels which are not included in the RFS Site Investigation and Remediation Order nor this SMP. Figure C-2 shows the Richmond Field Station in relation to the Berkeley Global Campus, Regatta Property, and outboard parcels.

The RAW establishes the remedial goals and final remedy for the RES and groundwater at the Richmond Field Station. The remainder of the Richmond Field Station consisting of areas designated for NOS is not addressed by the RAW. Continued investigation within the NOS will continue under the RFS Site Investigation and Remediation Order. The Richmond Field Station, including the RES and NOS, is shown on Figure C-3.

The RAW identifies specific actions to be conducted within the RES at the Richmond Field Station as follows:

<u>Soil Remedy</u>

- Excavation of polychlorinated biphenyl (PCB)–impacted soils at the Building 112 and Building 150 Transformer Areas and three areas within the Corporation Yard with total PCB concentrations exceeding the remedial goal (1 milligram per kilogram [mg/kg]).
- Excavation of mercury-impacted soil at the Mercury Fulminate Area (MFA) with concentrations exceeding the remedial goal (275 mg/kg).

- Excavation of benzo(a)pyrene equivalent (BAP[EQ])-impacted soil with concentrations exceeding the remedial goal (0.4 mg/kg) and dioxin-impacted soil with concentrations greater than the remedial goal (1.6.4E-05 mg/kg) at the Corporation Yard.

- Management of cinders encountered during soil excavations.

- Implementation of site-wide land use controls (LUC) consisting of deed restrictions identifying the future use of the Site as commercial only, and mandating that future site soil disturbance or soil movement be conducted under the SMP.

- Implementation of the SMP which provides a framework for excavation and soil management, in conjunction with redevelopment or construction projects for chemicals in soil exceeding Criteria I or II levels within the RES.

Groundwater Remedy

- Monitoring natural attenuation of groundwater with carbon tetrachloride concentrations exceeding the remedial goal (2.63 micrograms per liter) at the western edge of the Coastal Terrace Prairie.

- Continuing groundwater monitoring at the Richmond Field Station.

- Treatment and monitoring of contaminants in groundwater originating from the former Zeneca Site, including trichloroethene (TCE) and its breakdown components, under the DTSC Site Investigation and Remediation Order for the former Zeneca Site (IS/E-RAO 06/07-005) (Zeneca Order).

- Implementation of site-wide LUCs consisting of deed restrictions prohibiting groundwater extraction for purposes other than groundwater monitoring/treatment or construction dewatering.

This SMP supports the implementation of LUCs by providing a framework to prohibit uncontrolled soil excavation or disturbance activities which may expose workers or visitors to unsafe exposures to environmental contaminants. The objective of this SMP is to ensure that soil disturbance activities do not adversely impact human health or the environment and that the soils are handled, stored and disposed of, or reused onsite in accordance with applicable laws, regulations, and UC policies. The SMP ensures that soils disturbed during future construction, redevelopment, or maintenance projects will be sampled and managed to ensure that no uncontrolled exposures to, or releases of contaminants within the RES occur. This SMP has been effective since July 18, 2014, when the final RAW was published.

Revision 2 supersedes the original version of the SMP and Revision 1, and should be used in its place. The final version addresses comments received from DTSC on the Draft SMP Revision 2, as documented in Attachment C1, DTSC Comments.

The SMP will be reviewed annually or more frequently if necessary, and an updated version of the SMP will be published if warranted due to significant content changes.

1.1 Scope

All activities conducted in the RES of the Richmond Field Station impacting surface cover conditions, surface soil, or subsurface soil are subject to the direct oversight of UC Office of Environment, Health & Safety (EH&S), and are subject to all state and federal soil disposal requirements.

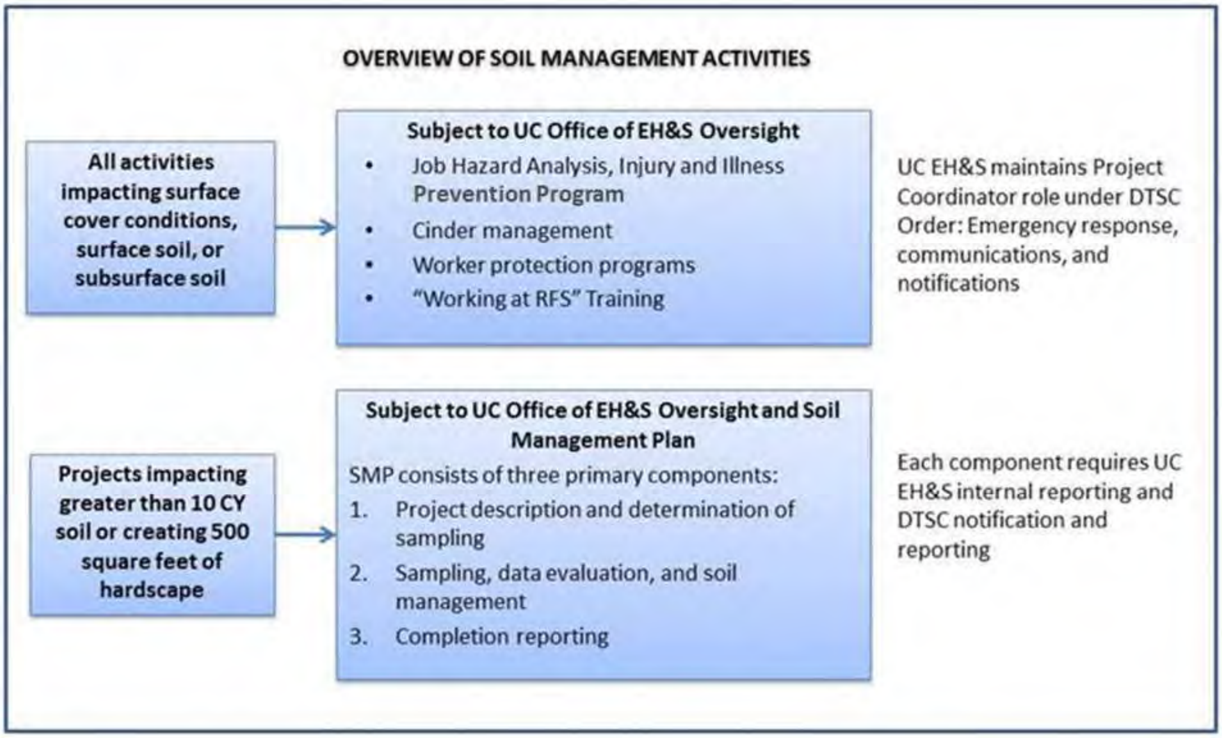
EH&S provides the following services for UC activities at the Richmond Field Station:

- Emergency Response – the EH&S Dedicated Spill Response Team is trained and equipped to address the majority of chemical spills and releases on campus. Team members serve as the liaison to the Richmond Fire Department Hazardous Materials Team and obtain specialized assistance from outside responders as necessary.
- Environmental Protection – programs include acutely hazardous materials management program, campus resources for environmental protection, construction coordination, construction resources, drain disposal restrictions (water quality), environmental management systems, groundwater quality, outdoor air quality, spare the air, surface water quality, and wastewater quality.
- Hazardous Materials – programs include biohazardous waste management, chemical exchange program, compressed gas cylinders, controlled substances disposal, hazardous material management resources, hazardous materials shipping, hazardous waste program, PCBs, and potentially explosive chemicals.
- Health & Safety – programs include asbestos safety, biosafety program, chemical hygiene plan, chemical inventory program, confined space, controlled substances used in research, dedicated spill response team, department safety coordinator program, field safety, hazard communication, hearing conservation, indoor air quality, industrial equipment, industrial safety, injury and illness prevention program, job safety analysis library, material safety data sheets, respiratory protection, sanitation program, standard operating procedures (SOP), toxic gas program, and training (all EH&S). The Health & Safety program includes oversight and approval of any subsurface soil disturbance activities, including utility clearance and cinder management, if present.
- Radiation Safety – programs include radiation safety forms and additional resources, radiation safety training, radiation surveys, radiation use authorization, and radioactive waste management.

In addition to conforming to the EH&S programs above, projects impacting greater than or equal to 10 cubic yards (CY) of in situ soil, or any projects resulting in a new hardscape surface of greater than 500 square feet, are subject to this SMP, which presents an evaluation of sampling requirements, reporting, and DTSC notification. Soil disturbance activities impacting less than 10 CY of in situ soil or less than 500 square feet of hardscape surface are not subject to the requirements of the SMP; however, they will be managed directly by EH&S through its existing programs listed above. If any condition arises that may pose an imminent or substantial endangerment to public health or safety or the environment, DTSC will be notified and a determination will be made whether the SMP is applicable or some other action needs to be taken.

The provisions of the SMP consist of three primary components: (1) project description and determination of sampling; (2) sampling, data evaluation, and soil management action; and (3) completion reporting. Implementation of the SMP will be conducted on a site-specific basis, following the DTSC notification and reviews presented in the SMP. The SMP also provides prescriptive approaches for implementing each component without seeking DTSC-approval for each step; however, DTSC notification requirements will still be met.

An overview of soil management activities is presented below.



1.2 APPROACH

The SMP provides a systematic process intended to ensure that future projects impacting surface and subsurface soils will not result in uncontrolled exposures to or releases of contaminants. This SMP outlines the process required for safe management of soil activities with specific document submittals to DTSC. The SMP also allows for self-implementation of soil sampling and management actions, coupled with DTSC notification, provided UC follows the prescribed protocols outlined in Sections 3.0 through 6.0 of this SMP. The prescribed protocols are not intended as sampling requirements for all projects; instead, they serve as a starting point for sampling protocols and analyses. UC may elect to select alternative methods for soil sampling and management for any project, in which case UC will request and receive approval from DTSC.

This SMP outlines protocols to be followed for soil sampling, data analyses, soil management actions or disposal practices; and final reporting. EH&S will notify DTSC through the submittal of SMP checklist forms. Soil sampling will be based on site-specific strategies, or may follow the prescribed sampling density, depths, and chemicals of concern (COC), which are determined based on the proposed footprint and location of the project. Soil management actions and disposal requirements are based on comparison of soil sample results to screening criteria described herein and various waste acceptance criteria, and final reporting is conducted through preparation of a completion report that will also be provided to DTSC once the project has been completed. Soil may be disposed of at permitted landfills following federal and state hazardous waste laws and regulations, and would be subject to review by DTSC's enforcement program.

The three primary components of the SMP and an overview of the process are presented below and on the SMP Decision Framework diagram on the following page.

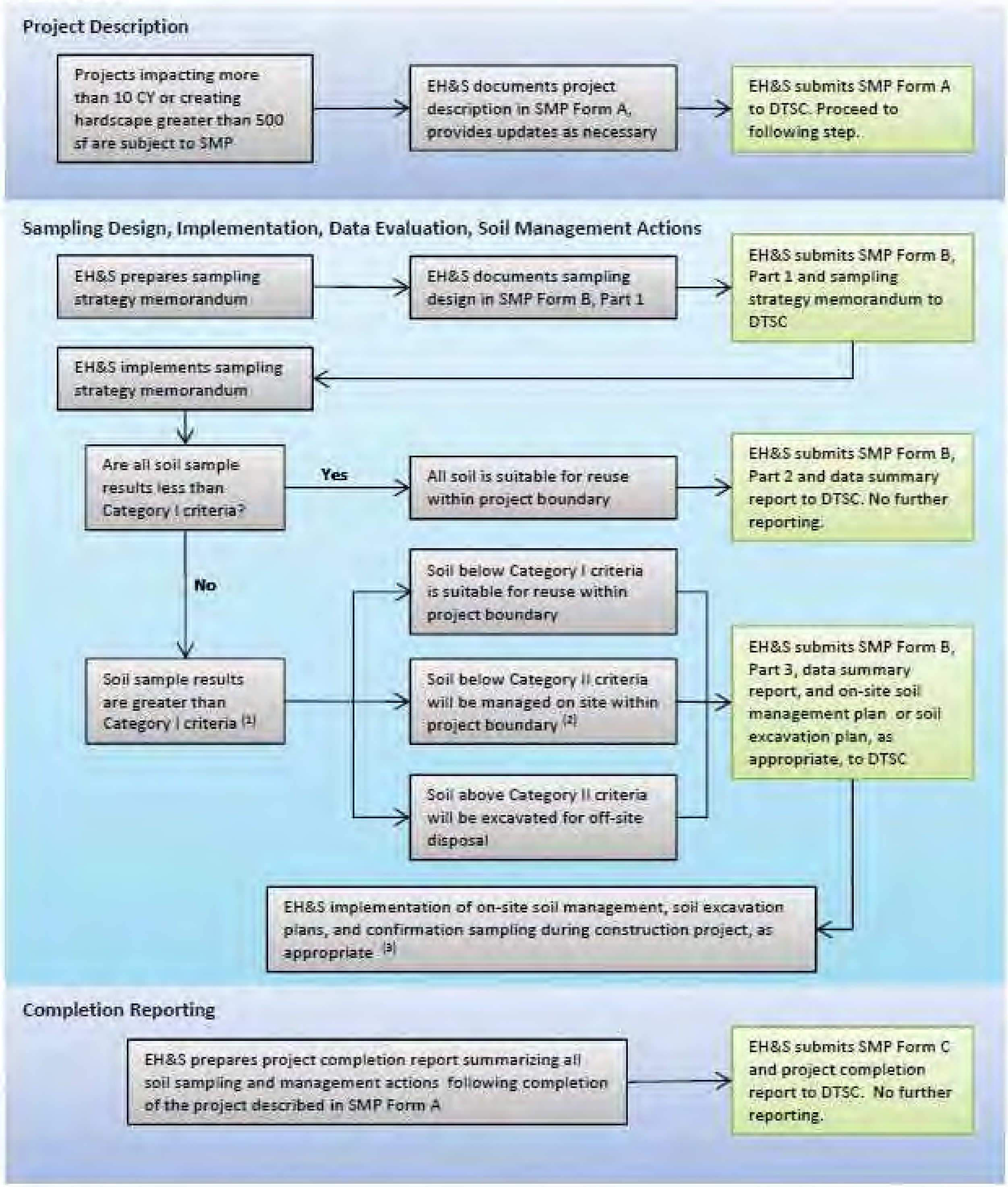
1. Project Description and Determination of Sampling. The first component of the SMP process is the determination by EH&S if the project is subject to the SMP requirements. Projects subject to SMP requirements are any construction, redevelopment, renovation, subsurface or utility repairs, grading, landscaping activities impacting at least 10 CY of soil, or any resulting in a hardscape cover more than 500 square feet.

   Projects impacting soils less than 10 CY or 500 square feet of existing hardscape or unexposed soil surfaces are considered *de minimis* projects and will not be subject to SMP requirements; these impacted soil volumes are expected to result in less than one small roll-off bin of soil. The intent of *de minimis* projects is to not expend unnecessary sampling and administrative costs for small projects already under the oversight of UC EH&S as described in Section 1.1. Examples of *de minimis* projects are presented in Section 3.1.

   For projects subject to the SMP requirements, EH&S will provide a project description and determination of sampling by submitting *SMP Form A, Project Overview* (Exhibit C1) to DTSC prior to initiation of the project. EH&S may complete SMP Form A for *de minimis* projects or use other forms of documentation to ensure proper administrative recordkeeping as well as documenting the rationale for the *de minimis* determination.

2. Sampling Design, Data Evaluation, and Soil Management Actions. The SMP provides sampling protocols for projects requiring sampling in the previous step. Sampling protocols consist of the number of sampling locations per defined area (density), sampling intervals (depths), and analytical requirements. The protocols are based on the size of the proposed soil disturbance (horizontal and vertical); COCs are based on the history of the area (former operations or previous sampling data). Sampling protocols may follow the prescriptive protocols presented, or be conducted on a site-specific basis. The SMP requires submittal of the sampling strategy to DTSC prior to sampling.

SMP Decision Framework



Notes

1. Any soil may be moved off-site for reuse or disposal at an appropriate waste facility at any point within the process, with prior notification to DTSC.
2. Managed on site consists of being covered with 2 feet of soil with concentrations below Category I criteria; being used as fill beneath hardscaped surfaces such as roadways, parking areas, or building structures; or any placement eliminating the direct exposure pathway to potential receptors.
3. Confirmation sampling or any additional characterization sampling may be conducted throughout the project duration.

Analytical data will be compared to numerical screening criteria presented in the SMP (Table C-1). Soil with chemical concentrations less than Category I criteria is suitable for reuse within the project area described in SMP Form A. Soil with chemical concentrations below Category II criteria may be managed on site within the SMP project area – management on site consists of being covered with 2 feet of soil having concentrations less than the Category I criteria, or used as fill beneath hardscaped surfaces such as roadways, parking areas, or building structures, thereby eliminating the direct exposure pathway to potential receptors. EH&S will request DTSC concurrence for any proposed deviations from the prescriptive soil management protocols. Soil will remain within the SMP project area, unless UC requests project-specific approval from DTSC to use the soil in another location at the Richmond Field Station.

Category I and II screening criteria include conditions protective of commercial workers, maintenance workers, construction workers, on-site visitors, and off-site receptors; Category I screening criteria are based on the lowest of the calculated risk-based concentrations (RBC), unless background, ambient, or Toxic Substance Control Act (TSCA) criteria are available, in which case the alternate values are selected. Category I criteria for TPH constituents are based on the San Francisco Bay Regional Water Quality Control Board (RWQCB) ESL. Category II criteria are based on 10 times the Category I criteria, with exceptions noted on Table C-1.

For each SMP project, site-specific conditions will be considered when selecting a remedial goal for a cleanup action. Category I or II screening criteria may be selected as remedial goals for a cleanup action within an SMP project area. However, a different remedial goal may be selected based on the appropriate receptors. The SMP is intended to protect all current and future receptors, however, for example, if the SMP project is known to not consist of a utility corridor, then the maintenance worker need not be considered if it is more stringent than the RBCs for the other receptors.

Soil with chemical concentrations exceeding Category II criteria will be considered for off-site disposal, or may be managed on site with DTSC approval. UC will prepare internal documentation of soil management actions, including an on-site management plan or an excavation plan if appropriate. If soil cannot be managed according to the prescribed requirements specified in this SMP, for example if there are significant building constraints or limitations, UC will request approval of an alternative soil management approach from DTSC.

Notification to DTSC and documentation of this information is provided in *SMP Form B, Sampling, Data Evaluation, and Soil Management Action* (Exhibit C1). SMP Form B will be submitted to DTSC at three stages: (1) prior to sampling, with a sampling strategy memorandum as an attachment; (2) following sampling, with a data summary report as an attachment; and (3) prior to implementation of a soil management action, if required.

If soils have concentrations less than Category I criteria, SMP activities and documentation will be considered complete following submission of SMP Form B with the data summary report.

For projects involving soil with concentrations greater than Category I, additional soil management actions such as on-site management or excavation will be required; in this case SMP Form B will be submitted to DTSC prior to implementation of a soil excavation or on-site management plan (and will include the soil excavation or on-site management plan as an attachment).

4. Completion Reporting. For projects where soil management actions are required, UC will prepare a report summarizing the sampling design, data results and evaluation, soil management actions, and final site conditions following project completion.

Notification to DTSC and documentation of this information will be provided in *SMP Form C, Completion Reporting* (Exhibit C1), which will include the completion report as an attachment. SMP Form C and the completion report will be provided following completion of all construction activities to ensure documentation of final soil management.

1.3 DOCUMENTATION AND SMP UPDATES

Compliance with SMP requirements will be documented through EH&S submitting SMP Forms A, B, and C and associated documentation to DTSC. DTSC may require changes to sampling plans based on their review of the SMP Forms. Documentation requirements are as follows:

- Initial notification of projects subject to the SMP consists of EH&S submitting SMP Form A to DTSC, along with a project map. Projects not recommended for sampling will conclude with DTSC concurrence with SMP Form A. Examples include projects with sufficient existing sampling information, or projects being conducted entirely within clean fill.
- If sampling is required, EH&S will submit SMP Form B, Part 1 to DTSC, along with a sampling strategy memorandum describing the sampling strategy.
- Following sampling, EH&S will submit SMP Form B, Part 2 to DTSC. Documentation for projects with soils having concentrations less than Category I criteria will conclude with EH&S submitting SMP Form B and an attached data summary report to DTSC. For projects with soils having concentrations greater than Category I criteria, EH&S will submit SMP Form B, an attached data summary report, and a recommendation to conduct remedial action.
- For projects with soils having concentrations greater than Category I criteria, EH&S will submit SMP Form B, Part 3 to DTSC, along with either a soil excavation plan or on-site management plan, depending on the soil management strategy selected.
- Following completion of the soil management action, documentation for an SMP project will conclude with EH&S submitting SMP Form C and a completion report to DTSC.

UC will maintain records of all completed SMP Forms A, B, and C, in addition to required attachments supporting the sampling design, data evaluation, and soil management decisions copies of the records will be available to the public and will be maintained in the administrative office at Building 478 and EH&S offices.

UC will conduct annual reviews, or more frequently if necessary, of the SMP to evaluate screening criteria, protocols, and sampling requirements to ensure they continue to meet the intended purpose of the SMP. Suggested improvements or changes to the SMP will be proposed to DTSC for review and approval, and documented formally as a part of the 5-year review process of the RAW, or more frequently if justified. Copies of completed SMP Forms A, B, and C will also be included as a part of the 5-year review of the RAW.

1.4 COMMUNITY NOTIFICATION PROCESS

Community members will be notified of SMP activities similar to current notification practices. EH&S will use following methods of communication:

- Regularly scheduled town hall meetings for staff and tenants at the Richmond Field Station
- Posting of SMP Forms A, B, and C and required documentation on the RFS environmental website (http://www.rfs-env.berkeley.edu/index.html, or equivalent address) prior to soil disturbance
- Routine email communications to staff at the Richmond Field Station
- Hard copies of primary documents, and SMP Forms A, B, and C and required documentation will be available for review at a desk in the lobby of Building 478
- DTSC work notices
- Posting of SMP Forms A, B, and C and required documentation to DTSC's Envirostor database

In addition, a spreadsheet tracking all SMP projects will be available to the public via the RFS environmental website.

Notification practices will be reviewed on an annual basis and modified if deemed necessary.

1.5 ROLES AND RESPONSIBILITIES

The roles and responsibilities for implementing the SMP are provided below.

Name and Affiliation	Role	Responsibility
UC, EH&S	Project Coordinator	Directs environmental health and safety compliance of the SMP. Receives notices, comments, approvals, and related communications from DTSC. Reports to and interacts with the DTSC for all SMP tasks. Signatory to SMP Forms A, B, C.
UC, EH&S	Project Geologist	Reviews all technical documents for technical accuracy and adherence with California laws and regulations. Signatory to SMP Form A.
UC, EH&S	Project Civil Engineer	Reviews all design and management plans for technical accuracy and adherence with California laws and regulations. Signatory to SMP Form A (if Project Geologist does not sign).

Name and Affiliation	Role	Responsibility
DTSC	Remedial Project Manager	Reviews environmental health and safety compliance of the SMP. Signatory to 5-year RAW review process including updated SMP, if appropriate. Receives notices, comments, and related communications from UC. Interacts with UC for all SMP tasks. Reviews all submittals and notifications to DTSC for quality and completeness.

1.6 SMP CONTENT

This SMP is organized consistent with the three primary elements discussed in the approach above. SMP text, tables, and figures provide the required background information and technical information necessary to identify the sampling protocols, data evaluation, soil management action, and completion reporting. The exhibits provide supporting information and reference materials for the implementation of the SMP. A summary of the SMP content is presented below.

- Section 1.0 – Introduction and Purpose. Presents an overview of SMP purpose, scope, approach, protocols for soil management notifications and SMP document updates, roles and responsibilities, and SMP content.
- Section 2.0 – Background. Presents the current and historical land use activities, previous sampling and remedial activities, and summary of COCs. Introduces the geographic delineation of SMP Areas to assist with the review of background information and determination of sampling design.
- Section 3.0 – Project Description and Determination of Sampling. Describes projects subject to the SMP, including small projects which may not require sampling to large projects which will implement the prescriptive sampling requirements of the SMP, or will require consultation with DTSC. Includes description of the information to be presented in SMP Form A.
- Section 4.0 – Sampling, Data Evaluation, and Soil Management Actions. Provides specific protocols to implement the SMP sampling requirements. Provides the sampling frequency and recommended analytes based on previous sampling results and background of the applicable SMP Areas, as referenced in Section 2.0. Identifies the sampling density and sampling depths based on the horizontal and vertical extent of the planned soil disturbance activities. Provides Category I and II criteria for the characterization of soil, and resulting soil management action options. Identifies internal documentation requirements as well as a description of the information to be presented in SMP Form B.
- Section 5.0 – Implementation of Soil Management Actions. Presents protocols and management practices that will be implemented during the soil management actions.
- Section 6.0 – Completion Reporting. Presents a description of the reporting requirements necessary for the completion report and a description of the information to be presented in SMP Form C.
- Section 7.0 – References. Lists sources referenced within the SMP.

The SMP also includes two exhibits essential to the implementation of the SMP:

- Exhibit C1: SMP Forms A, B and C provides templates for documentation of notification requirements and EH&S approval of SMP activities.
- Exhibit C2: The Sampling and Analysis Plan (SAP) provides sampling protocols, policies, and procedures for implementing the sampling conducted under the SMP.

2.0 BACKGROUND

This section presents the current and historical land use activities, previous sampling and remedial activities, and summary of COCs in the RES. It introduces the geographic delineation of SMP Areas to assist with the review of background information and proposed sampling design criteria.

The summary of known conditions provided in this section is intended to provide an overview only. Specific information about historical sources, remediation activities, nature and extent of known contamination, and fate and transport of contaminants are available in the following reference documents:

- Final RAW (Tetra Tech 2014)
- Final Site Characterization Report (SCR) (Tetra Tech 2013)
- Final Current Conditions Report (CCR) (Tetra Tech 2008a)

2.1 CURRENT AND HISTORICAL ACTIVITIES

This section discusses the history of the Richmond Field Station and provides an overview of current and historical land use and features. Current physical features, including buildings, are shown on Figure C-4. The historical potential source areas from former industrial operations as well as all sampling locations are shown on Figure C-5. Former California Cap Company facilities are shown on in more detail on Figures C-6 and C-7. Historic radiologic use and sampling locations are shown on Figure C-8. Further details, as well as historical aerial photographs, are in the CCR (Tetra Tech 2008a).

The RES has been subject to numerous land alterations through its history of development, including creation of ditches and culverts to channel storm drainage; placement of fill in the upland areas; and construction of buildings and utilities.

2.1.1 Current Land Use

The Richmond Field Station is an academic teaching and research facility for UC Berkeley that has been used primarily for large-scale engineering research since 1950. Teaching and research facilities are available for public health investigations, civil engineering, mechanical engineering, transportation, fine arts, ergonomics, and occupational and environmental health. With more than 500,000 assignable square feet of research space, the Richmond Field Station accommodates a range of space-intensive activities—including the UC Berkeley Northern Regional Library Facility, the Pacific Earthquake Engineering Research Center Earthquake Shaking Table Laboratory (one of the world's largest earthquake simulator multidirectional shaking tables), the Geosciences Well Field, sophisticated test facilities for advanced transportation research, and a robotics laboratory. The Richmond Field Station also provides for a variety of smaller-scale engineering research projects not conducted on the central UC Berkeley campus. No sources of contamination have been identified as a result of research activities, with the exception of the Former Forest Product Laboratory Wood Treatment Laboratory (FPL WTL), for which a time-critical removal action (TCRA) was conducted and the small area of total petroleum hydrocarbon (TPH)-affected soil associated with leaks from the Earthquake Engineering hydraulic lines at

Building 484. The UC Regents also lease space to non-UC Berkeley tenants. Current tenants include the U.S. Environmental Protection Agency (EPA) Region 9 Laboratory; Center for Occupation and Environmental Health; Ergomek LLC; The Watershed Project; Marine Advanced Research; Cybertran; New Sun Road; and The Earth Team. In 1989, UC management estimated that 250 to 300 people worked at the RFS (Ensco Environmental Services, Inc. 1989). Staffing in 2017 is approximately 300 people. In 1989, UC management estimated that 250 to 300 people worked at the RFS (Ensco Environmental Services, Inc. 1989). Staffing in 2018 is approximately 350 people.

The LRDP for the property (UC 2014) identifies the developable portion of the new campus as the RES and the remainder as NOS Area. An LRDP is defined by statute (Public Resources Code 21080.09) as a "physical development and land use plan to meet the academic and institutional objectives for a particular campus or medical center of public higher education." The LRDP for the property will guide growth and development of the campus through year 2050.

2.1.2 Historic Uses

Prior to settlement of the East Bay plain by the Spanish beginning in 1772, Native Americans used the area for fishing and harvesting shellfish. In the late 1800s, portions of the property were sold, and chemical and explosives industries moved into the area. Between the 1880s and 1948, several companies, including the California Cap Company (CCC), manufactured explosives at the RES (see RAW Figure 2-3). The CCC plant hosted several operations, including manufacturing explosives (primarily mercury fulminate), shells, and blasting caps; testing explosives; and storing explosives (URS Corporation [URS] 1999).

Two small companies, the U.S. Briquette Company and the Pacific Cartridge Company, are presumed to have operated on a portion of the RES. Both companies are shown on the 1912 and 1916 Sanborn maps, although the U.S. Briquette Company was noted as "not in operation" as of January 1912. Neither company is listed on the 1930 Sanborn map. No additional information is available about either facility. By 1920, the CCC was the only remaining explosives manufacturer on site.

The chief constituent of the explosive manufactured by the CCC was a nitrocellulose (guncotton) base called "tonite." Manufacture of the explosive included production of mercury fulminate, a whitish-gray solid with the chemical formula $Hg(ONC)_2$, a key ingredient in blasting caps. The former mercury fulminate facility was in the southeastern portion of the RES (see RAW Figure 2-4). Other former facilities associated with the CCC included the former CCC shell manufacturing areas in the southern portion of the RES; the blasting cap manufacturing area in the central portion of the RES; an explosives test pit area in the northeast portion of the RES; and two explosive storage areas, both southwest of the former explosives test pit area (URS 1999).

According to an article published in the July 1922 edition of the CCC newspaper, The Detonator, the manufacturing plant consisted of approximately 150 buildings, including administration buildings, a shell and metal drawing unit, a wire drawing unit, the blasting cap line unit, an electric blasting cap unit, and fulminate nitrating and recovery units. A tram line, evident on Sanborn maps and historical photographs, was present between these buildings (see RAW Figure 2-5). It appears from the photograph that the tram line was a rail system with a horsedrawn cart that moved supplies and other goods around the property. The entire CCC facility covered approximately 30 acres, with an additional 30 acres of trees surrounding the facility.

2.2 Previous Investigations and Remediation

This section summarizes previous investigations and remediation activities within the RES and RFS-wide groundwater. Section 2.2.1 briefly summarizes investigations that were conducted in the RES prior to the Field Sampling Workplan (FSW) that was prepared by UC Berkeley and approved by DTSC in 2010. Section 2.2.2 summarizes FSW Phases I, II, III, and IV investigation activities and sampling results from 2010 through 2012. Section 2.2.3 summarizes previous cleanup actions that have been conducted in portions of the RES between 2002 and 2004 as well as two TCRAs.

2.2.1 Pre-FSW Investigations

Investigations conducted between 1981 and 2008 involved collection of soil and groundwater samples in a variety of locations within the RES. Soil samples were generally analyzed for metals, PCBs, polycyclic aromatic hydrocarbons (PAH), semivolatile organic compounds (SVOC), or pesticides (Tetra Tech 2013). The investigations conducted prior to 2010 focused on potential source areas (see RAW Figure 2-3), and identified areas requiring further investigation. The data collected during these investigations is summarized in the CCR (Tetra Tech 2008a) and SCR (Tetra Tech 2013).

2.2.2 FSW Investigations

UC Berkeley completed FSW Phases I, II, III, and IV data gap investigations between 2010 and 2016. The FSW addresses data gaps identified in the CCR that warranted additional characterization or evaluation at RFS (Tetra Tech 2008a). The scope of the FSW groundwater investigation (Phase I) covered the entire Richmond Field Station. The majority of the Phase II and III FSW soil investigations occurred within the RES; the Phase IV soil investigation of the Upland Meadows took place in the NOS. The Phase IV investigation also included investigation of the carbon tetrachloride area, which is located in the RES and NOS, via soil gas sampling. During the Phase IV investigation, two other investigations were conducted in the NOS: groundwater well installation and sampling in the vicinity of the biologically active permeable barrier within Western Stege Marsh, and an exploratory excavation of the Bulb.

The purpose of the FSW investigation was to close previously-identified data gaps, and to identify any immediate or potential risks to public health and the environment. Results are briefly summarized below and are described in detail in the SCR (Tetra Tech 2013) and in the Phase IV Sampling Results Technical Memorandum (Tetra Tech 2016).

2.2.3 Previous Cleanup Actions

Remedial activities occurred in three phases beginning in 2002. Remedial Phases 1 through 3 were completed in 2002, 2003, and 2004, respectively, under oversight of the RWQCB. A TCRA occurred near the FPL WTL in fall 2007 to remove arsenic-contaminated soils; the results are summarized in the TCRA Implementation Report (Tetra Tech 2008b). A second TCRA was conducted south of the RES in fall 2008 to excavate soil associated with ash piles with elevated levels of PCBs; the results are summarized in the TCRA Implementation Report (Tetra Tech 2009). The TCRAs were completed under DTSC oversight. Figure C-5 shows locations of the previously remediated areas and sampling locations. Table C-2 briefly summarizes these remediation activities.

2.3 CHEMICALS OF CONCERN

The results of the historical and FSW investigations indicate that elevated concentrations of certain metals, PAHs, and PCBs occur in RES soils, and soil sampling for these constituents is recommended throughout the RES. Other potential contaminants more limited in RES soils include dioxins, TPH, and volatile organic compounds (VOC); these contaminants are recommended for analysis in select locations of the RES.

Based on the historical use of explosives, explosives constituents are also recommended for sampling and analysis in select locations in the RES; however, explosives constituents have not been detected in previous soil sampling in the RES above Category I criteria.

For the purposes of this discussion, "elevated" concentrations in soil refers to soil concentrations above the screening criteria used in the SCR. Soil screening criteria used in the SCR include:

- Calculated human health RBCs for future commercial workers for metals, VOCs, SVOCs, pesticides, PCBs, and explosives (Tetra Tech 2013);
- The background value for arsenic (16 mg/kg) as established for the adjacent Campus Bay site and approved by DTSC for the Richmond Field Station (Erler & Kalinowski, Inc. 2007; DTSC 2007);
- The background value for cobalt (73 mg/kg), manganese (5,900 mg/kg), and nickel (280 mg/kg as established in SMP Revision 1. Aluminum was eliminated as a chemical of concern in SMP Revision 1.
- The ambient value for carcinogenic PAHs, as represented by BAP (EQ), which is equal to the 95th percentile Upper Confidence Limit (UCL) of the mean BAP (EQ) values of the ambient surface soil dataset from urban environments in Northern California of 0.4 mg/kg (DTSC 2009; Environ Corporation and others 2002);
- TSCA cleanup criteria for total PCBs in soil, high occupancy areas with no conditions (1 mg/kg) (EPA 2005); and
- Commercial environmental screening levels for TPH constituents (RWQCB 2013).

The SCR also identified two VOCs in groundwater (TCE and carbon tetrachloride) which have been detected above the calculated human health vapor intrusion RBCs for future commercial workers (Tetra Tech 2013). While these VOCs are not COCs in soil, future soil disturbance activities which occur in areas where the groundwater concentration exceeds vapor intrusion RBCs must take into consideration proper countermeasures to ensure protection of future commercial workers.

Metals

Arsenic concentrations above background levels in soils are the result of historical placement of pyrite cinders as fill material in the RES. Pyrite cinders, such as those used in production of sulfuric acid at the former Stauffer production areas, are produced from ore that is composed mostly of iron sulfide but may also contain other metal sulfides, such as arsenopyrite, and concentrations of arsenic and other metals are often found above background levels in pyrite cinders. Other possible sources of arsenic include the historic use of arsenic containing herbicides on railways and the use of arsenic wood preservatives at the former FPL WTL. A removal action conducted at FPL WTL in 2007 removed arsenic contamination above background levels in the area of the research laboratory.

Potential sources of lead at RES include (1) historic emissions from automobiles, (2) a component of metals used in manufacture of shells and blasting caps, (3) pyrite cinders used as fill throughout RES, and (4) leaded paint from former or existing buildings. Some elevated concentrations of lead are in isolated areas of RES soils, perhaps attributable to the “nugget effect” that can occur when lead-based paint chips into soil.

Mercury is present at elevated concentrations in RES soils primarily due to historical activities associated with manufacturing explosives. The former CCC historically used elemental or liquid mercury in the MFA. This form of mercury can volatilize into the atmosphere from soil, sediment, or water. Drawings of the mercury fulminate production plant show an open structure (presumably for ventilation) and air stack which could have contributed to aerial deposition of mercury in the areas surrounding the mercury fulminate plant in the central meadow. Drawings also identify storage tanks rinsate areas in the MFA. Movement of the blasting caps around the facility via the tram system could have tracked mercury away from the mercury fulminate plant. As part of the remedy for the RES, UC has proposed a soil removal action in the MFA where concentrations of mercury elevated above the commercial risk-based concentration are present.

PAHs

PAHs in the RES are likely a result of burning carbon-containing compounds (including at the former waste incinerator near Building 120 and the former Field Laboratory), aerial industrial emissions from surrounding industrial facilities, and gasoline and diesel exhaust from regional roadways and railyards. An assessment of the soil data obtained from RES soils, mostly in the Corporation Yard, indicates that concentrations of PAHs decrease with depth; where PAHs are present, concentrations of PAHs are elevated above screening criteria in surface soils (0 to 0.5 feet below ground surface [bgs]), but are typically less than screening criteria at deeper depths (2 to 2.5 feet bgs), and non-detect below 2 to 2.5 feet bgs.

PCBs

PCBs are biopersistent organic chemicals that were used for many purposed from the initial commercial use in 1929 to when use was banned by EPA in 1979, including heat transfer fluids for gas turbines, hydraulic fluids for vacuum pumps, fire retardants, and plasticizers in adhesives, textiles, surface coatings, sealants, printing, and carbonless copy paper (Lloyd and others 1975). Aroclors-1248, -1254, and -1260 are commonly found in the RES, and are likely associated with hydraulic fluids and dielectrical fluids in capacitors and transformers. A release of PCBs to surface soils from a spill would have migrated little from its original release point, as PCBs sorb strongly to soil. This model is supported by the sampling data obtained during the FSW Phase II investigation, which sampled near former PCB-containing transformers. Where PCB contamination was detected, elevated concentrations of PCBs were limited to a small area, both horizontally and vertically, confirmed through step-out sampling.

PCBs have also been detected at low concentrations (below screening criteria) in surficial soils within the RES, most of which may not be attributed to a spill but possibly to aerial deposition from surrounding industrial facilities, including the PG&E facility northwest of the RES. As part of the removal action for the RES, UC will remove soils with total PCB concentrations greater than 1 mg/kg. The areas identified for PCB removal are located at two transformer areas and the Corporation Yard.

Dioxins

Dioxins in the environment are the result of burning chlorine-based chemical compounds with hydrocarbons, such as stack emissions from the incineration of municipal refuse and certain chemical wastes, or exhaust from automobiles powered by leaded gasoline. The former waste incinerator at Building 120 may be a potential historical source of dioxins; soil samples collected for dioxin analysis near the former incinerator location indicate that dioxin concentrations in that area exceed the commercial risk-based concentration in surficial soil, but concentrations decrease as sample depth increases.

VOCs

Although RES soils have not been found to contain concentrations of VOCs exceeding screening criteria, groundwater results indicate that TCE and carbon tetrachloride exceed groundwater screening criteria.

Groundwater impacted with elevated levels of TCE exceeding the commercial vapor intrusion risk-based concentration and the California and federal maximum contaminant levels (MCL) has migrated onto the Site from the adjacent former Zeneca Site. UC concludes that TCE and related breakdown products originated from legacy industrial activities at the former Zeneca Site, based on (1) the measured groundwater gradient from the former Zeneca Site to the Site, (2) known historical TCE sources and groundwater contamination at the upgradient former Zeneca Site, and (3) lack of measured or identified TCE sources within the Site. The remedy for contaminants in groundwater originating from the former Zeneca Site, including TCE and its breakdown components, is subject to the Zeneca Order.

Carbon tetrachloride was detected at piezometer location CTP (located in the upland meadows) at concentrations exceeding the commercial vapor intrusion risk-based concentration and California MCL during the FSW Phase I investigation. Carbon tetrachloride has also been detected at some of the piezometer locations downgradient of location CTP at concentrations exceeding the California MCL. No source of carbon tetrachloride has been identified in the immediate area or upgradient of the piezometer CTP. Soil gas sampling in October 2014 did not indicate a source in the investigation area, or a direction of a possible source.

TPH

Low concentrations of TPH compounds in soil may originate from small diesel spills from equipment, from aboveground storage tanks (AST) or former underground storage tanks (UST), from incomplete combustion of petroleum from nearby automobiles and industrial uses, or as a carrier in herbicides. No spills were observed at any of the ASTs still in place, and all USTs have been removed and administratively closed. Soil sample results indicated that the Earthquake Engineering hydraulic lines at Building 484 leaked and soil excavation within this area was completed in October 2014 as a maintenance activity (UC Berkeley 2014b).

Explosives

Between the late 1800s and 1948, the CCC and other smaller companies, manufactured blasting caps, shells, and explosives on the property. The chief constituent of the explosive used by the CCC was a nitrocellulose (guncotton) base called “tonite,” the manufacturing of which included the production of mercury fulminate. Documentation indicates that nitrocellulose and mercury fulminate were the primary explosives used in manufacturing explosives on the property, however, other explosives such as octahydor-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), cyclotrimethylenetrinitramine, or 2,4,6-trinitrotoluene may have been employed. Historical documents indicate that explosives were tested and stored in the north-central portion of the property (RAW Figure 2-3). Soil data to date indicates that HMX may have been used, as it was detected at a low level in one sample collected near the explosive storage area at a concentration of 0.37 mg/kg, five orders of magnitude below the commercial risk-based concentration.

2.4 SOIL MANAGEMENT PLAN AREAS

In order to determine the analytical requirements and density of sampling required for the SMP, the RES was divided into 25 SMP Areas. SMP Areas were created by reviewing historical activities, results of sampling conducted to date, contaminants previously detected, and removal actions conducted to date. Areas with similar site histories and uses that were adjacent were placed into the same SMP Area. Figure C-3 presents the 25 SMP Areas, and Table C-2 presents a summary of the characteristics considered for each SMP Area, including historical and current activities, previous cleanups, potential for pyrite cinders, and whether a groundwater concentration exceeds the commercial vapor intrusion risk-based concentration. EH&S will review Table C-3 annually to incorporate data from sampling conducted following the publication of this SMP.

3.0 PROJECT DESCRIPTION AND DETERMINATION OF SAMPLING

This section describes types of projects subject to the SMP, spanning from small projects that may not require sampling to large projects which will implement the full range of sampling and soil management requirements presented in this SMP.

3.1 TYPES OF WORK

The LRDP for the Richmond Field Station property includes redevelopment and construction of new buildings and support infrastructure within the RES which are anticipated to require large-scale soil disturbance. Routine maintenance and repair activities which require small-scale soil disturbance will also be required in the RES on an ongoing basis, independent of redevelopment under the LRDP.

The SMP will be implemented for all future projects or activities conducted within the RFS portions of the RES that (1) impact greater than or equal to 10 CY of in-situ surface or subsurface soils or (2) result in a hardscaped surface of greater than 500 square feet or disturbances of 500 square feet of surficial soil not currently exposed. Examples of typical soil disturbance activities that are subject to the SMP include the following:

- Building construction
- Road construction
- Sidewalk construction
- Parking lot construction
- Major underground utilities construction associated with a project
- Significant landscaping activities
- Removal or disturbance of groundcover exposing previously-covered soil

Soil disturbance activities that impact less than 10 CY of soil or less than 500 square feet of hardscape or covered surface are not subject to the prescriptive requirements outlined in this SMP. These *de minimis* projects will be managed and overseen by UC EH&S as discussed in Section 1.1. Larger projects may not be identified as *de minimis* projects to avoid prescriptive sampling measures. For *de minimis* projects, EH&S may prepare SMP Form A to document the rationale for the *de minimis* determination or maintain other forms of documentation, such as emails. UC will notify DTSC and the community of *de minimis* activities consistent with current notifications provided to DTSC and the Richmond Field Station community (e.g., work notices, posting of documents to DTSC's Envirostor database, regularly scheduled town hall meetings for Richmond Field Station workers and tenants). Typical *de minimis* projects that will not be subject to the SMP include the following:

- Minor sidewalk or utility repairs
- Landscaping activities such as tree or shrub planting or removal and weed removal

- Installation of fence posts or signage
- Roadway asphalt repair
- Installation and decommissioning of soil boreholes and monitoring wells

Dewatering projects related to construction or soil disturbance activities are also subject to review under the SMP. In areas with known impacts to groundwater, the following actions will be implemented by EH&S:

- Perform an assessment of current groundwater monitoring reports to determine if there are impacts to groundwater in the work area, prior to installing dewatering wells.
- Prevent advancing any borings for dewatering purposes (or installing dewatering wells) which are screened across multiple water-bearing units.
- Secure all appropriate permits to discharge to sanitary sewer if dewatering is done in areas where impacts to groundwater are known.
- Enforce all groundwater discharge permit requirements associated with collecting or storing impacted groundwater, batch sampling, treatment prior to discharge to the sanitary sewer, or off-site disposal.

All soil disturbance or dewatering activities with the RES are subject to review and approval by EH&S. Soil disturbance activities within the RES subject to the SMP require written EH&S notification and approval, which is initiated through the completion of *SMP Form A, Project Overview*, included in Exhibit C1. Activities requiring permits or work plan approvals, including the installation and decommissioning of soil boreholes and monitoring wells, will be obtained prior to the start of work. The extent of the EH&S approval process and supporting documentation will depend on the nature, size, and complexity of the project, as well as location of the project within the RES. A spreadsheet tracking all SMP projects is available to the public via the RFS environmental website.

The requirements of the SMP will be based on the scale and location of the proposed activity. All soil disturbance activities will require EH&S approval of the activity prior to soil disturbance, and projects subject to the SMP will require EH&S approval of SMP Form A. EH&S will provide SMP Form A to DTSC at least 14 days prior to the start of work or as soon as practicable during the next working day if the 14 days advance notification is not possible, such as for emergency repairs or other time-critical projects. In cases where pre-approval cannot be attained for projects requiring SMP Form A, such as for emergency repairs, EH&S will notify DTSC by telephone within 24 hours of the start of the activity or on the next working day if emergency repairs occur on a weekend or holiday, and SMP Form A will be completed within 48 hours, or on the next working day if emergency repairs occur on a weekend or holiday. Notification to all other appropriate agencies will also be provided as required by law.

3.2 POTENTIAL IMPACTS TO PROTECTED SPECIES OR WETLANDS

Efforts should be made to minimize any impacts to California native plant species listed in the California Native Plant Society registry. FigureC-9 indicates these species mapped previously at the Richmond Field Station. Efforts should be made to minimize any impacts to potential wetland or hydrologic features currently mapped at the Richmond Field Station, as identified on Figure C-10.

3.3 POTENTIAL IMPACTS TO GROUNDWATER PIEZOMETER NETWORK

The RAW for the RES and Site-wide groundwater includes ongoing sampling at piezometers located throughout the RES. Efforts should be made to minimize any impacts to existing piezometers from a proposed soil disturbance activity. In the event that an activity impacts a piezometer, the piezometer must be properly destroyed and abandoned per Contra Costa County Environmental Health Department guidelines and a permit must be obtained; UC will notify DTSC to propose a new piezometer location. All existing piezometer locations are shown on Figure C-5.

3.4 SAMPLING REQUIREMENTS

Soil disturbance projects under the scope of this SMP are subject to the prescriptive sampling requirements discussed in Section 4.0. If UC proposes an alternative sampling plan which does not specifically follow the prescriptive requirements, EH&S will notify DTSC for review and approval of the proposed sampling plan.

3.5 DOCUMENTATION

EH&S will document EH&S approval and DTSC notification of projects subject to the SMP through the completion and submission of SMP Form A, Project Overview.

Instructions for Completing SMP Form A, Project Overview	
1. Tracking No., Revision No., and Date	Provide unique tracking number, revision number, and date of latest revision. For the tracking number, use the format YYYY-MM-DD-[Abbreviated Project Name].
2. Project Name	Provide unique project name.
3. Description	Include details necessary to implement SMP. Include specific location, description of activities impacting soil, estimate of total soil disturbance in cubic yards. Attach map indicating project location.
4. Points of Contact	Provide EH&S point of contact, facilities point of contact, or any other UC or other third party responsible for implementation of SMP requirements.
5. Estimated Schedule	Identify estimated schedule of entire project through completion. Update as necessary.
6. DTSC Work Notice Requirements	EH&S must provide DTSC a 14-day notice regarding projects involving excavation, drilling, or sampling for the purpose of collecting environmental samples or addressing soil management. DTSC issues a Work Notice to a community distribution list.
7. Impacts to Piezometer Network	Consult with SMP Figure C-5 to ensure project does not impact an existing piezometer, or propose replacement location to DTSC if necessary.

Instructions for Completing SMP Form A, Project Overview	
8. Affected Area Overlaps with NOS	Indicate if the project area footprint extends into area designated as NOS. If yes, then implement mitigation measures per the EIR for the property.
9. Radiological Status	Consult with SMP Figure C-8 and Table C-4 to determine if project is within an area of former radiological use. If yes, EH&S will coordinate with UC Berkeley's EH&S Radiological Safety Program to determine the radiological status and protocols necessary prior to proceeding.
10. Total Volume of Soil Excavation Planned (in CY) and New Hardscape	Calculate the total in-situ volume of soil that is planned for excavation to complete the building or construct new hardscape.
11. *De Minimis* Status	Indicate if the project is exempt from SMP prescriptive requirements based on the volume of excavation or size of hardscaped area affected. Projects impacting less than 10 cubic yards of in-situ soil or 500 feet of hardscaped area are exempt from the SMP prescriptive requirements. EH&S may document the rationale for *de minimis* determinations in the SMP Form A.
12. Notes	Add notes here that do not fit into the above categories.
13. SMP Form A Approvals: EH&S; Facilities Management, UC Berkeley College of Engineering; and Professional Civil Engineer or Geologist	Form A must be signed and dated by EH&S staff responsible for implementation of SMP activities, as well as a representative from facilities management for the College of Engineering, and a professional civil engineer or geologist. Signature indicates review and approval of Items 1 through 6. Signature indicates that proper additional documentation necessary is included within EH&S files. EH&S will provide Completed SMP Form A to DTSC.

SMP Form A, which will include the project location map, will be completed by EH&S and submitted to DTSC and posted on the RFS Environmental website prior to any soil disturbance activities. SMP Form A will be updated and provided to DTSC if the project scope or conditions change, for example if the project area or estimated soil volume increases or the schedule has been revised. If after 6 months the project has not proceeded to the next step, the information on SMP Form A will be reviewed and updated as necessary. EH&S will maintain within UC files any additional internal documentation necessary in support of the information presented in SMP Form A. Supplemental documentation, if prepared, will be provided to DTSC or be available upon request from DTSC.

4.0 SAMPLING, DATA EVALUATION, AND SOIL MANAGEMENT ACTIONS

This section outlines the objectives and basis for projects subject to sampling under the SMP. Projects will be evaluated to determine the scope of sampling and analysis to be conducted prior to initiating earthwork activities.

The sampling protocols will be established on a site-specific basis, or may follow the prescribed protocols (number of sampling locations, sample depth, sample intervals), and chemical analyses presented in Section 4.1. Soil sampling will be conducted following the protocols outlined in Exhibit C2, SAP. Soil sampling data will be evaluated per the guidelines in Section 4.2 to determine the appropriate soil management action determination presented in Section 4.3. Section 4.4 presents the planning documents necessary to manage soil in place or for off-site disposal. All sampling approaches will be submitted to DTSC prior to implementation.

4.1 PRESCRIPTIVE SAMPLING DESIGN

The sampling design is based on the location, footprint, and depth of the proposed soil disturbance. The prescriptive sampling designs presented below may be used in the event that a site-specific sampling strategy is not recommended by UC EH&S or DTSC.

Sampling Density and Recommended Analytes

Sampling design is initiated by identifying the SMP Area(s) impacted by the project through comparison to Figure C-11. Table C-3 presents the recommended sampling density and analytical requirements for each of the SMP Areas delineated on Figure C-11.

Samples will generally be collected in a grid pattern to provide representative lateral coverage over the project area. Three categories of sampling density have been defined (low, medium, and high) as described below. The recommended sampling density for each SMP Area is a function of historical activity in the area and the results of previous investigations. Sample locations must be documented on scaled figure with appropriate landmarks or buildings identified. The required sample density for each SMP Area is specified in Table C-3.

- Low density sampling requires sampling on a 125-foot grid spacing (one sample location per 15,625 square feet) – applicable in SMP Areas where no historical industrial activities occurred;
- Medium density sampling requires sampling on a 100-foot grid spacing (one sample location per 10,000 square feet) – applicable in SMP Areas where some historical industrial activities occurred, or an adjacent SMP Area has had a high level of historical industrial activities; and
- High density sampling requires sampling on a 75-foot grid spacing (one sample location per 5,625 square feet) – applicable in SMP Areas where a high level of historical industrial activities occurred.

There is no minimum number of sample locations required for each project; however, if a 95 UCL is to be calculated, as described in Section 4.2.2, a minimum of ten samples will be collected.

If PCBs are identified as the potential contaminant of concern, then incremental sampling methodology protocols will be used for sample collection, per request by U.S. EPA TSCA Division. Revision 2 provides an update to Exhibit C2, Sampling and Analysis Plan, presenting incremental sampling methodology protocols.

Known site conditions within the project area will be considered when developing the sampling design and analytes, to determine if any additional sampling is needed, or if sampling locations should be moved to characterize certain areas of the project to meet the intent of this SMP. Factors to be considered include:

- Existing buildings, utilities and site features (current and any which will be demolished by a proposed project);
- Building construction history to determine potential for organochlorine termicides under the foundation or PCBs, lead or asbestos in materials or near surface soils;
- Former buildings, remediated areas, and known pyrite cinder areas, as shown on Figure C-5, Figure C-6, and Figure C-7;
- Historical soil sample locations, sample depths, and sample analysis results, as presented in the Final SCR (Tetra Tech 2013). Historical sampling information may be used to supplement the sampling design; and
- Recent sampling data, if available.

Sampling Depth and Intervals

Samples will be collected in 0.5-foot depth intervals every 2 feet starting at the surface and extending to a depth of 2.5 feet below the depth of planned soil disturbance. This will allow documentation of potential residual soil contamination beneath the excavation. If the depth of the planned soil disturbance varies within the project area, the sampling design should be adjusted to provide representative coverage for the variable depths or by sampling subareas separately. Soil samples will be collected by hand or advanced through hand-auger techniques up to 5 feet bgs. For temporary projects (such as limited time installation research) or shallow utility line extensions, sample depths are not required to extend below the depth of the planned soil disturbance. Sampling methodologies will be conducted according the SAP.

Samples may also be collected at depths greater than 2.5 feet below the proposed excavation depth as part of characterization sampling; these samples will be held in the laboratory and analyzed in the case that concentrations from samples from 2.5 feet below the proposed excavation depth exceed criteria. Similarly, samples may be collected outside of the proposed excavation boundary and held in the laboratory, and analyzed in the case that concentrations from samples at the edge of the proposed excavation exceed criteria. Samples being held pending analysis will only be analyzed if the holding time has not expired. In cases where the holding time is exceeded, an additional sample would be collected at the edge of the final excavation to confirm that the criteria are not exceeded.

EH&S will determine the need for professional land-surveying for sampling locations on a project-by-project basis. For all other projects, hand-held devices using global positioning systems will be used to record sampling locations and will be tracked in the geographic information system (GIS) database.

Soil Sampling for Lead Based Paint around Existing Buildings

Paints applied to the exterior of buildings constructed prior to 1993 are likely to have contained lead (DTSC 2006). Lead-based paint (LBP) may be present in the immediate vicinity of these buildings as a result of weathering, or past renovation activities resulting in deposition of LBP fragments to surface soil. Lead in soil from LBP from exterior paint is generally present only in the immediate vicinity of the building and in the top few inches of surface soil. LBP is generally not present where the building perimeter is hardscaped, such that paint chips are carried away by rain or wind, and does not accumulate.

Sampling for LBP-impacted soil will be conducted where the planned project boundary includes a building constructed prior to 1993.

Area of Potential Groundwater Concern

TCE and carbon tetrachloride concentrations exceed commercial vapor intrusion RBCs in portions of the RES, as discussed in Section 2.3. Table C-3 identifies the six SMP areas where groundwater concentrations exceed the commercial vapor intrusion RBCs, indicating that indoor air concentrations of those VOCs may be present at levels posing risk to potential commercial receptors (Tetra Tech 2013). The selected remedy for groundwater at the Richmond Field Station includes an ongoing groundwater monitoring program and implementation of the groundwater remedy for the adjacent former Zeneca site, which consists of treatment and ongoing monitoring. The groundwater remedy also includes monitored natural attenuation with a contingency for active treatment to address the carbon tetrachloride contamination in the northwest part of the RES (SMP Area 15).

If a soil disturbance project (1) consists of the construction of a new building or (2) extends deep enough to contact groundwater, and (3) is located in a SMP Area where groundwater results exceed the commercial vapor intrusion RBCs for VOCs identified in Table C-1, then EH&S will consult DTSC before creating a sampling plan. Because VOC concentrations in groundwater are expected to change over time, site-specific evaluation is needed to determine if additional sampling protocols or worker protection precautions will be required, based on the project location. Given the ongoing nature of the groundwater monitoring programs, EH&S will consult the most current groundwater data available. A prescriptive approach for addressing potential groundwater concerns in the SMP is not appropriate.

If there is a concern regarding groundwater contamination along newly created-preferential pathways as a result of a new construction project (for example a deep utility corridor), then engineering parameters, such as impervious linings, will be developed under the project-specific design plan.

UC will evaluate potential impacts to groundwater in the event that a project involves the construction of a swale or permeable landscaping intended for the management of stormwater.

4.2 DATA EVALUATION

Soil sample data will be evaluated to confirm that the data set is complete, and data quality is acceptable. Data acceptance criteria and data validation protocols are provided in Exhibit C2, SAP. Deviations from the sampling design, such as change in sample location, or analytical results which do not meet data quality criteria, will be evaluated to determine whether additional sampling is required.

4.2.1 Screening Criteria

Soil sampling data will be compared to two soil screening criteria to determine the management action that needs to be taken: (1) Category I criteria represent the most protective risk-based concentration (or background, ambient, or regulatory criteria, if available) and are protective of all future workers and visitors to the RES; and (2) Category II (On-Site Management) criteria represent the maximum concentration of chemicals in soil which may be managed in place within the SMP project area described in SMP Form A with a cover to prevent exposure to commercial workers or visitors. Category I and II criteria are presented in Table C-1.

Category I criteria are based on the lowest of the calculated RBCs (of the commercial worker, construction worker, maintenance worker, and off-site receptor [inhalation only]), unless a background, ambient, or TSCA criterion is available, in which case the alternate values are selected. Category II criteria are generally based on the equivalent of one order of magnitude greater than the Category I criteria, with exceptions identified in Table C-1. Screening criteria will be reviewed at least annually during periods when projects are occurring, in addition to the evaluation of remedy implementation that will occur as part of the five-year review process.

The section below discusses updates made to the screening criteria since the original publishing date (July 2014). The intent of this section is to maintain a record and chronology of changes along with the rationale for each change.

Updates to the Screening Criteria

The following updates were made to the screening criteria for Revision 1:

- Category I and Category II criteria for TPH constituents were updated to reflect the most stringent of the RWQCB Direct Exposure Soil Screening Levels for Commercial/Industrial Worker Exposure, any Land Use or Depth Construction Worker Exposure (Table S-1), or Leaching to Groundwater Nondrinking Water (Table S-2) (RWQCB 2016). These levels are protective of commercial workers and are appropriate for the exposure scenarios expected to occur at the RFS Site.

- The RBCs for total PCBs were updated to "- -" (not applicable) for each receptor to remove the inappropriately summed risk values. The Category I and II criteria of 1 mg/kg were maintained, in accordance with TSCA.

- Screening criteria for cobalt, manganese, and nickel were updated based on the Final Ambient Metals Evaluation, Aluminum, Cobalt, Manganese, and Nickel (Tetra Tech 2015).
- Aluminum was eliminated as a chemical of concern based on the Final Ambient Metals Evaluation, Aluminum, Cobalt, Manganese, and Nickel (Tetra Tech 2015).
- The Category II criteria for barium was updated to 21,100 mg/kg.

Revision 2 does not provide any changes to the screening criteria

4.2.2 Determination of Soil Management Action

A comparison of the maximum sample result or the calculated 95 UCL (if available) to the Category I and II criteria will be used to determine how to manage the project soil. UC will determine the appropriate soil management actions for sampled project soil using the following decision matrix:

Comparison of Soil Concentrations to Screening Criteria	Soil Management Action
Maximum soil concentration or 95 UCL concentration does not exceed Category I criteria	No action; suitable for commercial reuse within the SMP project area.
Maximum soil concentration or 95 UCL concentration exceeds Category I criteria but does not exceed Category II criteria	Soil may be managed in place within the SMP project area with appropriate cover. Appropriate cover consists of hardscape (roadway, parking lot, sidewalk, or building) or a minimum of 2 feet of soil with concentrations less than Category I criteria, or as approved by DTSC.
Maximum soil concentration or 95 UCL concentration exceeds Category II criteria	Soil will be evaluated for off-site disposal, or DTSC will be contacted if proposed to be managed in place.

<u>Delineation of Soil Exceeding Criteria</u>

Additional soil samples may be collected in order to delineate the lateral and vertical extent of soil contamination exceeding Category I or II criteria in order to reduce the amount of soil that is planned for excavation or management in place. The sampling grid size for additional delineation sampling will be no less than twice the frequency of the original sampling. If significant excavation activities are already planned for the proposed project, additional sampling may be conducted during excavation activities rather than prior to excavation.

If the project soil concentrations are less than the Category I criteria, then the project may proceed without specific soil management practices, as outlined in the table above. Soil generated from the project must remain within the project boundaries described in SMP Form A unless DTSC has provided approval otherwise. The sampling results will be documented in a summary report and submitted by EH&S to DTSC with SMP Form B.

If soil is less than Category II criteria, then soil can either be managed in place within the SMP project area described in SMP Form A or excavated and managed through placement beneath 2 feet of soil below Category I criteria, or beneath a hardscaped surface, such as a roadway, sidewalk, parking, or building foundation, to prevent exposure of commercial workers and visitors to soil. Soil with concentrations exceeding Category II criteria will be excavated to a depth of 2 feet below the planned soil disturbance, effectively eliminating the direct contact exposure pathway, unless DTSC is contacted for approval to manage the soil in place. Soil excavated from a SMP project area will remain within the same SMP project area unless it is disposed of off-site; if UC proposes to use the excavated soils in other portions of the RES, UC will contact DTSC for approval. The sampling results will be documented in a summary report and submitted by EH&S to DTSC with SMP Form B following project completion, as described in Section 6.0, Completion Reporting.

Soils exceeding Category II criteria will be transported off site to an appropriate disposal facility. Any deviations from the specified soil management requirements will be discussed with DTSC. Only soil which meets the DTSC Information Advisory, Clean Imported Fill Material requirements (DTSC 2001) may be managed without DTSC oversight or land use controls.

If the COC is PCBs (Aroclors), the soil will continue to be excavated until concentrations of total PCBs are less than or equal to 1 mg/kg. DTSC and EPA will be consulted on a case-by-case basis if soils with total PCB concentrations greater than 1 mg/kg are present below 10 feet bgs to determine if excavation below that depth is appropriate.

4.3 Soil Management Actions

Soil management will be conducted based on the criteria described in Section 4.2.

4.3.1 On-Site Management Plan

Soils exceeding Category I criteria, but less than Category II criteria, may be managed within the SMP project area described in SMP Form A, provided there is acceptable cover to eliminate the potential exposure pathway of human contact with the soil. Human receptors in the RES are commercial workers, construction workers, maintenance workers, and any on-site visitors. Category I criteria are protective of exposure to chemicals by off-site receptors via the inhalation pathway.

Acceptable covers include:

- A minimum of 2 feet of soil with chemical concentrations below Category I criteria; the overlying soil may not be breached. Prevention of breaches to the soil will be stipulated in the on-site management plan and managed by EH&S. In the event that the cover is breached, the breached area would be subject to renewed SMP requirements.
- Concrete building foundations and slabs with continuous coverage, which is laid directly over the soil or base rock layer above soil that will prevent contact with the soil;
- Asphalt or concrete pavement (and accompanying base rock) with continuous coverage, which is laid directly over the soil that exceeds the criteria.

A physical horizontal and vertical demarcation layer, such as geosynthetic fabric or snow fencing, will be placed over areas where soils exceeding Category I criteria, but are less than Category II criteria, are excavated or left in place and covered with an acceptable cover; the demarcation layer will be placed below the acceptable cover. Demarcation will not be required in the event that at least 2 feet of in-situ Category I soil (to be left in place) already covers Category II soil.

The on-site management plan will document the following:

- Summary of the proposed soil disturbance work, including location and depths of soil disturbance
- Data evaluation that supports the decision that the soil within the project area can be managed-in-place in accordance with the SMP
- Text and associated analytical results describing the cover or the materials to eliminate direct contact exposure pathway to commercial workers and visitors
- Figure showing the proposed cover area, material, and thickness

The on-site management plan will serve as the basis for the soil management action to be conducted during construction activities. The locations of covered soils will be documented in the closure reports for each SMP project, as well as in a centralized GIS database. The depth, cover material (if applicable), and management date of each of the excavated or covered areas will also be documented in the closure report for the SMP project and in the GIS metadata.

4.3.2 Soil Excavation Plan

Soil that exceeds Category II criteria will be excavated to a depth of 2 feet below the depth of project soil disturbance, or EH&S will consult with DTSC if other soil management actions are proposed. The area will be backfilled such that at least 2 feet of clean fill, or a permanent hardscaped surface, is placed above soil remaining in the excavation which exceeds Category I or Category II criteria. If site circumstances justify leaving the soil in place, UC will contact DTSC for approval.

A physical horizontal and vertical demarcation layer, such as geosynthetic fabric or snow fencing, will be placed over areas where soils exceeding Category II criteria have not been excavated. The demarcation layer will be covered with soil below Category I criteria.

The excavation plan will document the following:

- Summary of the proposed soil disturbance work, including location and depths of soil disturbance
- Data evaluation that supports the decision that the soil within the project area containing concentrations greater than the Category II criteria will be excavated for off-site disposal
- Text describing the placement and source of the imported clean fill or Category I soil, if applicable, to eliminate the direct contact exposure pathway to commercial workers and visitors
- Figure showing previous sampling locations and the proposed excavation and depths

- Description of how the excavated soil will be stockpiled, profiled and transported off-site for disposal

- Confirmation sampling plan

The excavation plan will serve as the basis for the soil management action to be conducted during excavation activities. The locations of excavated soils will be documented in the closure reports for each SMP project, as well as in a centralized GIS database. The boundaries of the covered areas will be determined using a hand-held GPS device or by other means to accurately map locations and incorporated into a site-wide figure showing movement of soils. The depth and excavation date of each of the excavated areas will also be documented in the closure report for the SMP project and in the metadata of the GIS figure.

4.4 DOCUMENTATION

EH&S approval of the sampling design, data evaluation, and soil management will be documented through the completion of SMP Form B, Sampling Design, Data Evaluation, and Soil Management Parts 1, 2, and 3 (Exhibit C1), and required supporting documentation. Whether or not EH&S elects to follow the prescriptive protocols or site-specific sampling, the sampling will be outlined in a sampling strategy memorandum provided to DTSC with SMP Form B, Part 1. EH&S will submit a data summary report with SMP Form B, Part 2, documenting the results of the sampling activities. If SMP Form B, Part 3 is required, EH&S will submit the soil management or excavation plan with sufficient detail, including the selection of remedial goals and the proposed actions. Instructions for completing SMP Form B and supplemental documents are presented below.

Instructions for Completing SMP Form B, Sampling, Data Evaluation, Soil Management	
1. Sampling Design	
a. SMP Areas Affected	Consult SMP Figure C-11 to identify SMP areas affected by project.
b. Sampling Density	Consult SMP Figure C-11 and Table C-3 to determine the number of sampling locations.
c. Chemicals of Concern	Consult SMP Table C-3 to identify soil analytical requirements. Include a summary of existing data within the sampling strategy memorandum.
d. Sampling Depth	Consult SMP Section 4.1 to identify required total sampling depth and intervals.
e. Project is within area of groundwater above screening criteria	Consult SMP Table C-3 to determine if project is within SMP area with potential for groundwater contamination or vapor intrusion. If so, consult with current groundwater monitoring program.
f. Sampling design meets all SMP prescriptive requirements	Evaluate if proposed sampling meets the prescriptive requirements outlined in SMP. If not, indicate if DTSC concurrence has been received on the site-specific sampling strategy.
2. Data Evaluation (Post-Sampling)	
a. Sampling Design Completed	Confirm all samples were collected and analyzed according to sampling design in Item 1.

Instructions for Completing SMP Form B, Sampling, Data Evaluation, Soil Management	
b. Sample Results below Category I	Consult SMP Table C-1 for soil categorization criteria. If results do not exceed Category I criteria, EH&S submits SMP Form B with attached data summary report to DTSC. No further soil management actions are required. Category I soils are suitable for commercial use, and can be managed within the SMP project area. Soil excavated from a SMP project area will remain within the same SMP project area unless it is disposed of off-site; if UC proposes to use the excavated soils in other portions of the RES, UC will contact DTSC for approval.
c. Soil Exceeding Category I is Defined Vertically and Laterally	If sample results exceed Category I criteria, then soil management is required, and the boundaries of contaminants exceeding criteria must be defined. If the project requires excavation, additional sampling may be conducted during or following excavation activities.
d. Soil Less Than Category II Criteria	If sample results are less than Category II criteria, soil may be managed on site within the SMP project area according to SMP Section 4.3, and an on-site management plan is required. If sample results are above Criteria II criteria, off-site disposal is required unless DTSC provides approval for on-site management. Review and approval of the plans is included in the item below. EH&S will submit SMP Form B to DTSC following project completion reporting discussed in Section 6.0.
3. Soil Management Action	
a. On-Site Management Plan Meets SMP Requirements	Consult SMP Section 4.3 regarding on-site management plan requirements. DTSC must be notified if deviations result in not adhering to the intent of the prescriptive portions of the SMP, for example, if sampling depths or frequencies are less than described in Section 4.1.
b. Excavation Plan Meets SMP Requirements	Consult SMP Section 4.3 regarding excavation plan requirements. DTSC must be notified of deviations which result in not adhering to the intent of the prescription portions of the SMP, for example if soils above Criteria II remain in place or the proposed cover does not meet the criteria presented in Section 4.2.1.
4. SMP Form B EH&S Approval	Form B must be signed and dated by EH&S staff responsible for implementation of SMP. Signature indicates review and approval of Items 1, 2, and 3. Signature indicates that proper additional documentation necessary is included within EH&S files. Completed Form B must be provided to DTSC.
5. References Used to Complete Form	Include names and dates of documents used to complete form.

EH&S will maintain within UC files additional internal documentation necessary in support of the information presented in SMP Form B. If SMP Form B has not been approved or no activities have occurred for 1 year, the information contained in the form must be reviewed and updated as necessary prior to work occurring in the project area. Supporting documentation will be available upon request from DTSC.

The following documents will be submitted as attachments to SMP Form B, as appropriate.

SMP Form B, Part 1 Sampling Design will document the planned sampling design. Prior to conducting sampling, a sampling strategy memorandum will be submitted as an attachment to DTSC with Part 1 of SMP Form B completed, which will include the following:

- Summary of the proposed soil disturbance work, including location and depths of soil disturbance
- Identification of the SMP Areas affected by the project area and corresponding sampling density and required analytes
- Description of the proposed sampling locations, sampling depths, sample identification scheme, and sample collection methodology
- Figures depicting project area, depths of proposed soil disturbance, and sampling locations, drawn to scale

SMP Form B, Part 2 Data Evaluation will document the sampling results. Following completion of sampling, if soil concentrations are less than the Category I criteria (no action required), EH&S will submit a data summary report with SMP Form B to DTSC and include:

- Summary of soil sampling conducted in accordance with the sampling design
- Summary of soil sampling location, depths, sample identification and analytical results compared to soil criteria
- Laboratory analytical reports
- Soil data evaluation results, including data completeness, and data quality

Documentation will be completed for these projects with the submittal of SMP Form B, Part 2.

For all other projects, where soil concentrations are greater than the Category I criteria, SMP Form B, Part 3 Soil Management Action will also be required, along with a soil excavation plan or on-site management plan with the components listed in Section 4.3; these documents will be submitted to DTSC prior to conducting the soil management action.

5.0 IMPLEMENTATION OF SOIL MANAGEMENT ACTIONS

This section describes management practices that will be employed whenever applicable during implementation of projects subject to the requirements of the SMP.

5.1 PRE-EXCAVATION ACTIVITIES

Pre-construction activities for any SMP project may include (1) permitting and notification, (2) health and safety, (3) stormwater pollution prevention plan (SWPPP) development and implementation, (4) utility clearance, (5) clearing and grubbing, (6) groundwater water level measurement, (7) piezometer abandonment and replacement, (8) building demolition and abatement, and (9) implementation of grassland protection measures. Determination of the need for each activity will be determined by EH&S.

5.1.1 Permitting and Notification

The following permits and notifications will be required to perform any soil disturbance activity subject to the requirements of the SMP:

- EH&S will approve contractor personnel and subcontracts for access consistent with UC Berkeley policies.
- DTSC notification at least 14 days in advance of field work.
- RFS on-site worker and employee notifications.
- Amend the existing Notice of Intent (NOI) and SWPPP or create a new NOI and SWPPP in compliance with the Construction General Permit and upload to the California State Water Resources Control Board SMARTS database.
- Well abandonment and well installation permits for piezometers planned for abandonment and installation from Contra Costa County Environmental Health.
- Appropriate permits associated with RES adjacency to NOS or other shoreline conditions, including San Francisco Bay Conservation and Development Commission, U.S. Army Corps of Engineers, or RWQCB notifications.

5.1.2 Health and Safety

All personnel entering the project control area which encompasses the excavation area and support areas, will read and comply with the requirements set forth in a site-specific Health and Safety Plan (HSP) prepared by the contractor. All contractors will be responsible for operating in accordance with the most current requirements of Title 8, California Code of Regulations, Section 5192 (8 California Code of Regulations 5192) and Title 29, Code of Federal Regulations (CFR), Section 1910.120 (29 CFR 1910.120), Standards for Hazardous Waste Operations and Emergency Response. Onsite personnel will be responsible for operating in accordance with all applicable regulations of the Occupational Safety and Health Administration outlined in 8 California Code of Regulations General Industry and Construction Safety Orders and 29 CFR 1910 and 29 CFR 1926, Construction Industry Standards, as well as other applicable federal, state and local laws and regulations. All personnel working at the site shall have reviewed and signed the HSP, and a safety meeting shall be conducted at the beginning of each work day to review potential site hazards and safe working procedures.

In the case that an excavation is greater than 4 feet deep, the contractor will be required to submit to EH&S a detailed plan showing the design of shoring, bracing, sloping, or other provisions to be made for worker protection from the hazards of caving ground during the excavation, as appropriate. The proposed plan will comply with the State of California Construction Safety Orders and Title 24 of the California Code of Regulations. If the detailed plan varies from such shoring system standards, it shall be prepared by a registered civil or structural engineer.

5.1.3 Storm Water Pollution Prevention Plan Compliance

The current SWPPP that was developed for stockpiling of clean soils in the RES will be modified to incorporate information about excavation activities in the RES (4LEAF, Inc. 2013), or a new SWPPP will be completed. The SWPPP will outline the Best Management Practices that shall be used to prevent erosion or runoff of soil, silts, gravel, non-stormwater discharges, hazardous chemicals, or other materials that are prohibited by the General Construction Permit from being discharged from the project boundaries. The SWPPP will include specific references to regulatory guidelines and applicable UC SOPs.

5.1.4 Utility Clearance

Prior to mobilization for any soil disturbance activity impacting soils greater than 2 feet bgs, underground utilities must be cleared and marked with UC facility management and utility locator. UC facility management will be consulted to first check for the presence of known utility lines in the vicinity of the proposed excavation area, based on existing utility maps, available information, and a site walk. An underground utility survey will be conducted by a utility location contractor. It should be noted that existing utility location data at the facility may be incomplete: not all lines are identified on a map, and accuracy of identified utility line locations are limited. Plastic utility lines without metal tracer wire may be present. Underground pipes or utilities will be identified using hand-held detection devices, and utilities will be marked on the ground with indications (standard colors, letters, and numbers) of the assumed type of utility. This information will be provided to the EH&S for approval to excavate, prior to excavation activities. Regardless of utility clearance activities, all soil sampling to 5 feet will be conducted with hand auger equipment.

5.1.5 Ground Clearance and Grubbing

Prior to excavation, large debris, fencing and large vegetation (trees/shrub) will be cleared from the area to be excavated, either manually or using heavy equipment. Small trees/shrubs may be left in place for removal by heavy equipment during excavation. Water shall be applied to the soil surface to mitigate potential dust generation during all intrusive activities.

5.1.6 Groundwater Level Measurement

Groundwater in the RES varies from 3 to 16 feet bgs. For excavation activities disturbing soil to depths greater than 3 feet bgs, the depth to groundwater will be measured in the piezometers in the vicinity; ideally, measurement will be collected from three piezometers surrounding the area, within a time period of few hours. The potentiometric surface elevation of the shallow groundwater at the proposed excavation site calculated using this information, will assist the field team to determine at which depth groundwater is likely to occur while excavating or disturbing soils.

5.1.7 Piezometer Abandonment and Replacement

If a piezometer is located within the project footprint and cannot be maintained following the project, the existing piezometer will be abandoned properly prior to the excavation of the area. The groundwater data to date will be reviewed and EH&S will determine whether a replacement piezometer should be installed. The abandonment of the existing piezometer, and a location of a replacement piezometer, if applicable, will be proposed to DTSC for review and approval prior to abandoning the impacted piezometer. The existing piezometer will be abandoned and the replacement piezometer will be installed according to Contra Costa County Environmental Health regulations. The replacement piezometer location and elevation will be surveyed by a licensed surveyor. The replacement piezometer will be developed to accommodate use for future monitoring activities.

5.1.8 Hazardous Material Abatement

As part of hazardous material abatement for building demolition projects, a number of programs will be followed regarding the survey, abatement, and mitigation of the potential presence of hazardous materials related to LBP, asbestos or asbestos-containing materials, PCB-containing caulking, or the application of pesticides at building foundations.

Soil containing hazardous material identified in the survey will be removed as directed by EH&S. The removal activity may be conducted in conjunction with the building demolition work, following relevant health and safety procedures for the work.

5.1.9 Implementation of Grassland Protection Measures

Prior to construction activities near the grasslands, the core prairie area will be marked at a minimum with temporary fencing and signage, consistent with the recommendations in the Coastal Terrace Prairie Management Plan (UC 2014, Appendix G). Temporary construction fencing in the vicinity of the grassland portion of the NOS shall consist, at minimum, of steel t-posts and 4 feet tall red plastic netting.

5.1.10 Implementation of Archeological Resource Protection Measures

To protect archaeological artifacts potentially present in subsurface soils, all subsurface activities, including the possible identification and recovery of archaeological artifacts, would be conducted in accordance with the applicable health and safety plans to ensure protection from known and potential hazards. In addition, consistent with DTSC protocols for addressing archaeological artifacts in contact with contaminated media, UC would work directly with DTSC and the appropriate trustee organization for each artifact on a case-by-case basis to ensure proper treatment of the artifacts.

5.2 EXCAVATION ACTIVITIES

The following subsections describe management practices that will be implemented as applicable when excavating contaminated soil. The excavation process may include: (1) excavation of contaminated soil, (2) pyrite cinder management, (3) erosion and dust control, (4) decontamination, (5) confirmation sampling, and (6) contaminated soil management. Applicable excavations include:

- Excavation to remove soil containing chemical concentrations greater than Category I criteria, but less than Category II criteria (for potential use below an acceptable cover within the SMP project area described in SMP Form A)
- Excavation to remove soil containing chemical concentrations greater than Category II criteria (for off-site disposal)

Implementation practices for excavation activities conducted (1) to geotechnically or structurally prepare a project footprint for construction; or (2) within project footprints that have been pre-characterized as containing soil with concentrations less than Category I criteria (and thus no soil management action is required) are not included in this SMP, and will be described within the project-specific construction documents.

5.2.1 Excavation

Excavation activities will be conducted when characterization soil sampling results (based on the 95 UCL concentrations, or the maximum concentration if less than ten samples are collected) are greater than Category I or II criteria, per the soil management options described in Section 4.0. Characterization sampling will be conducted prior to excavation. During excavation, soils will be visually observed for unusual soils such as pyrite cinders, petroleum stains, or alum mud; if observed, excavation will be stopped until the identified soil is managed by EH&S staff.

Excavation will be conducted in a safe manner with proper sloping of sidewalls. Excavation will not extend below groundwater level. Workers will not be allowed to enter the excavation when it is deeper than 4 feet, unless the excavation is properly shored or sloped. All identified utilities in the excavation footprint will be deenergized or disconnected prior to any excavation.

5.2.2 Confirmation Sampling

To determine the final depth and width of the excavation, confirmation soil samples will be collected from the bottoms and sidewalls of the excavations to evaluate if sufficient soil impacted with concentrations of chemicals exceeding Category I or II criteria has been removed. Confirmation samples will initially be analyzed for all analytes specified in the prescriptive sampling plan (Table C-3). All sampling and analysis activities will be conducted consistent with the protocols identified in the SAP (Exhibit C2).

Confirmation samples will be collected at the same grid spacing as indicated on Figure C-11 (low, medium, or high density). Sampling required for each of the grid spacing categories consists of the following:

- Low – 125-foot grid spacing (one sample location per 15,625 square feet) – applicable in SMP Areas where no historical industrial activities occurred;
- Medium – 100-foot grid spacing (one sample location per 10,000 square feet) – applicable in SMP Areas where some historical industrial activities occurred, or an adjacent SMP Area has had a high level of historical industrial activities; and
- High – 75-foot grid spacing (one sample location per 5,625 square feet) – applicable in SMP Areas where a high level of historical industrial activities occurred.

At least one confirmation sample will be collected at the base of each excavation and one sidewall sample will be collected from each excavation sidewall. If chemicals are present in confirmation samples (based on the 95 UCL concentrations, or the maximum concentration if less than ten samples are collected) at a concentration exceeding the Category I or Category II criteria (depending on the remediation criteria), then the excavation will be expanded either laterally for sidewall samples or vertically for bottom samples. Confirmation sampling frequency may be increased based on the results of the initial or subsequent confirmation sampling results, or visual observations.

For sidewall samples that exceed the criteria, the excavation will be expanded approximately 5 feet laterally, and then resampled. For bottom confirmation samples that exceed the criteria, the excavation will be expanded approximately 1 foot vertically, with the provision that excavation will not extend to such depth as to extend into standing groundwater. The distance to expand an excavation laterally and vertically may be adjusted based on site-specific or project-specific conditions. The excavation and confirmation sampling process will repeat until sample results are below the appropriate criteria, or unless DTSC has approved adequate excavation has been conducted. EH&S will contact DTSC for concurrence if there are proposed deviations from this approach.

The horizontal location and depth of each confirmation sample will be accurately recorded on the as-built plans and all final confirmation sample results will be recorded for presentation in the Completion Report, which will accompany SMP Form C.

Continuous observation of soil will be required as it is excavated to observe the soil for indications of potential contamination such as pyrite cinders or unusual debris. If workers observe unusual debris, EH&S will be notified prior to proceeding with excavation in the area. If pyrite cinders are observed, the soil will be managed as described below.

5.2.3 Cinder Management

Cinder management applies to the management of pyrite cinders and soils impacted by pyrite cinders during any soil disturbance activity, regardless of the size of the expected soil disturbance. Cinder management is based on and is consistent with the previous cinder management strategy implemented at Richmond Field Station, as documented in the *Pyrite Cinder-Containing Soil Management Procedures* (UC Berkeley 2007) and its attachments *Regulatory Status of Soils Excavated During Replacement of Old Sewer Lines* (DTSC 1993) and In-Trench Reuse of Contaminated Trench Spoils during Utility Excavations (RWQCB 1995).

EH&S or EH&S-trained personnel will conduct inspections during excavation where cinders are expected during the following activities:

- Building construction earthwork
- Drainage pipe or culvert installation
- Sewer or water main installation or removal
- Road work where excavation is required as part of drainage or road base installation
- Building renovation work that involves the types of underground utility work discussed above

EH&S does not expect that direct oversight and inspections will be necessary during smaller projects, including:

- Tree planting and removal
- Minor landscaping projects not intended to impact subsurface soils such as routine maintenance, weed control, and plantings
- Small irrigation line work and repairs
- Emergency utility work

During soil disturbance activities that are not conducted to remove contaminated soil, excavated soils, including those mixed with cinders, may be deposited back into the original excavation, assuming that there is no complete exposure pathway identified. Exposure pathways are eliminated if cinders are placed beneath 2 feet of native or clean fill, or a hardscaped feature such as a roadway, parking lot, or building foundation. Cinders will not be placed back into the original excavation if the highest measured groundwater is within 5 feet of the bottom of the excavation and placed no closer than 2 feet to the surface, unless approved by DTSC. If cinders are excavated from an excavation less than 2 feet deep, cinders cannot be replaced in that excavation unless covered with hardscape, or with DTSC approval. For projects which qualify as *de minimis*, EH&S will evaluate if placement of cinders within shallow excavations is protective of possible future exposure. To the extent that no removal of cinders from the project area is involved and that all material can be placed back into the excavation, EH&S will likely not perform cinder sampling.

During soil disturbance activities that are conducted to remove contaminated soil, cinders will be removed from the excavation if they are within the original excavation footprint.

Displaced soil suspected of, or known to contain cinders, which cannot be placed back into the excavation will be assessed to determine if it exhibits a characteristic specified in Identification and Listing of Hazardous Waste, Chapter 11, Title 22, California Code of Regulations. EH&S will sample the material and determine the proper method of disposal. While sample results are pending, the material will be stored in covered stockpiles, covered bins, or drums. If the displaced soil is determined to be a hazardous waste, it will be managed in accordance with all California and Federal hazardous waste laws and regulations. If the presence of cinders has not been confirmed, then soil characterized as having concentrations below Category I criteria may be reused within the SMP project area. Soil characterized as having concentrations below Category II criteria can be managed in place within the SMP project area described in SMP Form A. Soil management in place generally consists of placement of soil beneath 2 feet of clean fill, under a roadway or parking lot, or building foundation, as defined in Section 4.3.1.

EH&S will track areas where cinders are encapsulated in a GIS-based map to ensure that the cinder material remains isolated. Any cinders-contaminated soil discovered during small excavations that is not managed in place will be sampled for management and disposal and results will be reported in writing to DTSC.

5.2.4 Erosion, Dust Control, and Air Monitoring

All excavated soils will be managed to prevent dust, spills to the ground or water, disposal into drains, and exposure risk to people or the environment. Excavation, transportation, and handling of all soil must result in no visible dust at the fence line of the excavation. Any soil material proposed to be placed as fill, whether from an offsite source or onsite source, will be kept covered or moist to facilitate eventual compaction and to control dust during earthwork operations. A water truck, water tank, or hydrant will be available to supply water in sufficient quantity on the job site while earthwork operations are underway. Sufficient water will be applied to suppress dust while exercising care to avoid generating runoff to any area outside the project boundary. Dust control measures will be implemented, as appropriate and necessary, beginning with site mobilization and continuing during all phases of the construction activities. Water will not be applied if there is a possibility of spreading contaminated soil or leaching contaminants from the soil, or if it results in hazardous working conditions.

Erosion and Dust Control

Contractors will not be allowed to stockpile material containing or suspected to contain hazardous waste or contamination unless covered and protected from rain or wind erosion for the duration of the construction project. Stockpiles of material containing hazardous waste or contamination will be placed on plastic sheeting of adequate thickness to contain the soils, and will not be placed in areas potentially affected by surface run-on or run-off. Contaminated and clean soils material will not be allowed to enter storm drains, inlets, or waters of the State. The plastic sheeting used to cover the soil must be anchored to the ground and weighted as necessary to securely and completely cover the stockpiled soil to prevent wind-blown dust from being generated. All stockpiled soil must be managed in accordance with the requirements outlined in the SWPPP and Section 5.1.4 of the RAW. EH&S will review and approve the project-specific SWPPP prior to submittal to the State Water Board. EH&S or EH&S-trained personnel will conduct inspections during work where soil is disturbed, including:

- Building construction earthwork
- Excavation of contaminated soil
- Loading and transportation of soil
- Drainage pipe or culvert installation

- Sewer or water main installation or removal
- Road work where excavation is required as part of drainage or road base installation

The construction general permit, if applicable to the project, requires that all SWPPP-related inspections must be performed by a Qualified SWPPP Practitioner (QSP) or Developer (QSD). The QSP or QSD can delegate other trained staff to perform some of the inspections on their behalf but the QSD or QSP must do some of the inspections since they have to certify the inspections.

EH&S does not typically require direct oversight and inspections for smaller projects, including:

- Tree planting and removal
- Landscaping projects impacting less than 10 CY
- Small irrigation line work and repairs
- Soil sampling and piezometer installation
- Emergency utility work

If the excavation is to be conducted when rain is possible, the site work must be carefully executed to contain potentially contaminated surface water, groundwater in excavations, muddy soils within the project area, and prevent off-site tracking of sediment and soils to adjoining roads.

Air Monitoring

Exposure monitoring and air sampling will be evaluated for each SMP project to monitor possible airborne levels of contaminants down-wind from any excavation and stockpile areas, and ensure that all on- and off-site workers are protected. The monitoring will help assure that excavation activities do not pose unacceptable concentrations to project personnel or any down-wind human receptors.

Prior to beginning construction for a project, a description of the conditions under which air monitoring would take place, the general approach that would be used by EH&S to develop action levels, a general description of the air monitoring equipment expected to be employed, and a citation to any appropriate health and safety plans.

Pertinent project information to decide if a project requires air monitoring include:

- Project size and location
- Nature of project and potential to generate airborne particulates or dust
- Contaminant concentrations
- Proximity to potential on-site and off-site receptors

Should air monitoring be required for a project, action levels will be developed using available soil sampling data to determine the chemicals of potential concern for the project, the potential concentration of the chemicals in dust, and acceptable concentrations in dust (including risk-based concentration). The potential concentrations of chemicals in dust will then be compared to the acceptable concentrations and action levels will be established. It is anticipated that only large projects or projects in areas with elevated soil concentrations would require perimeter dust monitoring using real-time aerosol monitors (such as the MIE Personal Data RAMs) equipped with data loggers to provide immediate information for the total dust levels present. Should analyte-specific monitoring be required (such as for mercury vapors), equipment and additional action level criteria will be included in the project construction plans or a separate air monitoring plan.

5.2.5 Decontamination

An exclusion zone will be established around the project's excavation area. Access to and from the exclusion zone by personnel and equipment will be controlled to mitigate site risks and prevent the spread of contamination. Decontamination procedures for workers will be established in the HSP.

A lined decontamination pad appropriately sized for storage and treatment of all anticipated rinse water will be placed just outside the exclusion zone and near the excavation area. The pad should be sized to collect decontamination water and overspray. Collection and removal of the decontamination water and precipitation captured in the decontamination pad will be conducted utilizing sumps, dikes, ditches, and holding tanks as required. The pad design will depend on the size and duration of the project. For smaller projects, a lined bermed area with water collection to drums via a sump pump at the low end is sufficient. The decontamination pad design will be approved by EH&S prior to construction.

All wastes including liquid wastes and non-hazardous or hazardous contaminated soils will be managed to prevent uncontrolled releases outside of the project area. Contaminated material handling and storage is discussed in Section 5.2.6.

All vehicles exiting the site will be inspected to be free of mud on tires, wheel wells, undercarriage, and other exposed surfaces outside the covered truck bed or roll-off bin. Vehicles will be cleaned as necessary prior to leaving the decontamination area.

5.2.6 Waste Handling and Storage

Wastes generated during excavation and investigation will include hazardous and nonhazardous soil, decontamination water, and other investigation-derived waste (IDW). Wastes will be handled and stored according to the protocols below and all state and federal laws. Storage containers will be in good condition and constructed of materials that are compatible with the material to be stored. Storage of IDW and soil stockpiles will not be allowed on coastal terrace prairie grasslands, or anywhere in the NOS. Each container will be clearly labeled with an identification number and a written log will be kept to track the source of contaminated material in each temporary storage container. Samples of soils and liquids will be collected and analyzed for contaminated material in conformance with state and federal criteria as well as to the requirements of the treatment or landfill facility, as further described in Section 5.3.1 below.

Hazardous Soils

Soil with chemical concentrations known to be TSCA waste, Resource Conservation and Recovery Act hazardous waste, or California hazardous waste, based on results from prior sampling or EH&S knowledge, will be stockpiled separately from soils with unknown chemical concentrations, or concentrations less than hazardous waste criteria.

For temporary storage of contaminated soil or hazardous soil remediation waste storage, securely covered stockpiles, drums, or metal containers will be utilized. Drums and other metal containers must be appropriately labeled per all applicable legal requirements.

Stockpiles will be constructed to isolate stored contaminated material from the environment. Stockpiles will be placed on and covered with a chemically resistant geomembrane liner free of holes and other damage. Stockpiles will be managed in compliance with Section 5.1.4 of the RAW and the applicable SWPPP as modified for the soil management action, to prevent pollutants from being discharged from the project boundaries.

Roll-off bins used to temporarily store contaminated material will be water-tight. A cover will be placed over the bins to prevent precipitation from contacting the stored material. Excavated soil containing pyrite cinder must be segregated and stored in covered bins, drums, or other suitable container.

Nonhazardous Soils Waste

Excavations and investigations may generate nonhazardous soil waste. Soils that are considered potentially contaminated will be segregated from nonhazardous waste and clean soils until characterized. Soils with chemical analysis results that do not exceed state or federal hazardous waste criteria concentrations are considered nonhazardous soils only if approved by EH&S.

Nonhazardous soils may be used on-site consistent with the provisions of the SMP, or may be removed from the property only if directed and approved by EH&S.

Waste Water

Liquid collected from personnel and equipment decontamination operations will be temporarily stored in drums or other suitable containers. Water from heavy equipment decontamination, excavations, and stockpile areas will be temporarily stored in tanks, drums, or other suitable containers. Stored wastewater containers will be appropriately labeled per all applicable legal requirements.

Aqueous waste will be analyzed per the requirements of the SWPPP and project COCs. If analytical test results show that the water is not contaminated and within limits for onsite discharge then it will be disposed of on-site per the SWPPP. Waste water not suitable for on-site disposal will be managed consistent with Section 5.3.1.

5.3 POST-EXCAVATION ACTIVITIES

Post-excavation activities include waste classification and transportation, and site restoration.

5.3.1 Waste Classification, Transportation, and Disposal

Wastes and their expected waste classifications anticipated to be generated during excavation will include the following:

Type of Waste	Expected Waste Classification
Soil containing chemical concentrations less than hazardous waste criteria	Nonhazardous solid waste
Soil containing chemical concentrations greater than hazardous waste criteria	Hazardous solid waste
Soil containing PCB concentrations greater than 1 mg/kg	TSCA solid waste
Aqueous wastes from decontamination water and any surface water contained onsite	Nonhazardous or hazardous liquid waste (pending waste characterization results)
IDW (PPE and disposable sampling equipment)	Nonhazardous solid waste or hazardous solid waste, consistent with soil or aqueous waste determinations

Waste Classification

Waste codes applicable to each hazardous waste stream will be identified based on the requirements in 40 CFR 261 and California Title 22 California Code of Regulation 66261, and any other applicable state law or regulation. All applicable treatment standards in 40 CFR 268 and state land disposal restrictions will be identified and a determination will be made as to whether or not the waste meets or exceeds the standards. Wastes with total PCB concentrations greater than 1 mg/kg will be disposed of off-site at an appropriate facility for TSCA waste. Waste profiles, analyses, classification, and treatment standards will be according to the requirements of receiving facility and will be reviewed and approved by EH&S prior to any waste disposal activities.

Existing data for the excavated soil may be sufficient to meet disposal facility profiling requirements. If, however, the selected disposal facilities require additional profiling, or if EH&S elects to conduct additional waste profiling, samples will be collected from the excavated soil and analyzed for the constituents specified by the selected disposal facilities.

To characterize soil for disposal, waste characterization samples will be collected to adequately meet the representativeness and variability goals identified in SW-846 Chapter 9. Waste characterization sampling will be proposed on a case-by-case basis, to allow for incorporation of site conditions, SMP sampling results, and waste stream volumes.

Analytical criteria are dependent on the requirements of the receiving facility; therefore, the receiving facility will be consulted prior to analysis of the samples. Additional tests may be needed based on the results of the initial tests. Once characterized, the waste will be classified and disposed according to federal and state regulations.

A waste acceptance letter will be obtained from each selected disposal facility. Waste profile sample results and documentation will be included in the Completion Report, which will accompany SMP Form C.

Waste Transportation

Manifests will be used for transporting hazardous wastes as required by 40 CFR 263 and applicable state law or regulation. Transportation will comply with all requirements in the Department of Transportation referenced regulations in the 49 CFR series. Manifests and waste profiles will be reviewed and approved by EH&S prior to any waste transportation activities. Land disposal restriction notifications will be prepared as required by 40 CFR 268 and any applicable state law or regulation for each shipment of hazardous waste and will be reviewed and approved by EH&S. Hazardous waste manifests will be prepared for each shipment of waste shipped offsite using instructions in 40 CFR 761, Sections 207 and 208 and all other applicable requirements. Soil waste will be removed from the site in compliance with all U.S. Department of Transportation regulations and will be covered to prevent soil loss during transport.

Waste Disposal

No soils will be removed from the site for offsite disposal without EH&S permission. Soils designated for off-site soil disposal will first be sampled according to the requirements of the potential receiving facility and in compliance with all state and federal waste classification requirements. All contaminated nonhazardous or hazardous soil waste will be disposed at an appropriately permitted landfill or treatment facility. Personal protective equipment (PPE) and disposable sampling equipment will be disposed of offsite as hazardous or nonhazardous waste.

5.3.2 Site Restoration

Excavations will be backfilled as soon possible after all contaminated materials have been removed and confirmation test results have been evaluated by EH&S. As discussed in Section 4.3.1, before placing backfill, a demarcation layer will be placed along the bottom and sides of the excavation, if soil exceeding Category I criteria is to be left-in-place, to indicate the extent to which soil was excavated and backfilled. If UC construction specifications apply, soil will be spread, moisture conditioned, and compacted in 8- to 12-inch thick loose lifts to 95 percent relative compaction or greater relative to the modified proctor standard (American Society for Testing and Materials D1557).

<u>Backfill Material</u>

All fill material, imported or otherwise, will be entirely free of refuse and any other deleterious material. If UC construction specifications apply, a testing laboratory or the project geotechnical engineer will be retained to certify that all fill has been spread, compacted, and tested to meet the compaction standards established for the project.

As discussed in Section 5.2.6, soil with concentrations of COCs below Category I criteria may be used as backfill in the same excavation, or at another location within the RES with DTSC approval.

Other sources of imported clean fill are also permitted at the Richmond Field Station. In order to minimize the potential of introducing contaminated fill material, documentation will be verified that the fill source is appropriate, as outlined in the Imported Soils Sampling and Analysis

Requirements to Assess Contaminant Concentrations included as Attachment C2. Potential sources of imported fill will be sampled as recommended in the Cal/EPA DTSC Information Advisory, Clean Imported Fill Material (DTSC 2001). Fill documentation will include detailed information on the previous use of the land from where the fill is taken, whether an environmental site assessment was performed and its findings, and the results of analytical testing performed. If such documentation is not available or is inadequate, samples of the fill material will be chemically analyzed. Analytical methods required for the fill material will be based on the source of the fill and knowledge of the prior land use. The number of samples per volume of imported fill will be determined according to the table in the "Waste Characterization" section above.

Analytical results of potential imported fill will be compared to the following criteria to determine if the fill can be imported and used:

- Category I criteria (Table C-1)
- Total threshold limit concentrations (Title 22 of the California Code of Regulations)

EH&S personnel will review fill documentation before approving acceptance of fill soil, and will notify DTSC before any soil is imported for use. EH&S will provide written notification, all analytical results, and location and history of source area to DTSC, as part of the documentation included in SMP Form C.

6.0 COMPLETION REPORTING

Completion reporting is conducted for all projects requiring soil excavation or on-site management. Completion reporting will document all portions of the SMP relevant to proper sampling and management of soils.

Projects with soils exceeding Category I criteria will require an on-site management or excavation plan per Section 4.3 and will also require documentation of all activities following completion of the soil disturbance project. Documentation of project completion will be addressed through SMP Form C, Completion Report (Exhibit C1) and within a final project completion report. Instructions for completing SMP Form C are presented below. Geologic or engineering plans, specifications, drawings, and reports contained in the Completion Report will be prepared by, or under the direct supervision of, a California professional geologist or civil engineer, as appropriate, who will review and sign all such documents indicating responsibility for their content. If UC elects to select alternative methods for soil sampling and management for a project, EH&S will prepare a detailed completion summary report for submittal to DTSC for concurrence in lieu of SMP Forms and attachments. If SMP Form C has not been approved or no activities have occurred for 1 year, the information contained in the form will be reviewed and updated as necessary prior to submittal of the completion report.

Instructions for SMP Form C, Completion Report	
1. Summary of Completed Construction Project	Provide description of the completed construction project, with specific attention to final surface grade, including asphalt, concrete, landscaped areas, or building footings. The intent is to describe any possible exposure pathways to Category II soils, if applicable.
2. Dates of On-Site Project Work	Provide the dates of each step of the project conducted on-site (sampling, soil management actions, soil disposal).
3. Summary of Completed Soil Management Actions	Provide description of any on-site or excavation soil management activities completed.
4. On-Site Management Plan Implemented	Confirm that the on-site management plan was implemented according to SMP Form B, Item 3a, if applicable. Include any deviations from the plan, if appropriate.
5. Soil Excavation Plan Implemented	Confirm that the excavation plan was implemented according to SMP Form B, Item 3b, if applicable. Include any deviations from the plan, if appropriate.
6. Project Completion Report Meets SMP Requirements	Final confirmation that all soil sampling and management activities were completed according to the SMP requirements. Attach completion report which discusses soil sampling design, sampling results, data evaluation, soil management practices, and final construction project completion, and includes a reference list.
7. SMP Form C EH&S Approval	Form C must be signed and dated by EH&S staff responsible for implementation of SMP. Signature indicates review and approval of Items 1 through 4. Signature indicates that proper additional documentation necessary is included within EH&S files. EH&S will provide SMP Form C to DTSC.

In addition to SMP Form C, EH&S will prepare a completion report to provide to DTSC. As discussed in Section 1.4, UC will post completion reports on the RFS Environmental website, and DTSC will post completion reports to DTSC's Envirostor website for the former RFS. The completion report will include the following information documenting the soil management action completion:

- Summary of previous soil sampling, analytical results, and data evaluation
- Summary of soil management strategies and actions conducted
- Summary of the soil excavation work, including location and depths of excavation activities
- Discussion of any deviations from the soil excavation or on-site management plan
- Text describing the final cover or the materials to eliminate direct contact exposure pathway to commercial workers and visitors
- Figures indicating all sampling locations, Criteria I or II exceedances, final excavation areas, and cover area, material, and thickness, if appropriate
- Summary of disposition of excavated soil (off-site disposal or on-site management)
- Summary of all confirmation sample results
- Summary of backfill, final grade, and final project description
- Copies of signed hazardous waste manifest and bill of ladings

7.0 REFERENCES

4LEAF, Inc. 2013. Storm Water Pollution Prevention Plan for the Stockpiling of CRT Soil at the Richmond Field Station, Richmond, California. January 23 (revision to original submitted October 22, 2012).

California Department of Toxic Substances Control (DTSC). 1993. Regulatory Status of Soils Excavated During Replacement of Old Sewer Lines. Prepared by Watson Gin, Chief, Permit Streamlining Branch, Hazardous Waste Management Branch, Department of Toxic Substances Control. December 2.

DTSC. 2001. Department of Toxic Substances Control, Information Advisory, Clean Imported Fill Material. October. Available on-line at: www.dtsc.ca.gov/Schools/upload/SMP_FS_Cleanfill-Schools.pdf

DTSC. 2006. Interim Guidance, Evaluation of School Sites with Potential Soil Contamination as a Result of Lead from Lead-based Paint, Organochlorine pesticides from Termiticides, and Polychlorinated biphenyls from Electrical Transformers. Revised June 9. http://www.dtsc.ca.gov/Schools/upload/Guidance_Lead_Contamination_060912.pdf

DTSC. 2007. Letter to Doug Mosteller, Cherokee Simeon Venture I, LLC, from Barbara Cook, DTSC, Concurring on the Recommendation of 16 mg/kg Arsenic as a Good Estimator of the Upper Range of the Ambient Distribution of Arsenic at the Campus Bay Site. October 1.

DTSC. 2009. Use of the Northern and Southern California Polynuclear Aromatic Hydrocarbon (PAH) Studies in the Manufactured Gas Plant Site Cleanup Process. July 1.

Ensco Environmental Services, Inc. 1989. “Environmental Assessment of University of California Richmond Field Station.” Richmond, California. August.

Environ Corporation, Entrix, IRIS Environmental, and Env America. 2002. Background Levels of Polycylic Aromatic Hydrocarbons in Northern California Surface Soil. Prepared for: Pacific Gas and Electric Company and U.S. Navy. June 7.

Erler & Kalinowski, Inc. 2007. Technical Memorandum: Background Concentrations of Arsenic in Soil at Campus Bay, Campus Bay Site, Richmond, California. July 23.

Lloyd, R.J.W, R.M. Moore, B.S. Woolf, and H.P. Stein. 1975. “Polychlorinated Biphenyls (PCBs), NIOSH Current Intelligence Bulletin 7.” Available on-line at: http://www.cdc.gov/Niosh/78127_7.html

New World Environmental Inc. 2012. “Final Status Survey Report for UC Berkeley Capital Projects, Richmond Field Station, Buildings B102 and B110.” November 18.

New World Environmental, Inc. 2013. “Final Status Survey Report for Richmond Field Station Buildings 112, 113, 117 and 150.” August 3.

San Francisco Bay Regional Water Quality Control Board. (RWQCB). 1995. "Memorandum: In-Trench Reuse of Contaminated Trench Spoils during Utility Excavations." August 31.

RWQCB. 2013. "May 2013 Update to Environmental Screening Levels." May. Available on-line at: http://www.waterboards.ca.gov/rwqcb2/water_issues/programs/esl.shtml.

RWQCB. 2016. "Environmental Screening Levels, San Francisco Bay Regional Water Quality Control Board." February. Available on-line at: http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/ESL/ESL%20Workbook_ESLs_Interim%20Final_22Feb16_Rev3_PDF.pdf

Tetra Tech (Tetra Tech EM Inc. [1996-2012]; currently Tetra Tech, Inc.). 2008a. "Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond California." November 21.

Tetra Tech. 2008b. "Implementation Summary Report for a Time-Critical Removal Action at the Forest Products Laboratory Wood Treatment Laboratory." March 14.

Tetra Tech. 2009. "Final Implementation Summary Report for a Time-Critical Removal Action at Two Subareas in the Western Transition Area, University of California Berkeley, Richmond Field Station, Richmond, California." May 26.

Tetra Tech. 2011. "Final Phase I Groundwater Sampling Results Technical Memorandum, University of California, Berkeley, Richmond Field Station, Richmond, California." May 11.

Tetra Tech. 2013. "Final Site Characterization Report, Proposed Richmond Bay Campus, University of California, Berkeley, Richmond Field Station." May 28.

Tetra Tech. 2014. "Final Removal Action Workplan, Richmond Bay Campus, Richmond, California, Research, Education, and Support Area and Groundwater within the Former Richmond Field Station Site" July 18.

Tetra Tech. 2015. "Final Ambient Metals Evaluation, Aluminum, Cobalt, Manganese, and Nickel, Technical Memorandum. Richmond Field Station Site, Berkeley Global Campus at Richmond Bay, University of California, Berkeley." December 11.

Tetra Tech. 2016. "Final Phase IV Sampling Results Technical Memorandum, Richmond Field Station Site, Berkeley Global Campus at Richmond Bay, University of California, Berkeley." May 15.

Tetra Tech. 2017. "Final Soil Management Plan, Revision 1, Removal Workplan, Attachment C, Berkeley Global Campus at Richmond Bay, Richmond, California." April 12.

University of California (UC). 2014. "Richmond Bay Campus Long Range Development Plan." May 15.

UC Berkeley. 2007. Pyrite Cinder-Containing Soil Management Procedures. Prepared by Greg Haet, Associate Director, University of California, Office of Environment, Health and Safety. May 16.

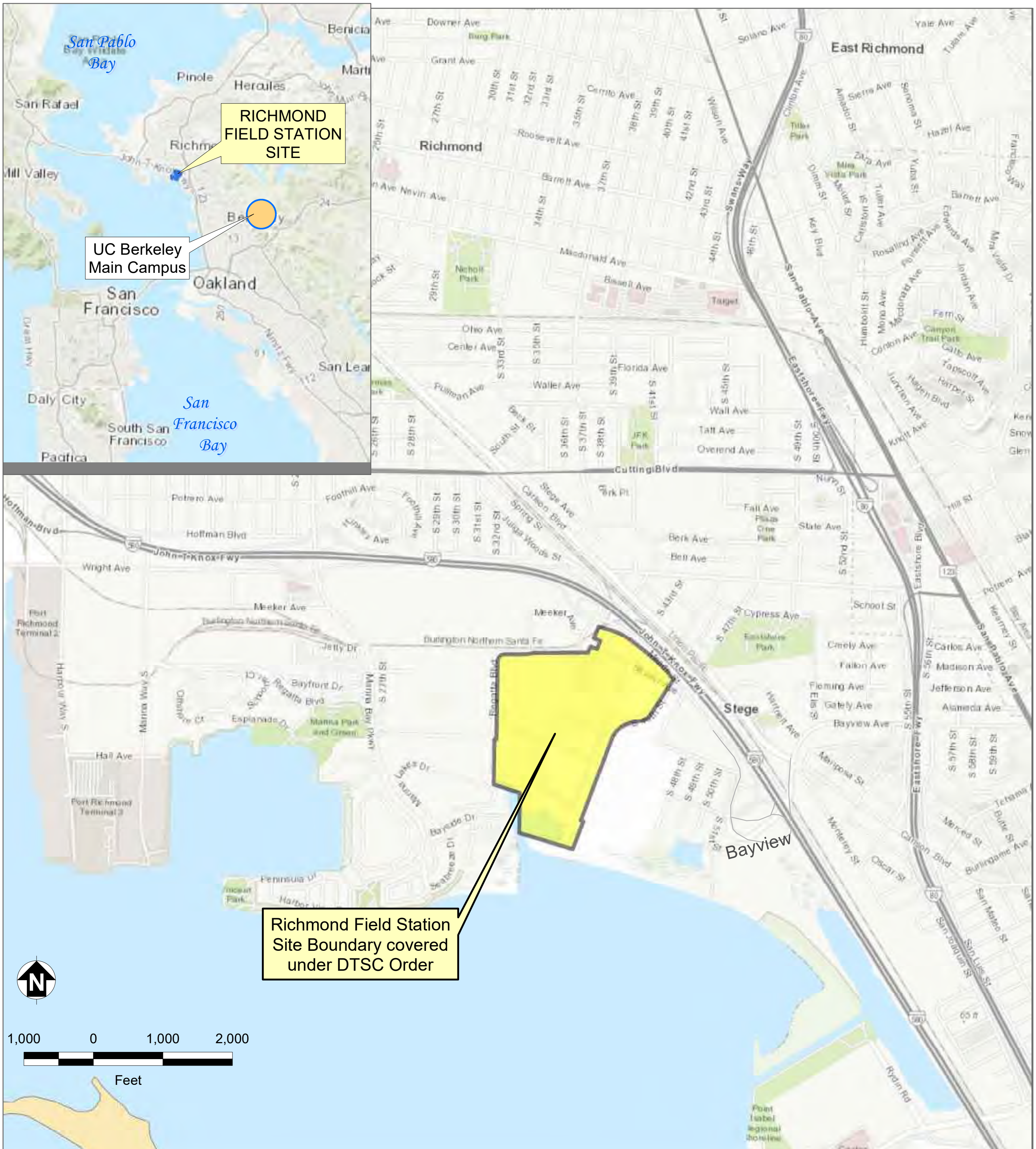
UC Berkeley. 2014a. Letter from Dan Hibbing, Radiation Safety, UC Berkeley Environmental Health & Safety to Karl Hans, UC Berkeley. Richmond Field Station Bulb Investigation Letter Report. August 5.

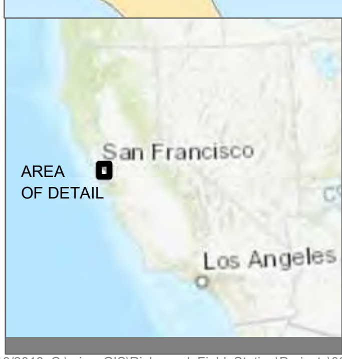
UC Berkeley. 2014b. Letter to Lynn Nakashima, DTSC, from Greg Haet, UC Berkeley. Pacific Earthquake and Engineering Research Excavation Report and Results, Richmond Field Station Site, Berkeley Global Campus. October 31.

URS Corporation (URS). 1999. "Final Field Sampling and Analysis Plan and Tiered Risk Evaluation, University of California, Berkeley, Richmond Field Station." December 10.

U.S. Environmental Protection Agency (EPA). 2005. Polychlorinated Biphenyl (PCB) Site Revitalization Guidance Under the Toxic Substances Control Act. November. Available on-line at: http://www.epa.gov/osw/hazard/tsd/pcbs/pubs/pcb-guid3-06.pdf

FIGURES





Notes:
DTSC Department of Toxic Substances Control.

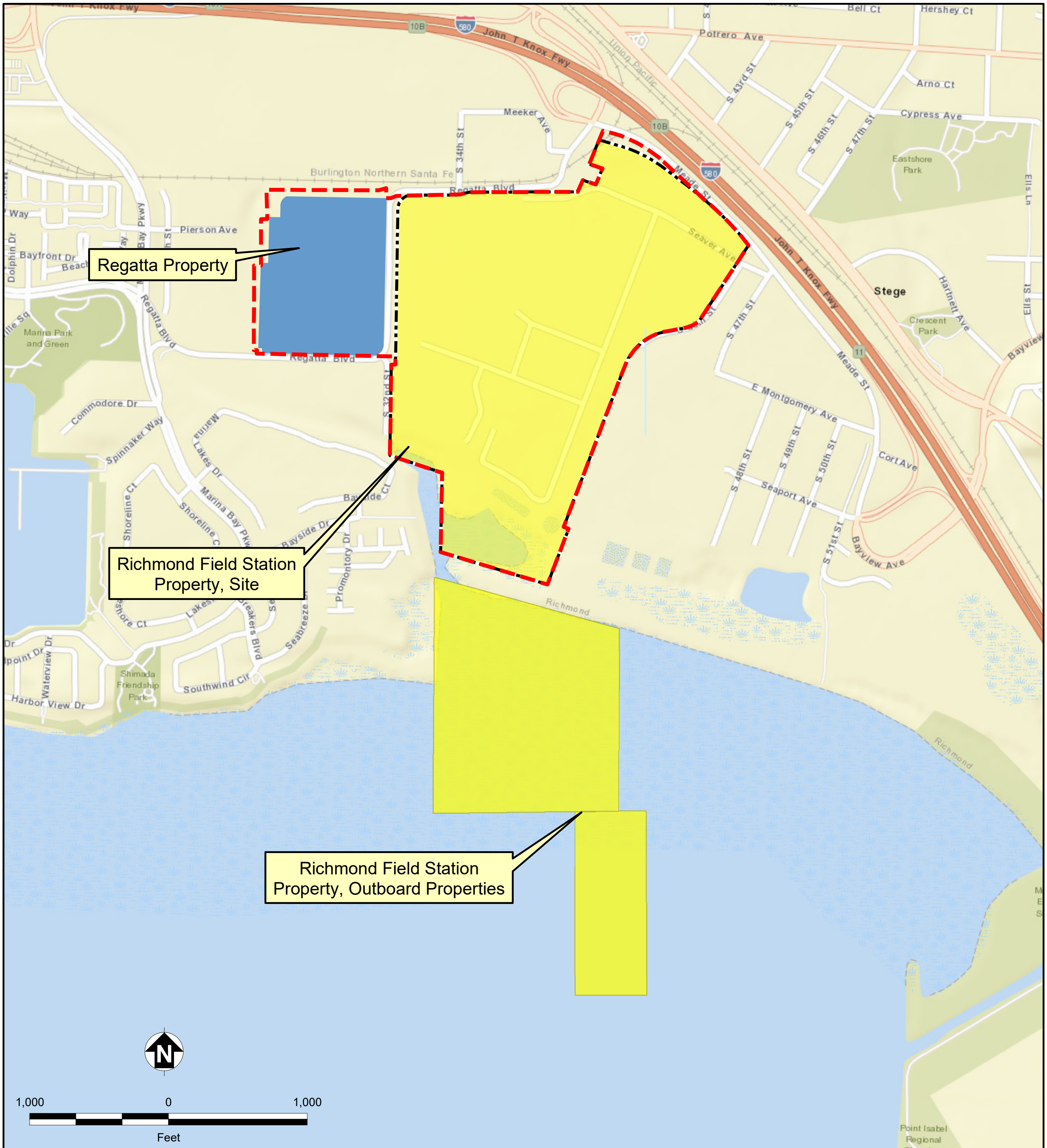
TETRA TECH

Richmond Field Station Site
University of California, Berkeley

FIGURE C-1
SITE LOCATION MAP

Soil Management Plan

9/13/2018 C:\misc_GIS\Richmond_Field_Station\Projects\06_SMP\C-1_Site_Location Map.mxd TtEMI-OAK michelle.handley



Richmond Field Station Property

Portion of RFS Property Subject to DTSC order, Defined as "Site"

Regatta Property

Berkeley Global Campus at Richmond Bay

Notes:
DTSC Department of Toxic Substances Control
RFS Richmond Field Station

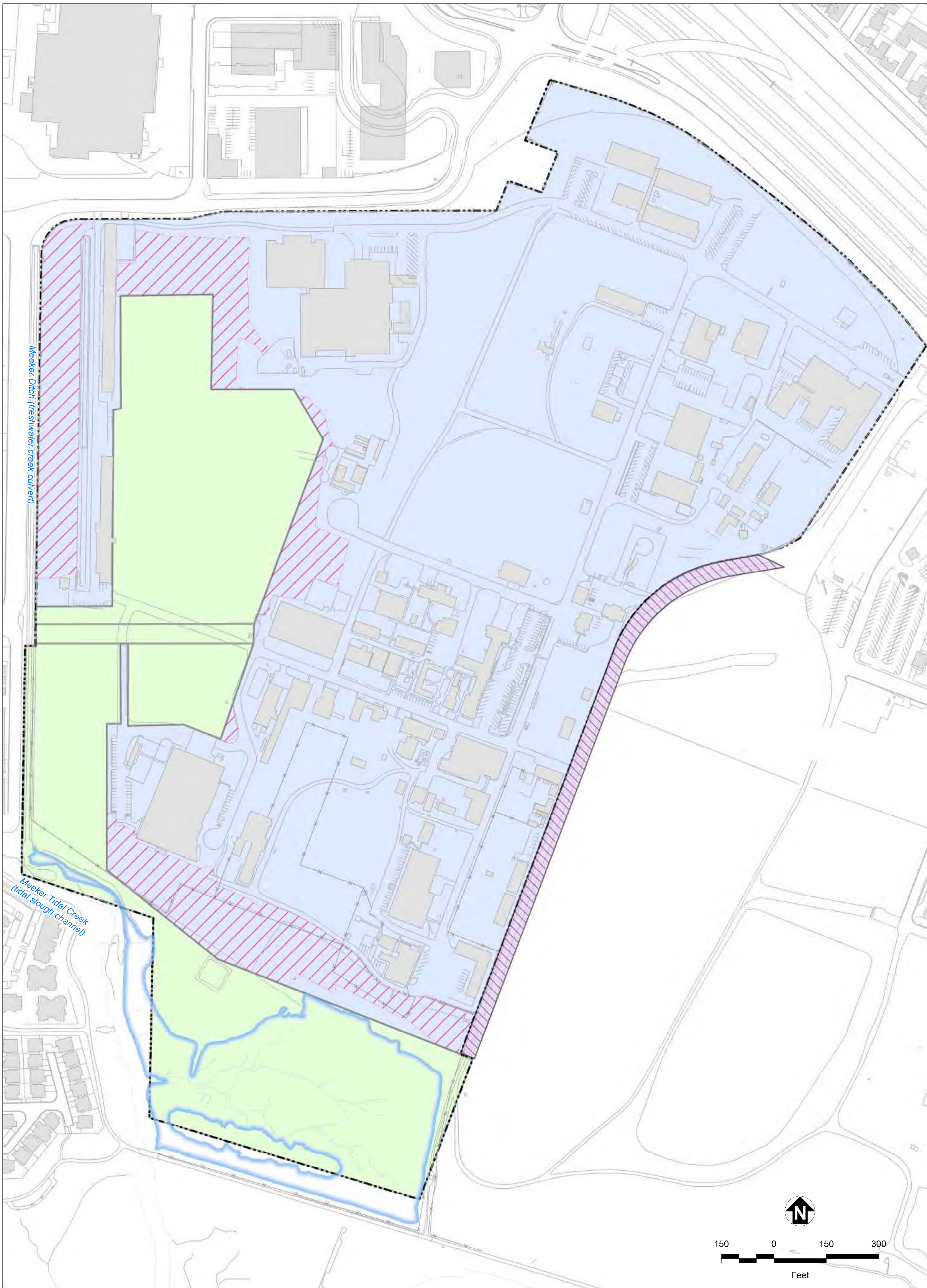
TETRA TECH

Richmond Field Station Site
University of California, Berkeley

FIGURE C-2
UNIVERSITY OF CALIFORNIA PROPERTIES

Soil Management Plan

2018-10-26 C:\misc_GIS\Richmond_Field_Station\Projects\06_SMP\C-2_University of California Properties.mxd TtEMI-OAK michelle.handley.



- Research, Education & Support Area
- Natural Open Space
- The portion of South 46th Street owned by UC and Zeneca under a 1/3 and 2/3 shared interest is subject to the RAW
- Habitat within RES Area
- Existing Building
- Portion of RFS Property Subject to DTSC order, Defined as "Site"
- Roads and Other Landscape Features
- Marsh Boundary

Note:

DTSC	Department of Toxic Substances Control
RAW	Removal Action Workplan
RES	Research, Education, & Support
RFS	Richmond Field Station
UC	University of California

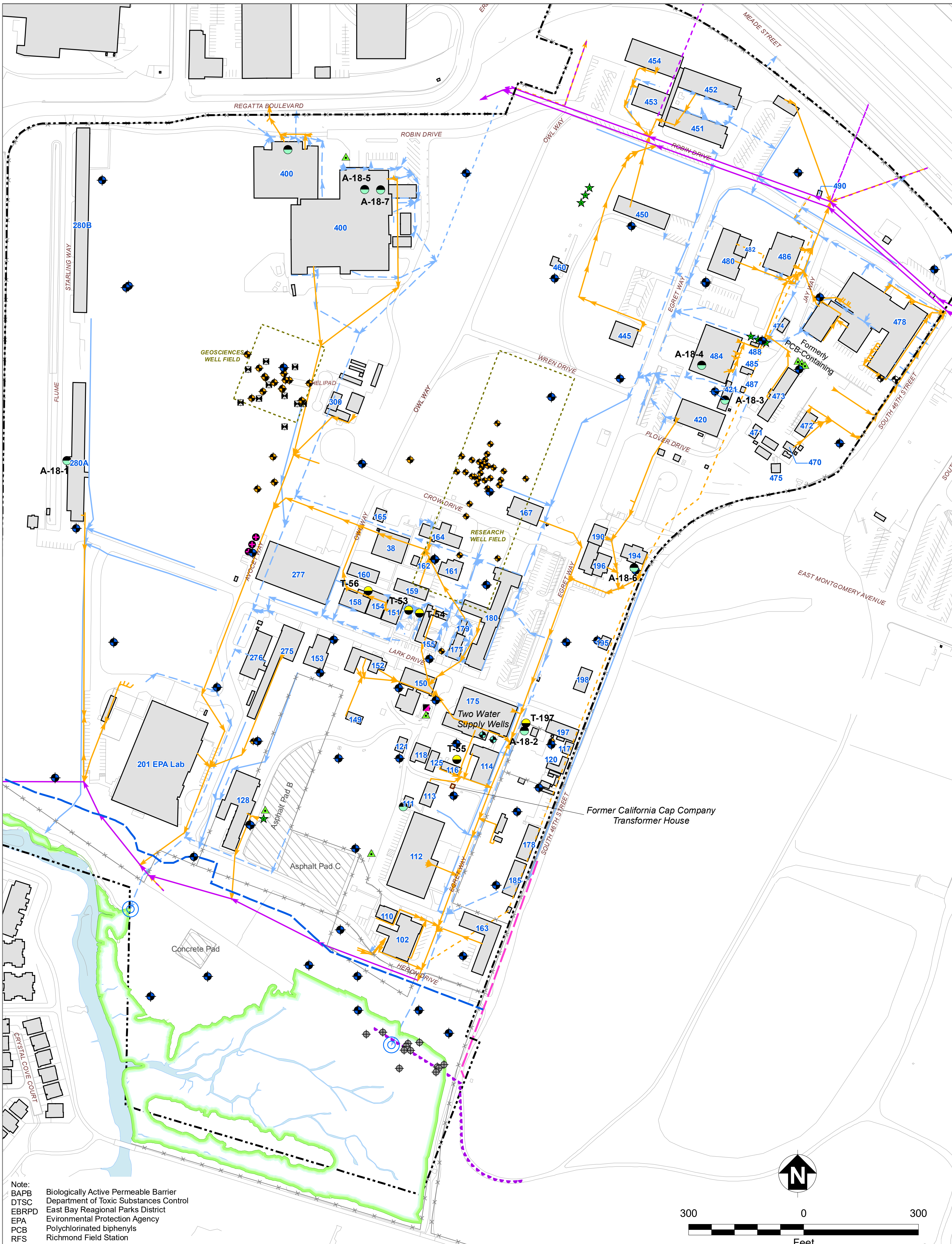
TETRA TECH

Richmond Field Station Site
University of California, Berkeley

FIGURE C-3
RESEARCH, EDUCATION AND SUPPORT AREA AND NATURAL OPEN SPACE WITHIN SITE BOUNDARY

Soil Management Plan

2018-09-12 C:\misc_GIS\Richmond_Field_Station\Projects\06_SMP\C-3_RES Area and Natural Open Space within RFS Boundary.mxd TtEMI-ABQ michelle.handley.



Note:
BAPB Biologically Active Permeable Barrier
DTSC Department of Toxic Substances Control
EBRPD East Bay Reagional Parks District
EPA Evironmental Protection Agency
PCB Polychlorinated biphenyls
RFS Richmond Field Station

- Existing Building (Building Numbers Shown in Blue)
- Marsh Boundary
- Surface Water
- Asphalt/Concrete Pads
- Well Field Boundary
- Portion of RFS Property Subject to DTSC order, Defined as "Site"
- Fenceline
- Biologically Active Permeable Barrier Wall
- Former Seawall
- Slurry Wall
- Aboveground Storage Tank (AST)
- Former Underground Storage Tank (UST)

- Open Well (Not in Use)
- Closed Well (Pressure Grouted)
- Open Piezometer
- Open Geosciences Well
- BAPB Wells on RFS Property
- Zeneca Wells on RFS Property

Transformer Locations:
- Pad-Supported, Non PCB-Containing
- Pad-Supported, Former PCB-Containing (Removed)
- Pole-Mounted, Non PCB-Containing
- Pole-Mounted, Former PCB-Containing (Removed)

City Sanitary Sewer Lines:
- Existing City of Richmond Sewer
- Abandoned City of Richmond Sewer
- Existing RFS Sewer
- Abandoned RFS Sewer

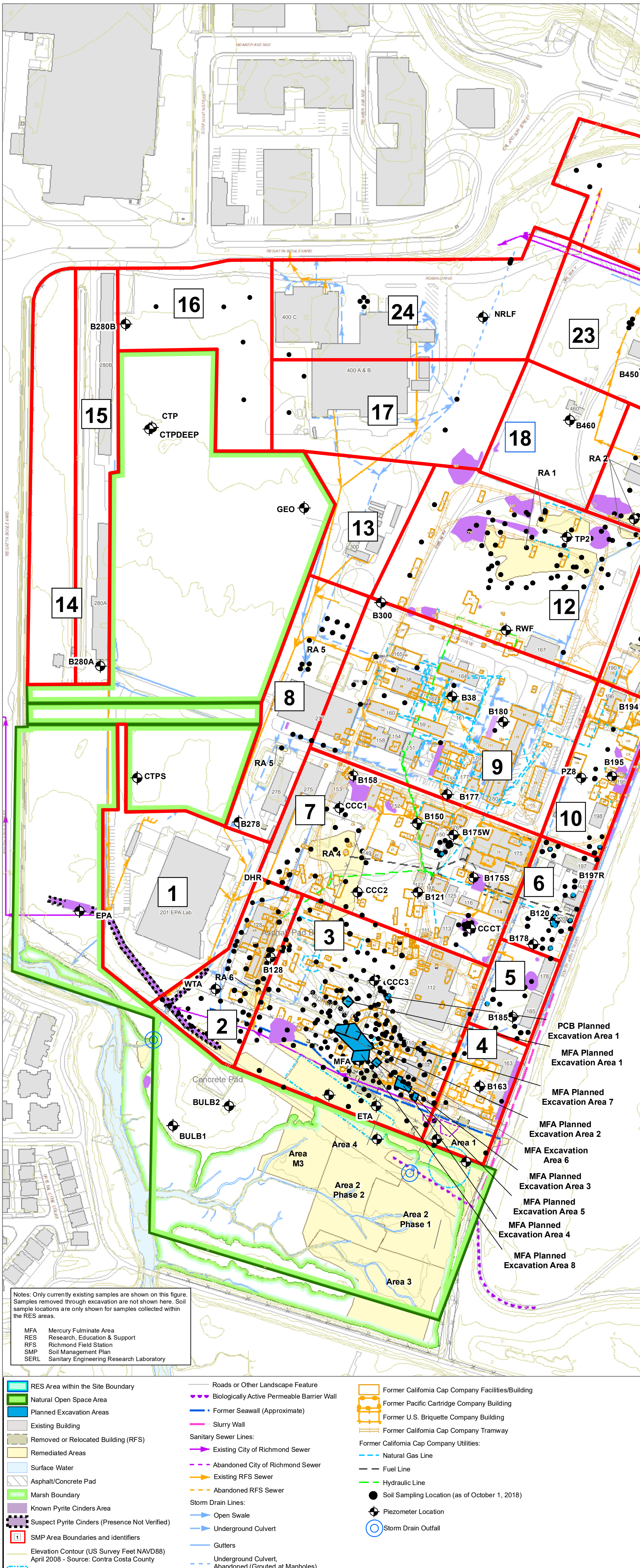
Storm Drain Lines:
- Open Swale
- Underground Culvert
- Gutters
- Underground Culvert, Abandoned (Grouted at Manholes)
- Storm Drain Outfalls

TETRA TECH

Richmond Field Station Site
University of California, Berkeley

FIGURE C-4
PHYSICAL FEATURES

Soil Management Plan

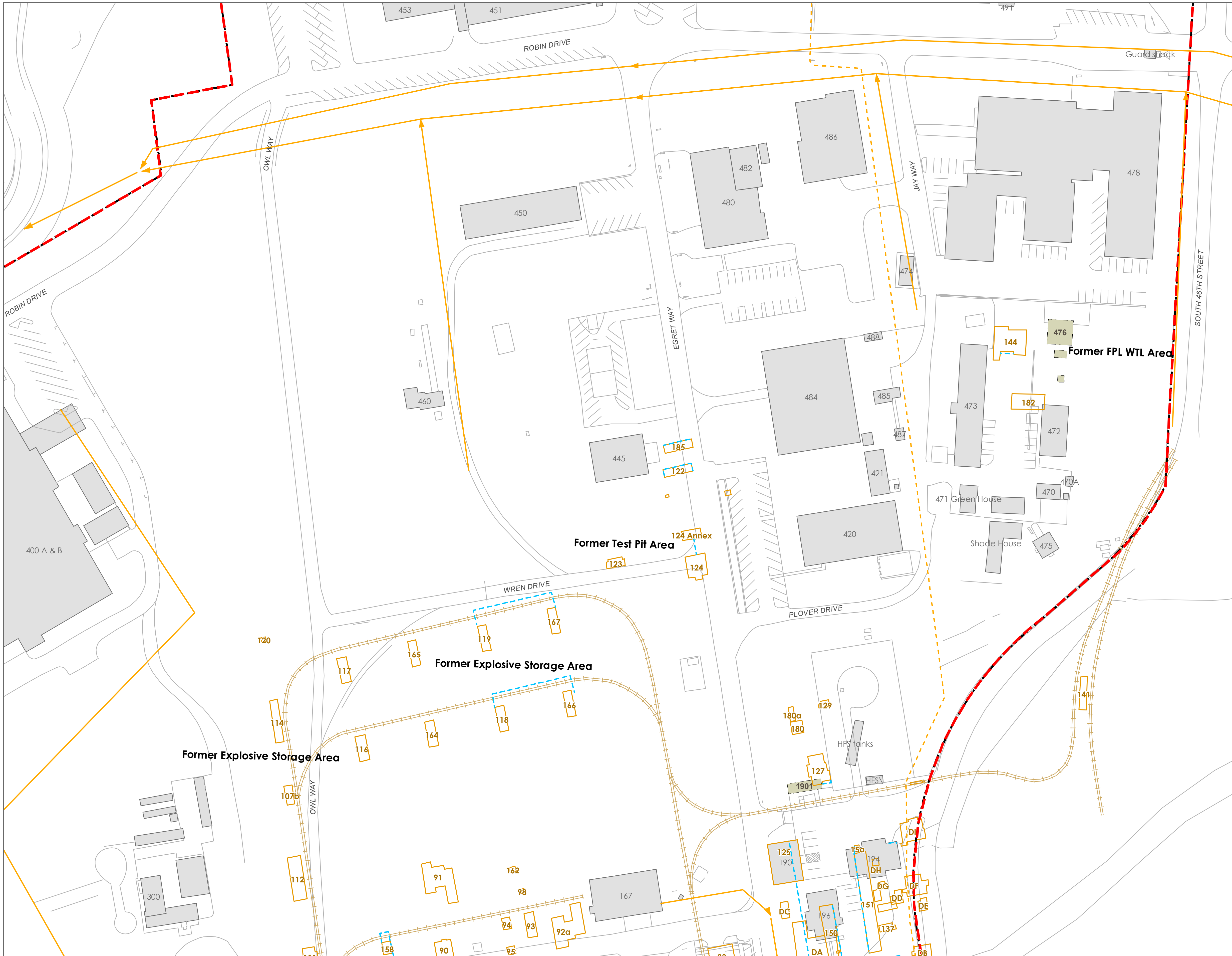


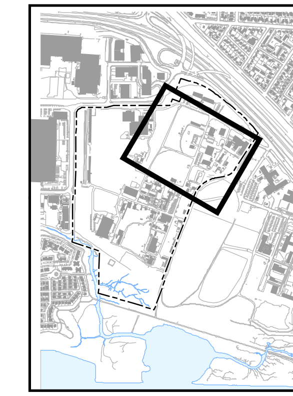
Richmond Field Station Site
University of California, Berkeley

FIGURE C-5
SOIL MANAGEMENT PLAN AREAS

Soil Management Plan

10/31/2018 C:\misc_GIS\Richmond_Field_Station\Projects\06_SMP\C-5_SMP Plan Areas.mxd TtEMI-ABQ michelle.handley





- Existing Building
- Removed or Relocated Building (RFS)
- Former California Cap Company Facilities/Buildings
- Former California Cap Company Tramway
- Former California Cap Company Natural Gas Line
- Portion of RFS Property Subject to DTSC order, Defined as "Site"
- Richmond Bay Campus
- Roads and Other Landscape Features

Sanitary Sewer Lines:

- Existing Sewer Line
- Removed Sewer Line
- Abandoned Sewer Line

Notes:
1. Some locations are approximate.

2. Former California Cap Company facility information is based on Sanborn maps from 1930 and 1941 and an earlier undated map signed by "J. Geo. Smith, C.E., Emeryville."

DTSC	Department of Toxic Subsances Control
FPL	Forest Products Laboratory
RFS	Richmond Field Station
WTL	Wood Treatment Lab

120 0 120

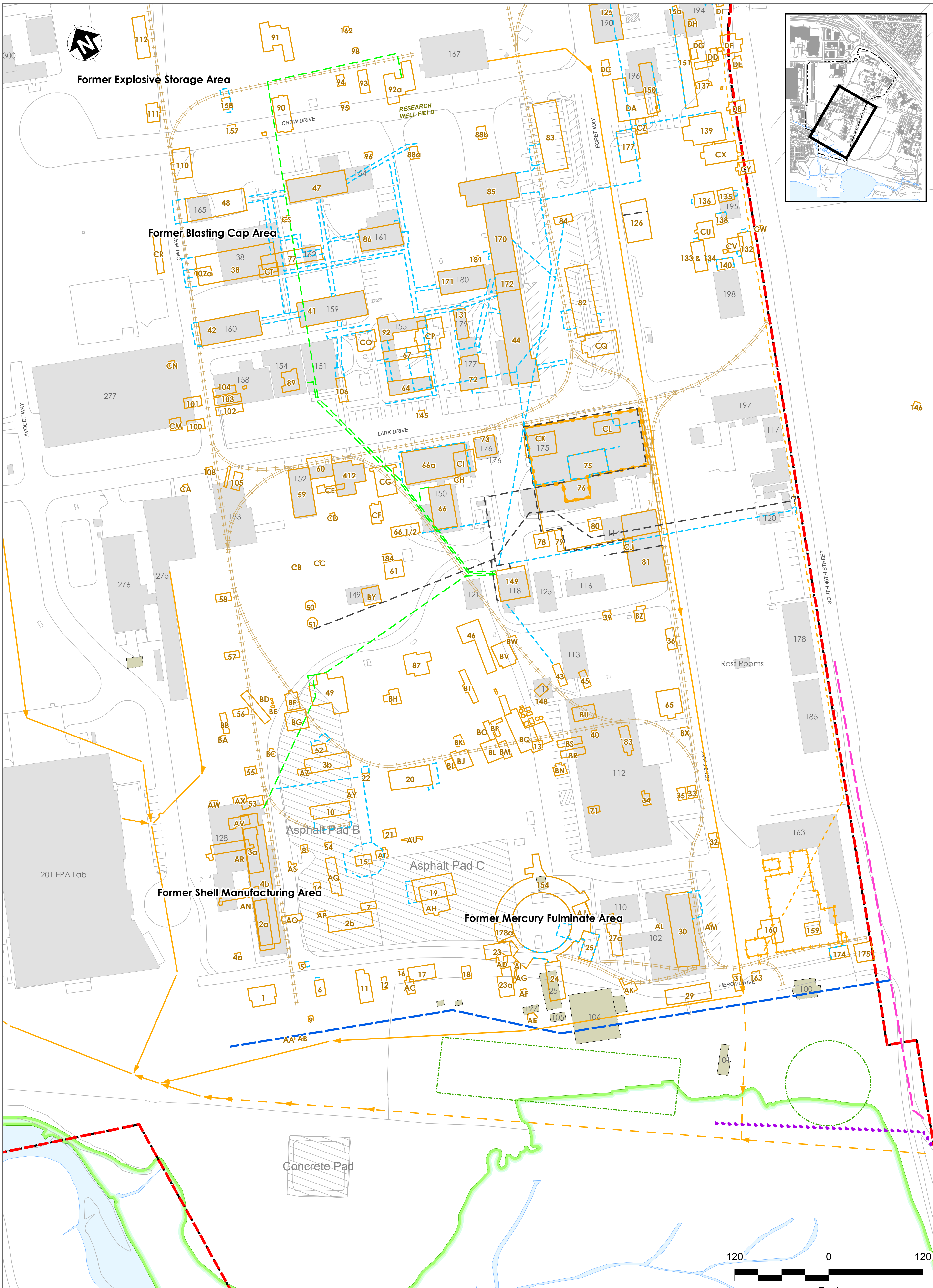
Feet

TETRA TECH

Richmond Field Station Site
University of California, Berkeley

FIGURE C-6
LOCATION OF FORMER AND CURRENT FACILITIES IN THE NORTHERN PORTION OF SITE

Soil Management Plan



Existing Building
Roads and Other Landscape Features
Removed or Relocated Building (RFS)
Former California Cap Company Facilities/Buildings
Former Pacific Cartridge Company Buildings
Former U.S. Briquette Company Building
Former California Cap Company Tramway
Former SERL Pond
Portion of RFS Property Subject to DTSC order, Defined as "Site"

Richmond Bay Campus
Marsh Boundary
Former Seawall (Approximate)
Slurry Wall
Biologically Active Permeable Barrier Wall
Asphalt/Concrete Pads
Surface Water

Sanitary Sewer Lines:
Existing Sewer Line
Removed Sewer Line
Abandoned Sewer Line

Former California Cap Company Utilities:
Natural Gas Line
Fuel Line
Hydraulic Line

Notes:
1. Some locations are approximate.

2. Former California Cap Company facility information is based on Sanborn maps from 1930 and 1941 and an earlier undated map signed by "J. Geo. Smith, C.E., Emeryville."

DTSC Department of Toxic Substances Control
RFS Richmond Field Station
SERL Sanitary Engineering Reseach Laboratory

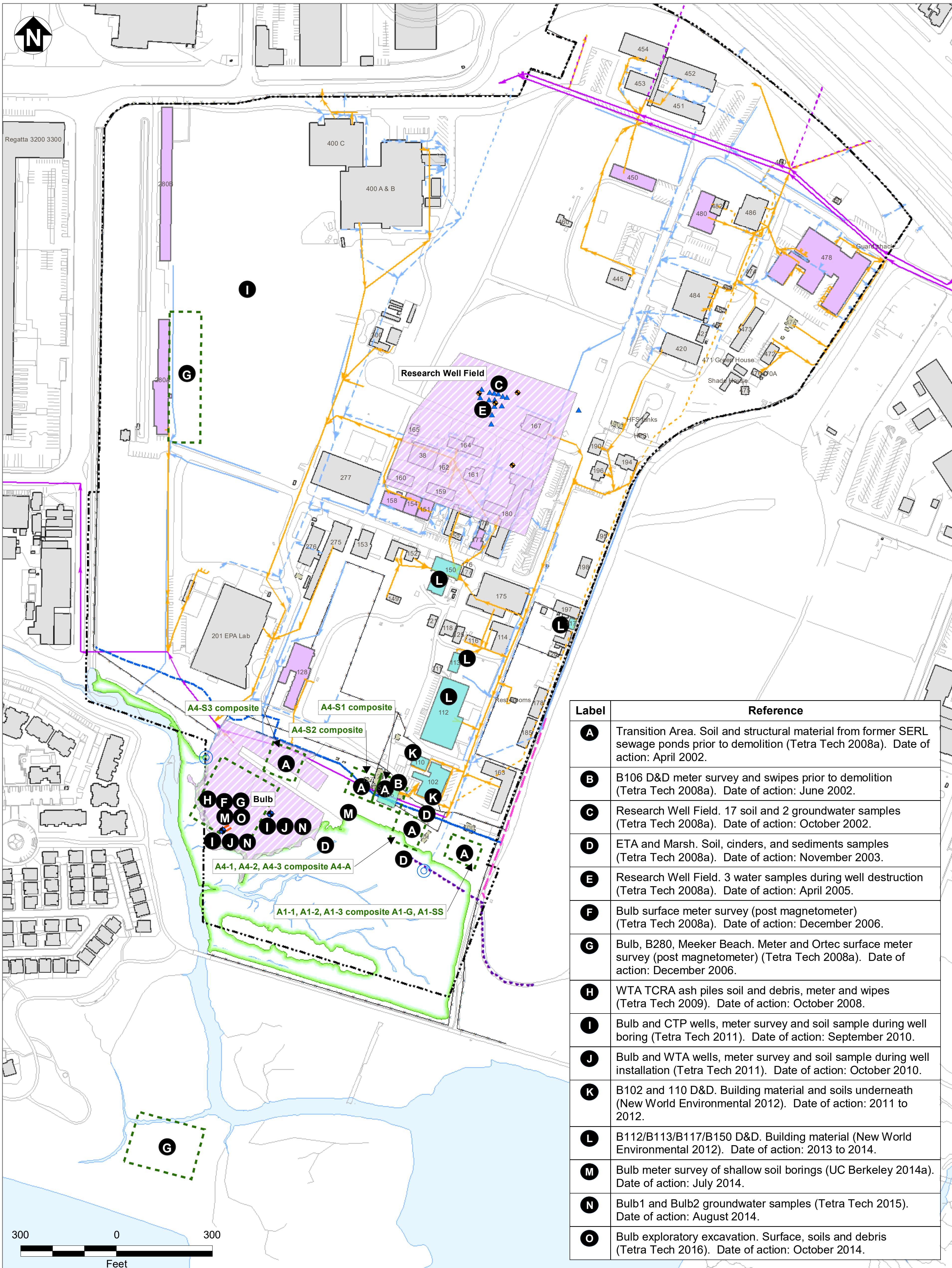
TETRA TECH

Richmond Field Station Site
University of California, Berkeley

FIGURE C-7
LOCATION OF FORMER AND CURRENT FACILITIES IN THE CENTRAL PORTION OF SITE

Soil Management Plan

10/26/2018 C:\misc_GIS\Richmond_Field_Station\Projects\06_SMP\C-7_Former_Cap_Co_Bldgs-RFS_Central.mxd TtEMI-OAK michelle.handley



Label	Reference
A	Transition Area. Soil and structural material from former SERL sewage ponds prior to demolition (Tetra Tech 2008a). Date of action: April 2002.
B	B106 D&D meter survey and swipes prior to demolition (Tetra Tech 2008a). Date of action: June 2002.
C	Research Well Field. 17 soil and 2 groundwater samples (Tetra Tech 2008a). Date of action: October 2002.
D	ETA and Marsh. Soil, cinders, and sediments samples (Tetra Tech 2008a). Date of action: November 2003.
E	Research Well Field. 3 water samples during well destruction (Tetra Tech 2008a). Date of action: April 2005.
F	Bulb surface meter survey (post magnetometer) (Tetra Tech 2008a). Date of action: December 2006.
G	Bulb, B280, Meeker Beach. Meter and Ortec surface meter survey (post magnetometer) (Tetra Tech 2008a). Date of action: December 2006.
H	WTA TCRA ash piles soil and debris, meter and wipes (Tetra Tech 2009). Date of action: October 2008.
I	Bulb and CTP wells, meter survey and soil sample during well boring (Tetra Tech 2011). Date of action: September 2010.
J	Bulb and WTA wells, meter survey and soil sample during well installation (Tetra Tech 2011). Date of action: October 2010.
K	B102 and 110 D&D. Building material and soils underneath (New World Environmental 2012). Date of action: 2011 to 2012.
L	B112/B113/B117/B150 D&D. Building material (New World Environmental 2012). Date of action: 2013 to 2014.
M	Bulb meter survey of shallow soil borings (UC Berkeley 2014a). Date of action: July 2014.
N	Bulb1 and Bulb2 groundwater samples (Tetra Tech 2015). Date of action: August 2014.
O	Bulb exploratory excavation. Surface, soils and debris (Tetra Tech 2016). Date of action: October 2014.

Historic Area of Radiological Materials Use
Suspected Use or Disposal - Exterior Locations
Decontamination and Decommissioning Complete
Exploratory Excavation Trenches
Area of Radiological Survey or Sampling
Discrete Radiological Sampling Location
Closed Well Where Radiological Sampling Occured
(A) Indicates reference to investigation; see back of this figure for full list of report references
Existing Piezometer
Existing Building
Removed or Relocated Building (RFS)
Marsh Boundary
Surface Water
Richmond Field Station Site Boundary

Road or Other Landscape Feature
Biologically Active Permeable Barrier Wall
Fenceline
Former Seawall
Slurry Wall

Sanitary Sewer Lines:
Existing City of Richmond Sewer
Abandoned City of Richmond Sewer
Existing RFS Sewer
Abandoned RFS Sewer

Storm Drain Lines:
Open Swale
Underground Culvert
Gutters
Underground Culvert, Abandoned (Grouted at Manholes)
Storm Drain Outfalls

Notes:
1. All radiological reference documents are included in Section 7.0 References.
2. Table C-4 provides additional radiological survey and sampling information.

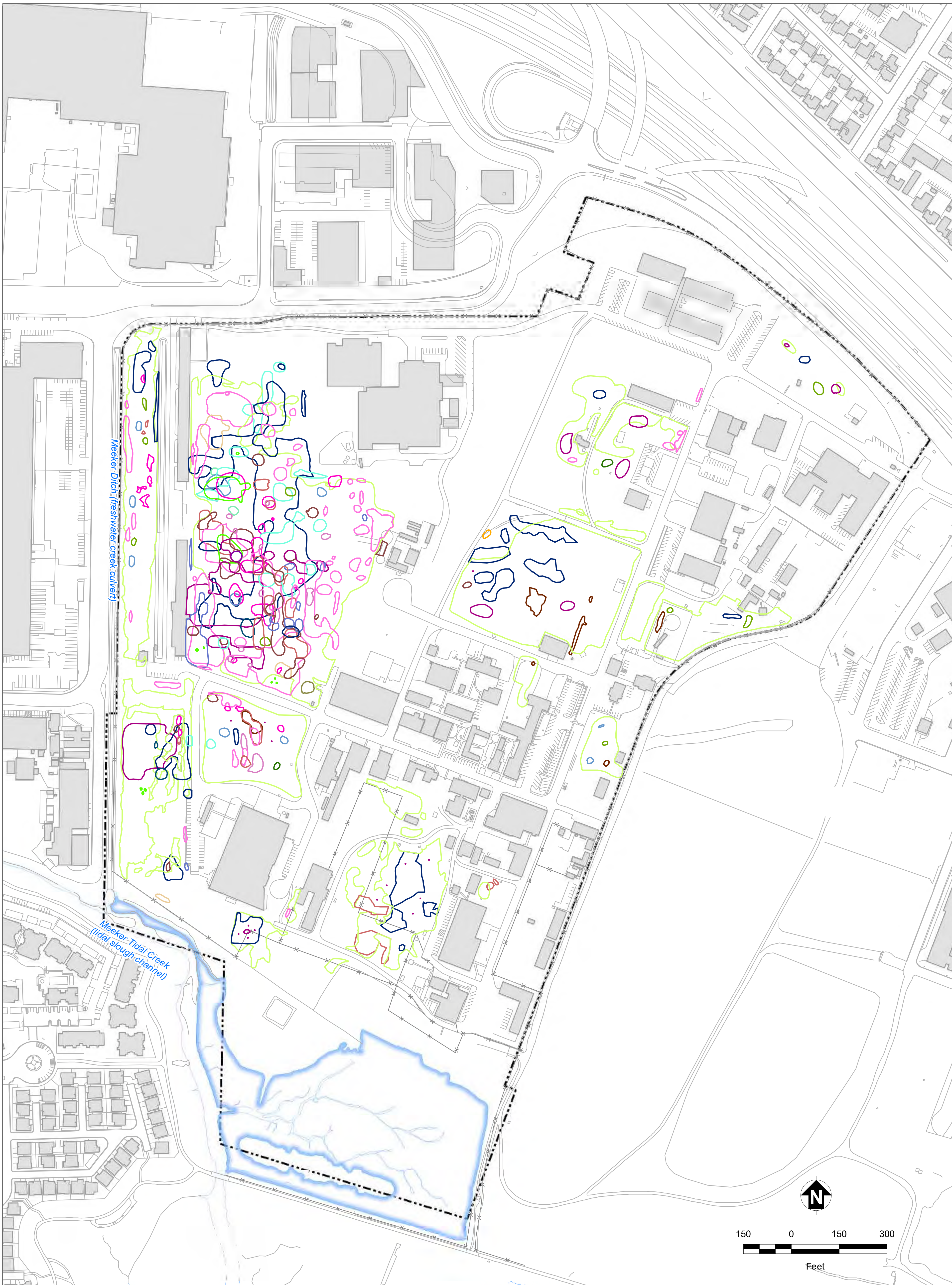
TETRA TECH

Richmond Field Station Site
University of California, Berkeley

FIGURE C-8
HISTORIC RADIOLOGIC USE AND SAMPLING LOCATIONS

Soil Management Plan

10/31/2018 C:\misc_GIS\Richmond_Field_Station\Projects\06_SMP\C-8 Historic RAD and Sampling Locations_revised.mxd - michelle.handley



California oatgrass (Danthonia californica)
Hansen's wildrye (Elymus hansenii)
Oregon timwort (Cicendia quarangularis)
ajuga hedge nettle (Stachys ajugoides)
big squirreltail (Elymus multisetus)
brown-headed rush (Juncus phaeocephalus)
clustered toadrush (Juncus bufonius)
coast spikeweed (Deinandra corymbosa)
coastal eryngo, coyote thistle (Eryngium armatum)
dense sedge (Carex densa)
false pimpernel (Centunculus minimus)
foothill sedge (Carex tumulicola)
hairy gumplant (Grindelia hirsutula)
hayfield tarweed (Hemizonia congesta)
ladies-tresses (Spiranthes romanzoffiana)
purple needlegrass (Nassella pulchra)
slender wheatgrass (Elymus trachycaulus)
small-bract sedge (Carex subbracteata)
suncups (Camissonia ovata)
wild hyacinth, white brodiaea (Triteleia hyacinthi
willow-leaved dock (Rumex salicifolius)

Existing Building
Portion of RFS Property Subject to DTSC order, Defined as "Site"
Roads and Other Landscape Features
Marsh Boundary

Note:
DTSC Department of Toxic Substances Control
RFS Richmond Field Station

TETRA TECH

Richmond Field Station Site
University of California, Berkeley

FIGURE C-9
SENSITIVE PLANT SPECIES

Soil Management Plan

2018-10-26 C:\misc_GIS\Richmond_Field_Station\Projects\06_SMP\C-9_SensitiveVegetation.mxd TtEMI-ABQ michelle.handley.

Drainage Swale
Roads and Other Landscape Features
Restoration Plot
Monarch Roosting Area
Disturbed Coastal Terrace Prairie
Non Native Dominated Grassland on Fill
Ornamental Trees
Eucalyptus
Property Boundary
Approximate Property Boundary
Surface Water
Wet Meadows (possible wetlands)
Surveyed
Not Surveyed

Cordgrass (*Spartina foliosa*)
Salty Susan (*Jaumea carnosa*)
Bulrush (*Scirpus americanus*)
Saltgrass (*Distichlis spicata*)
Pickleweed (*Salicornia virginica*)
Ecotone
Restored Native Upland
Non-Native Transitional Upland
Mud
Building
Coastal Terrace Prairie

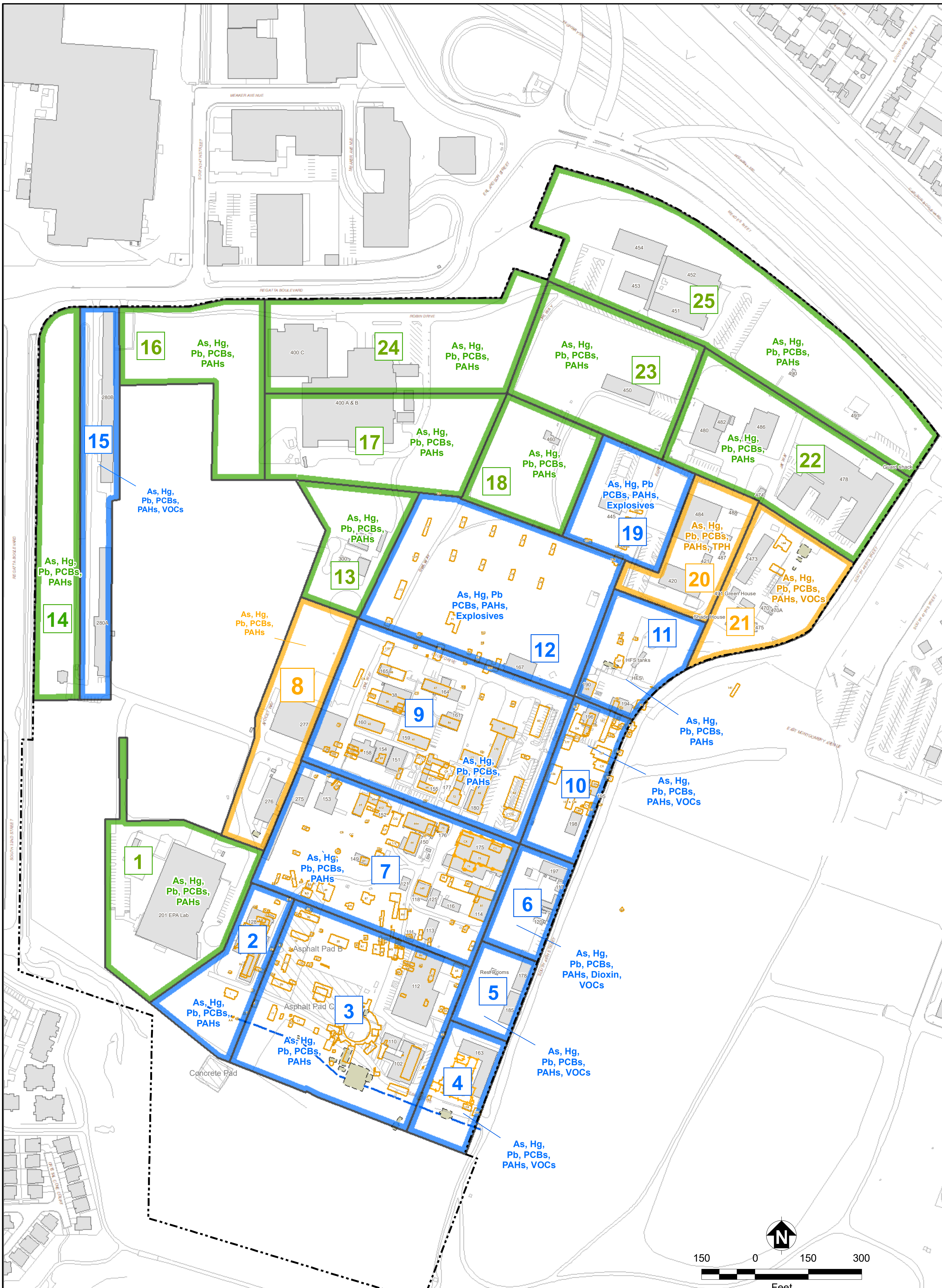
TETRA TECH

Richmond Field Station
University of California, Berkeley

FIGURE C-10
HABITAT AND WETLANDS MAP

Soil Management Plan

2008-11-17 v:\misc_gis\richmond_field_station\projects\habitat surveys\habitat_surveys_wetlands_10_28_cjf_edits.mxd TtEMI-SF cf



Existing Building

Removed or Relocated Building

Asphalt/Concrete Pad

Former Seawall (Approximate)

Approximate Site Boundary

Roads or Other Landscape Feature

Former California Cap Company Facilities/Building

SMP Area Boundaries and Identifiers with Density Protocol

1 Low Density Sampling Area: 125 foot grid spacing; one sample per 15,625 square feet.

8 Medium Density Sampling Area: 100 foot grid spacing; one sample per 10,000 square feet.

2 High Density Sampling Area: 75 foot grid spacing; one sample per 5,625 square feet.

Notes:

As	Arsenic
Hg	Mercury
PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
PCB	Polychlorinated biphenyl
SMP	Soil Management Plan
TPH	Total petroleum hydrocarbons
VOC	Volatile organic compound

TETRA TECH

Richmond Field Station Site
University of California, Berkeley

FIGURE C-11
SOIL MANAGEMENT PLAN AREAS SAMPLING DENSITIES AND RECOMMENDED ANALYTES
Soil Management Plan

10/26/2018 C:\misc_GIS\Richmond_Field_Station\Projects\06_SMP\C-11_SMP Plan Areas Sampling Densities and COCs.mxd TtEMI-OAK michelle.handley

TABLES

Table C-1: Category I and II Criteria
Richmond Field Station

Chemical [3]	Risk-Based Concentrations [1,2]					Category I Criteria [4]	Category II On-Site Management Criteria [5]
	Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	Other Criteria		
Metals							
Aluminum [6]	1,120,000.000	**20,600**	516,000	7,090,000	Eliminated	20,600	100,000
Antimony	467	142	3,540	--	--	142	1,420
Arsenic [7, 8]	**0.253**	0.85	1.77	888	16	16	16
Barium	217,000	**2,120**	53,100	709,000	--	2,120	21,200
Beryllium	232	**21.4**	128	1,590	--	21.4	214
Boron	233,000	**39,200**	979,000	28,400,000	--	39,200	100,000
Cadmium	778	**36.6**	73.0	909	--	36.6	366
Chromium	**1,750,000**	531,000	13,300,000	--	--	100,000	100,000
Cobalt	347	**21.1**	34.1	424	73	73.0	210
Copper	46,700	**14,200**	354,000	--	--	14,200	100,000
Iron	**818,000**	248,000	6,190,000	--	--	100,000	100,000
Lead [8,9]	**320**	320	320	--	--	320	800
Manganese [6]	25,600	**213**	5,340	70,900	5,900	5,900	5,900
Mercury [10]	187	**39.6**	989	42,500	--	39.6	396
Molybdenum	5,840	**1,770**	44,200	--	--	1,770	17,700
Nickel	11,100	**60.4**	1,180	14,700	280	280.0	604
Selenium	5,840	**1,730**	43,400	28,400,000	--	1,730	17,300
Silver	5,840	**1,770**	44,200	--	--	1,770	17,700
Thallium	11.70	**3.54**	88.5	--	--	3.54	35.4
Vanadium	5,780	**351**	8,780	142,000	--	351	3,510
Zinc	350,000	**106,000**	2,650,000	--	--	100,000	100,000
VOCs							
1,2-Dichloropropane	11.00	65.8	213.0	**2.880**	--	2.880	28.80
Acetone	**671,000**	271,000	6,780,000	441,000	--	100,000	100,000
Benzene	1.43	32.4	32.4	**0.343**	--	0.343	3.43
Ethylbenzene	25	529	529	**6.37**	--	6.37	63.70
m,p-Xylene	2,370	2,310	57,600	**570**	--	570	5,700
o-Xylene	2,800	2,700	67,600	**674**	--	674	6,740
Toluene	5,320	4,680	117,000	**1,340**	--	1,340	13,400
Trichloroethylene	6.05	17.4	126.0	**1.06**	--	1.06	10.6

Table C-1: Category I and II Criteria
Richmond Field Station

Chemical [3]	Risk-Based Concentrations [1,2] Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	Other Criteria	Category I Criteria [4]	Category II On-Site Management Criteria [5]
SVOCs							
BAP (EQ) [11, 12]	**1.27**	7.07	8.29	1,250	0.400	0.400	4.00
1-Methylnaphthalene	**43.9**	294	294	17,100	--	43.9	439
2-Methylnaphthalene	1,260	**433**	10,800	968	--	433	4,330
4-Methylphenol	52,900	**14,300**	357,000	851,000,000	--	14,300	100,000
Acenaphthene	23,000	**6,930**	173,000	35,300	--	6,930	69,300
Acenaphthylene	23,000	**6,930**	173,000	35,300	--	6,930	69,300
Anthracene	130,000	**35,900**	897,000	654,000	--	35,900	100,000
Benzo(a)anthracene	**12.400**	82.30	82.30	41	--	12.4	124
Benzo(a)pyrene	**1.270**	7.070	8.290	1,250	--	1.3	12.7
Benzo(b)fluoranthene	**12.70**	82.90	82.90	12,500	--	12.7	127
Benzo(g,h,i)perylene	13,500	**3,620**	90,600	297,000	--	3,620	36,200
Benzo(k)fluoranthene	**127**	654.00	654.00	12,500	--	127	1,270
bis(2-Ethylhexyl)phthalate	**106**	715	715	1,590,000	--	106	1,060
Chrysene	**1,270**	6540.0	6540.0	125,000	--	1,270	12,700
Dibenz(a,h)anthracene	**0.311**	2.070	2.070	1,150	--	0.311	3.11
di-n-Butylphthalate	52,900	**14,400**	359,000	--	--	14,400	100,000
Fluoranthene	18,200	**4,880**	122,000	--	--	4,880	48,800
Fluorene	16,700	**4,730**	118,000	46,900	--	4,730	47,300
Indeno(1,2,3-cd)pyrene	**12.700**	82.90	82.90	12,500	--	12.700	127
Naphthalene	16.7	399	399	**3.82**	--	3.82	38.2
Phenanthrene	18,200	**4,880**	122,000	--	--	4,880	48,800
Pyrene	13,500	**3,620**	90,600	297,000	--	3,620	36,200
PCBs							
Aroclor-1242 [13]	**0.580**	3.98	3.98	2.90	1	1	1
Aroclor-1248 [13]	**0.582**	3.99	3.99	3.07	1	1	1
Aroclor-1254 [13]	**0.588**	2.29	4.00	4.15	1	1	1
Aroclor-1260 [13]	**0.595**	4.01	4.01	6.44	1	1	1
Total PCBs [14]	0.577	3.98	3.98	2.61	1	1	1

Table C-1: Category I and II Criteria
Richmond Field Station

Chemical [3]	Risk-Based Concentrations [1,2] Commercial Worker	Construction Worker	Maintenance Worker	Off-Site Receptor (Inhalation)	Other Criteria	Category I Criteria [4]	Category II On-Site Management Criteria [5]
Pesticides							
4,4'-DDD	**6.18**	4.3	41.5	55,300	--	4.31	43.1
4,4'-DDE	**9.28**	70.5	70.5	60.7	--	9.28	92.8
4,4'-DDT	**7.06**	49.9	49.9	39,400	--	7.06	70.6
Aldrin	**0.184**	1.41	1.41	0.984	--	0.184	1.84
alpha-BHC	**0.235**	1.58	1.58	2,120	--	0.235	2.35
alpha-Chlordane	**6.10**	43.60	43.60	42.9	--	6.10	61.0
beta-BHC	**0.82**	5.54	5.54	7,200	--	0.823	8.23
Carbazole	**1270**	6540	6540	125,000	--	1270	12,700
Chlordane	**6.10**	43.6	43.6	42.9	--	6.10	61.0
delta-BHC	**0.823**	5.54	5.54	7,200	--	0.823	8.23
Dieldrin	**0.093**	0.623	0.623	830	--	0.0926	0.926
Endosulfan I	6,030	**1,990**	49,600	10,300	--	1,990	19,900
Endosulfan II	6,030	**1,990**	49,600	10,300	--	1,990	19,900
Endosulfan sulfate	3,180	**855**	21,400	34,000,000	--	855	8,550
Endrin	159	**43.1**	1,080	--	--	43.1	431
Endrin aldehyde	159	**43.1**	1,080	--	--	43.1	431
gamma-BHC (Lindane)	**2.01**	14.0	14.0	12,300	--	2.01	20.1
gamma-Chlordane	**6.10**	43.6	43.6	42.9	--	6.10	61.0
Heptachlor	**0.626**	5.14	5.14	1.03	--	0.626	6.26
Heptachlor epoxide	**0.330**	2.59	2.59	0.910	--	0.330	3.30
Mirex	**0.167**	1.31	1.31	0.472	--	0.167	1.67
Pentachlorophenol	**2.04**	13.3	13.3	749,000	--	2.04	20.4
Dioxin							
Dioxin TEQ [15]	**0.0000179**	0.000129	0.000129	0.000145	--	0.0000179	0.000179
Explosives							
HMX	54,500	**16,300**	407,000	--	--	16,300	100,000
TPH							
Diesel range organics [16]	--	--	--	--	**880**	880	880
Gasoline range organics [16]	--	--	--	--	**2,800**	2,800	2,800
Motor oil range organics [16]	--	--	--	--	**32,000**	32,000	32,000

Table C-1: Category I and II Criteria
Richmond Field Station

Notes:
All values are in mg/kg.
1 Risk-based concentrations are calculated using the default DTSC exposure parameters (DTSC 2019a) and DTSC toxicity values (DTSC 2019b). If a DTSC default exposure value is not available, then an USEPA default exposure value (USEPA 2014) was selected or professional judgment was used to select a value. If a chemical is not included in DTSC's screening levels, then USEPA toxicity values were selected (USEPA 2019). Risk-based concentrations are shown with 3 significant figures, except where the default value of 100,000 mg/kg applies (where calculated value exceeds 100,000 mg/kg).
2 **Bold** values indicate the lowest of the risk-based concentrations for all potential future receptors.
3 All chemicals detected at the site are included in this table. If a chemical is detected in the future that is not included in the table, risk-based concentrations will be calculated for it, and DTSC will be consulted.
4 Category I criteria are based on the lowest of the calculated risk-based concentrations, unless background, ambient, or TSCA criterion are available, in which case the alternate values are selected and noted within this table. Category I criteria for TPH constituents are based on the RWQCB ESL (SFBRWQCB 2019).
5 Category II criteria are based on 10 times the Category I criteria, unless otherwise noted. In cases where 10 times the Category I criteria is greater than 100,000 mg/kg, the default value of 100,000 mg/kg is used.
6 Screening levels for cobalt, manganese, and nickel were updated, and aluminum was eliminated as a chemical of concern, based on the Final Ambient Metals Evaluation, Aluminum, Cobalt, Manganese, and Nickel (Tetra Tech 2015).
7 The background level for arsenic (16 mg/kg) was established for the RFS Site as approved within the Final Removal Action Workplan (Tetra Tech 2014). The arsenic criteria is a not to exceed value, except in cases where arsenic is associated with cinders in soil (see note 8).
8 If lead or arsenic is associated with cinders, manage on site per Section 5.2.3 of the Soil Management Plan. If not associated with cinders, investigate further, determine if source is present, and dispose of off-site.
9 A risk-based concentration was not calculated for lead. Rather, the industrial screening level of 320 mg/kg (DTSC 2019b) was used for the commercial, construction, and maintenance worker scenarios. The Category II lead value is based on industrial RSL from EPA (2019).
10 The toxicity criteria and chemical properties for mercuric chloride was used as a surrogate for mercury to calculate the risk-based concentration.
11 The toxicity criteria for benzo(a)pyrene was used as a surrogate for BAP (EQ) to calculate the risk-based concentration.
12 The ambient level for BAP (EQ) (0.4 mg/kg) is based on the 95 UCL concentration of the ambient dataset for BaP (EQ) in surface soils in Northern California (DTSC 2009; Environ Corporation and others 2002).
13 The other criterion is based on the TSCA High Occupancy, no further conditions threshold criterion for total PCBs from EPA (2005). The TSCA criterion is a not-to-exceed value.
14 PCB COCs include Aroclor-1248, Aroclor-1254, and Aroclor-1260. The receptor-specific risk-based concentration for total PCBs is based on the toxicity
values for "Polychlorinated Biphenyls (high risk)." The TSCA criteria for Aroclors of 1 mg/kg is applicable for total PCBs (the sum of all detected
15 The toxicity criteria for 2,3,7,8-TCDD was used as a surrogate for Dioxin TEQ to calculate the risk-based concentration.
16 Criteria for TPH constituents are based on the Environmental Screening Levels Direct Exposure Human Health Risk Levels (SFRWCQB 2019).

--	Not applicable	HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
BAP (EQ)	Benzo(a)pyrene equivalent	mg/kg	Milligrams per kilogram

Table C-1: Category I and II Criteria
Richmond Field Station

BHC	Hexachlorocyclohexane	OEHHA	Office of Environmental Health Hazard Assessment
Cal/EPA	California Environmental Protection Agency	PCB	Polychlorinated biphenyl
DDD	Dichlorodiphenyldichloroethane	TCDD	Tetrachlorodibenzo-p-dioxin
DDE	Dichlorodiphenyldichloroethylene	TPH	Total Petroleum Hydrocarbons
DDT	Dichlorodiphenyltrichloroethane	TSCA	Toxic Substances Control Act
DTSC	California Department of Toxic Substances Control	VOC	Volatile organic compound

References:

California Department of Toxic Substances Control (DTSC). 2009. Use of the Northern and Southern California Polynuclear Aromatic Hydrocarbon (PAH) Studies in the Manufactured Gas Plant Site Cleanup Process. July.

DTSC. 2019a. *HERO Note Number 1: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Hazardous Waste Sites and Permitted Facilities* . Office of Human and Ecological Risk. May 9.

DTSC. 2019b. *Human Health Risk Assessment Note 3 – DTSC-Modified Screening Levels (DTSC-SLs)* . April 20.

Environ Corporation, Entrix, IRIS Environmental, and Env America. 2002. Background Levels of Polycyclic Aromatic Hydrocarbons in Northern California Surface Soil. Prepared for: Pacific Gas and Electric Company and U.S. Navy. June 7.

United States Environmental Protection Agency (USEPA). 2005. PCB Site Revitalization Guidance Under the Toxic Substances Control Act. November.

USEPA. 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER 9200.1-120.

USEPA. 2019. Regional Screening Levels (RSLs) for Chemical Contaminants. November.

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). 2019. “2019 Update to Environmental Screening Levels.” Revision 2. July 25.

Tetra Tech. 2014. Final Removal Action Workplan, Research, Education, and Support Area and Groundwater within the Richmond Field Station Site. July 18.

Tetra Tech. 2015. Final Ambient Metals Evaluation, Aluminum, Cobalt, Manganese, and Nickel, Technical Memorandum. December 11.

Table C-2: Summary of SMP Areas and Historical Activities

SMP Area	Historical Activities	UC Berkeley Activities [1]	Previous Cleanups [2]	Depth of Completed Cleanup (ft bgs)	COC of Completed Cleanup	Report Reference for Cleanup	Known Pyrite Cinders?	Commercial Vapor Intrusion RBC Exceedance in GW
1	--	--	--	--	--		Y	N
2	CCC, Shell Manufacturing, Pyrite Cinder Disposal	B128	Area 4 - Phase 2 RA 6 (AOC U6) - Phase 3	1 - 1.5 [3] 2 - 5	Pyrite Cinders, Hg Hg, PCBs	URS 2004 URS 2005	Y	N
3	CCC, MFA, Pyrite Cinder Disposal	B102, B112	Area 4 - Phase 2 RA 4 (AOC U4) - Phase 3 RA 6 (AOC U6) - Phase 3	1 - 5 [3] 1 2 - 5	Pyrite Cinders, Hg As, Cr, Cu, Pb, Hg Hg, PCBs	URS 2004 URS 2005	Y	N
4	CCC, Briquette, Pyrite Cinder Disposal	B163	Area 1 - Phase 1	11	Pyrite Cinders, Hg	URS 2003b	N	N
5	CCC	--	--	--	--		Y	Y [4]
6	CCC	B120 chemical and petroleum product storage, maintenance equipment storage, incinerator, UST (removed)	--	--	--		Y	Y [5]
7	CCC, Pacific Cartridge Company	B118, B125, B275, UST (removed)	RA 4 (AOC U4) - Phase 3	1	As, Cr, Cu, Pb, Hg	URS 2005	Y	N
8	--	B276, B277	RA 5 (AOC U8) - Phase 3	2	PCBs	URS 2005	N	N
9	CCC	B151, B158, B165, B277, UST (Removed)	--	--	--	--	N	N
10	CCC	AST	--	--	--	--	Y	N
11	CCC	--	--	--	--	--	N	N
12	CCC, Explosives Storage Area	B167	RA 1 (AOC U1) - Phase 3 RA 2 (AOC U2) - Phase 3	1 1 - 3 [6]	As, Cu, Pb As, Cu	URS 2005	Y	N
13	--	B300	--	--	--	--	N	N
14	--	--	--	--	--	--	N	N
15	--	B280A, B280B, AST	--	--	--	--	N	Y [5]
16	--	--	--	--	--	--	N	N
17	--	--	--	--	--	--	Y	N
18	--	B460	--	--	--	--	N	N
19	CCC, Explosives Test Pit	--	RA 2 (AOC U2) - Phase 3	1 - 3 [6]	As, Cu	URS 2005	Y	N
20	--	B420, B421, B484, AST, B421 hydraulic oil spill	--	--	--	--	N	N
21	--	FPL WTL (B470-B473)	RA 3 (AOC U3) - Phase 3 FPL WTL TCRA	1 2 - 3.5	As, Cu As	URS 2005 Tetra Tech 2008c	N	Y [4]
22	--	FPL (B474, B478, B480)	--	--	--	--	N	N
23	--	B450, AST	--	--	--	--	N	N
24	--	--	--	--	--	--	N	N
25	--	--	--	--	--	--	N	N

Table C-2: Summary of SMP Areas and Historical Activities

Notes:

1 See Section 1.1.4.1 of the CCR (Tetra Tech 2008d) for a description of research activities associated with each building. Tranformers are present in SMP Areas 2, 3, 7, 8, 20, 21, and 24. All transformers have been investigated. Remediation activities are planned to remove PCB contamination near the B112 and B150 transformers in SMP Areas 3 and 7. PCB levels at all other transformers do not require remediation.

2 Cleanups planned for mercury in SMP Area 3, and for PCBs in SMP Areas 3 and 7.

3 Depth indicated is the range of depths of the remediated area within the SMP Area.

4 TCE groundwater concentration exceeds site-specific goal of 270 µg/L established by DTSC for the Campus Bay site (EKI 2008; Terraphase 2012).

5 Carbon tetrachloride groundwater concentration exceeds commercial RBC of 2.63 µg/L (Tetra Tech 2013).

6 A wooden vault approximately six foot by six foot by six feet deep containing cinders was discovered during the remedial action. The structure and cinders were removed.

Acronyms:

--	None/not applicable	N	No
µg/L	Micrograms per liter	MFA	Mercury Fulminate Area
AOC	Area of concern	Pb	Lead
As	Arsenic	PCB	Polychlorinated biphenyl
AST	Aboveground storage tank	RA	Remedial area
CCC	California Cap Company	RBC	Risk-based concentration
Cr	Chromium	SMP	Soil management plan
COC	Chemical of concern	TCE	Trichloroethene
Cu	Copper	TCRA	Time-critical removal action
DTSC	Department of Toxic Substances Control	Terraphase	Terraphase Engineering, Inc.
EKI	Erler & Kalinowski, Inc.	Tetra Tech	Tetra Tech, Inc. (formerly Tetra Tech EM Inc.)
FPL WTP	Forest Products Products Laboratory Wood Treatment Laboratory	UC	University of California
ft bgs	Feet below ground surface	URS	URS Corporation
GW	Groundwater	UST	Underground storage tank
Hg	Mercury	Y	Yes

References:

EKI. 2008. "Revised Human Health Risk Assessment and Calculation of Site-Specific Goals for Lots 1, 2, and 3. Campus Bay Site, Richmond, California." April 30.

Terraphase. 2012. "Response to Department of Toxic Substances Control Comments Regarding the 'Revised TCE Risk Evaluation.' Campus Bay Site, Richmond, California." July 19.

Tetra Tech. 2008c. "Implementation Summary Report for a Time-Critical Removal Action at the Forest Products Laboratory Wood Treatment Laboratory." March 14.

Tetra Tech. 2008d. "Current Conditions Report, University of California, Berkeley, Richmond Field Station, Richmond California." November 21.

Tetra Tech. 2013. "Final Site Characterization Report, Proposed Richmond Bay Campus, University of California, Berkeley, Richmond Field Station, Richmond, California." May 28.

URS. 2003b. "Implementation Report, Phase 1 Subunit 2A, Meade Street Operable Unit, University of California, Berkeley, Richmond Field Station." September 4.

URS. 2004. "Implementation Report, Phase 2 Subunit 2A and 2B, Meade Street Operable Unit, University of California, Berkeley, Richmond Field Station." December 3.

URS. 2005. "Implementation Report, Phase 3 Upland Portion of Subunit 2B, Meade Street Operable Unit, University of California, Berkeley, Richmond Field Station." June 16.

Table C-3: Recommended Soil Sampling Density and Analysis for Sampling Design

SMP Area [1]	Sampling Density [2]	Recommended Analytes [3]				
		As, Hg, Pb, PCBs, PAHs	TPH	Dioxins	Explosives	VOCs
1	Low	X	--	--	--	--
2	High	X	--	--	--	--
3	High	X	--	--	--	--
4	High	X	--	--	--	X
5	High	X	--	--	--	X
6	High	X	--	X	--	X
7	High	X	--	--	--	--
8	Medium	X	--	--	--	--
9	High	X	--	--	--	--
10	High	X	--	--	--	X
11	High	X	--	--	--	--
12	High	X	--	--	X	--
13	Low	X	--	--	--	--
14	Low	X	--	--	--	--
15	High	X	--	--	--	X
16	Low	X	--	--	--	--
17	Low	X	--	--	--	--
18	Low	X	--	--	--	--
19	High	X	--	--	X	--
20	Medium	X	X	--	--	--
21	Medium	X [4]	--	--	--	X
22	Low	X [4]	--	--	--	--
23	Low	X	--	--	--	--
24	Low	X	--	--	--	--
25	Low	X	--	--	--	--

Notes:

1 See Figure C-5 for location of SMP Areas.

2 Low, medium, and high sampling densities correspond to those defined in Section 4.1 of the SMP.
Low = 1 sample location per 15,625 square feet of project area (125 foot grid spacing)
Medium = 1 sample location per 10,000 square feet of project area (100 foot grid spacing)
High = 1 sample location per 5,625 square feet of project area (75 foot grid spacing)

3 Existing sample results will be evaluated when selecting analytes at each sampling location.

4 Soil containing concentrations of arsenic in this SMP Area exceeding commercial RBCs may be associated with the FPL WTL and should be considered for off-site disposal.

Acronyms:

--	None/not applicable	PCB	Polychlorinated biphenyl
As	Arsenic	RBC	Risk-based concentration
FPL WTP	Forest Products Products Laboratory Wood Treatment Laboratory	SMP	Soil management plan
Hg	Mercury	TPH	Total petroleum hydrocarbons
PAH	Polycyclic aromatic hydrocarbons	VOC	Volatile organic compounds
Pb	Lead		

Table C-4 Historic Radiological Use and Sampling Locations, Reference List

Letter	Area/ Building	Investigation	Date	Reference
A	Transition Area	Sewage Treatment Experimental Ponds areas and B106 perimeter soils prior to demolition	4/22/2002	Tetra Tech 2008 Current Conditions Report Section 1.1.4.5 pages 29-32 and Appendix G copy of May 3, 2002 LBNL memo from Dave to Rod with 5/3/2002 analyses of twelve samples of miscellaneous structural material from the two historic research ponds including asphalt, sewage, gunite, soil, cinders and sediment.
B	B106	Building 106 decommissioning, meter survey and swipes, prior to demolition	6/1/2002	Tetra Tech 2008 Current Conditions Report Section 1.1.4.5 pages 29-32. Note, the concrete from demolition crushed and used as aggregate base under north end of Egret Way in 2003 repaving project.
C	Research Well Fields	Seventeen soil samples and two groundwater well water samples	10/1/2002	Tetra Tech 2008 Current Conditions Report Section 1.1.4.5 pages 29-32 and Appendix G copies of reports: Eberline Services. 2002. Water Sample Results from RFS-Well Field – Tritium. November 23.Eberline Services. 2002. Soil Sample Results from RFS-Well Field – Cesium-137. November 7. And UCB_ORS R210062 report. See also December 8, 2005 "Revised Technical Specifications for Well Destructions" Stellar Environmental, pages 15 and 16, and Attachment B (for documents listed above) .
D	Eastern Transition Area and adjacent Upland Area behind Seawall	Gamma spectroscopy of Phase 2 excavation areas including cinders, M3 marsh sediment, and upland side of the sea wall	11/20/2003	Tetra Tech 2008 Current Conditions Report Section 1.1.4.5 pages 29-32 and Appendix G excerpt from the December 3, 2004 URS Corporation "Implementation Report, Phase 2 Subunit 2A and 2B, Meade Street Operable Unit, University of California, Berkeley, Richmond Field Station" remedial activities summary and January 7, 2004 Eberline analytical report. (Sample locations are approximate on figure.)
E	Research Well Fields	Tritium and gross beta analysis of water in three wells during well destruction	4/11/2005	Tetra Tech 2008 Current Conditions Report Section 1.1.4.5 pages 29-32 and Appendix G copies of report: Eberline Services. May 17, 2005 analytical report "Richmond Field Station, 2005-21, Eberline Services Report R504066-8411 for groundwater sample results for three wells (224Southeast, New 50 West, and 50 East) collected for decommissioning waste characterization, copied from December 8, 2005 Revised Technical Specifications for Well Destructions, Stellar Environmental.
F	Bulb	Site B "Bulb" Survey Area	12/11/2006	Tetra Tech 2008 Current Conditions Report Section 1.1.4.5 pages 29-32 and Appendix G UC Berkeley. December 11, 2006 memorandum to the Richmond Field Station File from Zack Phillips of the Office of Environment, Health & Safety, regarding Follow up to Magnetometer Findings.
G	Meeker Beach, Bulb, B280	Site A Meeker Beach Survey Area, Site B "Bulb" Survey Area , Site C B280 Survey Area Ludlum meters and Ortec Detective surveys	12/21/2006	Tetra Tech 2008 Current Conditions Report Section 1.1.4.5 pages 29-32 and Appendix G report: January 3, 2007 Follow Up Survey of Three Separate Sites at RFS memorandum to the Richmond Field Station File and January 23, 2007 Ortec Detective memorandum to the Richmond Field Station File both from Zack Phillips of the Office of Environment, Health & Safety.
H	Western Transition Area Ash Piles	WTA Ash Pile Sampling	10/2/2008	Tetra Tech May 26, 2009. "Implementation Summary Report for a Time-Critical Removal Action at Two Subareas in the Western Transition Area, University of California, Berkeley, Richmond Field Station, Richmond, California." and February 2009 "Richmond Field Station Radiological Survey Report Debris Pit" by Jim Reese, ERS Solutions.
I	Bulb and CTP well	Bulb1, Bulb2 and CTP soil sampling during geoprobe boring prior to well installation	9/29/2010	Tetra Tech May 11, 2011 Final R1 Phase I Groundwater Sampling Results (page 7) and Tetra Tech April 1, 2011. Sampling Results for Waste Characterization Sampling from the Phase I Field Sampling Workplan Groundwater Investigation Attachment 1 RAD2. Note: CTP was sampled as "background".
J	Bulb and WTA well	Bulb1 and Bulb2 soil samples and meter survey of soil cuttings during well installation and WTA meter survey	10/13/2010	Tetra Tech May 11, 2011 FINAL R1 Phase I Groundwater Sampling Results (page 7) and Tetra Tech April 1, 2011. Sampling Results for Waste Characterization Sampling from the Phase I Field Sampling Workplan, Attachment 1 RAD2. Note WTA was used as "background" for meter survey.
K	B102/B110	Building 102 and 110 D&D, interior and soil underneath buildings	2011-2012	New World Environmental Inc November 18, 2012. Final Status Survey Report for UC Berkeley Capital Projects, Richmond Field Station, Buildings B102 and B110. CDPH License Amendment #90 issued 11/30/2012
L	B112/B113/ B117/B150	B112/B113/B117/B 150 D&D	2013-2014	New World Environmental August 3, 2013. Final Status Survey Report for Richmond Field Station Buildings 112, 113, 117 and 150, with follow-up and January 21, 2014 and May 19, 2014 letters from UC Berkeley EH&S to CDPH. CDPH License Amendment #95 issued July 2, 2014.
M	Bulb	EH&S Bulb meter survey of soil during shallow soil sample collection	7/27/2014	UC Berkeley EH&S August 5, 2014. Richmond Field Station Bulb Investigation letter report, UC Berkeley H&S (Karl Hans: Dan Hibbing, Radiation Safety to Karl Hans Environmental Protection.)
N	Bulb	Bulb1 and Bulb2 Pre-excavation groundwater sampling	10/14/2014	Tetra Tech. April 2015. Phase IV Sampling Results Technical Memorandum. University of California, Berkeley, Richmond Field Station, Richmond. California. April X .
O	Bulb	Bulb Exploratory Excavation	10/28/2014 - 10/30/2014	Tetra Tech April 2015 Phase IV Sampling Results Technical Memorandum. University of California, Berkeley, Richmond Field Station, Richmond. California.Attachment 5 Final Completion Report Exploratory Excavation for Magnetic Anomaly Source in Bulb, Cabrera Services March 2015.

EXHIBITS

EXHIBIT C1 Soil Management Plan Forms A, B, C

Richmond Bay Campus

Soil Management Plan
Project Approval Checklist

University of California

SMP FORM A: PROJECT OVERVIEW	
1. Tracking No, Revision No. and Date:	*If after 6 months the project has not proceeded to the next step, the information on this form must be reviewed and updated as necessary.*
2. Project Name:	
3. Description:	*Attach figure identifying project location*
4. Points of Contact:	Name: Position: Email: Phone:
5. Estimated Schedule:	
6. DTSC Work Notice Requirements	Yes ☐ No ☐ If Yes, notify DTSC 14 days prior to activity
7. Impacts to Piezometer Network	Yes ☐ No ☐ Piezometer ID: If Yes, notify DTSC
8. Radiological Status Have radioactive materials been used within the project area? If yes, have buildings within the project area been properly decontaminated, decommissioned, and cleared by CDPH?	Yes ☐ No ☒ Yes ☐ No ☐ If No, contact CDPH; do not investigate project area until it is cleared by CDPH
9. Total Volume of Soil Excavation Planned (in CY)	
10. *De Minimis* Status	Project exempt from SMP prescriptive requirements based on volume (< 10 CY or 500 square feet of hardscape)? Yes ☐ No ☐
11. SMP Form A Approval a. Greg Haet, Project Coordinator, EH&S b. Scott Shackleton, Facilities Management, UCB, College of Engineering c. Professional Civil Engineer or Geologist	(Signature, Date) (Signature, Date) (Name, Signature, Date, Stamp)

SMP FORM B: SAMPLING, DATA EVALUATION, SOIL MANAGEMENT ACTION	
Project Name: ______________________________ Tracking Number: ____________ Revision Number: ____________ Date Submitted to DTSC: ____________ EH&S Point of Contact: ____________ *If this form has not been approved or no activities have occurred for 1 year, the information contained herein must be reviewed and updated as necessary prior to work occurring in the project area.*	
1. Sampling Design (attach Sampling Strategy Memorandum)	
a. SMP Areas Affected	*Consult SMP Figure 6*
b. Sampling Density and Planned Number of Sample Locations	*Consult SMP Figure 6*
c. Chemicals of Concern and Summary of Existing Data	*Consult SMP Tables 1 and 2, and the most current groundwater report* *Include data summary in sampling strategy memorandum*
d. Sampling Depths and Intervals	*Consult SMP Section 4.1*
e. Project is within area of GW above screening criteria	Yes ☐ No ☒ *Consult SMP Table 1* If Yes, consult RAW, notify DTSC
f. Sampling design meets all SMP prescriptive requirements	Yes ☐ No ☐ If No, DTSC concurrence received? Yes ☐ No ☐
2. Data Evaluation (Post-Sampling) (attach Data Summary Report)	
a. Sampling Design Implemented	Yes ☐ No ☐ If No, describe deviations:
b. Sample Results Meet Category I	Yes ☐ No ☐ *Consult SMP Table 3* If Yes, submit summary report with SMP Form B If sample results indicate unanticipated contamination or discovery, notify DTSC
c. Soil Exceeding Category I is Defined Vertically and Laterally	Yes ☐ No ☐ NA ☐ If No, consult sampling requirements or defer to excavation confirmation sampling
d. Soil Meets Category II Criteria	Yes ☐ No ☐ NA ☐ Soil proposed for on-site management requires plan Soil above Category II criteria requires excavation plan
3. Soil Management Action (attach On-Site Management or Soil Excavation Plan)	
a. On-Site Management Plan Meets SMP Requirements	Yes ☐ No ☐ *Consult SMP Section 4.3* If No, provide explanation or contact DTSC:
b. Excavation Plan Meets SMP Requirements	Yes ☐ No ☐ *Consult SMP Section 4.3* If No, provide explanation or contact DTSC:

SMP FORM B: SAMPLING, DATA EVALUATION, SOIL MANAGEMENT ACTION

Project Name: ____

Tracking Number: ___________________ Revision Number: _____________________

Date Submitted to DTSC: _____________________

EH&S Point of Contact: _____________________

If this form has not been approved or no activities have occurred for 1 year, the information contained herein must be reviewed and updated as necessary prior to work occurring in the project area.

4. SMP Form B Approval a. Greg Haet, Project Coordinator, EH&S	(Signature, Date)
b. Scott Shackleton, Facilities Management, UCB, College of Engineering	(Signature, Date)
c. Professional Civil Engineer or Geologist	(Name, Signature, Date, Stamp)
5. References Used to Complete Form	*Include names and dates of documents*

SMP FORM C: COMPLETION REPORT

Project Name: ______________________________

Tracking Number: ____________________ Revision Number: ________

Date Submitted to DTSC: ____________________

EH&S Point of Contact: ______________________________

If this form has not been approved or no activities have occurred for 1 year, the information contained herein must be reviewed and updated as necessary prior to work occurring in the project area.

1. Summary of Completed Construction Project, Including Project Date (attach Completion Report)			
2. Dates of On-Site Project Work			
3. Summary of Completed Soil Management Actions			
4. On-Site Management Plan Implemented	Yes ☐ If No, describe deviations:	No ☐	NA ☐
5. Soil Excavation Plan Implemented	Yes ☐ If No, describe deviations:	No ☐	NA ☐
6. Project Completion Report Meets SMP Requirements	Yes ☐ If No, contact DTSC	No ☐	

7. SMP Form C Approval a. Greg Haet, Project Coordinator, EH&S	(Signature, Date)
b. Scott Shackleton, Facilities Management, UCB, College of Engineering	(Signature, Date)
c. Professional Civil Engineer or Geologist	(Name, Signature, Date, Stamp)

EXHIBIT C2 Sampling and Analysis Plan

Final

Sampling and Analysis Plan for the Soil Management Plan Removal Action Workplan, Exhibit C2

Research, Education, and Support Area within the Richmond Field Station

December 31, 2019

Prepared for

Office of Environment, Health & Safety
University of California, Berkeley
317 University Hall No. 1150
Berkeley, California 94720

Prepared by

TETRA TECH, INC.
1999 Harrison Street, Suite 500
Oakland, California 94612

Jason Brodersen, PG

REGISTERED GEOLOGIST
JASON L BRODERSEN
No. 6262
STATE OF CALIFORNIA

CONTENTS

CONTENTS (Continued)

Tables

ACRONYMS AND ABBREVIATIONS

CAS	Chemical Abstracts Service
CCC	California Cap Company
CHSSL	California Human Health Screening Levels
COC	Chemical of concern
CPT	Cone penetrometer
DTSC	Department of Toxic Substances Control
EH&S	Environmental Health & Safety
EPA	Environmental Protection Agency
IDW	Investigation-derived waste
ISM	Incremental Sampling Methodology
LCS	Laboratory control sample
LRDP	Long Range Development Plan
mg/kg	Milligram per kilogram
MS	Matrix spike
MSD	Matrix spike duplicate
ng/kg	Nanograms per kilogram
PAH	Polycyclic aromatic hydrocarbons
PARCC	Precision, accuracy, representativeness, completeness, and comparability
PCB	Polychlorinated biphenyl
QA	Quality assurance
QC	Quality control
RAW	Remedial action work plan
RES	Research, Education, and Support
RFS	Richmond Field Station
RPD	Relative percent difference
SAP	Sampling and analysis plan
SMP	Soil Management Plan
Tetra Tech	Tetra Tech EM Inc. (1996-2012): currently Tetra Tech, Inc.
TPH	Total petroleum hydrocarbons
UC	University of California
UC Berkeley	University of California, Berkeley
VOC	Volatile organic compound

EXECUTIVE SUMMARY

This sampling and analysis plan (SAP) is one element of the Soil Management Plan (SMP) for the Richmond Field Station (RFS). The SMP is an appendix to the Removal Action Workplan, but is also intended to serve as a stand-alone document to guide management of future environmental actions conducted at the "Research, Education, and Support" (RES) Area of the RFS. The SMP establishes management requirements for areas at RFS to ensure that soil disturbance activities do not adversely impact human health or the environment and that the soils are handled, stored and disposed of, or reused onsite in accordance with applicable laws, regulations, and University of California policies. The SAP addresses the quality assurance (QA) and quality control (QC) aspects of the field, laboratory, and data reporting efforts associated with the proposed activates to address the data gaps. The success of an environmental data collection effort depends on the quality of the data collected and used to make decisions. The intent of this SAP is to establish protocols for assuring quality data collection and criteria for determining the quality of resultant data.

- **Section 1.0 – Project Description:** This section gives a brief overview of the history of the site, a description of the current conditions at the RFS. For more information about past or current conditions at the site, please refer to the Site Characterization Report, Proposed Berkeley Global Campus, Richmond, California (Tetra Tech EM Inc. (1996-2012): currently Tetra Tech, Inc. 2013). The second subsection describes the project objective, and the third contains a table summarizing roles and responsibilities of Environmental Health & Safety decision makers.

- **Section 2.0 – Sampling Design:** This section outlines the sampling evaluation process and sampling plan requirements for sampling projects within the RES Area.

- **Section 3.0 – Sampling Procedures:** This section presents specific procedures for various soil sampling methods.

  - Subsection 3.1 – Hand Auger: This subsection describes procedures for soil sample collection using a hand auger.
  - Subsection 3.2 – Drilling Methods: This subsection provides describes procedures for soil sample collection using drilling methods.

- **Section 4.0 – Analytical Procedures:** Section 4.0 describes the laboratory methods that may be used at the RES area for measurements and analysis. These methods are the same as those approved by the Environmental Protection Agency (EPA) unless otherwise documented.

  - Subsection 4.1 – Laboratory Methods: This subsection provides a summary of the EPA-approved laboratory analytical methods that will be used for the analysis of RFS samples.
  - Subsection 4.2 – Quantitation Limits: Analytical laboratories will be required to ensure that quantitation limits are sufficiently low to allow comparison to the risk based concentration screening criteria.
  - Subsection 4.3 – Laboratory Selection: This subsection presents the criteria to be considered when evaluating contract laboratories.

- **Section 5.0 – Quality Assurance Objectives:** Section 5.0 defines the specific QA and QC activities that will be applied to ensure that the environmental data collected are of the type and quality needed.
  - Subsection 5.1 – Data Quality Objective Process: This subsection describes the overall QA objective for collecting data that will provide results that are usable for their intended purpose.
  - Subsection 5.2 – Quality Assurance Objectives for Measurement Data: This subsection addresses the level of QC effort and objectives for sensitivity; accuracy and precision; and representativeness, completeness, and comparability of data.
  - Subsection 5.3 – Field Quality Control Samples: This subsection indicates the quality control samples that will be collected and analyzed for this project.
- **Section 6.0 – Sample Custody:** This section describes sample handling procedures including sample identification, labeling, documentation, and chain-of-custody forms. It also discusses proper practices for packing and shipping samples to laboratories. Equipment decontamination and management of investigation derived waste are also briefly described.
- **Section 7.0 – Data Reduction, Validation, and Reporting:** This section describes the methods used for verifying and validating data in the field, laboratory, and office.
- **Section 8.0 – Data Assessment Procedures:** This section describes the evaluation of the data to determine whether data objectives have been met.
- **Section 9.0 – References:** This section lists site reports, scientific reference materials, and regulatory guidance and standards cited throughout the document.

1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) is one element of the Soil Management Plan (SMP), which is intended to guide management of future environmental actions conducted at the Research, Education, and Support (RES) Area of the Richmond Field Station (RFS). The SAP addresses the quality assurance (QA) and quality control (QC) aspects of the field, laboratory, and data reporting efforts associated with the future proposed construction activities. The success of an environmental data collection effort depends on the quality of the data collected and used to make decisions. The intent of this SAP is to establish protocols for assuring quality data collection and criteria for determining the quality of resultant data.

1.1 BACKGROUND

The Richmond Field Station is an academic teaching and research facility, located at 1301 South 46th Street, Richmond, California, along the eastern shoreline of the Richmond Inner Harbor of the San Francisco Bay and northwest of Point Isabel, approximately 6 miles northwest of the University of California (UC) Berkeley Central Campus. The SMP and SAP focus on the portions of the RFS which are designated as developable under the Long Range Development Plan (LRDP), identified as the RES Area. The RES Area consists of 82.5 acres within the RFS. The RES Area occupies portions of the upland area and Transition Area. The proposed LRDP also designates a portion of the RFS preserved as Natural Open Space Area (26.5 acres). This Natural Open Space Area is not a part of the SMP.

Between the 1880s and 1948 and prior to UC ownership, the California Cap Company (CCC) operated facilities on portions of the RFS property for the manufacturing of blasting caps, shells, and explosives. Two small companies, the U.S. Briquette Company and the Pacific Cartridge Company, are presumed to have operated on a portion of the RFS property. By 1920, the CCC was the only remaining explosives manufacturer on site.

In October 1950, the CCC property was purchased by UC with the agreement that the CCC would remove all hazardous materials from the property. However, subsequent site observations and testing revealed the presence of hazardous materials on RFS. For example, several explosions reportedly occurred between 1950 and 1953 during a controlled burn for clearing. These explosions likely were associated with residual chemicals used by the CCC. Previous investigations in the test pit and explosive storage area found a single detection of explosives at a concentration close to the detection limit (URS Corporation 2000).

The RFS was initially established by UC Berkeley for large-scale engineering research that required significant space and resources that were not available on UC Berkeley's central campus in downtown Berkeley. In addition to UC Berkeley-related operations, the UC Regents have leased space to non-UC Berkeley tenants. Complete environmental site conditions are presented in the Draft Site Characterization Report for the Proposed Berkeley Global Campus (Tetra Tech EM Inc. [1996-2012]: currently Tetra Tech, Inc. [Tetra Tech] 2013).

1.2 PROJECT OBJECTIVE

The SMP provides a systematic process intended to ensure that future projects in the RES area impacting subsurface soils will not result in uncontrolled exposures to unknown or unidentified contaminants. The SMP prescribes protocols for Department of Toxic Substances Control (DTSC) notification; soil sampling, data analyses, soil management or disposal practices; and final reporting. DTSC notification is conducted through the submittal of SMP checklist forms throughout the process. Soil sampling is based on prescribed sampling frequency, depths, and chemicals of concern which are determined based on the size and location of the project. Soil management and disposal practices are based on comparison of soil sample results to screening criteria, and final reporting is conducted through submittal of a completion report once the project has been completed.

All soil disturbance activities within the RES Area require Office of Environment, Health & Safety (EH&S) notification. This notification will be provided in the form of a three-part Project Approval Checklist (SMP Forms A, B and C). This SAP establishes protocols for assuring quality data collection and criteria for determining the quality of resultant data in support of *SMP Form B, Sampling Design, Data Evaluation, and Soil Management.*

1.3 PROJECT ORGANIZATION AND RESPONSIBILITIES

The roles and responsibilities of the RFS project team members with respect to sampling and analysis are provided in Table C2-1. Principal decision makers are further defined in the accompanying SMP.

TABLE C2-1: KEY PERSONNEL

Organization	Role	Responsibilities
UC, EH&S	Project Coordinator	Directs environmental health and safety compliance of the SMP. Receives notices, comments, approvals, and related communications from DTSC. Reports to and interacts with the DTSC for all SMP tasks. Signatory to SMP Forms A, B, C.
UC, EH&S	Project Geologist	Reviews all documents for technical accuracy.
DTSC	Remedial Project Manager	Reviews environmental health and safety compliance of the SMP. Signatory to 5-year remedial action work plan (RAW) review process including updated SMP, if appropriate. Receives notices, comments, and related communications from UC. Interacts with UC for all SMP tasks. Reviews all submittals and notifications to DTSC for quality and completeness.
Project-by-Project Basis	Field team Leader	Responsible for directing day-to-day field activities conducted by subcontractor personnel. Verifies that field sampling and measurement procedures follow the sampling planning document. Provides project manager with regular reports on status of field activities.
Laboratory	Project Manager	Responsible for delivering analytical services that meet requirements of SAP. Reviews chains of custody to understand analytical requirements. Works with project chemist to confirm sample delivery schedules. Reviews laboratory data package before submittal.

2.0 SAMPLING DESIGN

This section outlines the sampling evaluation process and sampling plan requirements for sampling projects within the RES Area. Based on knowledge of the location and depth of the proposed soil disturbance activity, identify the soil sampling and analysis needed to evaluate the soil within the footprint of the proposed project. Projects which are not exempted from sampling, as discussed in Section 3.4 of the SMP, require collection, analysis and evaluation of additional soil chemical data in order to determine the appropriate soil management decision and action. EH&S must approve the sampling design (Form B) prior to implementation.

General

Sampling Design will be project-specific, depending on the geographical location, size, and depth of soil to be disturbed by the proposed project. As a first step, identify the SMP Area(s) (see SMP Figure C-6 and Table C-2) corresponding to the proposed project area. The minimum soil sample location density and chemicals of concern (COC) for each of the 25 SMP Areas are listed in Table C-3 of the SMP.

Soil Sampling Methodology

Soil samples should be collected in accordance with the methods found in Section 6.0 of this SAP.

Analytical Requirements

Analytical requirements for soil are summarized on Table C-3 of the SMP and will vary depending on the location of the project within the RES Area. Soil samples should be analyzed in accordance with the methods designated in Table C2-2.

Design Documentation

Sampling Design must be documented with sufficient detail for reviewer to (1) understand the project geographical area within the RES Area and depths of proposed soil disturbance, including project figure; (2) to check that the proposed sampling locations, depths and analysis meet the requirements of the SMP; and (3) the Sampling Design adequately takes into account known conditions within the project area, such as presence of existing buildings, remediated areas, or prior soil sample data. Section 4.1 of the SMP details the Sample Design process. The Sampling Design shall be approved by EH&S on Form B of Checklist prior to embarking on the field sampling effort.

3.0 SAMPLING PROCEDURES

The following sections describe methods for collecting soil samples. Samples will be collected for analysis of volatile organic compounds (VOC) and total petroleum hydrocarbons (TPH)-gasoline using an EnCore sampler. For all other analytical parameters, samples will be collected in sleeves or jars (Table C2-2).

3.1 HAND AUGER

A hand auger equipped with extensions and a “T” handle is used to obtain samples from a depth of up to 6 feet. If necessary, a shovel may be used to excavate the topsoil to reach the desired subsoil level. If topsoil is removed, its thickness should be recorded. Samples obtained using a hand auger are disturbed in their collection, so that determining the exact depth at which samples are obtained is difficult. The hand auger is screwed into the soil at an angle of 45 to 90 degrees from horizontal. When the entire auger blade has penetrated soil, the auger is removed from the soil by lifting it straight up without turning it, if possible. If the desired sampling depth has not been reached, the soil is removed from the auger and deposited onto plastic sheeting. This procedure is repeated until the desired depth is reached and the soil sample is obtained. The auger is then removed from the boring, and the soil sample is collected directly from the auger into an appropriate sample container.

All soil samples collected from less than 5 feet will be collected through hand auger equipment to ensure safety from unidentified utility lines.

3.2 DRILLING METHODS

Primary drilling methods expected to be of potential use at the site include traditional auger drilling, direct-push methods, and potentially some type of small sonic drilling tools. Because of the proximity of the site to buildings and workers, the preferred methods will generally be direct-push methods because they are agile and create less of a disturbance, and are mobile and can be moved easily and quickly based on field sampling results.

3.2.1 Direct Push

Direct-push platforms have gained widespread acceptance in the environmental industry over the past decade because of their versatility, relatively low cost, and mobility. Using the weight of the truck in combination with a hydraulic ram or hammer, a tool string is pushed into the ground. All borehole locations must be advanced by hand auger equipment up to 5 feet before use of direct push techniques.

The two major classes of direct-push platforms are cone penetrometer (CPT) and percussion hammer systems. The distinction between these units is that CPT units advance the tool string by applying a hydraulic ram against the weight or mass of the vehicle alone, while percussion hammer units add a hammer to the hydraulic ram to compensate for their lower mass. These platforms share the same principle of operation, similar tools, and a number of advantages and limitations. They differ in scale, application, and to some extent the types of instruments and tools that have been developed for each. For these reasons, CPT and percussion hammer platforms fill different niches in the environmental field. CPT rigs can generally push to greater depths and push larger-diameter rods; they allow sampling from depths that are inaccessible using percussion hammer rigs. Percussion hammer rigs are generally smaller, more portable, and require less training to use; they allow samples to be collected from places, including inside of buildings that are inaccessible to a CPT rig. Although they are sometimes limited in the depths to which they can penetrate, some of the smaller percussion hammer units as well as smaller CPT rigs can be anchored to the ground using earth augers to add to the reaction mass of the vehicle alone.

Because of their methods of operation, direct-push systems provide some unique advantages when collecting soil and soil-gas samples. In particular, direct-push systems are quicker and more mobile than traditional drill rigs. Sampling and data collection are faster, reducing the time needed to complete an investigation and increasing the number of sample points that can be collected during the investigation. Soil sampling systems have been developed in response to a need to collect samples of unconsolidated material from a range of depths, without generating large volumes of cuttings. Direct-push soil samplers also allow investigators to collect soil samples from a specific depth, with minimal disturbance to soil stratigraphy.

3.2.2 Hollow-Stem Auger

Hollow-stem augers are readily available and are recommended for penetrating unconsolidated materials when direct-push applications are not appropriate. Auger rigs are light and maneuverable. Each section or flight is typically 5 feet in length. A head is attached to the first flight, and cuttings are rotated to the surface as the borehole is advanced. A pilot bit (or center bit) can be held at the base of the first flight with drill rods to prevent cuttings from entering. When the bit is removed, formation samples can be obtained through the auger using split-spoon or thin-wall samplers.

3.3 INCREMENTAL SAMPLING METHODOLOGY

Soil samples for characterizing PCBs will be collected using incremental sampling methodology (ISM). ISM consists of a highly-structured sample designed to identify representative and repeatable average concentrations for a specific volume of soil. The volume of soil sampled under ISM is defined as a decision unit. A minimum of 75 soil increments will be collected from each decision unit. The soil mass from all increments comprise the sample to be analyzed for the decision unit. The target soil mass for each sample is 1 kilogram. The locations of the soil increments are identified on a case-by-case basis, but are generally designated through a random-stratified grid throughout the decision unit. The number, location, and size of the decision units and sample depth will be based on site information such as the presence of a leaking transformer, known spill, etc.

Each increment can be collected by a disposable trowel, drill cuttings, or via a drill auger. A single increment of approximately 15 grams is collected from each location and compiled together to form the 1 kilogram sample mass for analysis. The laboratory will subsample the 1 kilogram mass for the appropriate analysis. Soil samples will be analyzed for PCBs by EPA method 8082A using 3540C Soxhlet extraction.

Field triplicate samples will also be collected as appropriate. Field triplicates consist of an independent sample collected from each decision unit at different increment locations. Field triplicates are used to help evaluate the precision of the sampling method, site heterogeneity, and field sampling and the laboratory analysis variability. The triplicates will be used to calculate a relative standard deviation which can be used to help evaluate field precision, representativeness, and reproducibility. UC Berkeley recommends that a relative standard deviation of 35 be used as a benchmark for evaluation; however, other factors such as the relative difference between the measured concentrations and the action levels will also be considered. The benchmark is not intended to be used as a pass/fail criteria.

3.4 OTHER

If a construction footprint at the site includes an existing monitoring well, it will be necessary to move the well and collect a groundwater sample from the new well. For groundwater well installation and sampling, refer to Appendix A of the Field Sampling Workplan (Tetra Tech 2010).

4.0 ANALYTICAL PROCEDURES

The following sections the analytical methods and laboratory selection criteria for samples collected for the RES area.

4.1 ANALYTICAL METHODS

The COCs in the RES area are metals, polycyclic aromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCB). In addition, VOCs, TPH, and dioxins may need to be investigated. SMP Form B will indicate the appropriate analyses for each investigation. Table C2-2 specifies the analytical methods, maximum holding time, sample containers, and preservation for the possible chemicals to be investigated in the RES area.

4.2 QUANTITATION LIMITS

To ensure risk based screening criteria are met, analytical laboratories will be required to ensure quantitation limits are sufficiently low to allow comparison to the screening criteria. Table C2-3 lists the chemical, risk based concentration screening criteria, and required laboratory quantitation limit. If the laboratory reporting limit for a given chemical is not sufficiently low to allow comparison to the risk based screening criteria, a further discussion of that chemical with DTSC is required, or alternative methods should be pursued.

TABLE C2-2: ANALYTICAL REQUIREMENTS TABLE

Matrix	Analytical Group	Analytical Method	Containers	Sample Volume	Preservation Requirements	Maximum Holding Time (preparation / analysis)
All RES areas						
Soil	Metals	SW-846 EPA 6010/7471	8 ounce glass jar or sleeve	5 grams	Cool, 4+/- 2˚C	180 days (28 days mercury)
Soil	PAHs	SW-846 EPA 8270-SIM		30 grams	Cool, 4+/- 2˚C	14 days/40 days
Soil	PCBs	SW-846 EPA 8082		30 grams	Cool, 4+/- 2˚C	14 days/40 days
Potential analyses						
Soil	VOCs	SW-846 EPA 5035/8260	EnCore sampler	5 grams	Cool, 4 °C ± 2	48 hours to preserve/14 days
Soil	Dioxins	SW-846 EPA 8280	4 ounce glass jar or sleeve	30 grams	Cool, 4 °C ± 2	30 days
Soil	TPH-purgeables	SW-846 EPA 5035/8015	EnCore sampler	5 grams	Cool, 4 °C ± 2	48 hours to preserve/14 days
Soil	TPH-extractables	SW-846 8015	4 ounce glass jar or sleeve	30 grams	Cool, 4 °C ± 2	14 days/40 days

Note:

EPA Environmental Protection Agency

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA

Total Metals (EPA 6010/7471)

Chemical	CAS Number	Risk Based Concentration Screening Criteria (mg/kg)	Required Laboratory Quantitation Limit (mg/kg)	MS/MSD %Recovery	MS/MSD Relative Percent Difference	Laboratory Control Sample %Recovery	Duplicate Relative Percent Difference
Antimony	7440-36-0	109	15	75 - 125	20	85 - 115	20
Arsenic	7440-38-2	16.0[1]	10	75 - 125	20	85 - 115	20
Barium	7440-39-3	2,110	2,000	75 - 125	20	85 - 115	20
Beryllium	7440-41-7	29	10	75 - 125	20	85 - 115	20
Cadmium	7440-43-9	68.1	35	75 - 125	20	85 - 115	20
Chromium	7440-47-3	100,000	50,000	75 - 125	20	85 - 115	20
Cobalt	7440-48-4	73	50	75 - 125	20	85 - 115	20
Copper	7440-50-8	10,900	1,500	75 - 125	20	85 - 115	20
Iron	7439-89-6	100,00	27,000	75 - 125	20	85 - 115	20
Lead	7439-92-1	320	40	75 - 125	20	85 - 115	20
Mercury	7439-97-6	77	10	80 - 120	20	85 - 115	20
Manganese	7439-96-5	5,900	900	75 - 125	20	85 - 115	20
Molybdenum	7439-98-7	1,360	190	75 - 125	20	85 - 115	20
Nickel	7440-02-0	280	250	75 - 125	20	85 - 115	20
Selenium	7782-49-2	1,340	190	75 - 125	20	85 - 115	20
Silver	7440-22-4	1,360	190	75 - 125	20	85 - 115	20
Thallium	7440-28-0	2.72	0.50	75 - 125	20	85 - 115	20
Vanadium	7440-62-2	1,360	190	75 - 125	20	85 - 115	20
Zinc	7440-66-6	81,600	11,000	75 - 125	20	85 - 115	20

Notes:

1 Background
CAS Chemical Abstracts Service
mg/kg Milligram per kilogram
MS Matrix spike
MSD Matrix spike duplicate
QC Quality control

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA (CONTINUED)

Polycyclic Aromatic Hydrocarbons (EPA 8270-SIM)

Chemical	CAS Number	Risk Based Concentration Screening Criteria (mg/kg)	Required Laboratory Quantitation Limit (mg/kg)	MS/MS % Recovery	MS/MSD Relative Percent Difference	Laboratory Control Sample % Recovery	Surrogate % Recovery
Naphthalene	91-20-3	3.57	1.8	45 - 115	40	50 - 115	-
Acenaphthene	83-32-9	6,050	1,600	45 - 115	40	50 - 115	-
Acenaphthylene	208-96-8	6,050	1,600	45 - 115	40	50 - 115	-
Fluorene	86-73-7	4,030	40	45 - 115	40	50 - 115	-
Phenanthrene	85-01-8	4,030	1,100	45 - 115	40	50 - 115	-
Anthracene	120-12-7	30,200	8,200	45 - 115	40	50 - 115	-
Fluoranthene	206-44-0	4,030	1,100	45 - 115	40	50 - 115	-
Pyrene	129-00-0	3,020	820	45 - 115	40	50 - 115	-
Benzo(a)anthracene	56-55-3	0.880	0.04	45 - 115	40	50 - 115	-
Chrysene	218-01-9	8.80	0.40	45 - 115	40	50 - 115	-
Benzo(b)fluoranthene	205-99-2	0.880	0.04	45 - 115	40	50 - 115	-
Benzo(k)fluoranthene	207-08-9	0.880	0.04	45 - 115	40	50 - 115	-
Benzo(a)pyrene	50-32-8	0.145	0.007	45 - 115	40	50 - 115	-
Indeno(1,2,3-cd)pyrene	193-39-5	0.880	0.04	45 - 115	40	50 - 115	-
Dibenzo(a,h)anthracene	53-70-3	0.145	0.03	45 - 115	40	50 - 115	-
Benzo(g,h,i)perylene	191-24-2	13,020	820	45 - 115	40	50 - 115	-
1-Methylnaphthalene	90-12-0	36.4	7.4	45 - 115	40	50 - 115	-
2-Methylnaphthalene	91-57-6	403	110	45 - 115	40	50 - 115	-
2-Fluorobiphenyl	-	-	-	-	-	-	50 – 110
Terphenyl-d14	-	-	-	-	-	-	50 – 135

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA (CONTINUED)

Polycyclic Aromatic Hydrocarbons (EPA 8270-SIM) (Continued)

Chemical	CAS Number	Risk Based Concentration Screening Criteria (mg/kg)	Required Laboratory Quantitation Limit (mg/kg)	MS/MSD % Recovery	MS/MSD Relative Percent Difference	Laboratory Control Sample % Recovery	Surrogate % Recovery
2,4,6,-Tribomophenol	-	-	-	-	-	-	40 – 125
2-Fluorophenol	-	-	-	-	-	-	20 – 110
Nitrobenzene-d5	-	-	-	-	-	-	40 - 110

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA (CONTINUED)

Polychlorinated Biphenyls (EPA 8082)

Analyte	CAS Number	Risk Based Concentration Screening Criteria (mg/kg)	Required Laboratory Quantitation Limit (mg/kg)	MS/MSD % Recovery	MS/MSD Relative Percent Difference	Laboratory Control Sample % Recovery	Surrogate % Recovery
PCB-1242	53469-21-9	1	0.10	60 - 130	30	60 - 130	60 - 125
PCB-1248	12672-29-6	1	0.10	60 - 130	30	60 - 130	60 - 125
PCB-1254	11097-69-1	1	0.10	60 - 130	30	60 - 130	60 - 125
PCB-1260	11096-82-5	1	0.10	60 - 130	30	60 - 130	60 - 125

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA (CONTINUED)

Volatile Organic Compounds (EPA 8260B)

Chemical	CAS Number	Risk Based Concentration Screening Criteria (mg/kg)	Required Laboratory Quantitation Limit (mg/kg)	MS/MSD % Recovery	MS/MSD Relative Percent Difference	Laboratory Control Sample % Recovery	Surrogate % Recovery
1,1,1-Trichloroethane	71-55-6	-	-	65 – 130	40	70 - 125	-
1,1,1,2-Tetrachloroethane	630-20-6	-	-	65 - 130	40	70 - 125	-
1,1,2,2-Tetrachloroethane	79-34-5	-	-	65 – 130	40	70 - 125	-
1,1,2-Trichloroethane	79-00-5	-	-	65 - 130	40	70 - 125	-
1,2,3-Trichloropropane	96-18-4	-	-	65 – 130	40	70 - 125	-
1,1-Dichloroethane	75-34-3	-	-	65 - 130	40	70 - 125	-
1,1-Dichloroethene	75-35-4	-	-	65 – 130	40	70 - 125	-
1,2-Dibromo-3-chloropropane	96-12-8	-	-	65 - 130	40	70 - 125	-
1,2-Dibromoethane	106-93-4	-	-	65 – 130	40	70 - 125	-
1,2-Dichloroethane	107-06-2	-	-	65 - 130	40	70 - 125	-
1,2-Dichloropropane	78-87-5	0.993	0.46	65 – 130	40	70 - 125	-
2-Butanone	78-93-3	-	-	65 - 130	40	70 - 125	-
2-Hexanone	591-78-6	-	-	65 – 130	40	70 - 125	-
Acetone	67-64-1	100,000	24,000	65 - 130	40	70 - 125	-
Benzene	71-43-2	0.320	0.15	65 – 130	40	70 - 125	-
Bromodichloromethane	75-27-4	-	-	65 - 130	40	70 - 125	-
Bromoform	75-25-2	-	-	65 – 130	40	70 - 125	-
Bromomethane	74-83-9	-	-	65 - 130	40	70 - 125	-
Carbon disulfide	75-15-0	-	-	65 – 130	40	70 - 125	-
Carbon tetrachloride	56-23-5	-	-	65 - 130	40	70 - 125	-

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA (CONTINUED)

Volatile Organic Compounds (EPA 8260B) (Continued)

Chemical	CAS Number	Risk Based Concentration Screening Criteria (mg/kg)	Required Laboratory Quantitation Limit (mg/kg)	MS/MSD % Recovery	MS/MSD Relative Percent Difference	Laboratory Control Sample % Recovery	Surrogate % Recovery
Chlorobenzene	108-90-7	-	-	65 – 130	40	70 - 125	-
Chloroethane	75-00-3	-	-	65 - 130	40	70 - 125	-
Chloroform	67-66-3	-	-	65 – 130	40	70 - 125	-
Chloromethane	74-87-3	-	-	65 - 130	40	70 - 125	-
cis-1,2-Dichloroethene	156-59-2	-	-	65 – 130	40	70 - 125	-
cis-1,3-Dichloropropene	10061-01-5	-	-	65 - 130	40	70 - 125	-
Dibromochloromethane	124-48-1	-	-	65 – 130	40	70 - 125	-
Dibromomethane	74-95-3	-	-	65 - 130	40	70 - 125	-
Dichlorodifluoromethane	75-71-8	-	-	65 – 130	40	70 - 125	-
Ethylbenzene	100-41-4	5.94	2.5	65 - 130	40	70 - 125	-
Methylene chloride	75-09-2	-	-	65 – 130	40	70 - 125	-
Methyl tert-Butyl Ether	1634-04-4	-	-	65 - 130	40	70 - 125	-
Tetrachloroethene	127-18-4	-	-	65 – 130	40	70 - 125	-
Toluene	108-88-3	1,440	550	65 - 130	40	70 - 125	-
trans-1,2-Dichloroethene	156-60-5	-	-	65 – 130	40	70 - 125	-
trans-1,3-Dichloropropene	10061-02-6	-	-	65 - 130	40	70 - 125	-
Trichloroethylene	79-01-6	1.03	0.44	65 – 130	40	70 - 125	-
Trichlorofluoromethane	75-69-4	-	-	65 - 130	40	70 - 125	-
Vinyl chloride	75-01-4	-	-	65 – 130	40	70 - 125	-
o-Xylenes	95-47-6	725	340	65 - 130	40	70 - 125	-
m/p-Xylenes	6777-61-2	614	300	65 – 130	40	70 - 125	-
1,2-Dichlorethane-d4	-	-	-	-	-	-	70 – 120

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA (CONTINUED)

Volatile Organic Compounds (EPA 8260B) (Continued)

Chemical	**CAS Number**	**Risk Based Concentration Screening Criteria** (mg/kg)	**Required Laboratory Quantitation Limit** (mg/kg)	**MS/MSD % Recovery**	**MS/MSD Relative Percent Difference**	**Laboratory Control Sample % Recovery**	**Surrogate % Recovery**
4-Bromofluorobenzene	-	-	-	-	-	-	75 – 120
Dibromofluoromethane	-	-	-	-	-	-	85 – 115
Toluene-d8	-	-	-	-	-	-	85 - 120

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA (CONTINUED)

Total Petroleum Hydrocarbons (EPA 8015)

Chemical	CAS Number	Environmental Screening Level (mg/kg)	Required Laboratory Quantitation Limit (mg/kg)	MS/MSD %Recovery	MS/MSD Relative Percent Difference	Laboratory Control Sample %Recovery	Surrogate %Recovery
TPH-purgeables							
Gasoline	86290-81-5	2,800	210	70 – 130	40	75 – 125	-
Bromofluorobenzene	-	-	-	-	-	-	70 - 140
TPH-extractables							
Diesel (C10-C24)	68334-30-5	880	250	65 – 140	40	75 – 125	-
Motor Oil (C24-C36)	NA	32,000	1,250	65 – 140	40	75 - 125	-
Bromobenzene	-	-	-	-	-	-	50 - 150
Hexacosane	-	-	-	-	-	-	50 - 150

Source:

California Regional Water Quality Control Board 2016. "Environmental Screening Levels, San Francisco Bay Regional Water Quality Control Board." February. Available on-line at: http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/ESL/ESL%20Workbook_ESLs_Interim%20Final_22Feb16_Rev3_PDF.pdf

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA (CONTINUED)

Dioxins/Furans (EPA 8290)

Chemical	CAS Number	Toxicity Equivalence Factor	CHSSL (ng/kg)	Required Laboratory Quantitation Limit (ng/kg)	Laboratory Control Sample %Recovery	Surrogate %Recovery
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1746-01-6	1.0	19	19	70 - 130	-
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	40321-76-4	1.0	-	19	70 - 130	-
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	39227-28-6	0.10	-	1.9	70 - 130	-
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	57653-85-7	0.10	-	1.9	70 - 130	-
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	19408-74-3	0.10	-	1.9	70 - 130	-
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	35822-46-9	0.01	-	0.19	70 - 130	-
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	3268-87-9	0.0003	-	0.0057	70 - 130	-
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	51207-31-9	0.10	-	1.9	70 - 130	-
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	57117-41-6	0.03	-	0.57	70 - 130	-
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	57117-31-4	0.30	-	5.7	70 - 130	-
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	70648-26-9	0.10	-	1.9	70 - 130	-
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	57117-44-9	0.10	-	1.9	70 - 130	-
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	72918-21-9	0.10	-	1.9	70 - 130	-
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	60851-34-5	0.10	-	1.9	70 - 130	-
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	67562-39-4	0.01	-	0.19	70 - 130	-
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	55673-89-7	0.01	-	0.19	70 - 130	-
1,2,3,4,5,6,7,8-Octachlorodibenzofuran (OCDF)	39001-02-0	0.0003	-	0.0057	70 - 130	-
Total Tetrachlorodibenzo-p-dioxin (TCDD)	41903-57-5	-	-	-	-	-

TABLE C2-3: REQUIRED LABORATORY QUANTITATION LIMITS AND QC CRITERIA (CONTINUED)

Dioxins/Furans (EPA 8290) (Continued)

Chemical	CAS Number	Toxicity Equivalence Factor	CHSSL (ng/kg)	Required Laboratory Quantitation Limit (ng/kg)	Laboratory Control Sample %Recovery	Surrogate %Recovery
Total Pentachlorodibenzo-p-dioxin (PeCDD)	36088-22-9	-	-	-	-	-
Total Hexachlorodibenzo-p-dioxin (HxCDD)	34465-46-8	-	-	-	-	-
Total Heptachlorodibenzo-p-dioxin (HpCDD)	37871-00-4	-	-	-	-	-
13C 2,3,7,8,-TCDF	-	-	-	-	-	40 – 135
37C 1,2,3,7,8-TCDD	-	-	-	-	-	40 - 135

Notes:

CHSSL California Human Health Screening Levels
ng/kg Nanograms per kilogram

4.3 SELECTION OF ANALYTICAL LABORATORIES

The following criteria will be considered when evaluating contract laboratories:

- Quality assurance and quality control documents governing laboratory operations
- Status of laboratory certification and the most recent laboratory audit conducted
- Initial demonstration of proficiency results for all analysts on all methods performed
- Availability of technical support regarding methods to be used
- Standard operating procedures for the desired analyses
- Method detection limits and quantitation limits for the desired analyses
- Laboratory past performance on performance evaluation samples

Additional criteria to be considered include:

- Laboratory capacity for the desired analyses
- Costs per analysis or batch of analyses
- Typical turn-around times for the type of analytical work requested
- Method development/optimization protocol

The source of analytical services to be provided will in part be determined by the project-specific intended use of the resulting data and specific requirements and constraints such as quick turnaround of data. The project-specific chain of custody will identify the laboratories that have been selected to provide analytical services.

The laboratory performing analytical analyses for samples collected from the RES area shall have current certification from the California Department of Health Services Environmental Protections Laboratory Accreditation Program to perform Hazardous Materials analysis for each method specified in this SAP.

5.0 QUALITY ASSURANCE OBJECTIVES

The intent of this SAP is to establish protocols for assuring quality data collection and criteria for determining the quality of resultant data. Data collection, reporting requirements, and analytical protocols are established to meet the needs of the SMP. The SAP emphasizes the use of proven, validated, and EPA-approved sampling methods and analytical methods such as Test Methods for Evaluating Solid Waste (SW-846) (EPA 1996). The following subsections define the specific QA and QC activities that will be applied to ensure that the environmental data collected are of the type and quality needed. In addition, Form B of the SMP is critical for the collection and use of environmental data.

5.1 DATA QUALITY OBJECTIVE PROCESS

All projects will be evaluated to determine the scope of sampling and analysis which may be required prior to initiating earthwork activities. Sampling design shall be reviewed and approved by EH&S prior to the sampling event. Soil sampling data collected from the project area will be evaluated to determine the appropriate soil management decision.

Form B is used to track project status for fulfilling the requirements for Sampling, Data Evaluation, and Soil Management steps. The Sampling Design must be approved by EH&S prior to initiating sampling. EH&S approval signature on Form B documents that the soil sampling is complete, the data has been evaluated, and the soil management decision for the project is approved. The project may proceed once EH&S approval of the soil management decision is documented.

5.2 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall QA objective is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and data reporting that will provide results that are usable for their intended purpose. This section addresses the level of QC effort and the specific QA objectives for sensitivity, accuracy, precision, representativeness, completeness, and comparability of data. Specific procedures for sampling, chain-of-custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal QC, preventive maintenance of field equipment, and corrective action are described in other sections of this SAP. Form B will identify the numbers of samples that will be collected, and Table C2-3 identified the types of field and laboratory QC samples that will be required.

Analytical data will be evaluated for compliance with QC limits (Table C2-3). Typically, when analytical data do not meet the QC limits, corrective action must be initiated or the data will be qualified or rejected. Corrective action includes stopping the analysis; examining instrument performance, sample preparation, and analysis information; recalibrating instruments; re-preparing and reanalyzing samples; and informing the appropriate project staff member of the problem.

The following subsections address the level of QC effort and objectives for sensitivity; accuracy and precision; and representativeness, completeness, and comparability of data.

5.2.1 Sensitivity

The QA objective for sensitivity is generally expressed in the form of the method quantitation limit for the analytical method selected. Table C2-3 provides the concentrations of concern for contaminants known or suspected to be present at the sampling location based on risk-based criteria. The laboratory contracted for work under the SMP must be able to meet these quantitation limits. Quantitation limits reflect the influences of the sample matrix on method sensitivity and are typically higher than detection limits. Quantitation limits provide a reliable indication of the amount of material needed to produce an instrument response that can be routinely identified and reliably quantified when applying a particular analytical method to real environmental samples.

5.2.2 Precision and Accuracy

Precision and accuracy will be evaluated quantitatively by collecting the QC samples listed in Table C2-3. Section 7.3 describes field QC samples in detail. The sections below describe how each of the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters will be assessed.

5.2.2.1 Precision

Precision is the degree of mutual agreement between individual measurements of the same property under similar conditions. Usually, combined field and laboratory precision is evaluated by collecting and analyzing field replicates and then calculating the variance between the samples, typically as a relative percent difference (RPD):

$$RPD = \frac{|A-B|}{(A+B)/2} \ x \ 100\%$$

where:

A	=	First duplicate concentration
B	=	Second duplicate concentration

Laboratory analytical precision is evaluated by analyzing laboratory replicates or a MS and MSD. The results of the analysis of each MS/MSD and sample duplicate pairs will be used to calculate an RPD for evaluating precision. See Table C2-3 for MS/MSD RPD criteria.

5.2.2.2 Accuracy

Sample spiking will be conducted to evaluate laboratory accuracy. This includes analysis of the MS and MSD samples, laboratory control samples (LCS) or blank spikes, surrogate standards, and method blanks. MS and MSD samples will be prepared and analyzed at a frequency of 5 percent. LCS or blank spikes are also analyzed at a frequency of 5 percent. Surrogate standards, where available, are added to every sample analyzed for organic constituents. The results of the spiked samples are used to calculate the percent recovery for evaluating accuracy.

$$\text{Percent Recovery} = \frac{S - C}{T} \times 100$$

where:

S	=	Measured spike sample concentration
C	=	Sample concentration
T	=	True or actual concentration of the spike

Results that fall outside the project-specific accuracy goals will be further evaluated on the basis of the results of other QC samples. See Table C2-3 for spike recovery criteria.

5.2.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a qualitative parameter that depends on the proper design of the sampling program and proper laboratory protocol. The sampling network for each investigation will be designed to provide data that are representative of environmental conditions. During development of the SMP, consideration was given to past waste disposal practices, existing analytical data, current and former on-site physical setting and processes, and other relevant information.

Representativeness can also be affected by the time, place, and manner in which the samples are collected. The SMP identifies specific methods (i.e. grid frequency and prior investigation data) for achieving and demonstrating the representativeness of the samples to be collected.

Representativeness will also be satisfied by ensuring that this SAP and the Form B are followed, samples are collected in accordance with the appropriate DTSC guidance, proper analytical procedures are followed, and holding times of the samples are not exceeded in the laboratory.

5.2.4 Completeness

Completeness is a measure of the percentage of data that are valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this SAP, and when none of the QC criteria that affect data usability is exceeded. When all data validation is completed, the percent completeness value may be calculated by dividing the number of useable sample results by the total number of sample results.

Completeness will also be evaluated as part of the data quality assessment process (EPA 2006). The degree of completeness will be calculated by dividing the number of useable sample results by the total number of number of sample results. This evaluation will help determine whether there are any limitations on the decisions to be made based on the data collected. A minimum of 95% completeness per matrix type will be required for usable data.

5.2.5 Comparability

Comparability expresses the confidence with which one data set can be compared with another. Comparability of data will be achieved by consistently following standard field and laboratory procedures and by using standard measurement units in reporting analytical data.

5.3 FIELD QUALITY CONTROL SAMPLES

Field QC samples will be collected and analyzed to assess the quality of data generated from sampling activities. Table C2-4 presents QC samples to be collected and analyzed for RES area projects. These samples may include trip blanks, equipment rinsate blanks, field replicates, and field split samples as described below:

- **Trip blanks** are used to assess the potential for sample contamination during handling, shipment, and storage. One trip blank is usually included within every shipping cooler of liquid samples to be analyzed for VOCs. Trip blanks are sample bottles filled by the analytical laboratory with organic-free water. The trip blanks are sealed and transported to the field; kept with empty sample bottles and then with the investigative samples throughout the field effort; and returned to the laboratory for analysis with the investigative samples. Trip blanks are never opened in the field.

- **Equipment rinsate blanks** are collected when sampling equipment is used. These blanks assess the cleanliness of sampling equipment and the effectiveness of equipment decontamination. Equipment rinsate blanks are typically collected for each type of decontaminated sampling equipment. Equipment rinsate blanks are collected by pouring analyte-free water over surfaces of cleaned sampling equipment that contact sample media. Equipment rinsate blanks are collected after sampling equipment has been decontaminated but prior to being reused for sampling.

- **Source blanks** are collected from the water used for the final decontamination rinse of equipment. They are used to assess contamination in the water used for decontamination. One source blank is collected from each source of water used for decontamination.

- **Field replicate samples** are independent samples collected as close as possible in space and time to the original investigative sample. Collection of soil replicates are decided based on the data objectives for each site. Immediately following collection of the original sample, the field duplicate sample is collected using the same collection method. Care should be taken to collect the field duplicate sample as close to the location of the original sample as possible. Field duplicate samples can measure how sampling and field procedures influence the precision of an environmental measurement. They can also provide information on the heterogeneity of a sampling location.

- **Temperature blanks** are used to assess the temperature of the samples upon arrival at the laboratory. A sample container is filled with distilled water and placed each cooler. Upon arrival at the laboratory, the temperature of the water is measured. The temperature blank is not analyzed.

- **Field split samples** are usually a set of two or more samples taken from a larger homogenized sample. Field split samples may be collected to monitor how closely laboratories are meeting project-specific QA objectives. The larger sample is usually collected from a single sampling location, but can also be a composite sample. Field split samples can be sent to two or more laboratories and are used to provide comparison data between the laboratories.

TABLE C2-4: QC SAMPLES FOR PRECISION AND ACCURACY

QC Type	QA Sample Type	Precision / Accuracy	Default Frequency
Field QC	Field Replicates	Precision	1 every 10 soil or sediment samples
	Equipment Rinsate	Accuracy	1 per day per type of non-disposable sampling equipment
	Source Water Blank	Accuracy	1 per source of decontamination water
	Trip Blanks	Accuracy	1 per shipping container containing volatile samples
	Temperature Blanks	Accuracy	1 per shipping container
Laboratory QC	Method Blanks	Accuracy	1 per every batch of samples, type of matrix, or 20 samples (whichever is more frequent)
Laboratory QC	MS/MSD Percent Recovery	Precision	1 per every 20 samples
	Laboratory Replicates (blind)	Precision	1 per every 20 samples
	LCS or Blank Spikes Percent Recovery	Accuracy	1 per every batch of samples, type of matrix, or 20 samples (whichever is more frequent)
	Surrogate Standard Percent Recovery	Accuracy	Every sample for organic analysis by gas chromatography

Source:
EPA. 2005 Uniform Federal Policy for Quality Assurance Project Plans. Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities. EPA 505-B-04-900B.

6.0 SAMPLE CUSTODY

The sections below describe sample handling procedures, including sample identification and labeling, documentation, chain of custody, and shipping. Procedures for equipment decontamination and management of investigation derived waste are also briefly described below.

6.1 SAMPLE IDENTIFICATION

A unique sample identification number will be assigned to each sample collected during the various RES investigations. The sample numbering system allows each sample to be uniquely identified and provides a means of tracking the sample from collection through analysis.

6.2 SAMPLE LABELS

A sample label will be affixed to all sample containers. The label will be completed with the following information, written in indelible ink:

- Project name and location
- Sample identification number
- Date and time of sample collection
- Preservative used
- Sample collector's initials
- Analysis required

After it is labeled, each sample will be refrigerated or placed in a cooler that contains wet ice to maintain the sample temperature at or below 4 ±2°C.

6.3 SAMPLE DOCUMENTATION

Documentation during sampling is essential to ensure proper sample identification. Sampling personnel will adhere to the following general guidelines for maintaining field documentation:

- Documentation will be completed in permanent black ink.
- All entries will be legible.
- Errors will be corrected by crossing out with a single line and then dating and initialing the lineout.
- Unused portions of pages will be crossed out, and each page will be signed and dated.

The field team leader is responsible for ensuring that sampling activities are properly documented.

6.4 CHAIN OF CUSTODY

Standard sample custody procedures will be conducted to maintain and document sample integrity during collection, transportation, storage, and analysis. A sample will be considered to be in custody if one of the following statements applies:

- It is in a person's physical possession or view.
- It is in a secure area with restricted access.
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal.

Chain-of-custody procedures provide an accurate written record that traces the possession of individual samples from the time of collection in the field to the time of acceptance at the laboratory. The chain-of-custody record also will be used to document all samples collected and the analysis requested. Information that the field personnel will record on the chain-of-custody record includes:

- Project name and number
- Sampling location
- Name and signature of sampler
- Destination of samples (laboratory name)
- Sample identification number
- Date and time of collection
- Number and type of containers filled
- Analyses requested
- Preservatives used (if applicable)
- Filtering (if applicable)
- Sample designation (i.e. grab or composite)
- Sample media
- Signatures of individuals involved in custody transfer, including the date and time of transfer
- Air bill number (if applicable)
- Project contact and phone number

Unused lines on the chain-of-custody record will be crossed out. Field personnel will sign chain-of-custody records that are initiated in the field, and the air bill number will be recorded.

The record will be placed in a waterproof plastic bag and taped to the inside of the shipping container used to transport the samples. Signed air bills will serve as evidence of custody transfer between field personnel and the courier, and between the courier and the laboratory. Copies of the chain-of-custody record and the air bill will be retained and filed by field personnel before the containers are shipped.

Laboratory chain of custody begins when samples are received and ends when samples are discarded. Laboratories analyzing samples must follow custody procedures at least as stringent as are required by the EPA Contract Laboratory Program statements of work (EPA 2003, 2004). The laboratory should designate a specific individual as the sample custodian. The custodian will receive all incoming samples, sign the accompanying custody forms, and retain copies of the forms as permanent records. The laboratory sample custodian will record all pertinent information concerning the samples, including the persons who delivered the samples, the date and time they were received, condition of the sample at the time it was received (sealed, unsealed, or broken container; temperature; or other relevant remarks), the sample identification numbers, and any unique laboratory identification numbers for the samples. When the sample transfer process is complete, the custodian is responsible for maintaining internal logbooks, tracking reports, and other records necessary to maintain custody throughout sample preparation and analysis.

The laboratory will provide a secure storage area for all samples. Access to this area will be restricted to authorized personnel. The custodian will ensure that samples that require special handling, including samples that are heat- or light-sensitive, radioactive, or have other unusual physical characteristics, will be properly stored and maintained prior to analysis.

6.5 SAMPLE SHIPMENT

The following procedures will be implemented when collected samples are shipped:

- The chain-of-custody records will be placed inside a plastic bag. The bag will be sealed and taped to the inside of the shipping container. The air bill, if required, will be filled out before the samples are handed over to the carrier. The laboratory will be notified if the sampler suspects that the sample contains any substance that would require laboratory personnel to take safety precautions.

- The shipping container will be closed and taped shut with strapping tape around both ends. If the shipping container has a drain, it will be taped shut both inside and outside of the shipping container.

- Signed and dated custody seals will be placed on the front and side of each shipping container. Wide clear tape will be placed over the seals to prevent accidental breakage.

- The chain-of-custody record will be transported within the taped sealed shipping container. When the shipping container is received at the analytical laboratory, laboratory personnel will open the shipping container and sign the chain-of-custody record to document transfer of samples.

Multiple shipping containers may be sent in one shipment to the laboratory. The outside of the shipping container will be marked to indicate the number of shipping containers in the shipment.

6.6 DECONTAMINATION PROCEDURES

All reusable equipment will be decontaminated according to the following procedures. All reusable sampling tools will be decontaminated before sampling begins and between sample locations. Reusable sampling tools will be decontaminated by scrubbing in a solution of potable water and nonphosphate detergent (Alconox or Liquinox). The tools will then be double-rinsed with distilled water. Sampling tools that are not used immediately after decontamination will be allowed to air dry and wrapped in plastic.

6.7 MANAGEMENT OF IDW

All soils and debris generated from soil borings and well installations, and water from well purging and decontamination will be contained as investigation-derived waste (IDW). The soil or water will be placed in 55-gallon drums, labeled, and stored on a concrete containment pad in a fenced or secured location at the RFS. Samples will be collected from the drums for characterization of the waste. The results of the sample will dictate the exact disposal requirements. The drums will then be shipped off site to the appropriate facility.

Personal protective equipment and miscellaneous waste from sampling (paper towels, aluminum foil, and plastic sheeting) will be placed in large garbage bags, sealed, and disposed of in facility trash receptacles as solid waste, or disposed of at a proper off-site facility to prevent exposure to unauthorized personnel, as appropriate.

7.0 DATA REDUCTION, VALIDATION, AND REPORTING

The following section describes the methods used for verifying and validating data.

7.1 FIELD DATA VERIFICATION

Project team personnel will verify field data through reviews of data sets to identify inconsistencies or anomalous values. Any inconsistencies discovered will be resolved as soon as possible by seeking clarification from field personnel responsible for data collection. All field personnel will be responsible for following the sampling and documentation procedures described in this SAP so that defensible and justifiable data are obtained.

Data values that are significantly different from the population are called “outliers.” A systematic effort will be made to identify any outliers or errors before field personnel report the data. Outliers can result from improper sampling or measurement methodology, data transcription errors, calculation errors, or natural causes. Outliers that result from errors found during data verification will be identified and corrected; outliers that cannot be attributed to errors in sampling, measurement, transcription, or calculation will be clearly identified in project reports.

7.2 LABORATORY DATA VERIFICATION

Laboratory personnel will verify analytical data at the time of analysis and reporting and through subsequent reviews of the raw data for any nonconformances to the requirements of the analytical method. Laboratory personnel will make a systematic effort to identify any outliers or errors before they report the data. Outliers that result from errors found during data verification will be identified and corrected.

7.3 LABORATORY DATA VALIDATION

Data validation is a systematic process for reviewing and qualifying data against a set of criteria to determine whether they are adequate for their intended use. Reviewing and evaluating all analytical data for their PARCC parameters verifies adequacy. EH&S will indicate the level of validation required for the data. Criteria for data qualification during the cursory and full review are derived from EPA guidelines (EPA 2008, 2010), the SAP, SMP, sampling planning document, and associated analytical methods. General requirements for cursory and full validation are listed below.

7.3.1 Cursory Data Validation

Cursory review of the analytical reports includes evaluating the following parameters, as applicable: holding times, initial and continuing calibrations, laboratory and field blanks, accuracy, laboratory precision, and analytical and matrix performance. An overall assessment of the data will also be conducted. Cursory data validation is the default review for SMP-related project sampling.

7.3.2 Full Data Validation

Full review includes all the elements of a cursory review as presented above, and the following additional items, as applicable:

- Method compliance, instrument performance check samples, cleanup performance, system performance check samples, system performance, inductively coupled plasma or atomic emission spectroscopy interference check samples, and overall assessment of the data
- Target analyte identification
- Analyte quantitation
- Detection and quantitation limit verification

Full data validation may be selected on a project-by-project basis, if determined to be necessary by UC EH&S staff.

8.0 DATA ASSESSMENT PROCEDURES

After environmental data have been reviewed, verified, and validated, the data must be further evaluated to determine whether data objectives have been met. This section describes these procedures.

UC will systematically assess data quality and data usability. This assessment will include the following elements:

- A review of the sampling design and sampling methods to verify that these were implemented as planned and are adequate to support project objectives.
- A review of project-specific data quality indicators for PARCC parameters and quantitation limits to determine if acceptance criteria have been met.
- A review of project-specific objectives to evaluate whether they have been achieved by the data collected.
- An evaluation of any limitations associated with the decisions to be made based on the data collected. For example, if data completeness is only 90 percent compared with a project-specific completeness objective of 95 percent, the data may still be usable to support a decision, but at a lower level of confidence.

Deviations from the Sampling Design (Form B), such as change in sample location, or analytical results which do not meet data quality criteria, will be evaluated to determine whether additional sampling is required. Once the data set is deemed acceptable per project sampling design, the soil sample results will be compared to the SMP Category I and Category II criteria to determine if a soil management action is required.

9.0 REFERENCES

California Regional Water Quality Control Board. 2016. "Environmental Screening Levels, San Francisco Bay Regional Water Quality Control Board." February. Available on-line at: http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/ESL/ESL%20Workbook_ESLs_Interim%20Final_22Feb16_Rev3_PDF.pdf

Tetra Tech EM Inc. (Tetra Tech). 2010. "Field Sampling Workplan, Appendix A, Quality Assurance Project Plan, Richmond Field Station, Richmond, California." June 2.

Tetra Tech. 2013. "Site Characterization Report, University of California, Berkeley, Richmond Field Station, Richmond, California."

URS Corporation. 2000. "Field Sampling and Analysis Results, University of California Berkeley, Richmond Field Station/Stege Marsh." December.

U.S. Environmental Protection Agency (EPA). 1996. "Test Methods for Evaluating Solid Waste, 3rd Edition." SW-846. Promulgated revisions.

EPA. 2003. "USEPA Contract Laboratory Program Statement of Work for Organic Analysis." Document Number OLM04.3. March.

EPA. 2004. "USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review." Document Number EPA-540/R-04-004. October.

EPA. 2005. Uniform Federal Policy for Quality Assurance Project Plans. Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities. EPA 505-B-04-900B.

EPA. 2006. "Systematic Planning: A Case Study for Hazardous Waste Site Investigations. (EPA QA/CS-1)". Document Number EPA/240/B-06/004. February.

EPA. 2008. "Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review" EPA-540-R-08-01. June.

EPA. 2010. "Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review" EPA-540-R-10-011. January.

ATTACHMENT C1
DTSC COMMENTS

Department of Toxic Substances Control

Jared Blumenfeld
Secretary for
Environmental Protection

Meredith Williams, Ph.D.
Acting Director
700 Heinz Avenue
Berkeley, California 94710-2721

Gavin Newsom
Governor

April 4, 2019

Greg Haet, P.E.
EH&S Associate Director, Environmental Protection
Office of Environment, Health & Safety
University of California, Berkeley
University Hall, 3rd Floor, #1150
Berkeley, California 94720
Email: gjhaet@berkeley.edu

Dear Mr. Haet:

The Department of Toxic Substances Control (DTSC) received the *Draft Soil Management Plan, Revision 2 Removal Action Workplan, Attachment C* (SMP) for the University of California, Berkeley Richmond Field Station (RFS), located at 1301 South 46th Street, Richmond, California. The SMP, dated November 2, 2018, was prepared by Tetra Tech, Inc. on behalf of the University of California, Berkeley, and is the second revision to Attachment C of the Removal Action Workplan approved in 2014. The purpose of the SMP is to support land use controls within the Research, Education, and Support (RES) areas at the RFS. DTSC has reviewed the SMP and has the following comments:

1. Section 4.1, Prescriptive Sampling Design, Area of Potential Groundwater Concern: This section states that Table C-3 identifies four SMP areas where groundwater concentrations exceed the commercial vapor intrusion RBCs. Table C-3 includes six SMP areas marked for VOC soil analysis. Please revise the text or table.

2. Exhibit C2 Sampling and Analysis Plan, Section 3.3 (Incremental Sampling Methodology): This section states that for soil characterization of PCBs, 75 soil increments will be collected from each decision unit. The location of the soil increments will be identified on a case-by-case basis but are generally designated throughout a random-stratified grid throughout the decision unit.

   Include in the text that that the number, location and size of the decision units and sample depth will based on site information such as the presence of a leaking transformer, known spill, etc.

If you have any questions, please contact Lynn Nakashima at (510) 540-3839 or lynn.nakashima@dtsc.ca.gov.

Sincerely,

Lynn Nakashima, Project Manager
Senior Hazardous Substances Scientist
Site Mitigation and Restoration Program
Berkeley Office - Cleanup Operations

Gerard F. Aarons, PG, CHG
Senior Engineering Geologist
Site Mitigation and Restoration Program
Geological Services Branch

CERTIFIED HYDROGEOLOGIST
GERARD AARONS
CHG 771
PG 7430
STATE OF CALIFORNIA

cc: Alicia Bihler
University of California, Berkeley
Environment, Health & Safety
317 University Hall, No 1150
Berkeley, California 94720
abihler@berkeley.edu

Jason Brodersen, PG, QSD
Tetra Tech, Inc.
1999 Harrison Street, Suite 500
Oakland, CA 94612
Jason.Brodersen@tetratech.com

ATTACHMENT C2
IMPORTED SOILS SAMPLING AND ANALYSIS REQUIREMENTS TO ASSESS CONTAMINANT CONCENTRATIONS

University of California, Berkeley Global Campus at Richmond Bay
Imported Soils
Sampling and Analysis Requirements to Assess Contaminant Concentrations

Introduction

UC Berkeley's Richmond Field Station (RFS) Site portion of the Berkeley Global Campus at Richmond Bay (BGC) is subject to site investigation and cleanup under the State of California Department of Toxic Substances Control (DTSC) Order Docket No. IS/E-RAO 06/07-004 (September 15, 2006). Due to the DTSC order, all fill materials to be imported for use at the RFS must be selected and tested with approval by the UC Berkeley Office of Environment, Health & Safety (EH&S), DTSC, and potentially other regulatory agencies (for example the Regional Water Quality Control Board and the Army Corps of Engineers). All soils brought to the RFS for use as fill or for temporary storage must be sampled to demonstrate that the soils are clean. This guideline presents procedures that must be followed and criteria met to obtain University and agency approval for contaminant concentrations to insure that ecological and human receptors are not exposed to harmful levels of pollution or that site investigations and remediation activities completed to date are not adversely affected by import of contaminated media (soil, water, pavement, etc.).

Regulatory Guidance

1) DTSC Information Advisory, Clean Imported Fill Material, October 2001
2) DTSC Interim Guidance, Evaluation of School Sites with Potential Soil Contamination as a Result of Lead From Lead-Based Paint, Organochlorine Pesticides from Termiticides, and Polychlorinated Biphenyls from Electrical Transformers, June 9, 2006
3) Other- marsh fill and other open space areas may require compliance with US Army Corps of Engineers Dredging and Dredged Material Management Guidelines and/or the San Francisco Bay Regional Water Quality Control Board's SF Bay Plan.

Procedures

Borrow Area Assessment- In order to minimize the potential for introducing contaminated fill onto a site, it is necessary to verify through documentation that the fill source is appropriate for use at the RFS. Documentation required to be provided to the University should include detailed information on the previous land use from where the fill is taken. Proper documentation should include detailed information regarding the former land use, previous environmental site assessments, and the results of any testing performed.

In addition to source assessment documentation, the University requires that soils be sampled at a minimum frequency required in the DTSC Regulatory Guidance for imported fill material and analyzed for target compounds according to this guidance. Additional analyses may be required depending on the borrow source site history (for example, soils from LBNL must be analyzed for tritium). Soil imported for use in surface water or marsh restoration projects may also require review and approval by the San Francisco Bay Regional Water Quality Control Board, the US Army Corps of Engineers, and other agencies.

Sampling Method
Incremental sampling collection methods following the ITRC Incremental Sampling Methodology are highly preferred by UC Berkeley to discrete samples. Discrete samples will only be accepted based on a thorough documentation of borrow area history and soil pile appearance (high heterogeneous soils may be rejected if not adequately assessed for soil contaminant variability).

Material Sampling Schedule

Area of Individual Borrow Area	**Sampling Requirement**
2 acres or less	4 samples minimum
2 to 4 acres	1 sample every ½ acre minimum
4 to 10 acres	8 samples minimum
Greater than 10 acres	Minimum of 8 locations with 4 subsamples per location
Volume of Borrow Area Stockpile	**Samples per Volume**
Up to 1,000 cubic yards	1 sample per 250 cubic yards
1,000 to 5,000 cubic years	4 samples for first 1,000 cubic yards+ 1 additional sample per each additional 500 cubic yards
Greater than 5,000 cubic yards	12 samples for first 5, 000 cubic yards + 1 sample per each additional 1,000 cubic yards

Laboratory Analyses
All soil sampled should be analyzed by a state certified analytical laboratory for the following target compounds using the required test methods.

Analyte	**Method**
Heavy metals	EPA methods 6010B and 7471A
Petroleum	TPH modified EPA method 8015
PCBs	EPA method 8082
Polyaromatic Hydrocarbons (PAHs)	EPA method 8270C SIM Method
Organochlorine Pesticides	EPA method 8081A
Volatile Organic Compounds	EPA method 8260

In addition, if soil is being collected from an area known to contain natural serpentine soils it must be analyzed for asbestos by polarized light microscopy. Other analyses may be required depending on the site environmental history and planned use for the soil (for example, radioactive materials, plant pathogens [such as Sudden Oak Death], etc.]).

University Approval Process
The following required documentation must be provided to the campus Office of Environment, Health & Safety at least two weeks prior to proposed import for review.

1. Borrow source site history.
2. Soil sampling plan (note, it is preferred that proposed sampling plans be submitted to EH&S for review and approval prior to sampling)
3. Certified Laboratory Analytical Results

Note- if sampling plans appear to be inadequate or improper or insufficient laboratory analyses have been performed, the University may require additional laboratory analyses.

<u>RFS Criteria Imported Soil (effective June 2016)</u>
The following chemical criteria apply to RFS soil imported for use as clean fill material:

Arsenic: site specific concentration of 16 mg/kg
Radioactive materials: Indistinguishable from background
All other chemicals: the Soils Management Plan (July 18, 2014 and any most recent SMP updates) will be used to compare to Category I and Category II acceptance criteria (SMP Table C1) for all Research, Education, and Support designated areas of the BGC (as described in SMP Section 4.2.2 Determination of Soil Management Action). Natural Open Space soil criteria will be based on these SMP categories as well as ecological soil screening levels for plants, invertebrates, birds, and mammals using the EPA's Ecological Soil Screening Levels (Eco-SSL) or the Oak Ridge National Laboratory (ORNL) phytotoxicty and earthworm toxicity benchmarks.

Note that site use may also require specific testing of sources for geotechnical, plant pathogens, and soil nutrients requirements of specific projects.

APPENDIX B
UPDATED CLEANUP GOALS TABLES

Table B-1: Exposure Parameters for Calculation of Risk-Based Concentrations
Richmond Bay Campus, University of California, Berkeley

Symbol	Definition (units)	Value	Source	Notes
Toxicity Values				
CSFo	Cancer slope factor oral (mg/kg-d)-1	Chemical-specific	DTSC hierarchy	DTSC values then EPA hierarchy
IUR	Inhalation unit risk (ug/m3)-1	Chemical-specific	DTSC hierarchy	DTSC values then EPA hierarchy
RfDo	Reference dose oral (mg/kg-d)	Chemical-specific	DTSC hierarchy	DTSC values then EPA hierarchy
RfC	Reference dose inhalation (mg/m3)	Chemical-specific	DTSC hierarchy	DTSC values then EPA hierarchy
Target Risk and Hazard Quotient				
TR	Target cancer risk	1E-06	Risk threshold	
THQ	Target hazard quotient	1	Noncancer threshold	
Body Weight (kg)				
BWa	Body Weight, adult (kg)	80	EPA 2014	
BWc	Body Weight, child (kg)	15	EPA 2014	
Averaging Time				
	Ingestion and Dermal Pathways (days)			
ATc	Averaging Time - carcinogens (days)	25,550	EPA 2014	
	Averaging Time - noncarcinogens (days)			
ATnc_A	--Adult resident (20 years)	7,300	EPA 2014	ED for adult resident reduced from 24 years to 20 years.
ATnc_C	--Child resident (6 years)	2,190	EPA 2014	
ATnc_O	--Construction worker	365	EPA 2014	
ATnc_M	--Maintenance worker	9,125	Professional judgment	assumed to be the same as the C/I worker
ATnc_i	--Commercial/Industrial worker	9,125	EPA 2014	
	Inhalation Pathways (hours)			
ATc_inh	Averaging Time - carcinogens (hours)	613,200	EPA 2009	
	Averaging Time - noncarcinogens (hours)			
ATnc_inh_r	--Resident (20 years)	175,200	EPA 2009	
ATnc_inh_c	--Resident child (6 years)	52,560	EPA 2009	
ATnc_inh_o	--Construction worker	8,760	EPA 2009	
ATnc_inh_m	--Maintenance worker	219,000	Professional judgment	assumed to be the same as the C/I worker
ATnc_inh_i	--Indoor worker	219,000	EPA 2009	

Table B-1: Exposure Parameters for Calculation of Risk-Based Concentrations
Richmond Bay Campus, University of California, Berkeley

Symbol	Definition (units)	Value	Source	Notes
Exposed surface area for soil/dust (cm^2/day)				
SAa	--Adult resident	6,032	DTSC 2019	
SAc	--Child resident	2,373	DTSC 2019	
SAo	--Construction worker	6,032	DTSC 2019	
SAm	--Maintenance worker	6,032	Professional judgment	assumed to be the same as the CW
SAi	--Commercial/Industrial worker	6,032	DTSC 2019	
Adherence factor, soils (mg/cm^2)				
AFo	--Construction worker	0.8	DTSC 2019	
AFm	--Maintenance worker	0.8	Professional judgment	assumed to be the same as the CW
AFi	--Commercial/Industrial worker	0.2	DTSC 2019	
Skin absorption defaults (unitless)				
ABS	--Semi-volatile organics	Chemical-specific		
	--Volatile organics	Chemical-specific		
	--Inorganics	Chemical-specific		
Soil Ingestion Rate (mg/day)				
IRSo	Soil ingestion - construction worker (mg/day)	330	DTSC 2019	
IRSm	Soil ingestion - maintenance worker (mg/day)	330	Professional judgment	assumed to be the same as the CW
IRSi	Soil ingestion - commercial/industrial worker (mg/day)	100	USEPA 2014; DTSC 2019	
Fraction Ingested of Soil (percent/100)				
FI_o	Soil ingestion - construction worker (percent/100)	1	Professional judgment	
FI_m	Soil ingestion - maintenance worker (percent/100)	1	Professional judgment	
FI_i	Soil ingestion - commerical/industrial worker (percent/100)	1	Professional judgment	
Exposure Frequency (days/year)				
EFr	Exposure Frequency - residential (d/y)	350	USEPA 2014; DTSC 2019	
EFo	Exposure Frequency - construction worker (d/y)	250	USEPA 2014; DTSC 2019	
EFm	Exposure Frequency - maintenance worker (d/y)	10	Professional judgment	Based on site-specific data
EFi	Exposure Frequency - commerical/industrial worker (d/y)	250	USEPA 2014; DTSC 2019	

Table B-1: Exposure Parameters for Calculation of Risk-Based Concentrations
Richmond Bay Campus, University of California, Berkeley

Symbol	Definition (units)	Value	Source	Notes
Exposure Duration (years)				
EDr	Exposure duration - full residential (years)	26	USEPA 2014; DTSC 20:	EDa + EDc
EDa	Exposure duration - adult (years)	20	USEPA 2014; DTSC 20:	ED for adult resident reduced from 24 years to 20 years.
EDc	Exposure duration - child (years)	6	USEPA 2014; DTSC 2019	
EDo	Exposure duration - construction worker (years)	1	DTSC 2019	
EDm	Exposure duration - maintenance worker (years)	25	Professional judgment	assumed to be the same as the C/I worker
EDi	Exposure duration - commerical/industrial worker (years)	25	USEPA 2014; DTSC 2019	
Exposure Time (hours/day)				
ETr	Exposure Time - residential (h/d)	24	USEPA 2014; DTSC 2019	
ETo	Exposure Time - construction worker (h/d)	8	Professional judgment	assumed to be the same as the C/I worker
ETm	Exposure Time - maintenance worker (h/d)	8	Professional judgment	Based on site-specific data
ETi	Exposure Time - commerical/industrial worker (h/d)	8	USEPA 2014; DTSC 2019	
Surface Area While in Groundwater (Trench) (cm^2/day)				
SAWo	Surface area, Construction worker (cm2/day)	6,032	DTSC 2019	Same as soil exposure
SAWm	Surface area, Maintenance worker (cm2/day)	6,032	DTSC 2019	Same as soil exposure
Exposure Duration, Frequency and Events in Groundwater (days/year and events/day)				
EDWo	Exposure Duration - construction worker (years)	1	DTSC 2019	Same as soil exposure
EDWm	Exposure Duration - maintenance worker (years)	25	Professional judgment	Same as soil exposure
EFWo	Exposure Frequency - construction worker (day/year)	250	DTSC 2019	Same as soil exposure
EFWm	Exposure Frequency - maintenance worker (day/year)	10	Professional judgment	Same as soil exposure
EVWo	Event Frequency - construction worker (event/day)	1	DTSC 2019	
EVWm	Event Frequency - maintenance worker (event/day)	1	Professional judgment	assumed to be the same as the CW
Exposure Time in Groundwater (hours/day)				
ETWo	Exposure Time - construction worker (hour/day)	2	Professional judgment	Professional judgment
ETWm	Exposure Time - maintenance worker (hour/day)	2	Professional judgment	Professional judgment

Table B-1: Exposure Parameters for Calculation of Risk-Based Concentrations
Richmond Bay Campus, University of California, Berkeley

Symbol	Definition (units)	Value	Source	Notes
Dermal Factor in Groundwater (cm^2-event-day/kg)				
DFWo	Dermal Factor - construction worker (cm2-event-day/kg)	75.4	EPA 2004	
DFWm	Dermal Factor - maintenance worker (cm2-event-day/kg)	1885	EPA 2004	
Age-adjusted factors for Mutagens:	**Calculated age-adjusted values:**			
EDSMadj	Exposure duration, Mutagenic, resident, soils (years)	72	EPA 2019	
Other Miscellaneous Factors				
PEF	Particulate emission factor (m3/kg)	1.36E+09	DTSC 2019 default	
PEF_cw	Particulate emission factor (m3/kg) - construction worker	1.0E+06	DTSC 2019 default	
VFs	Volatilization factor for soil (m3/kg)	Chemical-specific	Chemical-specific	
sat	Soil saturation concentration (mg/kg)	Chemical-specific	Chemical-specific	

Sources:

California Department of Toxic Substances Control (DTSC). 2019. “HERO Note Number 1: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Hazardous Waste Sites and Permitted Facilities.” Office of Human and Ecological Risk. May 9.

United States Environmental Protection Agency (USEPA). 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. OSWER 9285.7-02EP.July

USEPA. 2009. RAGS (Part F, Supplemental Guidance for Inhalation RiskAssessment), EPA/540/R/070/002.

USEPA. 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER 9200.1-120.

USEPA. 2019. Regional Screening Levels for Chemical Contaminants at Superfund Sites. November.

Table B-2: Chemical Parameters for Calculation of Risk-Based Concentrations
Richmond Bay Campus, University of California, Berkeley

ANALYTE	CAS Number	Cancer Toxicity Factors [1] CSFo (mg/kg-day)$^{-1}$		Cancer Toxicity Factors [1] IUR (µg/m^3)$^{-1}$		Noncancer Toxicity Factors [1] RfDo (mg/kg-day)		Noncancer Toxicity Factors [1] RfC (mg/m^3)		GIABS [2]	VF [2] (m^3/kg)	ABS [2]	Kp [2] (cm/hr)	Trench VF [3] (L/m^3)	M if Mutagen [2]	Inorganic/ Organic
1,2-Dichloropropane	78-87-5	3.7E-02	P	3.7E-06	P	4.0E-02	P	4.0E-03	I	1	3.79E+03	0	7.71E-03	1.23E+01	--	O
1-Methylnaphthalene	90-12-0	2.9E-02	P	--		7.0E-02	A	2.8E-01	C	1	5.86E+04	0.13	9.08E-02	--	--	O
2-Methylnaphthalene	91-57-6	--		--		4.0E-03	I	1.6E-02	C	1	1.22E+04	0	9.73E-04	7.44E+00	--	O
4,4'-DDD	72-54-8	2.4E-01	I	6.9E-05	C	3.0E-05	P	--		1	5.80E+04	0.13	8.94E-02	--	--	O
4,4'-DDE	72-55-9	3.4E-01	I	9.7E-05	C	3.0E-04	P	1.2E-03	C	1	0.00E+00	0.1	1.72E-01	--	--	O
4,4'-DDT	50-29-3	3.4E-01	I	9.7E-05	I	5.0E-04	I	--		1	2.10E+06	0	1.49E-01	--	--	O
4-Methylphenol	106-44-5	--		--		1.0E-01	A	6.0E-01	C	1	1.06E+04	0	2.66E-03	9.33E+00	--	O
Acenaphthene	83-32-9	--		--		6.0E-02	I	2.4E-01	C	1	0.00E+00	0.1	7.61E-03	--	--	O
Acenaphthylene	83-32-9	--		--		6.0E-02	I	2.4E-01	C	1	1.41E+05	0.13	8.39E-02	7.93E+00	--	O
Acetone	67-64-1	--		--		9.0E-01	I	3.1E+01	C	1	1.41E+05	0.13	1.08E-01	7.27E+00	--	O
Aldrin	309-00-2	1.7E+01	I	4.9E-03	I	3.0E-05	I	1.2E-04	C	1	1.37E+04	0	5.20E-04	6.58E+00	--	O
alpha-BHC	319-84-6	6.3E+00	I	1.8E-03	I	8.0E-03	A	--		1	1.72E+06	0	1.41E-03	--	--	O
alpha-Chlordane	12789-03-6	3.5E-01	I	1.0E-04	I	5.0E-04	I	7.0E-04	I	1	0.00E+00	0.1	1.20E-02	--	--	O
Aluminum	7429-90-5	--		--		1.0E+00	P	5.0E-03	P	1	0.00E+00	0	1.00E-03	--	--	I
Anthracene	120-12-7	--		--		3.0E-01	I	1.2E+00	C	1	5.23E+05	0.13	1.38E-01	5.48E+00	--	O
Antimony	7440-36-0	--		--		4.0E-04	I	--		1	0.00E+00	0	1.00E-03	--	--	I
Aroclor-1242	53469-21-9	2.0E+00	I	5.7E-04	C	--		--		1	5.91E+05	0.14	2.53E-01	--	--	O
Aroclor-1248	12672-29-6	2.0E+00	I	5.7E-04	C	--		--		1	6.25E+05	0.14	4.12E-01	--	--	O
Aroclor-1254	11097-69-1	2.0E+00	I	5.7E-04	I	2.0E-05	I	8.0E-05	C	1	5.32E+05	0.14	4.12E-01	--	--	O
Aroclor-1260	11096-82-5	2.0E+00	I	5.7E-04	C	--		--		1	8.43E+05	0.14	4.50E-01	--	--	O
Arsenic	7440-38-2	9.5E+00	C	4.3E-03	I	3.5E-06	C	1.5E-05	C	1	1.31E+06	0.14	3.84E-01	--	--	O
BAP (EQ)	BAPEQ	1.0E+00	I	1.1E-03	C	3.0E-04	I	2.0E-06	I	1	0.00E+00	0.03	1.00E-03	--	--	I
Barium	7440-39-3	--		--		2.0E-01	I	5.0E-04	H	1	0.00E+00	0	1.00E-03	--	--	I
Benzene	71-43-2	1.0E-01	C	2.9E-05	C	4.0E-03	I	3.0E-03	C	1	3.54E+03	0	1.47E-02	1.49E+01	--	O
Benzo(a)anthracene	56-55-3	1.0E-01	I	1.1E-04	C	--		--		1	4.41E+06	0.13	4.54E-01	--	M	O
Benzo(a)pyrene	50-32-8	1.0E+00	I	1.1E-03	C	3.0E-04	I	2.0E-06	I	1	0.00E+00	0.13	6.70E-01	--	M	O
Benzo(b)fluoranthene	205-99-2	1.0E-01	I	1.1E-04	C	--		--		1	0.00E+00	0.13	6.70E-01	--	M	O
Benzo(g,h,i)perylene	129-00-0	--		--		3.0E-02	I	1.2E-01	C	1	0.00E+00	0.13	6.70E-01	--	M	O
Benzo(k)fluoranthene	207-08-9	1.0E-02	I	1.1E-04	C	--		--		1	0.00E+00	0.13	6.74E-01	--	M	O
Beryllium	7440-41-7	--		2.4E-03	I	2.0E-04	C	7.0E-06	C	1	0.00E+00	0	1.00E-03	--	--	I
beta-BHC	319-85-7	1.8E+00	I	5.3E-04	I	--		--		1	0.00E+00	0.1	1.16E-02	--	--	O
bis(2-Ethylhexyl)phthalate	117-81-7	1.4E-02	I	2.4E-06	C	2.0E-02	I	--		1	0.00E+00	0.1	2.42E-02	--	--	O
Boron	7440-42-8	--		--		2.0E-01	I	2.0E-02	H	1	0.00E+00	0	1.00E-03	--	--	I
Cadmium	7440439S	--		4.2E-03	C	1.0E-03	I	1.0E-05	A	1	0.00E+00	0.001	1.00E-03	--	--	I
Cadmium (Water)	7440439W	--		1.8E-03	I	5.0E-04	I	1.0E-05	A	1	0.00E+00	0.001	1.00E-03	--	--	I
Carbazole	86-74-8	1.0E-03	I	1.1E-05	C	--		--		1	1.17E+03	0	1.70E-02	1.52E+01	--	O
Carbon tetrachloride	56-23-5	7.0E-02	I	6.0E-06	I	4.0E-03	I	4.0E-02	C	1	1.53E+06	0.04	3.27E-02	--	--	O
Chlordane	12789-03-6	3.5E-01	I	1.0E-04	I	5.0E-04	I	7.0E-04	I	1	1.53E+06	0.04	3.64E-02	--	--	O

Table B-2: Chemical Parameters for Calculation of Risk-Based Concentrations
Richmond Bay Campus, University of California, Berkeley

ANALYTE	CAS Number	Cancer Toxicity Factors [1]				Noncancer Toxicity Factors [1]				GIABS [2]	VF [2] (m^3/kg)	ABS [2]	Kp [2] (cm/hr)	Trench VF [3] (L/m^3)	M if Mutagen [2]	Inorganic/ Organic
		CSFo (mg/kg-day)$^{-1}$		IUR (µg/m^3)$^{-1}$		RfDo (mg/kg-day)		RfC (mg/m^3)								
Chromium	7440-47-3	--		--		1.5E+00	I	--		1	1.18E+03	0	3.29E-03	1.86E+01	--	O
Chrysene	218-01-9	1.0E-03	I	1.1E-05	C	--		--		1	0.00E+00	0	2.00E-03	--	--	I
Cobalt	7440-48-4	--		9.0E-03	P	3.0E-04	P	6.0E-06	P	1	0.00E+00	0.13	4.54E-01	--	M	O
Copper	7440-50-8	--		--		4.0E-02	H	--		1	2.50E+03	0	7.67E-03	1.33E+01	--	O
delta-BHC	319-85-7	1.8E+00	I	5.3E-04	I	--		--		1	0.00E+00	0	4.00E-04	--	--	I
Dibenz(a,h)anthracene	53-70-3	4.1E+00	C	1.2E-03	C	--		--		1	0.00E+00	0	1.00E-03	--	--	I
Dieldrin	60-57-1	1.6E+01	I	4.6E-03	I	5.0E-05	I	2.0E-04	C	1	0.00E+00	0.1	2.01E-02	--	--	O
di-n-Butylphthalate	84-74-2	--		--		1.0E-01	I	--		1	0.00E+00	0.13	1.43E+00	--	M	O
Dioxin TEQ	1746-01-6	1.3E+05	C	3.8E+01	C	7.0E-10	I	4.0E-08	C	1	0.00E+00	0.1	1.19E-02	--	--	O
Endosulfan I	115-29-7	--		--		6.0E-03	I	2.4E-02	C	1	0.00E+00	0.1	2.34E-02	--	--	O
Endosulfan II	115-29-7	--		--		6.0E-03	I	2.4E-02	C	1	4.10E+05	0	2.81E-03	--	--	O
Endosulfan sulfate	1031-07-8	--		--		6.0E-03	I	2.4E-02	C	1	4.10E+05	0	2.81E-03	--	--	O
Endrin	72-20-8	--		--		3.0E-04	I	--		1	0.00E+00	0.1	1.77E-03	--	--	O
Endrin aldehyde	72-20-8	--		--		3.0E-04	I	--		1	0.00E+00	0.1	1.19E-02	--	--	O
Ethylbenzene	100-41-4	1.1E-02	C	2.5E-06	C	1.0E-01	I	1.0E+00	I	1	0.00E+00	0.1	8.98E-03	--	--	O
Fluoranthene	206-44-0	--		--		4.0E-02	I	--		1	5.67E+03	0	4.83E-02	1.28E+01	--	O
Fluorene	86-73-7	--		--		4.0E-02	I	1.6E-01	C	1	0.00E+00	0.13	2.16E-01	--	--	O
gamma-BHC (Lindane)	58-89-9	1.1E+00	C	3.1E-04	C	3.0E-04	I	--		1	2.81E+05	0.13	1.07E-01	5.59E+00	--	O
gamma-Chlordane	12789-03-6	3.5E-01	I	1.0E-04	I	5.0E-04	I	7.0E-04	I	1	0.00E+00	0.13	1.40E-01	3.03E+00	--	O
Heptachlor	76-44-8	4.5E+00	I	1.3E-03	I	5.0E-04	I	2.0E-03	C	1	0.00E+00	0.04	1.06E-02	--	--	O
Heptachlor epoxide	1024-57-3	9.1E+00	I	2.6E-03	I	1.3E-05	I	5.2E-05	C	1	4.79E+05	0	8.45E-03	--	--	O
HMX	2691-41-0	--		--		5.0E-02	I	--		1	8.43E+05	0	3.84E-02	--	--	O
Indeno(1,2,3-cd)pyrene	193-39-5	1.0E-01	I	1.1E-04	C	--		--		1	0.00E+00	0.006	1.21E-04	--	--	O
Iron	7439-89-6	--		--		7.0E-01	P	--		1	0.00E+00	0.13	9.90E-01	--	M	O
Lead	7439-92-1	--		--		--		--		1	6.21E+03	0	8.76E-02	1.21E+01	--	O
m,p-Xylene	108-38-3	--		--		2.0E-01	I	1.0E-01	I	1	0.00E+00	0	1.00E-04	--	--	I
Manganese	7439-96-5	--		--		2.4E-02	I	5.0E-05	I	1	5.47E+03	0	5.22E-02	1.28E+01	--	O
Mercuric Chloride	7487-94-7	--		--		1.6E-04	C	3.0E-05	C	1	0.00E+00	0	1.00E-03	--	--	I
Mirex	2385-85-5	1.8E+01	C	5.1E-03	C	2.0E-04	I	8.0E-04	C	1	2.19E+03	0	3.54E-03	1.41E+01	M	O
Molybdenum	7439-98-7	--		--		5.0E-03	I	--		1	8.58E+05	0	5.00E-02	--	--	O
Naphthalene	91-20-3	--		3.4E-05	C	2.0E-02	I	3.0E-03	I	1	0.00E+00	0	1.00E-03	--	--	I
Nickel	7440-02-0	--		2.6E-04	C	1.1E-02	C	1.4E-05	C	1	4.63E+04	0.13	4.57E-02	1.05E+01	--	O
o-Xylene	95-47-6	--		--		2.0E-01	I	1.0E-01	I	1	0.00E+00	0	2.00E-04	--	--	I
Pentachlorophenol	87-86-5	4.0E-01	I	5.1E-06	C	5.0E-03	I	--		1	6.46E+03	0	4.62E-02	--	--	O
Phenanthrene	206-44-0	--		--		4.0E-02	I	1.6E-01	C	1	0.00E+00	0.25	3.76E-01	--	--	O
Pyrene	129-00-0	--		--		3.0E-02	I	1.2E-01	C	1	2.38E+06	0.13	1.94E-01	1.63E+00	--	O
Selenium	7782-49-2	--		--		5.0E-03	I	2.0E-02	C	1	0.00E+00	0	1.00E-03	--	--	I
Silver	7440-22-4	--		--		5.0E-03	I	--		1	0.00E+00	0	6.00E-04	--	--	I

Table B-2: Chemical Parameters for Calculation of Risk-Based Concentrations
Richmond Bay Campus, University of California, Berkeley

ANALYTE	CAS Number	Cancer Toxicity Factors [1] CSFo (mg/kg-day)$^{-1}$		IUR ($\mu g/m^3$)$^{-1}$		Noncancer Toxicity Factors [1] RfDo (mg/kg-day)		RfC (mg/m^3)		GIABS [2]	VF [2] (m^3/kg)	ABS [2]	Kp [2] (cm/hr)	Trench VF [3] (L/m^3)	M if Mutagen [2]	Inorganic/ Organic
Thallium	7440-28-0	--		--		1.0E-05	P	--		1	0.00E+00	0	1.00E-03	--	--	I
Toluene	108-88-3	--		--		8.0E-02	I	3.0E-01	C	1	4.29E+03	0	1.43E-01	1.14E+01	--	O
Total PCBs	1336-36-3	2.0E+00	I	5.7E-04	C	--		--		1	4.29E+03	0	3.06E-02	1.38E+01	--	O
Trichloroethene	79-01-6	4.6E-02	I	4.1E-06	I	5.0E-04	I	2.0E-03	I	1	2.21E+03	0	1.15E-02	1.16E+01	TCE	O
Vanadium	7440-62-2	--		--		5.0E-03	I	1.0E-04	A	1	0.00E+00	0	1.00E-03	--	--	I
Zinc	7440-66-6	--		--		3.0E-01	I	--		1	0.00E+00	0	6.00E-04	--	--	I

Notes:

1 Toxicity values from DTSC (2019) were selected unless the chemical is not listed. If a chemical is not included on tables in DTSC (2019), then the toxicity values from USEPA (2019) were selected. The code for the source of the toxicity values are as follows:

- A Agency for Toxic Substances and Disease Registry
- C California Environmental Protection Agency Office of Environmental Health Hazard Assessment
- H Health Effects Assessment Summary Table
- I Integrated Risk Information System
- P Provisional Peer Reviewed Toxicity Values

2 Chemical parameters from USEPA (2019).

3 Calculated using the VDEQ trench model for groundwater less than 15 feet below surface (VDEQ 2007).

--	Not applicable	DDE	Dichlorodiphenyldichloroethylene	m^3/kg	Cubic meter per kilogram
$\mu g/m^3$	Microgram per cubic meter	DDT	Dichlorodiphenyltrichloroethane	mg/kg	Milligrams per kilogram
ABS	Dermal absorption factor	DTSC	California Department of Toxic Substances Control	mg/kg-day	Milligram per kilogram-day
BAP (EQ)	Benzo(a)pyrene equivalent	GIABS	Gastrointestinal absorption factor	mg/m^3	Milligram per cubic meter
BHC	Hexachlorocyclohexane	HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	O	Organic
Cal/EPA	California Environmental Protection Agency	I	Inorganic	PCB	Polychlorinated biphenyl
CAS	Chemical Abstracts Service	IUR	Inhalation unit risk	RfC	Reference concentration
cm/hr	Centimeter per hour	Kp	Permeability coefficient	RfDo	Reference dose - oral
CSFo	Cancer slope factor - oral	L/m^3	Liter per cubic meter	TEQ	Toxicity equivalent
DDD	Dichlorodiphenyldichloroethane	M	Mutagen	VF	Volatilization Factor

References:

California Department of Toxic Substances Control (DTSC). 2019. Human Health Risk Assessment Note 3 – DTSC-Modified Screening Levels (DTSC-SLs), April.

United States Environmental Protection Agency (USEPA). 2019. Regional Screening Levels (RSLs) for Chemical Contaminants. November.

Virginia Department of Environmental Quality (VDEQ). 2007. Voluntary Remediation Program Table 3.8 Exposure-point concentrations (inhalation) for construction/utility workers in a trench: Groundwater less Than 15 feet deep. October 5.

Table B-3: Risk-Based Concentrations for Soil
Richmond Bay Campus, University of California, Berkeley

Chemical	Future Commercial Worker			Future Construction Worker			Future Maintenance Worker			Unrestricted Use (inhalation only)		
	Cancer	Noncancer	Lower	Cancer	Noncancer	Lower	Cancer	Noncancer	Lower	Cancer	Noncancer	Lower
1,2-Dichloropropane	1.10E+01	6.63E+01	1.1E+01	2.13E+02	6.58E+01	6.6E+01	2.13E+02	1.65E+03	2.1E+02	2.88E+00	1.58E+01	2.9E+00
1-Methylnaphthalene	4.39E+01	2.21E+04	4.4E+01	2.94E+02	7.59E+03	2.9E+02	2.94E+02	1.90E+05	2.9E+02	--	1.71E+04	1.7E+04
2-Methylnaphthalene	--	1.26E+03	1.3E+03	--	4.33E+02	4.3E+02	--	1.08E+04	1.1E+04	--	9.68E+02	9.7E+02
4,4'-DDD	6.18E+00	1.59E+01	6.2E+00	4.15E+01	4.31E+00	4.3E+00	4.15E+01	1.08E+02	4.2E+01	5.53E+04	--	5.5E+04
4,4'-DDE	9.28E+00	3.40E+02	9.3E+00	7.05E+01	1.03E+02	7.0E+01	7.05E+01	2.58E+03	7.0E+01	6.07E+01	2.62E+03	6.1E+01
4,4'-DDT	7.06E+00	4.29E+02	7.1E+00	4.99E+01	1.23E+02	5.0E+01	4.99E+01	3.08E+03	5.0E+01	3.94E+04	--	3.9E+04
4-Methylphenol	--	5.29E+04	5.3E+04	--	1.43E+04	1.4E+04	--	3.57E+05	3.6E+05	--	8.51E+08	8.5E+08
Acenaphthene	--	2.30E+04	2.3E+04	--	6.93E+03	6.9E+03	--	1.73E+05	1.7E+05	--	3.53E+04	3.5E+04
Acenaphthylene	--	2.30E+04	2.3E+04	--	6.93E+03	6.9E+03	--	1.73E+05	1.7E+05	--	3.53E+04	3.5E+04
Acetone	--	6.71E+05	6.7E+05	--	2.71E+05	2.7E+05	--	6.78E+06	6.8E+06	--	4.41E+05	4.4E+05
Aldrin	1.84E-01	3.37E+01	1.8E-01	1.41E+00	1.03E+01	1.4E+00	1.41E+00	2.57E+02	1.4E+00	9.84E-01	2.15E+02	9.8E-01
alpha-BHC	2.35E-01	4.23E+03	2.4E-01	1.58E+00	1.15E+03	1.6E+00	1.58E+00	2.87E+04	1.6E+00	2.12E+03	--	2.1E+03
alpha-Chlordane	6.10E+00	3.63E+02	6.1E+00	4.36E+01	1.05E+02	4.4E+01	4.36E+01	2.63E+03	4.4E+01	4.29E+01	1.12E+03	4.3E+01
Aluminum	--	1.12E+06	1.1E+06	--	2.06E+04	2.1E+04	--	5.16E+05	5.2E+05	--	7.09E+06	7.1E+06
Anthracene	--	1.30E+05	1.3E+05	--	3.59E+04	3.6E+04	--	8.97E+05	9.0E+05	--	6.54E+05	6.5E+05
Antimony	--	4.67E+02	4.7E+02	--	1.42E+02	1.4E+02	--	3.54E+03	3.5E+03	--	--	--
Aroclor-1242	5.80E-01	--	5.8E-01	3.98E+00	--	4.0E+00	3.98E+00	--	4.0E+00	2.90E+00	--	2.9E+00
Aroclor-1248	5.82E-01	--	5.8E-01	3.99E+00	--	4.0E+00	3.99E+00	--	4.0E+00	3.07E+00	--	3.1E+00
Aroclor-1254	5.88E-01	8.44E+00	5.9E-01	4.00E+00	2.29E+00	2.3E+00	4.00E+00	5.72E+01	4.0E+00	4.15E+00	7.03E+01	4.1E+00
Aroclor-1260	5.95E-01	--	6.0E-01	4.01E+00	--	4.0E+00	4.01E+00	--	4.0E+00	6.44E+00	--	6.4E+00
Arsenic	2.53E-01	3.00E+00	2.5E-01	1.77E+00	8.50E-01	8.5E-01	1.77E+00	2.12E+01	1.8E+00	8.88E+02	2.13E+04	8.9E+02
BAP (EQ)	1.27E+00	1.35E+02	1.3E+00	8.29E+00	7.07E+00	7.1E+00	8.29E+00	1.77E+02	8.3E+00	1.25E+03	2.84E+03	1.3E+03
Barium	--	2.17E+05	2.2E+05	--	2.12E+03	2.1E+03	--	5.31E+04	5.3E+04	--	7.09E+05	7.1E+05
Benzene	1.43E+00	4.61E+01	1.4E+00	3.24E+01	4.49E+01	3.2E+01	3.24E+01	1.12E+03	3.2E+01	3.43E-01	1.11E+01	3.4E-01
Benzo(a)anthracene	1.24E+01	--	1.2E+01	8.23E+01	--	8.2E+01	8.23E+01	--	8.2E+01	4.05E+01	--	4.1E+01
Benzo(a)pyrene	1.27E+00	1.35E+02	1.3E+00	8.29E+00	7.07E+00	7.1E+00	8.29E+00	1.77E+02	8.3E+00	1.25E+03	2.84E+03	1.3E+03
Benzo(b)fluoranthene	1.27E+01	--	1.3E+01	8.29E+01	--	8.3E+01	8.29E+01	--	8.3E+01	1.25E+04	--	1.3E+04
Benzo(g,h,i)perylene	--	1.35E+04	1.3E+04	--	3.62E+03	3.6E+03	--	9.06E+04	9.1E+04	--	2.97E+05	3.0E+05
Benzo(k)fluoranthene	1.27E+02	--	1.3E+02	6.54E+02	--	6.5E+02	6.54E+02	--	6.5E+02	1.25E+04	--	1.3E+04
Beryllium	6.95E+03	2.32E+02	2.3E+02	1.28E+02	2.14E+01	2.1E+01	1.28E+02	5.35E+02	1.3E+02	1.59E+03	9.93E+03	1.6E+03
beta-BHC	8.23E-01	--	8.2E-01	5.54E+00	--	5.5E+00	5.54E+00	--	5.5E+00	7.20E+03	--	7.2E+03
bis(2-Ethylhexyl)phthalate	1.06E+02	1.06E+04	1.1E+02	7.15E+02	2.87E+03	7.1E+02	7.15E+02	7.19E+04	7.1E+02	1.59E+06	--	1.6E+06
Boron	--	2.33E+05	2.3E+05	--	3.92E+04	3.9E+04	--	9.79E+05	9.8E+05	--	2.84E+07	2.8E+07
Cadmium	3.97E+03	7.78E+02	7.8E+02	7.30E+01	3.66E+01	3.7E+01	7.30E+01	9.15E+02	7.3E+01	9.09E+02	1.42E+04	9.1E+02

Table B-3: Risk-Based Concentrations for Soil
Richmond Bay Campus, University of California, Berkeley

Chemical	Future Commercial Worker			Future Construction Worker			Future Maintenance Worker			Unrestricted Use (inhalation only)		
	Cancer	Noncancer	Lower	Cancer	Noncancer	Lower	Cancer	Noncancer	Lower	Cancer	Noncancer	Lower
Carbazole	1.27E+03	--	1.3E+03	6.54E+03	--	6.5E+03	6.54E+03	--	6.5E+03	1.25E+05	--	1.3E+05
Chlordane	6.10E+00	3.63E+02	6.1E+00	4.36E+01	1.05E+02	4.4E+01	4.36E+01	2.63E+03	4.4E+01	4.29E+01	1.12E+03	4.3E+01
Chromium	--	1.75E+06	1.8E+06	--	5.31E+05	5.3E+05	--	1.33E+07	1.3E+07	--	--	--
Chrysene	1.27E+03	--	1.3E+03	6.54E+03	--	6.5E+03	6.54E+03	--	6.5E+03	1.25E+05	--	1.3E+05
Cobalt	1.85E+03	3.47E+02	3.5E+02	3.41E+01	2.11E+01	2.1E+01	3.41E+01	5.27E+02	3.4E+01	4.24E+02	8.51E+03	4.2E+02
Copper	--	4.67E+04	4.7E+04	--	1.42E+04	1.4E+04	--	3.54E+05	3.5E+05	--	--	--
delta-BHC	8.23E-01	--	8.2E-01	5.54E+00	--	5.5E+00	5.54E+00	--	5.5E+00	7.20E+03	--	7.2E+03
Dibenz(a,h)anthracene	3.11E-01	--	3.1E-01	2.07E+00	--	2.1E+00	2.07E+00	--	2.1E+00	1.15E+03	--	1.1E+03
Dieldrin	9.26E-02	2.65E+01	9.3E-02	6.23E-01	7.13E+00	6.2E-01	6.23E-01	1.78E+02	6.2E-01	8.30E+02	2.84E+05	8.3E+02
di-n-Butylphthalate	--	5.29E+04	5.3E+04	--	1.44E+04	1.4E+04	--	3.59E+05	3.6E+05	--	--	--
Dioxin TEQ	1.79E-05	5.99E-04	1.8E-05	1.29E-04	1.72E-04	1.3E-04	1.29E-04	4.30E-03	1.3E-04	1.45E-04	8.16E-02	1.4E-04
Endosulfan I	--	6.03E+03	6.0E+03	--	1.99E+03	2.0E+03	--	4.96E+04	5.0E+04	--	1.03E+04	1.0E+04
Endosulfan II	--	6.03E+03	6.0E+03	--	1.99E+03	2.0E+03	--	4.96E+04	5.0E+04	--	1.03E+04	1.0E+04
Endosulfan sulfate	--	3.18E+03	3.2E+03	--	8.55E+02	8.6E+02	--	2.14E+04	2.1E+04	--	3.40E+07	3.4E+07
Endrin	--	1.59E+02	1.6E+02	--	4.31E+01	4.3E+01	--	1.08E+03	1.1E+03	--	--	--
Endrin aldehyde	--	1.59E+02	1.6E+02	--	4.31E+01	4.3E+01	--	1.08E+03	1.1E+03	--	--	--
Ethylbenzene	2.54E+01	2.05E+04	2.5E+01	5.29E+02	1.45E+04	5.3E+02	5.29E+02	3.64E+05	5.3E+02	6.37E+00	5.91E+03	6.4E+00
Fluoranthene	--	1.82E+04	1.8E+04	--	4.88E+03	4.9E+03	--	1.22E+05	1.2E+05	--	--	--
Fluorene	--	1.67E+04	1.7E+04	--	4.73E+03	4.7E+03	--	1.18E+05	1.2E+05	--	4.69E+04	4.7E+04
gamma-BHC (Lindane)	2.01E+00	2.36E+02	2.0E+00	1.40E+01	6.70E+01	1.4E+01	1.40E+01	1.67E+03	1.4E+01	1.23E+04	--	1.2E+04
gamma-Chlordane	6.10E+00	3.63E+02	6.1E+00	4.36E+01	1.05E+02	4.4E+01	4.36E+01	2.63E+03	4.4E+01	4.29E+01	1.12E+03	4.3E+01
Heptachlor	6.26E-01	5.13E+02	6.3E-01	5.14E+00	1.67E+02	5.1E+00	5.14E+00	4.16E+03	5.1E+00	1.03E+00	9.99E+02	1.0E+00
Heptachlor epoxide	3.30E-01	1.41E+01	3.3E-01	2.59E+00	4.41E+00	2.6E+00	2.59E+00	1.10E+02	2.6E+00	9.10E-01	4.57E+01	9.1E-01
HMX	--	5.45E+04	5.4E+04	--	1.63E+04	1.6E+04	--	4.07E+05	4.1E+05	--	--	--
Indeno(1,2,3-cd)pyrene	1.27E+01	--	1.3E+01	8.29E+01	--	8.3E+01	8.29E+01	--	8.3E+01	1.25E+04	--	1.3E+04
Iron	--	8.18E+05	8.2E+05	--	2.48E+05	2.5E+05	--	6.19E+06	6.2E+06	--	--	--
Lead	--	3.20E+02	3.2E+02	--	3.20E+02	3.2E+02	--	3.20E+02	3.2E+02	--	8.00E+01	8.0E+01
m,p-Xylene	--	2.37E+03	2.4E+03	--	2.31E+03	2.3E+03	--	5.76E+04	5.8E+04	--	5.70E+02	5.7E+02
Manganese	--	2.56E+04	2.6E+04	--	2.13E+02	2.1E+02	--	5.34E+03	5.3E+03	--	7.09E+04	7.1E+04
Mercury	--	1.87E+02	1.9E+02	--	3.96E+01	4.0E+01	--	9.89E+02	9.9E+02	--	4.25E+04	4.3E+04
Mirex	1.67E-01	2.17E+02	1.7E-01	1.31E+00	6.78E+01	1.3E+00	1.31E+00	1.70E+03	1.3E+00	4.72E-01	7.15E+02	4.7E-01
Molybdenum	--	5.84E+03	5.8E+03	--	1.77E+03	1.8E+03	--	4.42E+04	4.4E+04	--	--	--
Naphthalene	1.67E+01	5.70E+02	1.7E+01	3.99E+02	4.70E+02	4.0E+02	3.99E+02	1.17E+04	4.0E+02	3.82E+00	1.45E+02	3.8E+00

Table B-3: Risk-Based Concentrations for Soil
Richmond Bay Campus, University of California, Berkeley

Chemical	Future Commercial Worker			Future Construction Worker			Future Maintenance Worker			Unrestricted Use (inhalation only)		
	Cancer	Noncancer	Lower	Cancer	Noncancer	Lower	Cancer	Noncancer	Lower	Cancer	Noncancer	Lower
Nickel	6.42E+04	1.11E+04	1.1E+04	1.18E+03	6.04E+01	6.0E+01	1.18E+03	1.51E+03	1.2E+03	1.47E+04	1.99E+04	1.5E+04
o-Xylene	--	2.80E+03	2.8E+03	--	2.70E+03	2.7E+03	--	6.76E+04	6.8E+04	--	6.74E+02	6.7E+02
Phenanthrene	--	1.82E+04	1.8E+04	--	4.85E+03	4.8E+03	--	1.21E+05	1.2E+05	--	2.27E+08	2.3E+08
Pyrene	--	1.35E+04	1.3E+04	--	3.62E+03	3.6E+03	--	9.06E+04	9.1E+04	--	2.97E+05	3.0E+05
Selenium	--	5.84E+03	5.8E+03	--	1.73E+03	1.7E+03	--	4.34E+04	4.3E+04	--	2.84E+07	2.8E+07
Silver	--	5.84E+03	5.8E+03	--	1.77E+03	1.8E+03	--	4.42E+04	4.4E+04	--	--	--
Thallium	--	1.17E+01	1.2E+01	--	3.54E+00	3.5E+00	--	8.85E+01	8.8E+01	--	--	--
Toluene	--	5.32E+03	5.3E+03	--	4.68E+03	4.7E+03	--	1.17E+05	1.2E+05	--	1.34E+03	1.3E+03
Trichloroethene	6.05E+00	1.87E+01	6.0E+00	1.26E+02	1.74E+01	1.7E+01	1.26E+02	4.35E+02	1.3E+02	1.06E+00	4.61E+00	1.1E+00
Vanadium	--	5.78E+03	5.8E+03	--	3.51E+02	3.5E+02	--	8.78E+03	8.8E+03	--	1.42E+05	1.4E+05
Zinc	--	3.50E+05	3.5E+05	--	1.06E+05	1.1E+05	--	2.65E+06	2.7E+06	--	--	--

Notes: All units in milligrams per kilogram
Cancer and noncancer risk-based concnetrations calculated using exposure parameters provided on Table B-1 and chemical parameters provided on Table B-2 with the standard risk equations from USEPA (2019).

-- Not applicable
BAP (EQ) Benzo(a)pyrene equivalent
BHC Hexachlorocyclohexane
DDD Dichlorodiphenyldichloroethane
DDE Dichlorodiphenyldichloroethylene
DDT Dichlorodiphenyltrichloroethane
DTSC California Department of Toxic Substances Control
HMX Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
mg/kg Milligrams per kilogram
PCB Polychlorinated biphenyl
TEQ Toxic equivalency factor

References:

USEPA. 2019. Regional Screening Levels for Chemical Contaminants at Superfund Sites. November.

Table B-4: Risk-Based Concentrations for Groundwater
Richmond Bay Campus, University of California, Berkeley

	Future Commercial Worker (Vapor Intrusion into Indoor Air [1])			Future Construction Worker (in a Construction Trench [2])			Future Maintenance Worker (in a Construction Trench [2])		
Chemical	**Cancer**	**Noncancer**	**Lower**	**Cancer**	**Noncancer**	**Lower**	**Cancer**	**Noncancer**	**Lower**
Carbon Tetrachloride	2.8E+02	2.4E+04	2.8E+02	1.8E+01	6.2E+01	1.8E+01	1.8E+01	1.6E+03	1.8E+01

Notes:

All values are in micrograms per liter (µg/L).

1 The vapor intrusion screening levels were calculated using the USEPA's version of the Johnson and Ettinger Model update version 6 (USEPA 2018) with updated toxicity values (DTSC 2019, USEPA 2019).

2 The construction and maintenance worker groundwater screening levels were calculated using the volatilization factor calculated in the VDEQ trench model (VDEQ 2007) for inhalation exposure and dermal equations from the RSL calculator (USEPA 2019) for dermal exposure. Incidental ingestion of groundwater was considered to be *de minimus* and was not included in the risk-based concentrations.

References:

California Department of Toxic Substances Control (DTSC). 2019. Human Health Risk Assessment Note 3 – DTSC-Modified Screening Levels (DTSC-SLs), April 2019 Update. April. Available on-line: https://dtsc.ca.gov/human-health-risk-hero/

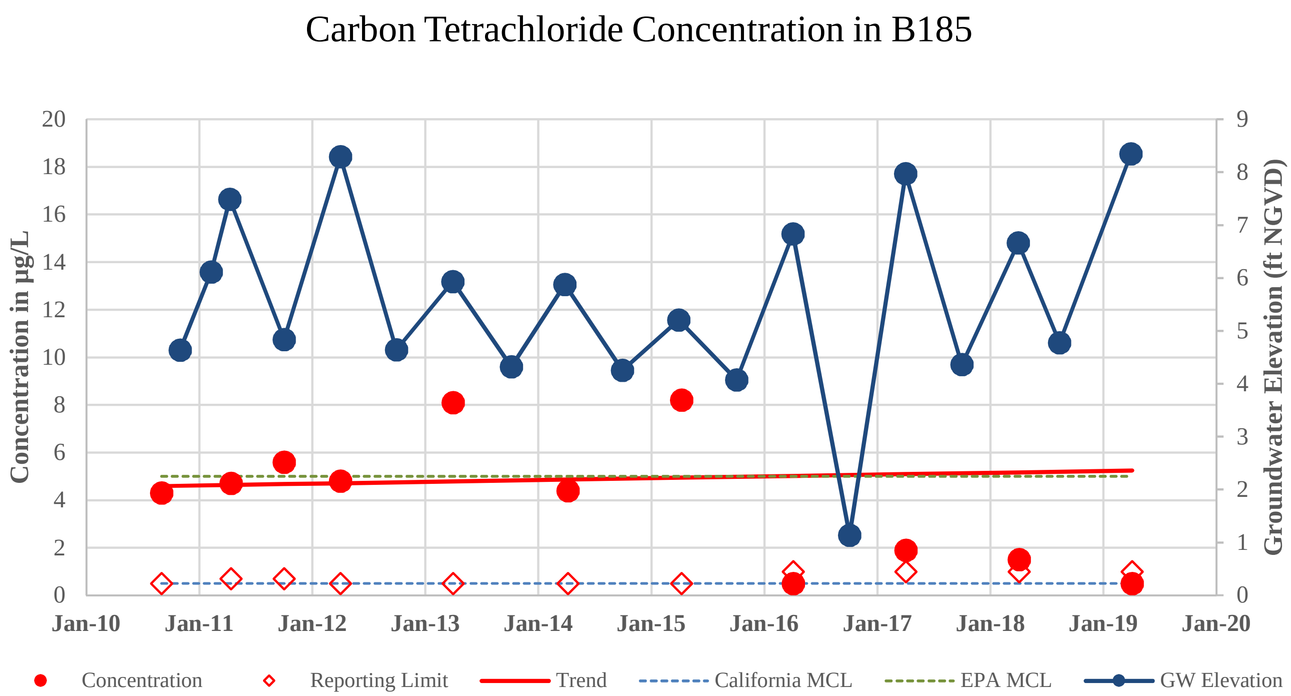
United States Environmental Protection Agency (USEPA). 2018. Johnson and Ettinger Model Spreadsheet Tool, Version 6.0. January 4. Available on-line: https://www.epa.gov/vaporintrusion/epa-spreadsheet-modeling-subsurface-vapor-intrusion

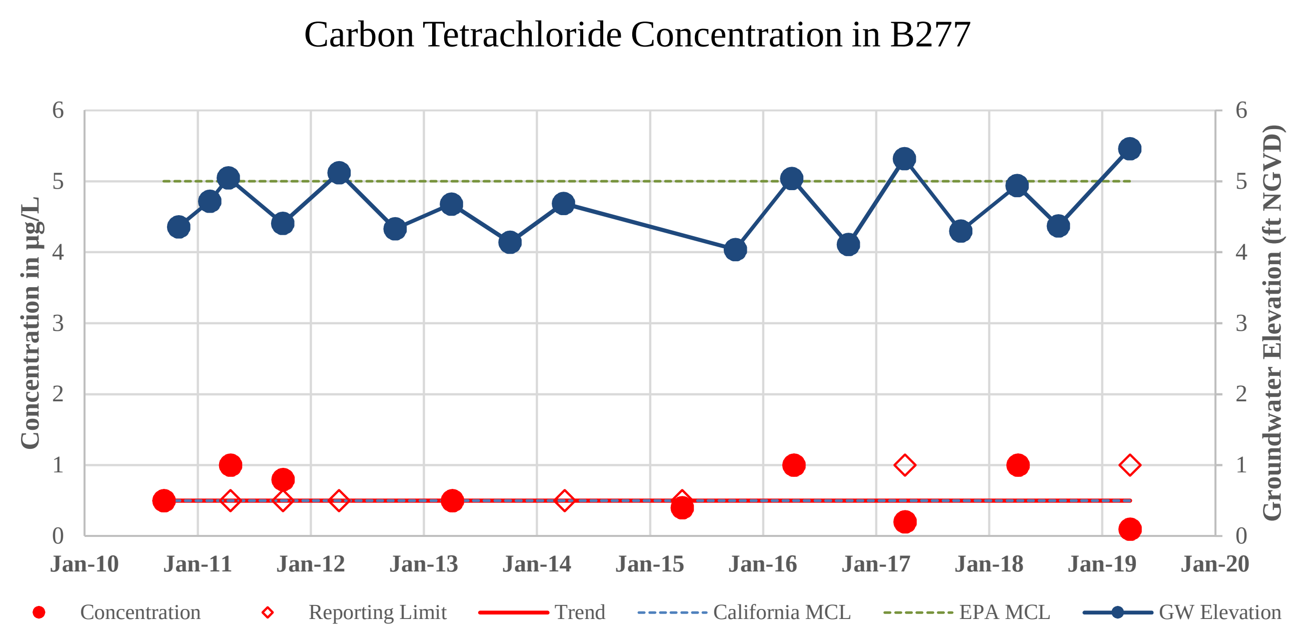
USEPA. 2019. Regional Screening Levels (RSLs) for Chemical Contaminants. November. Available on-line: https://www.epa.gov/risk/regional-screening-levels-rsls

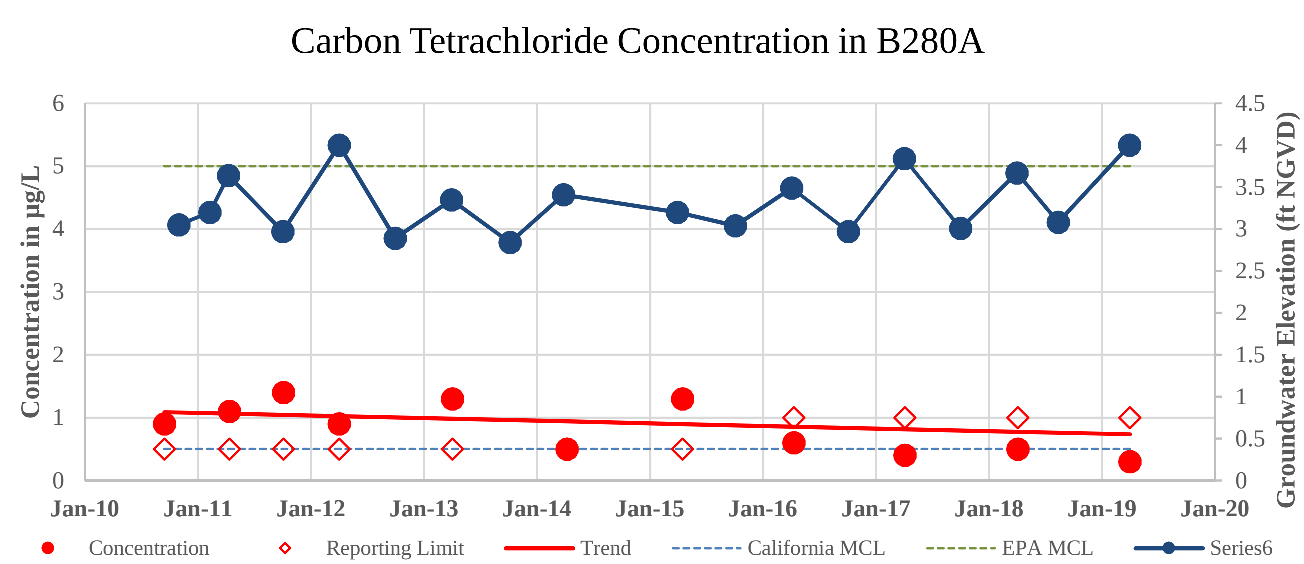
Virginia Department of Environmental Quality (VDEQ). 2007. Voluntary Remediation Program Table 3.8 Exposure-point concentrations (inhalation) for construction/utility workers in a trench: Groundwater less Than 15 feet deep. October 5.

APPENDIX C
CONCENTRATION-TIME GRAPHS FOR CARBON TETRACHLORIDE, MERCURY, AND TRICHLOROETHENE

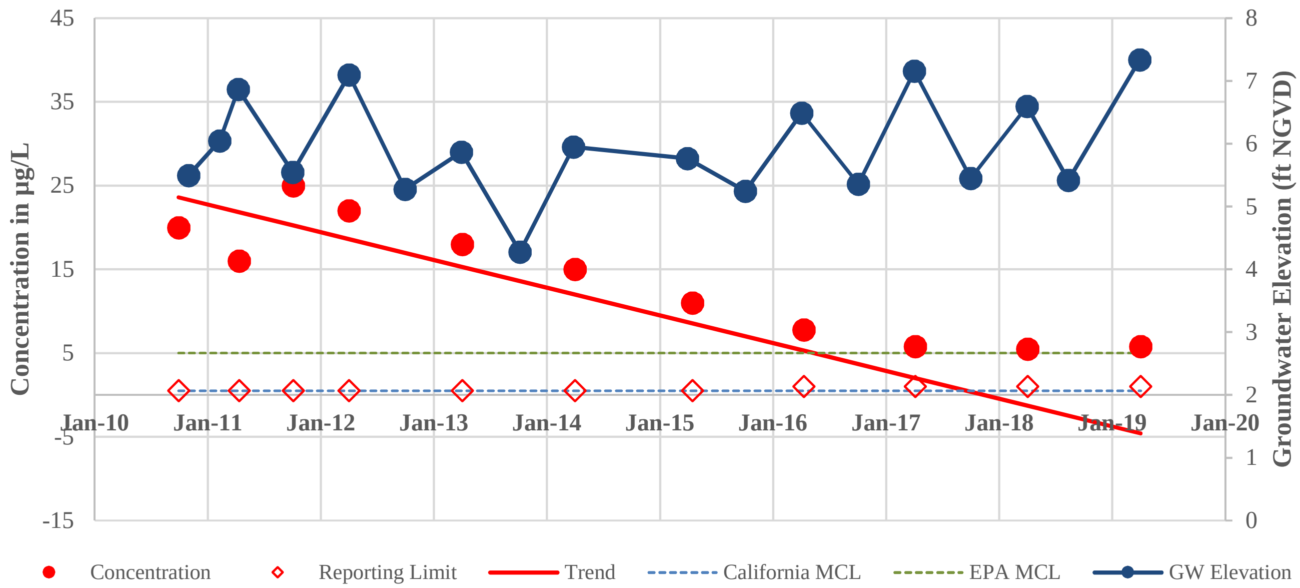
APPENDIX C
CONCENTRATION-TIME GRAPHS FOR CARBON TETRACHLORIDE, MERCURY, AND TRICHLOROETHENE


Carbon Tetrachloride Concentration in B185
Concentration in µg/L
Groundwater Elevation (ft NGVD)
20
18
16
14
12
10
8
6
4
2
0
9
8
7
6
5
4
3
2
1
0
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Concentration
Reporting Limit
Trend
California MCL
EPA MCL
GW Elevation

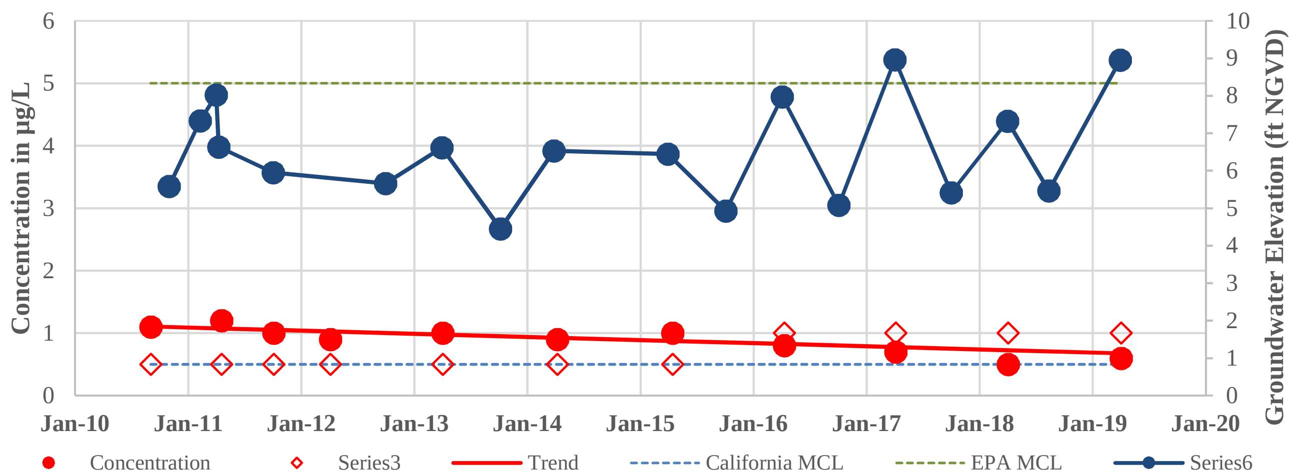

Carbon Tetrachloride Concentration in B277
Concentration in µg/L
Groundwater Elevation (ft NGVD)
6
5
4
3
2
1
0
6
5
4
3
2
1
0
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Concentration
Reporting Limit
Trend
California MCL
EPA MCL
GW Elevation


Carbon Tetrachloride Concentration in B280A
Concentration in µg/L
Groundwater Elevation (ft NGVD)
6
5
4
3
2
1
0
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Concentration
Reporting Limit
Trend
California MCL
EPA MCL
Series6

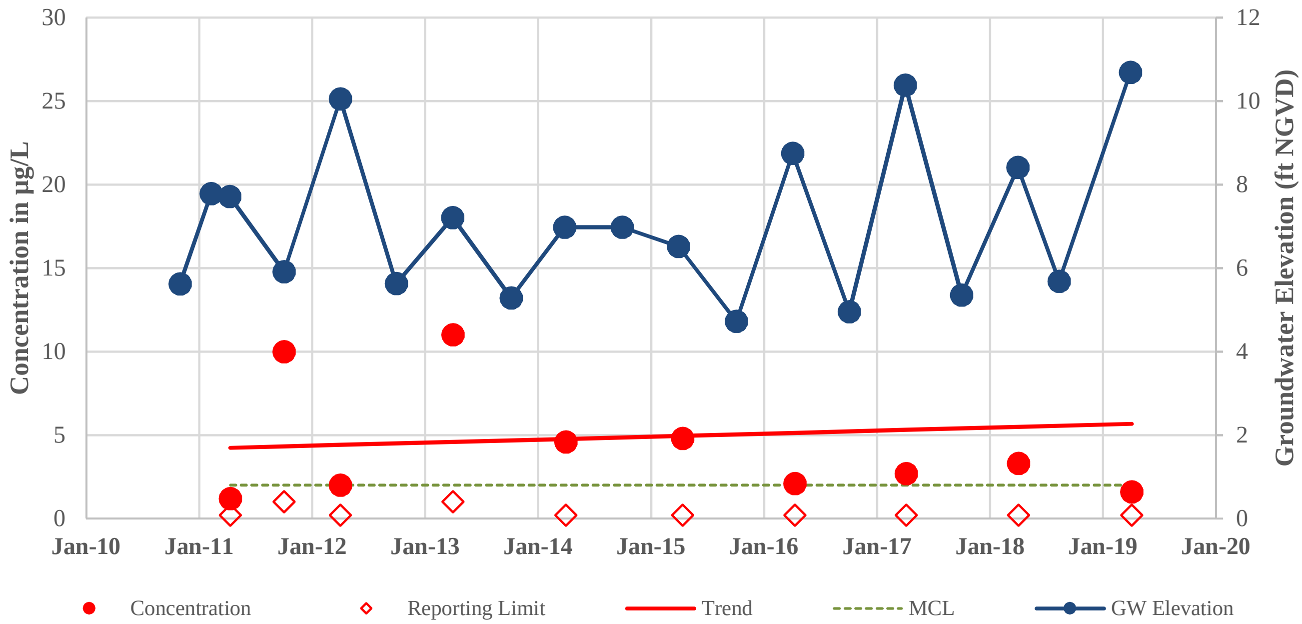
Carbon Tetrachloride Concentration in CTP



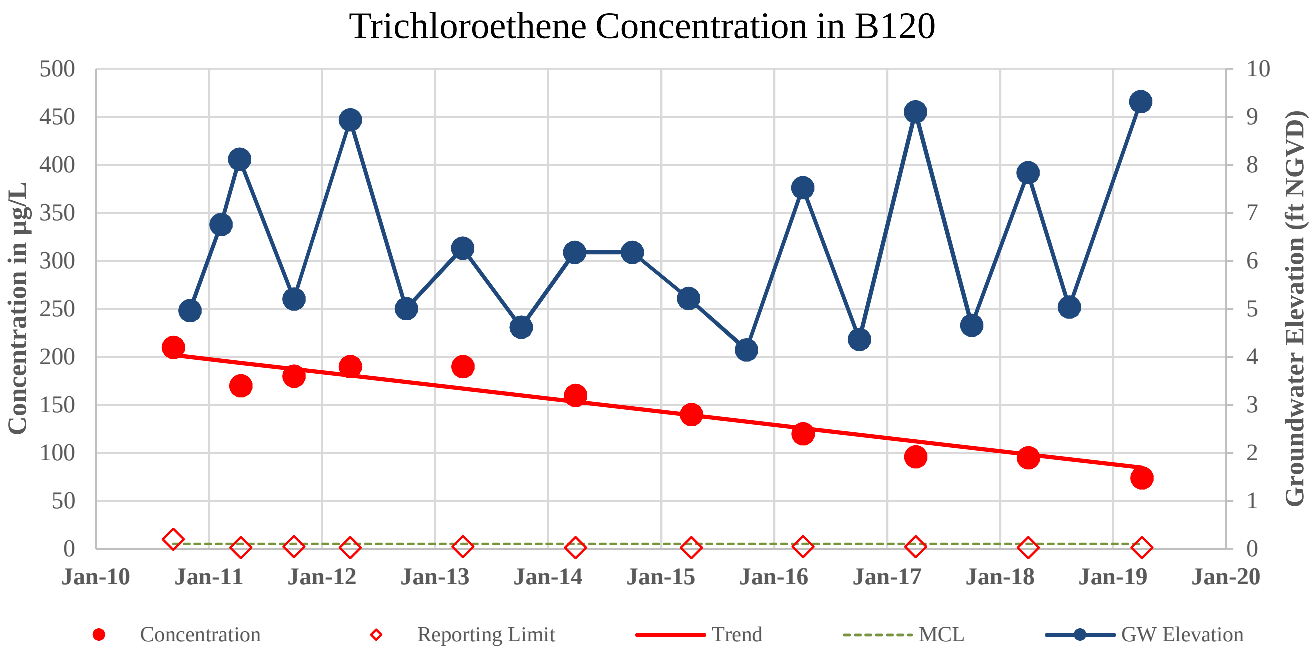
Carbon Tetrachloride Concentration in GEO

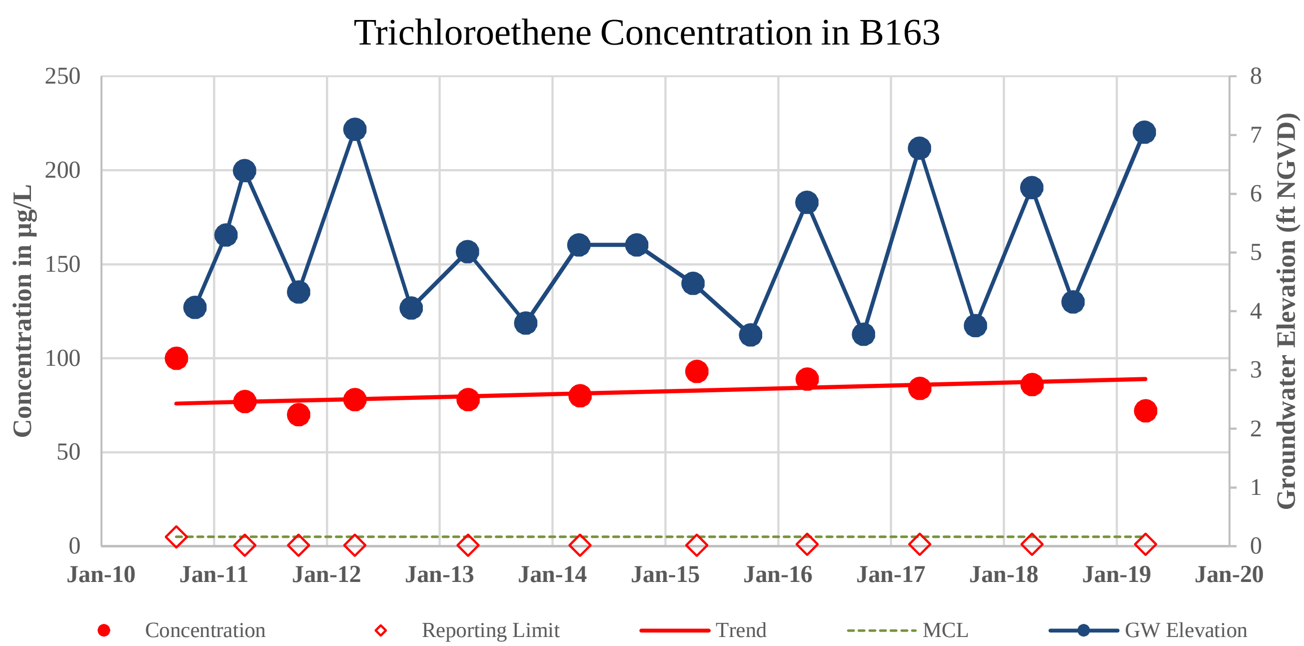


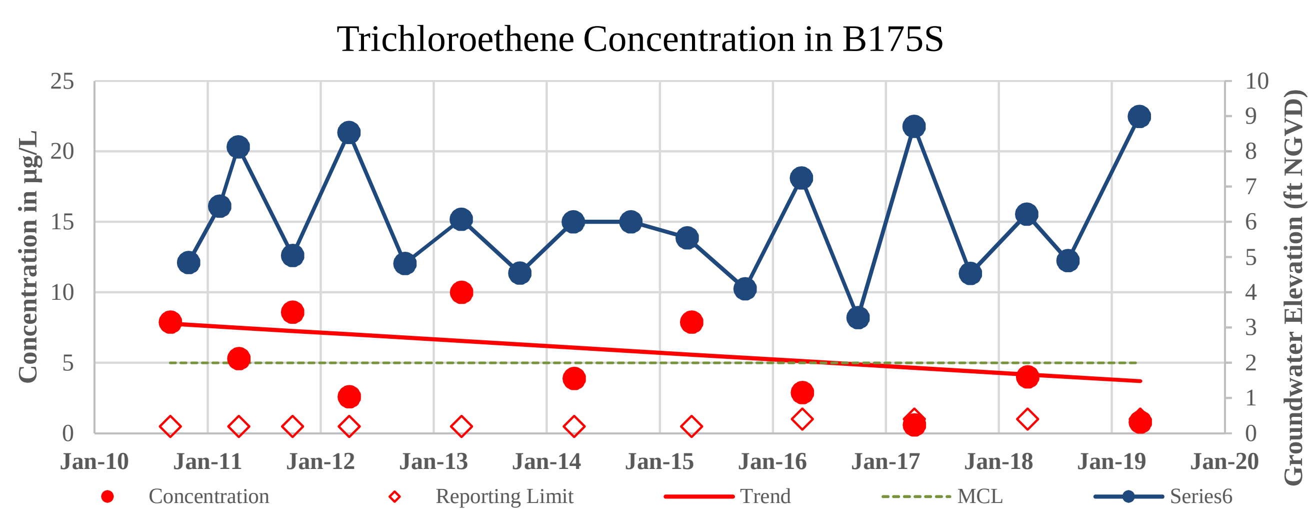
Dissolved Mercury Concentration in B195



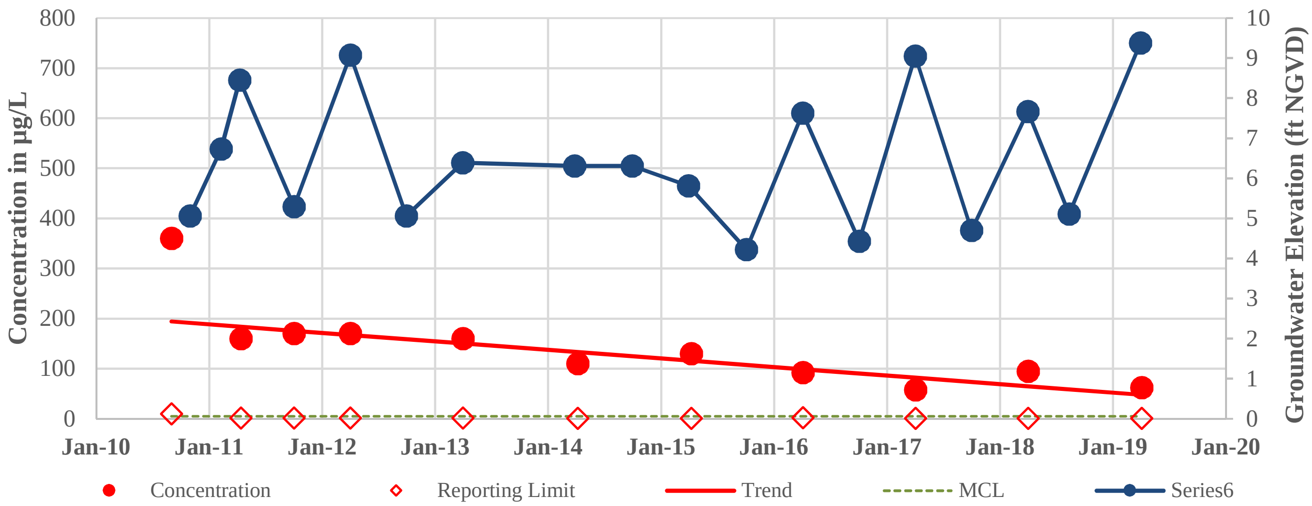
Note: Dissolved mercury concentrations were reported, as MCLs are based on dissolved concentrations of metals. Results for unfiltered mercury collected between 2010 and 2012 were not reported. See Appendix B for complete analytical results.


Trichloroethene Concentration in B120
Concentration in µg/L
Groundwater Elevation (ft NGVD)
500
450
400
350
300
250
200
150
100
50
0
10
9
8
7
6
5
4
3
2
1
0
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Concentration
Reporting Limit
Trend
MCL
GW Elevation

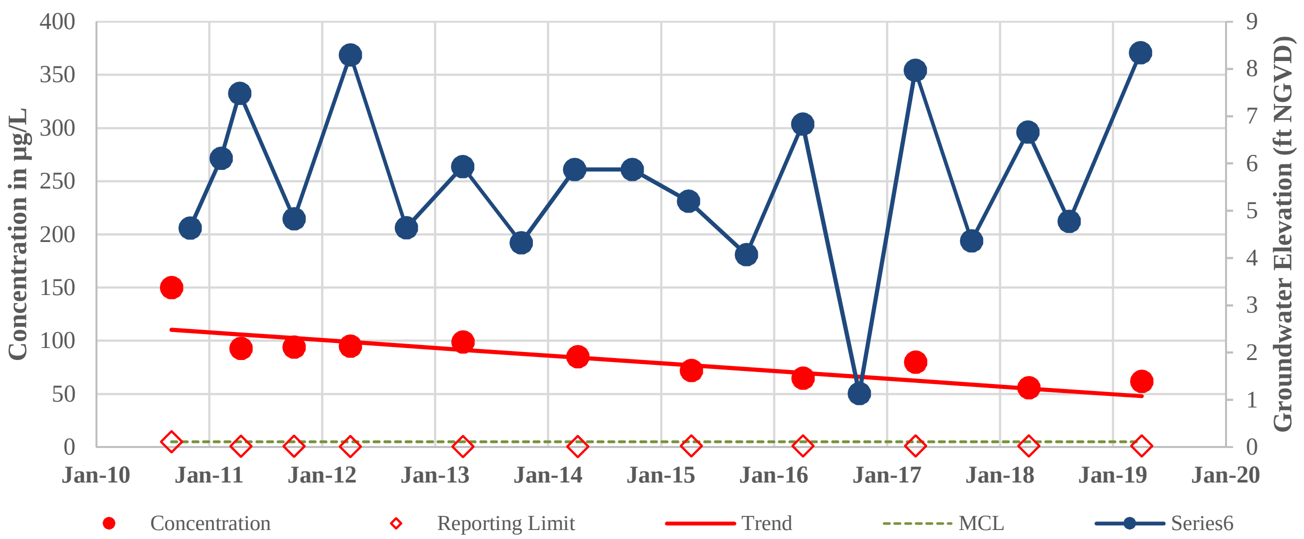

Trichloroethene Concentration in B163
Concentration in µg/L
Groundwater Elevation (ft NGVD)
250
200
150
100
50
0
8
7
6
5
4
3
2
1
0
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Concentration
Reporting Limit
Trend
MCL
GW Elevation


Trichloroethene Concentration in B175S
Concentration in µg/L
Groundwater Elevation (ft NGVD)
25
20
15
10
5
0
10
9
8
7
6
5
4
3
2
1
0
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Concentration
Reporting Limit
Trend
MCL
Series6

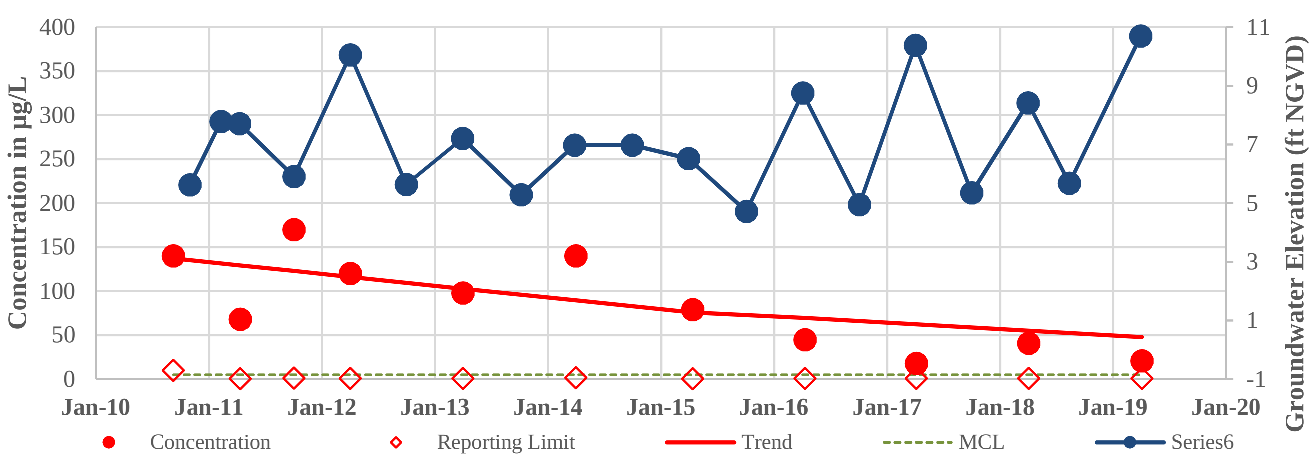
Trichloroethene Concentration in B178



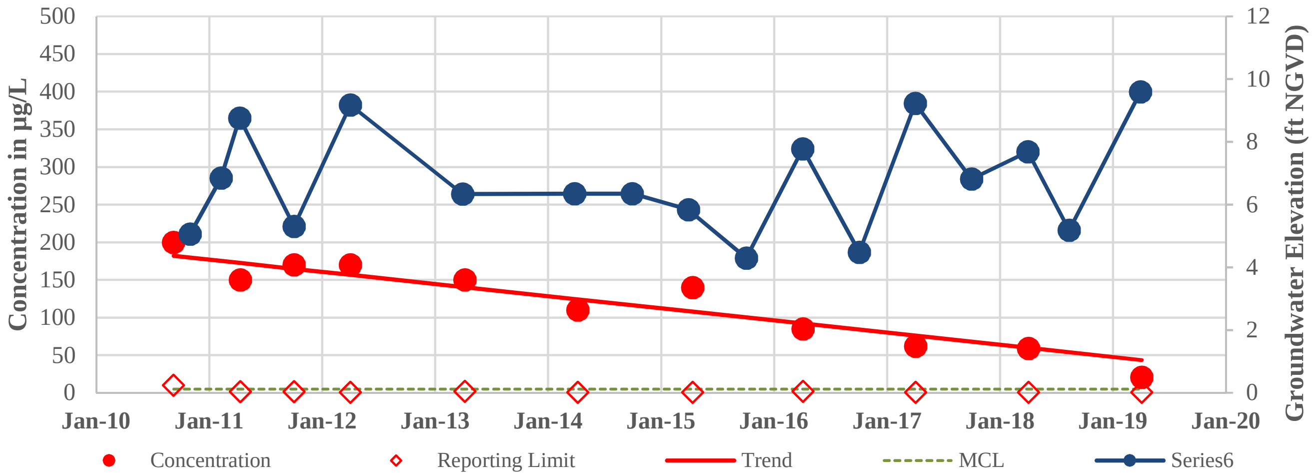
Trichloroethene Concentration in B185



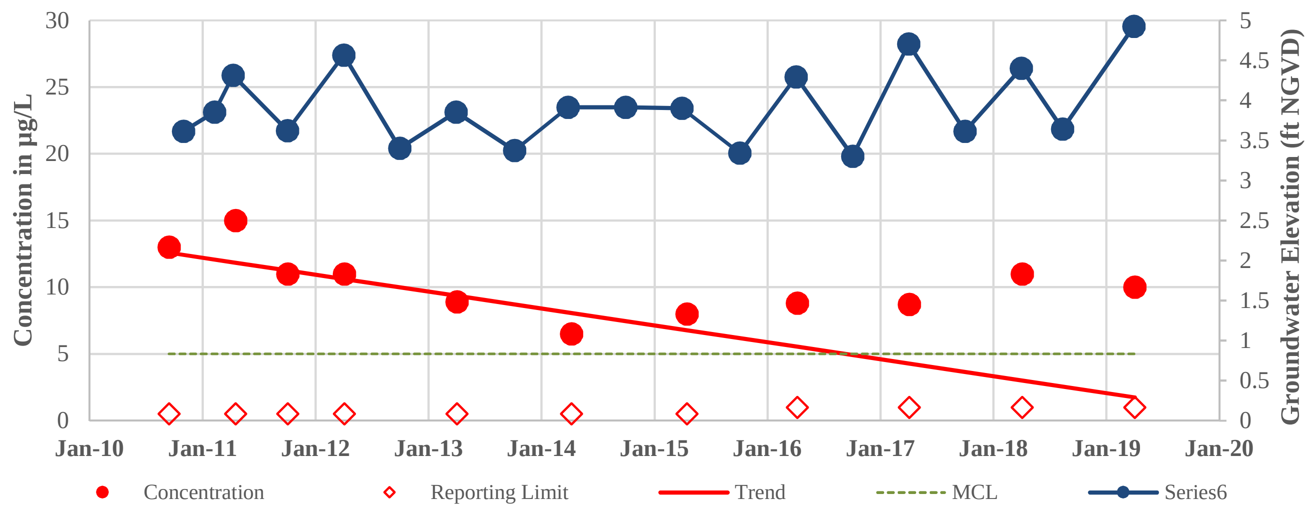
Trichloroethene Concentration in B195



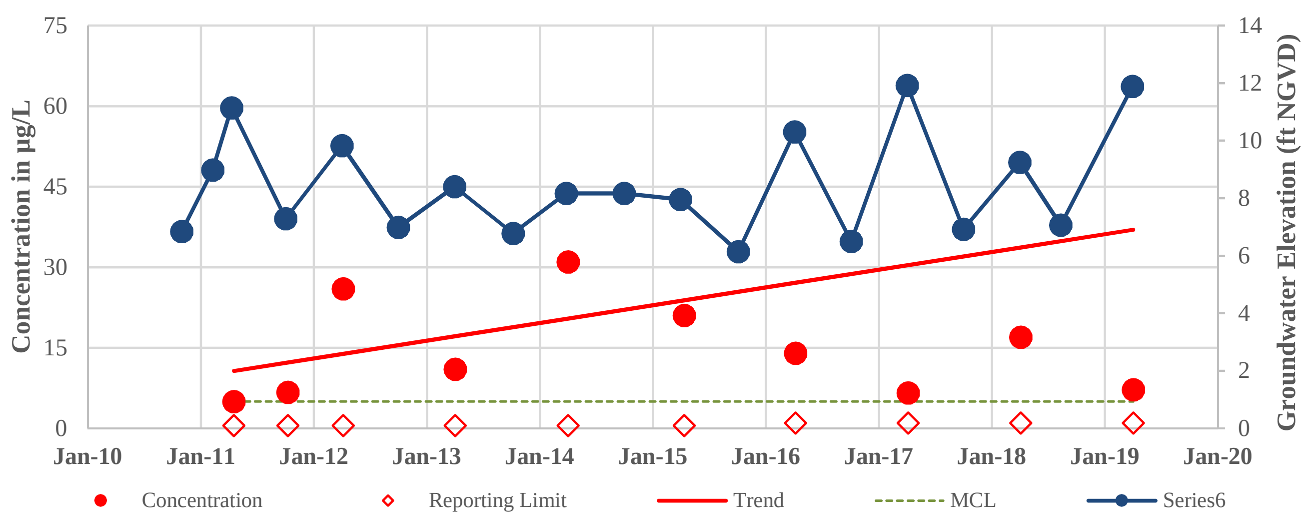
Trichloroethene Concentration in B197/B197R



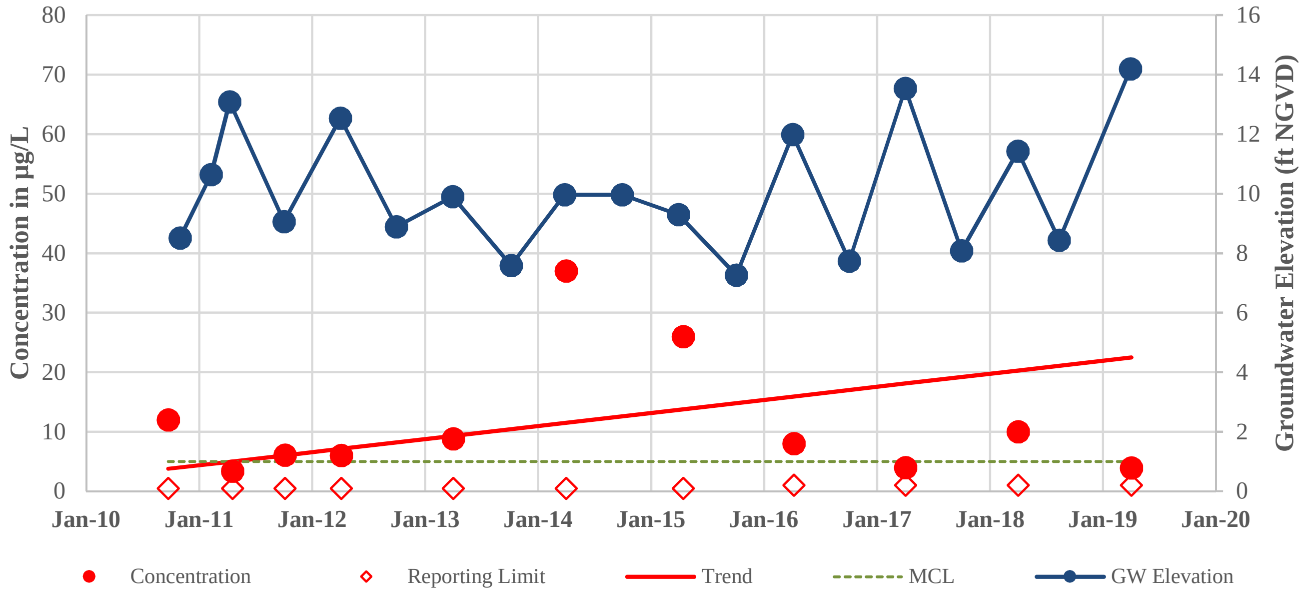
Trichloroethene Concentration in B278



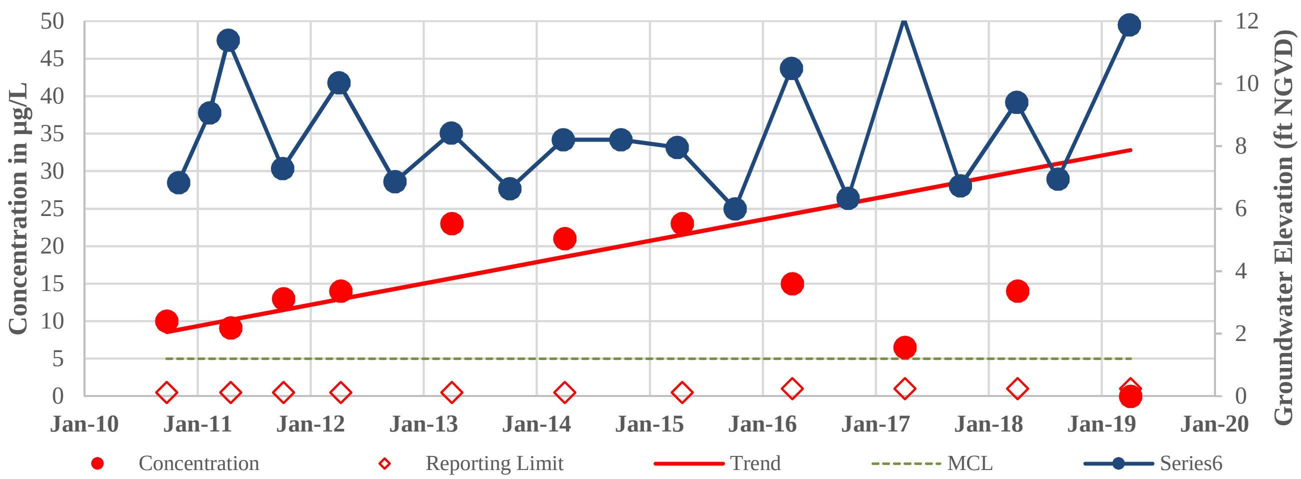
Trichloroethene Concentration in B450



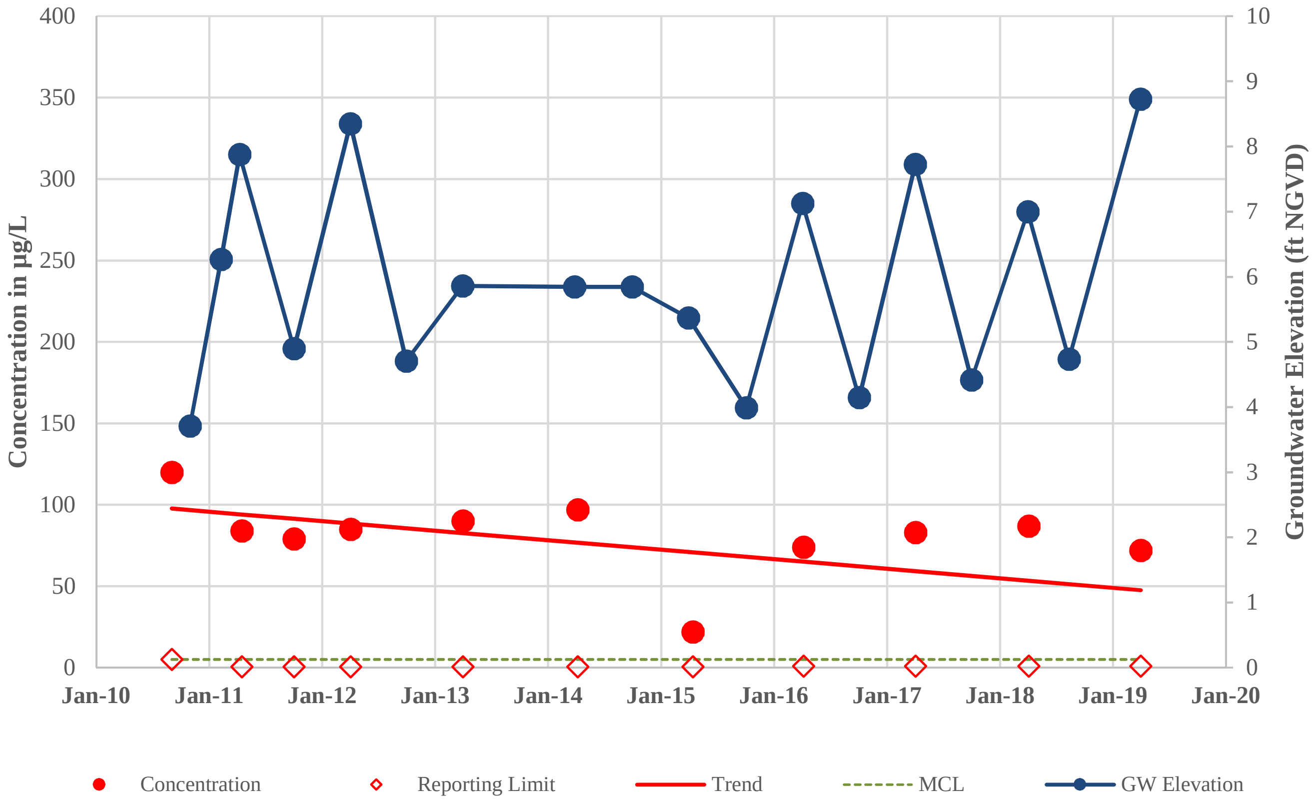
Trichloroethene Concentration in B473



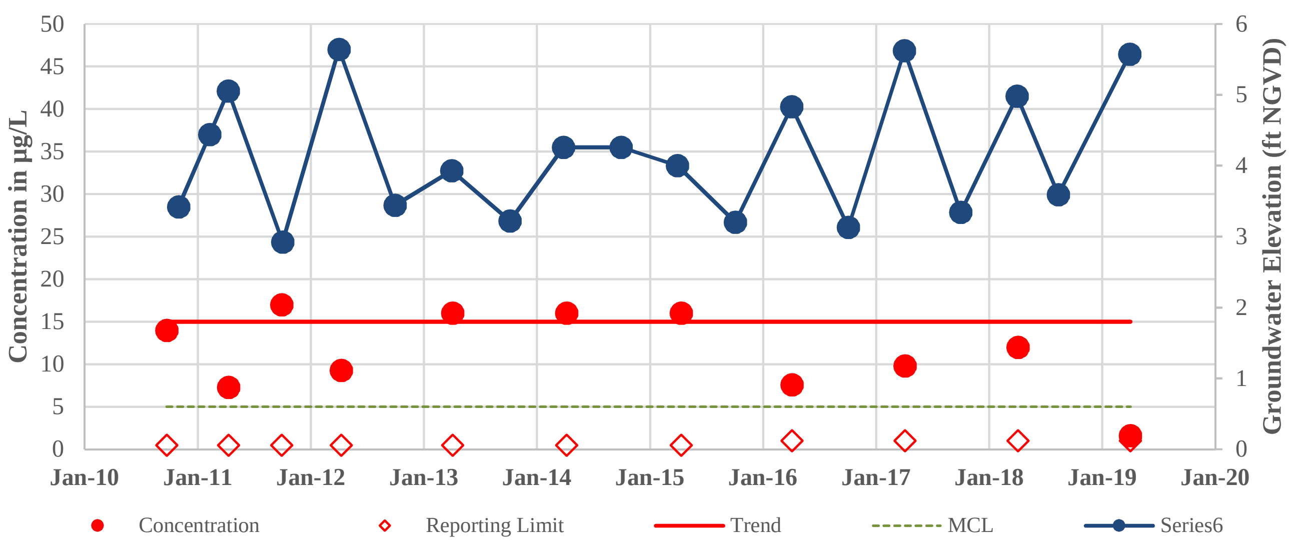
Trichloroethene Concentration in B480

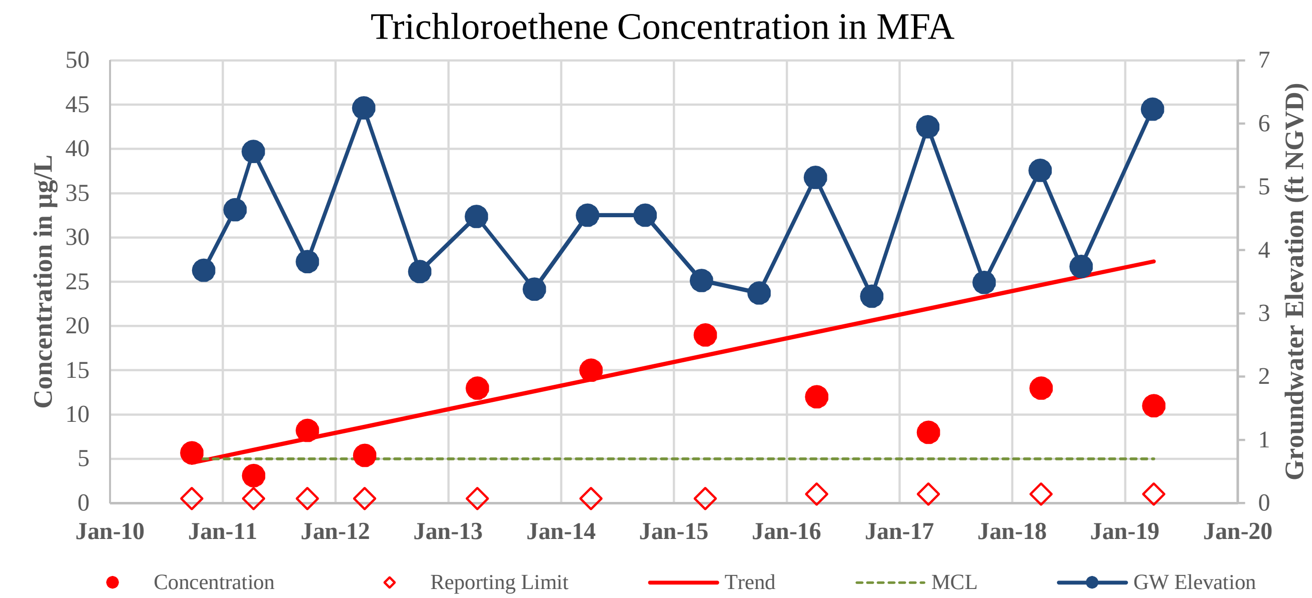


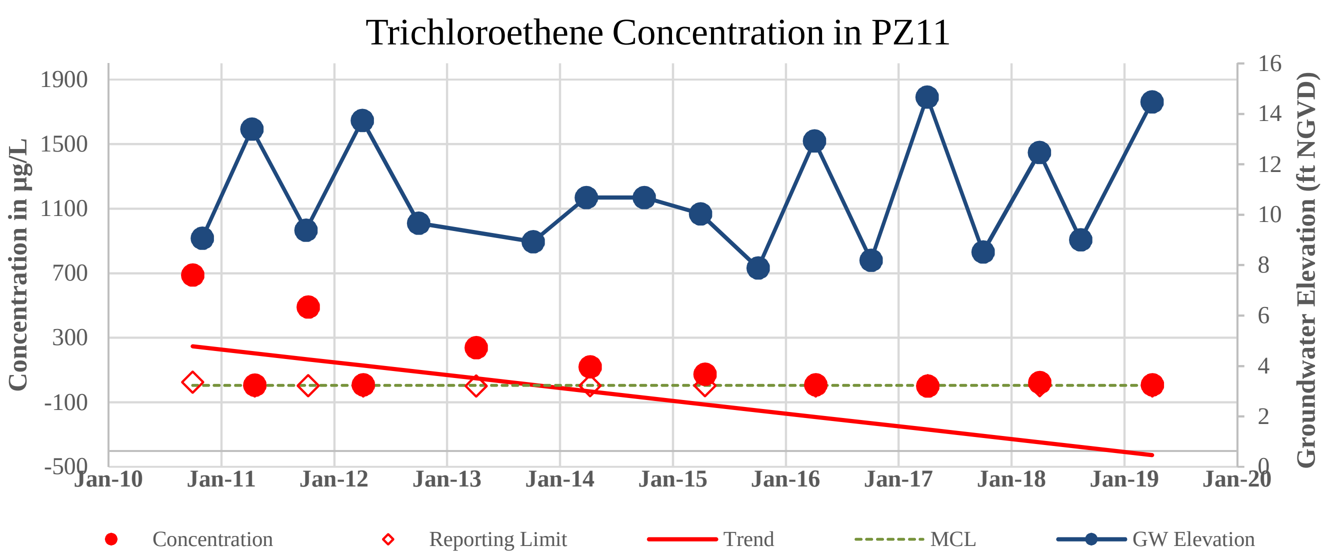
Trichloroethene Concentration in CCCT

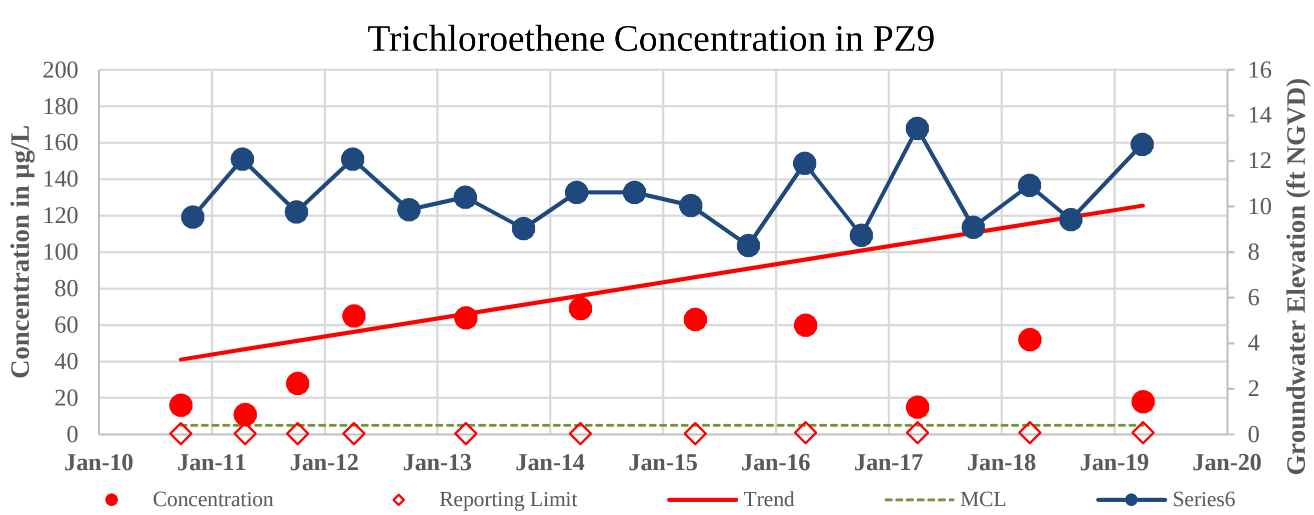


Trichloroethene Concentration in ETA

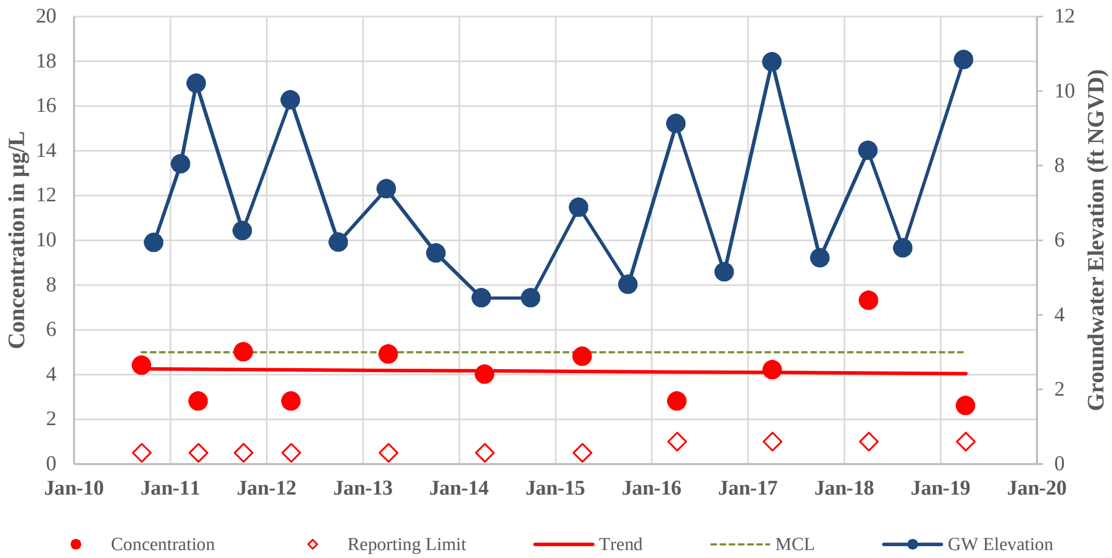



Trichloroethene Concentration in MFA
Concentration in µg/L
Groundwater Elevation (ft NGVD)
0
5
10
15
20
25
30
35
40
45
50
0
1
2
3
4
5
6
7
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Concentration
Reporting Limit
Trend
MCL
GW Elevation

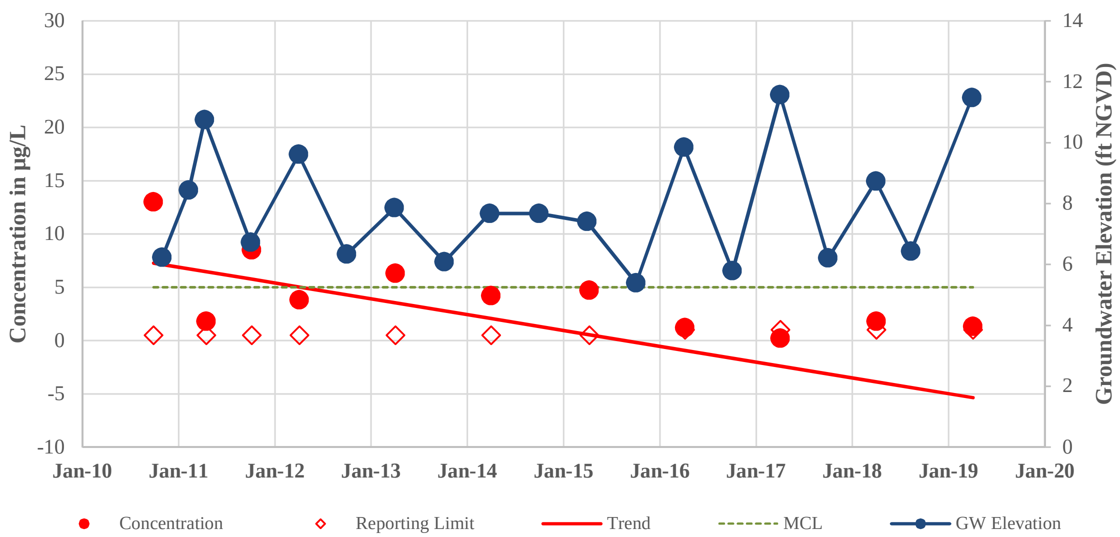

Trichloroethene Concentration in PZ11
Concentration in µg/L
Groundwater Elevation (ft NGVD)
-500
-100
300
700
1100
1500
1900
0
2
4
6
8
10
12
14
16
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Concentration
Reporting Limit
Trend
MCL
GW Elevation


Trichloroethene Concentration in PZ9
Concentration in µg/L
Groundwater Elevation (ft NGVD)
0
20
40
60
80
100
120
140
160
180
200
0
2
4
6
8
10
12
14
16
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Concentration
Reporting Limit
Trend
MCL
Series6

Trichloroethene Concentration in RWF



Trichloroethene Concentration in TP1



Trichloroethene Concentration in TP2