



**VAPOR INTRUSION
EVALUATION REPORT**

**FORMER TRW MICROWAVE
FACILITY
825 STEWART DRIVE
SUNNYVALE, CALIFORNIA**

FEBRUARY 2014

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1.0 INTRODUCTION

This *Vapor Intrusion Evaluation Report* was prepared in accordance with the *Vapor Intrusion Evaluation Sampling and Analysis Work Plan* (Work Plan, AECOM 2013) and in response to the following correspondence with regulators:

- 6 December 2012 *Requirement for Vapor Intrusion Sampling and Analysis Work Plan and Report* letter from the San Francisco Regional Water Quality Control Board (RWQCB);
- Comments issued on 17 May 2013 (revised per input from teleconference on 4 June 2013) by the RWQCB on the draft submittal of the work plan; and
- Additional comments issued on 23 August 2013 by the United States Environmental Protection Agency (USEPA) on the final submittal of the work plan.

The December 2012 letter from the RWQCB required Northrop Grumman Systems Corporation (Northrop Grumman) to submit a work plan for conducting vapor intrusion sampling and analysis at the former TRW Microwave Operable Unit (OU) (the "Site") at 825 Stewart Drive, Sunnyvale, California (Figure 1). The RWQCB regulates the site under Order No. 91-103. The USEPA also oversees the Site as it was added to the National Priorities List (NPL) in 1990 and has been following the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. A Record of Decision (ROD) addressing soil and groundwater at the Site as well as three neighboring OUs was approved by the USEPA in 1991 (USEPA 1991). The remedy selected in the ROD addressed groundwater impacted by trichloroethene (TCE) and related chlorinated volatile organic compounds (VOCs).

1.1 Background

During the post-ROD Five Year Review process the vapor intrusion (VI) pathway was identified as requiring evaluation for protectiveness and VI investigations were performed at the Site between 2003 and 2004 with results of these investigations summarized in the Third Five Year Review Report (Camp Dresser & McKee, Inc. [CDM] 2009).

This Report addresses the current VI pathway at the Site, which is occupied by a single, two-story building that overlies groundwater impacted with VOCs from both on and offsite sources. The building has been vacant since 2001 and is not equipped with mechanical ventilation, electricity, or plumbing. The area of the Site is currently zoned as industrial. Chemicals of concern (COCs) in the groundwater include the chlorinated VOCs: TCE, tetrachloroethene (PCE), and their degradation products (primarily cis-1,2-dichloroethene [cDCE] and vinyl chloride [VC]). Table 1 lists the groundwater COCs identified in the ROD, and other VOCs investigated as potentially of concern via the VI pathway.

1.2 Objective

The primary objective of this report is to assess the VI pathway at the current Site building and to evaluate the possible future need for a VI remedy, using results of indoor and outdoor (ambient) air and sub-slab vapor samples collected at the Site on 9 and 10 December 2013.

The report presents the methods and procedures used for collecting multiple lines of evidence for evaluating the VI pathway and the measures taken to ensure that data obtained are reliable and usable. Data obtained during the VI sampling event were used to assess potential risk to future industrial users. The project action limits (PALs) for groundwater COCs and VOCs detected at the Site during previous VI investigations are listed in Table 1. These PALs include USEPA Regional Screening Levels (RSLs) for indoor air industrial exposure, most recently published in November 2013 (USEPA 2013a), or more restrictive RWQCB Environmental Screening Levels (ESLs), most recently published in December 2013 (RWQCB 2013). The more restrictive ESLs apply to cDCE, PCE, and VC.

1.3 Report Organization

This Report is organized as follows:

- Section 1 provides an introduction, background, and the project objective.
- Section 2 provides a brief site background, chronology and summary of previous indoor air sampling activities, and conceptual site model related to VI.
- Section 3 describes the scope of the investigation, including pre-sampling activities, field activities, laboratory analyses, and quality assurance procedures.
- Section 4 describes how the data were evaluated.
- Section 5 includes interpretation of results, uncertainties inherent in the sampling and data evaluation process, conclusions and recommendations.
- Section 6 provides references.

2.0 SITE BACKGROUND

2.1 Site Location and Description

The Site is located in an industrial area occupied by a vacant two-story building. Prior to 1968, the Site was not used for industrial activities. Between 1968 and 1993, Site activities included the assembly and testing of microwave and semiconductor components. These operations involved the use of TCE. Other industrial solvents and hazardous wastes were generated as a by-product of the operations. Waste solvents, primarily TCE, were stored in an underground storage tank (UST) from 1970 to 1982. The UST was removed in early 1983 and the surrounding VOC-

impacted soil was excavated in 1984, after which the excavation was backfilled with gravel. A 6-inch perforated polyvinyl chloride (PVC) pipe, referred to as the Eductor, was installed within the backfilled excavation to facilitate groundwater extraction. Vadose zone treatment using soil vapor extraction (SVE) removed approximately 140 pounds of TCE between 1993 and 1998. The SVE system was dismantled in 1998 following demonstration that the criteria for closure had been met (CDM 1998). Groundwater extraction and treatment (GWET) was initiated in 1985 and approved for suspension in 2001. In 2000, an enhanced anaerobic bioremediation (EAB) program was initiated at the Site and has continued to the present day. A summary of historic groundwater results associated with groundwater remediation efforts is included in Appendix A. The 2013 groundwater sampling results from the Eductor and existing groundwater monitoring wells closest to the Site structure are shown on Figure 2.

Between 2001 and 2003, the exterior of the existing Site building was remodeled. As part of the remodel, a portion of the Site building was demolished, and a new structure contiguous with the existing structure was constructed (see red outline on Figure 2); this new structure overlies the former UST excavation. Per building drawings (available through the City of Sunnyvale Planning Department), a 10 mil (one mil equals 0.001 inch) thick vapor barrier was installed beneath the portion of the building that was remodeled. The interior of the building remains unfinished (Appendix B, Photographs B-1 through B-4). The Site has been unoccupied and without mechanical ventilation since January 2001.

The Site is surrounded by the following VOC-impacted sites: Advanced Micro Devices (AMD) Buildings 901/902 Thompson and 915 DeGuine; Philips Semiconductors (Philips; formerly Signetics Inc.) Buildings 811 Arques, 815 Stewart, and 440 Wolfe; and Mohawk Laboratories. Three of these facilities (AMD 901/902, Philips 811, and Mohawk Laboratories) are located hydraulically upgradient (south) of the Site; two facilities (Philips 815 and 440) are located approximately cross-gradient (west) of the Site, and one facility (AMD Building 915) is located downgradient (north) of the Site. These surrounding sites have historically used TCE and other chlorinated VOCs in their manufacturing processes and have released these VOCs to groundwater.

2.2 Summary of Previous Indoor Air Sampling Activities

The VI risk posed by VOCs present in groundwater at the Site was evaluated as part of a Baseline Public Health Evaluation (BPHE) and summarized in the ROD issued for the Site in 1991 (USEPA 1991). Risk estimates presented in the BPHE were based on modeling transport of vapors from groundwater into hypothetical residences using groundwater VOC concentrations current at the time of the BPHE. For the average exposure case, the excess cancer risk due to potential exposure to VOCs in indoor air was calculated to be 4×10^{-5} . In the more than two decades since the BPHE was performed, VOC concentrations in groundwater beneath the building have been significantly reduced through remedial activities at the Site.

The human health risk associated with VI was updated as part of indoor air quality sampling events conducted at the Site in 2003 and 2004. The first sampling event was conducted in October 2003. Sampling locations are presented on Figure 3. A complete presentation of the sample collection, analytical results, and performance analysis of this event was provided to the RWQCB in an *Evaluation of Indoor Air Sampling Results* (CDM 2004a). The concentrations of detected VOCs were compared to the following threshold values: ESLs for residential and commercial exposures listed in the RWQCB's *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater (Interim Final)* dated July 2003; and/or the target indoor air concentrations (TIACs) presented in USEPA's *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* dated 29 November 2002. Note that ESLs developed in accordance with the 2003 RWQCB guidance were those chemical concentrations that posed either a cancer risk level of 1 in a million (10^{-6}) or a non-cancer hazard quotient (HQ) of 0.2 while the USEPA TIACs were concentrations posing a cancer risk level of 1 in one hundred thousand (10^{-5}) or a non-cancer HQ of 0.1 (using toxicity criteria current at the time). VOCs detected above one or the other of these respective indoor air threshold levels included TCE, PCE, VC, and chloroform. Results are summarized in Table 2, which also includes a comparison to current (2013) indoor air RSLs (USEPA 2013a) for industrial exposure and ESLs (RWQCB 2013). In the *Work Plan for Indoor Air Sampling and Risk Assessment*, CDM (2003) proposed that the concentrations of indoor air VOCs exceeding threshold levels could be mitigated by building improvements including the installation and operation of a standard mechanical ventilation system with an air exchange rate (AER) of at least one (1) building volume per hour.

In April 2004, subsequent to issuance of a work plan (CDM 2004b) followed by RWQCB approval (RWQCB 2004a), additional air samples were collected, prior to and after installation and operation of a temporary mechanical ventilation system within the Site building. Refer to Table 2 for results of these April 2004 indoor air samples collected to evaluate the effectiveness of ventilation in reducing concentrations of VOCs below threshold levels (sampling locations shown on Figure 3). The temporary system maintained an AER of approximately 1.0 for several days inside the Site building. In May 2004, the *Report of Findings – Installation and Operation of a Temporary Mechanical Ventilation System and Indoor Air Sampling* (CDM 2004c) was submitted to the RWQCB. This report concluded that the rate of vapor intrusion into the Site building continued to be low enough to be mitigated solely with installation and operation of a standard ventilation system designed with an AER of 1. The RWQCB (2004b) approved this report in July 2004, but requested additional sampling without mechanical ventilation.

A third indoor air quality sampling event was conducted in October 2004 in accordance with a RWQCB-approved Work Plan (CDM 2004d and RWQCB 2004c). This third round of indoor air sampling was conducted without operation of a mechanical ventilation system to evaluate whether improvement in the groundwater conditions at the Site would eliminate the need for any further monitoring of indoor air quality. Results are summarized in Table 2 with sampling locations shown on Figure 3.

In November 2004, the *Report of Findings – October 2004 Indoor Air Sampling* (CDM 2004e) was submitted to the RWQCB. The report confirmed conclusions of the earlier report, namely that in the absence of a ventilation system, concentrations of TCE detected in indoor air exceeded the indoor air threshold limits for industrial exposure. However, the report concluded that mitigation of indoor VOC concentrations to below the threshold levels could be achieved solely with installation and operation of a standard ventilation system designed for an AER of 1. This conclusion remains valid when the results are compared to current 2013 threshold values included in Table 2.

In December 2004, the RWQCB approved the November 2004 report; recommended that adequate ventilation be maintained in the Site building if occupied in order to minimize risk to the health of building occupants; and requested an additional round of indoor air samples be collected from the building after installation/operation of the ventilation system but before it is occupied (RWQCB 2004d). The RWQCB further requested that Northrop Grumman prepare a Risk Management Plan (RMP) to guide future management of human health risks associated with occupancy of the Site building, with particular emphasis on the vapor intrusion pathway.

In April 2005, Northrop Grumman submitted a preliminary draft RMP (CDM 2005) to the RWQCB and property owner. The RMP was to be finalized upon occupancy of the Site building, identification of the intended use of the building, and installation of a ventilation system.

Table 2 summarizes the results from previous indoor air sampling events and includes a comparison to current USEPA RSLs and RWQCB ESLs for indoor air industrial exposure. As shown on the table, TCE was detected at similar concentrations in all three of the indoor air samples collected in October 2004, ranging from 4.3 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) to 5.1 $\mu\text{g}/\text{m}^3$ and was the only analyte that exceeded its 2013 indoor air RSL for industrial exposure of 3 $\mu\text{g}/\text{m}^3$.

A chronology of major events associated with Site VI investigations and actions is presented below:

Date	Event
October 2003	Initial indoor air sampling: six indoor air samples and one outdoor air sample were collected and results documented in a report prepared by Camp Dresser & McKee, Inc. (CDM 2004a). Refer to Figure 3 for the locations of all previous indoor air samples.
March 2004	Northrop Grumman submitted a work plan (CDM 2004b) to install and operate a temporary mechanical ventilation system prior to collecting additional indoor air samples within the Site building.
April 2004	Subsequent to RWQCB approval (RWQCB 2004a), CDM installed and operated a temporary mechanical ventilation system within the Site building and collected indoor air samples prior to and following activation of the temporary system.

Date	Event
May 2004	Northrop Grumman submitted a <i>Report of Findings – Installation and Operation of a Temporary Mechanical Ventilation System and Indoor Air Sampling</i> report to the RWQCB (CDM 2004c).
July 2004	RWQCB requested that "if the Site building is not occupied by October 2004, another round of indoor air samples be collected without mechanical ventilation to determine if improvements in groundwater quality reduced vapor intrusion to a level that does not require further monitoring" (RWQCB 2004b).
September 2004	In response to the RWQCB request, Northrop Grumman submitted a work plan (CDM 2004d) to conduct an additional round of indoor air sampling without mechanical ventilation.
October 2004	Subsequent to RWQCB approval (RWQCB 2004c) of the work plan, Northrop Grumman conducted another round of indoor air sampling without a mechanical ventilation system in operation.
November 2004	Northrop Grumman submitted a <i>Report of Findings – October 2004 Indoor Air Sampling</i> report to the RWQCB (CDM 2004e).
December 2004	RWQCB approved the October 2004 Indoor Air Sampling Report (RWQCB 2004d).
April 2005	Northrop Grumman submitted a preliminary draft Risk Mitigation Plan (RMP) to the Water Board (CDM 2005).
December 2012	RWQCB (2012) issued the 6 December 2012 <i>Letter of Requirement for Vapor Intrusion Sampling and Analysis Work Plan and Report</i> .

2.3 Geology/Hydrogeology and Conceptual Site Model

Figure 4 shows a conceptual site model (CSM) for vapor intrusion that depicts the subsurface geologic and hydrogeologic conditions beneath the Site building based on lithology and depth to groundwater observed in Site groundwater monitoring wells. Groundwater at the Site is encountered in sandy to silty clay in four aquifer zones. These zones are designated as Zone A (from the water table to approximately 25 feet below ground surface [bgs]) and Zones B1 through B5 (from approximately 30 to 100 feet bgs). For evaluation of VI, the concentrations in the shallowest zone, Zone A, encountered at a depth of 8 feet below the building, are considered most relevant. The CSM for the Site suggests that subsurface vapors containing VOCs volatilized from groundwater may travel upward through the vadose zone into the building through preferential pathways such as the Eductor. As described in Section 2.1, building drawings indicate that a vapor barrier was installed under the new portion of the building (outlined in red on Figure 2) constructed in 2002. Figure 2 also shows groundwater monitoring well locations and contaminant concentrations detected in groundwater in October 2013; groundwater flow is directed to the north.

There is no evidence that contaminant sources remain in the shallow vadose zone beneath or surrounding the building; vadose zone contamination was addressed by earlier SVE and source removal actions (CDM 1998). However, concentrations of VOCs detected in the indoor air may be attributed to volatilization from groundwater.

3.0 SCOPE OF WORK

Field activities were performed in accordance with the Work Plan (AECOM 2013). The protocol for the soil vapor sampling and analysis followed guidelines in the *Advisory – Active Soil Gas Investigations* (California Environmental Protection Agency [Cal-EPA] 2012). Other resources that were consulted during preparation of this report and development of the Work Plan include the *OSWER Final Guidance for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Sources to Indoor Air* (External Review Draft dated April 2013, USEPA 2013b), the *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (California Department of Toxic Substances Control [DTSC] 2011a), and the *Vapor Intrusion Mitigation Advisory* (DTSC 2011b).

Field activities included the installation and sampling of four sub-slab vapor wells (SS-1 through SS-4) and the collection of four indoor air samples (IA-1 through IA-4) and one outdoor ambient air sample (OA-1). Because the Site building interior is not equipped for occupancy, sample locations were not selected based on occupancy information, but rather were selected to evaluate the VI pathway in each of the three building sections (Sec. 1, Sec. 2, and Sec. 3) shown on Figure 5. Indoor Air Sample IA-1 was co-located with Sub-Slab Vapor Well SS-1 near the Eductor in Section 1 of the building. These locations (SS-1 and IA-1) vary slightly from those shown in the Work Plan as they had to be relocated due to subsurface obstructions identified during the geophysical survey. Also in Section 1, Sub-Slab Well SS-4 was located south of the Eductor to evaluate potential vapor sources from upgradient offsite groundwater contamination and Indoor Air Sample IA-4 was located near the elevator which may act as a conduit for VI. Indoor Air Samples IA-2 and IA-3 were co-located with Sub-Slab Wells SS-2 and SS-3 near the center of Sections 2 and 3 of the building. Outdoor ambient air sample OA-1 was collected outside of the northwest corner of the building (north of Sec. 1). Sample locations and photos are shown on Figure 5. Additional details regarding field activities are provided in the following sections.

3.1 Pre-Sampling Activities

A pre-sampling building survey was performed on 22 January 2013 (refer to Appendix C for completed building survey form). Construction on the building was stopped before plumbing, electricity, or a mechanical ventilation system was installed. Because the building interior is unfinished and not equipped for occupancy, no VOC products are located or used on site that might contribute to VOCs in the air. However, during the pre-sampling survey a drum of hydraulic fluid and a liquid sprayer were observed in the building. The sprayer was removed at least one week prior to sampling but the drum remained on-site. No other potential VOC sources were identified during either the pre-sampling survey or during sampling. Because the interior of the

building is unfinished, there are many openings through the concrete slab that could act as preferential pathways for VI, including open electrical conduits, restroom drains, and an elevator shaft (refer to Photographs B-5 through B-8). In addition, the Eductor and several groundwater monitoring wells located inside the building may act as conduits and contribute to the VI pathway (refer to Figure 4).

3.2 Field Activities

Sampling was performed on 9 and 10 December 2013. Sub-slab vapor wells were installed by TEG under the supervision of AECOM on 9 December 2013. After a minimum of 3 hours following vapor well installations, AECOM sampled the wells later on the same day. Sample times and other data were recorded on sub-slab vapor well field data sheets included in Appendix D.1. Indoor air and outdoor ambient air samples were collected on 10 December 2013. Prior to air sampling, a photoionization detector (PID) capable of detecting VOCs to one part per billion (ppb) was used to identify potential sources of VOCs at six locations inside the building (see circled numbers on Figure 5). As summarized in Table 3, all PID readings were negligible. Differential pressure measurements, recorded at the same locations (see forms included in Appendix D.2) ranged from -20 pascals (Pa) in the unfinished men's restroom located in Section 3 to -0.5 Pa near the center of Section 3. Temperatures inside the building ranged from 52 °F to 58 °F during sampling. Ambient weather conditions prior to and during sampling (recorded on field forms included in Appendix D.3) were dry with no rainfall; the outdoor temperature was in the low 40s (°F) representative of wintertime conditions in Northern California. Wind speed was negligible on the day of air sampling, with gusts of 6 to 8 miles per hour (mph). The outdoor air sample (OA-1) was positioned upwind and within 25 feet of the building at its northwest corner (refer to Figure 5).

Table 3. Field Measurements During Indoor Air Sampling

Location	Description	PID (ppb)	Pressure Differential (Pa)	Temperature (°F)
1. Section 1	Base of staircase by main entrance	0	-2.5	54
2. Section 1	Auxiliary room for elevator shaft	0	-4	53
3. Section 2	Southeast section of building	0	-1	55
4. Section 3	Center of Northern section of building	0	-0.5	55
5. Section 3	Unfinished Restroom (Women's)	0	-3	52

6. Section 3	Unfinished Restroom (Men's)	0	-20	58
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All field activities were performed in accordance with the Work Plan (AECOM 2013). The following subsections provide details regarding the procedures followed during sample collection.

3.2.1 Sub-Slab Vapor Well Installation and Sampling

AECOM subcontracted TEG to install four sub-slab vapor wells inside the building as shown on Figure 5. Each well was installed using a hand-held hammer drill fitted with a 1.5-inch diameter drill bit (Photograph B-9 in Appendix B). The boreholes were drilled to a depth of 3 inches below the concrete slab, which was determined to measure 5 inches in thickness. At the target depth, a stainless steel tip screen connected to 1/4-inch stainless steel tubing (Photograph B-10) was inserted into the bottom of the borehole so that the top of screen was 0.5 inch above the bottom of the borehole. Filter pack sand (#3) was placed around the well screen and extended to the bottom of the concrete, on top of which 1.5 to 3 inches of hydrated #8 bentonite crumbles were placed. The well was completed by pouring in quick-set cement to the floor surface, where the terminal end of the 1/4-inch stainless steel tubing was connected to a female-thread compression fitting with a metal screw plug flush with the building floor (Photograph B-11). A typical well completion diagram for the sub-slab vapor wells is shown on Figure 6. Well construction logs for the sub-slab wells are provided in Appendix D.4.

3.2.1.1 Sampling Equipment

All gauges and flow control manifolds were supplied by Test America Laboratories of Sacramento, California (TAMS). The gauges and manifolds were connected by chromatography-grade, stainless steel tubing and dedicated airtight, flexible, Teflon® tubing, materials that have a low capacity for adsorbing VOCs. Sample trains were assembled using 0.25-inch outer diameter nylon tubing for all vapor sampling. Swagelok® type connectors were used for connections between tubing and other sampling components.

Samples were collected in 1-liter Summa® canisters for the sub-slab vapor wells and 6-liter Summa® canisters for the indoor and outdoor air samples. All Summa® canisters were provided by TAMS with all 6-liter canisters individually certified as clean and the 1-liter Summa® canisters batch certified as clean. Canister certifications are provided in Appendix E. Each canister was field-verified to have a vacuum of at least 26 inches of mercury (in Hg) prior to sampling. Initial and final vacuum readings were recorded on field forms provided in Appendices D.1 and D.5.

3.2.1.2 Leak Testing

Prior to sampling, AECOM performed leak testing at each sub-slab well using lab-grade helium introduced into a clear plastic shroud covering the well (Photograph B-12 in Appendix B). The sampling equipment was connected in a sample train comprised of a PID used as a purge pump

and the Summa[®] canister equipped with the laboratory supplied flow regulator and vacuum gauge. Vapors were drawn from the well using the PID with built-in motor, and the magnitude of total VOCs was assessed. Laboratory-grade helium was used as the tracer gas to test for air leakage into the sampling system for the purpose of sample integrity verification. Helium from a cylinder was introduced via a port in the shroud to maintain a concentration of at least 10 percent helium by volume beneath the shroud. The helium concentration under the shroud was monitored using a helium detector via a second port in the shroud. A third port was connected to the PID for purging, leak testing, and measuring total volatile organic compounds (TVOCs) in the sample (Photograph B-13 in Appendix B). During leak testing, a portable helium detector was connected to the sampling train and used to confirm that helium was not detected in the sample train above a concentration of 5 percent of the helium concentration inside the shroud. The non-detection of helium above this concentration confirmed that the well was properly sealed and the sampling pump did not draw ambient air into the sample train. Helium measurements recorded during leak testing are provided on field forms included in Appendix D.1. Sampling equipment was thoroughly inspected to ensure tight fittings between all components. To minimize the potential for leakage, the soil vapor sampling rate was kept at less than (<) 200 milliliters per minute (mL/min) using a flow controller supplied by TAMS. Prior to sampling, a shut-in test was performed at each well. A shut-in test allows evaluation of the sample train for potential leaks and is accomplished by opening the Summa[®] canister valve with the well Swagelok[®] valve still closed. A vacuum was created and then the pump was closed off from the sample train and the initial vacuum pressure recorded. The sample train was considered to pass the leak test if constant vacuum was maintained for 10 minutes.

3.2.1.3 Purging

Prior to collecting a soil vapor sample, the sample train and vapor well were purged using a battery-powered PID to evacuate 3 well volumes; this procedure is followed so that the vapor samples collected are representative of actual soil vapor concentrations. Purge volumes were calculated based on the dimension specifications of all aboveground gauges, tubing, sampling equipment, and belowground tubing. The volumes of the well screen and sand pack were not included in the purge volume calculation because they are assumed to be in equilibrium with soil vapor in the subsurface. Purge volumes and durations were recorded on the vapor sampling field sheets included as Appendix D.1.

3.2.1.4 Sub-Slab Vapor Sample Collection

Sample collection from each of the soil vapor wells commenced immediately after purging and leak testing. Sample train integrity testing was performed using helium, concurrent with sampling, as described above. A vacuum was created to draw the soil vapor to the surface through the tubing and gauges. The vacuum was created using a PID equipped with a battery-powered pump with the sample collection point on the intake side of the pump to prevent any contaminants present in the pump from being drawn into the sample. A two-way valve and "T" fitting were used to isolate the pump from a separate tube connected to the vapor sample canister (Photograph B-13 in Appendix B). Figure 6 shows the sampling apparatus for sub-slab vapor sampling. To begin sampling, the valve on the Summa[®] canister was opened and the time and initial vacuum

were documented. As the canister filled, the pressure gauge on the flow controller was observed to confirm that vacuum in the canister was decreasing over time. The valve was closed when the canister vacuum had decreased to approximately 4 in Hg.

Once the samples were collected, the Summa[®] canister valves were closed and sealed using brass caps supplied by TAMS. Samples were labeled following standard chain-of-custody (CoC) protocols, including noting the final canister vacuums and the serial numbers of all canisters and flow controllers. AECOM documented the sampling activities, such as sampling times and conditions, in the field sheets included in Appendix D.1. Samples were delivered directly to the analytical laboratory under CoC protocols within 24 hours of sampling.

Summa[®] canister vacuum was noted in the field for each sample and upon receipt at the laboratory to evaluate sample integrity following shipment.

3.2.2 Indoor Air and Ambient Outdoor Air Sample Collection

Four indoor air samples were collected for laboratory analysis: one each (IA-1 through IA-3, Photographs B-14 through B-19 in Appendix B) in building Sections 1-3 and co-located with Sub-slab Vapor Samples SS-1 to SS-3; and the fourth (IA-4, Photographs B-20 and B-21 in Appendix B) positioned near the elevator shaft in Section 1 (refer to Figure 5). The ambient outdoor air sample (OA-1) was positioned approximately 35 feet upwind and on the northwest corner of the building (Photographs B-22 and B-23 in Appendix B). The Summa[®] canisters were equipped with flow regulators supplied by TAMS and set to allow a 12-hour sampling period. The outdoor air sample was collected to evaluate the contribution from ambient outdoor air to indoor air. Duplicate samples were collected for IA-1 located next to the Eductor and for outdoor air sample OA-1.

3.2.2.1 Indoor Air Sampling Procedure

Each indoor air sample was collected using a 6-liter Summa[®] canister supplied by TAMS, a California-certified laboratory. All Summa[®] canisters were individually certified clean by the laboratory (certifications are provided in Appendix E). Each canister was fitted with a vacuum gauge and evacuated by TAMS to a vacuum greater than 26 in Hg. The canisters were fitted with a laboratory-calibrated flow controller to collect an air sample at a constant flow rate over an approximate 12-hour period. Actual sampling durations varied from approximately 10 hours for OA-1 and IA-1 to 11 hours for IA-2 through IA-4. Sampling was stopped when canister vacuums fell below 5 in Hg. The canister vacuum was recorded prior to sampling, periodically during the filling period, and at the conclusion of the sampling interval. The canisters used to collect the indoor air samples were placed approximately 4 feet above the floor to provide a sample representative of the breathing zone. Field data sheets used to record sample times and vacuum pressures are included in Appendix D.5.

3.2.2.2 Outdoor Air Sampling Procedure

The outdoor air sample and duplicate were collected using certified clean 6-liter Summa® canisters supplied by TAMS. The canisters were fitted with a laboratory supplied vacuum gauge and were received under a vacuum of greater than 26 in Hg. The canister was fitted with a laboratory-calibrated flow controller regulated to collect the sample at a constant flow rate over an approximate 12-hour period. Sample collection was started prior to filling of the indoor air samples and stopped when the vacuum gauge reached 5 in Hg (as mentioned above, the actual sampling period was approximately 10 hours). As with the indoor air samples, the canister vacuum was recorded prior to sampling, periodically during the filling period, and at the conclusion of the sampling interval. The canisters for the normal and duplicate samples were placed in a cardboard box atop inverted buckets to allow protection from the elements.

3.3 Laboratory Analysis

All vapor samples collected from the sub-slab vapor wells were analyzed for VOCs using modified EPA Method TO-15 in full scan mode and all indoor and outdoor air samples were analyzed for VOCs using TO-15 selective ion monitoring (SIM). The analytes included in the TO-15 SIM analysis were selected in the Work Plan and include those chemicals identified as COCs in groundwater and four additional chemicals identified during previous indoor air sampling events at the building (refer to Table 1).

3.4 Quality Assurance Sampling and Procedures

A total of five sub-slab vapor samples and seven air samples were collected. One duplicate sample was obtained for the sub-slab vapor samples at Sub-Slab Vapor Well SS-1. A duplicate sample of indoor air was obtained at Sample IA-1 and a duplicate of the outdoor air was collected at Sample OA-1. Duplicate samples were obtained using a "T" splitter located between the flow controller and two sample canisters (refer to Photographs B-14 and B-22 in Appendix B).

Samples were labeled following standard CoC protocols, including noting the final canister vacuums and the serial numbers of canisters and flow controllers. AECOM documented sampling activities, including sampling times and conditions on field sheets (Appendix D). Samples were transported under CoC protocols within 24 hours to TAMS in Sacramento, California.

Results for all samples, including duplicates, underwent review and validation by Conestoga-Rovers and Associates (CRA). All sample collection, laboratory analyses, and data validation were performed according to procedures in the Work Plan (AECOM 2013). A Quality Assurance Summary Report (QASR) prepared by CRA is included in Appendix F. The QASR indicates that the sampling data included in this report met the quality objectives for precision, accuracy, representativeness, comparability, and completeness.

4.0 VAPOR INTRUSION PATHWAY EVALUATION AND RISK ANALYSIS

Laboratory analytical results for the sub-slab vapor samples are included in Table 4, with results for indoor and outdoor air included in Table 5. Complete laboratory analytical results are included in Appendix E.

4.1 Evaluation and Results

Indoor air VOC concentrations were compared to sub-slab vapor and ambient outdoor air concentrations to determine whether there is sufficient evidence of a complete VI pathway. Sufficient evidence is considered obtained if 1) a chemical is detected in the sub-slab vapor at a higher concentration than in the indoor air; 2) indoor air samples contain greater concentrations of VOCs than ambient outdoor air, and 3) the presence of the chemical cannot be explained by site activities or current chemical use. The USEPA, in VI guidance documents (USEPA 2002 and 2013b), has defined default attenuation factors based on source medium and typical building types. These default attenuation factors are identified in Table 6 below along with a comparison of default attenuation factors recommended by the California (CA) DTSC (DTSC 2011a).

Table 6. Default Attenuation Factors from VI Guidance

Contaminated Media	USEPA Default Attenuation Factor (Draft VI Guidance 2002)	USEPA Proposed Revised Default Attenuation Factor (Draft Final VI Guidance 2013)	CA DTSC Default Attenuation Factor (VI Guidance 2011)
Shallow soil gas (including sub-slab soil vapor)	0.1 (slab on grade foundation in a commercial setting)	0.03	0.05
Deep soil gas	0.01	0.03	0.05
Groundwater	0.001	0.001	0.001

For this report, soil vapor screening levels (SVSLs) were derived for sub-slab soil vapor using both the 2013 USEPA preferred default attenuation factor for shallow soil vapor of 0.03 and the CA DTSC preferred default attenuation factor for shallow soil vapor of 0.05. USEPA SVSLs were derived using the USEPA Region 9 RSLs (USEPA 2013a) divided by the USEPA preferred attenuation factor of 0.03. CA-SVSLs were derived using the CA DTSC preferred attenuation factor of 0.05 divided by the RSL and are included for comparison purposes. Where the RWQCB identifies ESLs (RWQCB 2013) that are more restrictive than the RSLs, ESL-SVSLs were derived using the ESLs divided by the USEPA preferred attenuation factor of 0.03. Site specific attenuation factors calculated for each of the three co-located Samples IA-1/SS-1, IA-2/SS-2, and IA-3/SS-3 are 0.1, 0.004, and 0.06, respectively. Note that Sample IA-1/SS-1 is located near the Eductor, which provides a conduit for VI into the building, and decreases the effectiveness of

the concrete slab and vapor barrier to attenuate sub-slab vapors. Additional conduits for VI (discussed in Section 3.1) may also diminish the effectiveness of the building foundation to attenuate sub-slab vapors.

The USEPA RSLs and the RWQCB ESLs that were used as PALs for the indoor air samples are presented in Table 1. RSLs are screening levels derived using equations presented in the RSL Users Guide (USEPA 2013a) that include default reasonable maximum exposure (RME) assumptions for an industrial scenario with an exposure time (ET) of 8 hours per day, exposure frequency (EF) of 250 days per year, and exposure duration (ED) of 25 years. Based on these assumptions, the RSLs are the lower of concentrations in air that correspond to a cancer risk of 1×10^{-5} or a hazard quotient (HQ) of 1.

For some chemicals, the RWQCB has established ESLs using similar exposure assumptions but more protective toxicity criteria than those used by USEPA to establish the RSLs. For these chemicals the ESLs are considered the PALs.

In September 2011, the USEPA published its *Toxicological Review of Trichloroethylene in Support of the Integrated Risk Information System (IRIS)*. In response to this review, USEPA Region 9 recommends prompt response actions to address short-term inhalation exposures to TCE in indoor air from the VI pathway. These guidelines identify short-term response action levels for residential and commercial TCE inhalation exposure from VI. Although not PALs, the USEPA Region 9 recommends a prompt response action level of $7 \mu\text{g}/\text{m}^3$ for commercial/industrial buildings with a 10-hour workday schedule and a prompt response action level of $9 \mu\text{g}/\text{m}^3$ for sites with an 8-hour workday schedule.

4.1.1 Sub-Slab Vapor Results

Chemicals detected in sub-slab vapor are presented in Table 4. Of the 24 chemicals detected, TCE is the only chemical detected above the SVSLs derived using both the USEPA preferred attenuation factor of 0.03 and the CA DTSC preferred attenuation factor of 0.05. TCE was detected above both the USEPA ($100 \mu\text{g}/\text{m}^3$) and CA-SVSLs ($60 \mu\text{g}/\text{m}^3$) in Sub-Slab Wells SS-2 and SS-3 (neither of which are located above the former site source area) and above the CA-SVSL in Sub-Slab Well SS-1 (above the former site source area vicinity) in both the normal and duplicate samples. The TCE vapor concentration in Sub-Slab Well SS-4 was equal to the CA-SVSL. Sub-slab vapor concentrations were highest in Sub-Slab Well SS-2 located southeast of the Eductor and positioned to monitor potential vapor sources from upgradient offsite groundwater contamination. Vapor concentrations in this well were more than an order of magnitude higher than concentrations in the other vapor wells and there are no known on-site sources in that area.

4.1.2 Indoor Air and Outdoor Ambient Air Results

Table 5 includes results of indoor air and outdoor air samples with comparison to the USEPA RSLs and the RWQCB ESLs for industrial exposure. Only two chemicals, TCE and VC were

detected above these PALs with TCE ranging from 6.8 $\mu\text{g}/\text{m}^3$ to 7.7 $\mu\text{g}/\text{m}^3$ in the indoor air samples. These concentrations are approximately twice the USEPA RSL for TCE of 3 $\mu\text{g}/\text{m}^3$ (there is not a more protective ESL for TCE). Note concentrations are approximately equal to USEPA's short-term "prompt response action level" for a 10-hour work day; however, the reader is reminded that results were collected inside an unfinished and unoccupied building having open conduits in the sub-slab for the future installation of utilities and therefore no "prompt response" is required at this time. Concentrations of VC ranging from 0.35 $\mu\text{g}/\text{m}^3$ to 0.52 $\mu\text{g}/\text{m}^3$ were detected in the indoor air samples, slightly above the ESL for VC of 0.16 $\mu\text{g}/\text{m}^3$. Concentrations of VC did not exceed the USEPA RSL for industrial exposure of 2.8 $\mu\text{g}/\text{m}^3$.

Outdoor air concentrations are used to evaluate if a background source may be contributing to or may be the source of indoor air concentrations. Table 5 includes results of the outdoor ambient air concentrations collected upwind of the building. A duplicate outdoor air sample was collected and submitted for laboratory analysis. Preliminary analytical results received from the analytical laboratory reported outdoor air samples in the normal sample at concentrations similar to indoor air concentrations with the duplicate sample having concentrations an order of magnitude lower or below detection limits. Because the relative percent difference (RPD) for the normal and duplicate sample far exceeded the quality assurance guideline included in the QAPP of 25 percent for several compounds (refer to Table 4 in Appendix F), these samples initially analyzed on 17 December 2013 were reanalyzed on 30 December 2013, due to the anomalous initial result. Results from the reanalysis of these samples are presented in Table 5 and qualified with a data qualifier that states the samples were reanalyzed on 30 December 2013. Results from the December 30th reanalysis fall within the RPD guidelines in the QAPP and are used in this report to evaluate the contribution of background concentrations in ambient air to the indoor air results.

4.1.3 Risk Results

A screening level risk assessment was conducted using the chemical results from the indoor air sampling described above. The objective of the screening level human health risk assessment was to assess the potential risks and hazards associated with the chemicals detected in the indoor air using default USEPA reasonable maximum exposure (RME) assumptions for industrial exposure.

The screening-level risk assessment was conducted in accordance with recommendations included in the RSL Users Guide (USEPA 2013a). The risk-based concentrations considered appropriate to a screening level assessment are those that have been developed for screening purposes and thus incorporate sufficiently health-protective assumptions to offset the uncertainties associated with predicting future lifetime risks.

Several sources of risk-based screening levels are available. The most extensive list of chemicals is provided by the USEPA RSLs (USEPA 2013a). These RSLs have been reviewed by the RWQCB and have been approved for use in screening-level assessments with the addition of alternate ESLs for some of the chemicals, which are provided in the ESL guidance (RWQCB 2013). Because both the state and federal regulatory agencies are involved in the

review of these risk results, risks and hazards have been calculated twice: first using the USEPA-recommended RSLs; and second using the RWQCB-recommended ESLs. Potential cumulative cancer risks and non-cancer hazard index (HI) were calculated on a sample-by-sample basis for each sampling location inside the building.

For carcinogens, the concentration of each individual chemical was divided by its RSL; that ratio was multiplied by 10^{-6} , and resultant risks summed to give an estimate of cumulative risk for the location. For non-carcinogens, the simple ratio of each chemical concentration to its RSL gave the HQ for that chemical; these HQs were summed to give the HI for the VI pathway at that location. Cumulative risk and HIs are listed at the bottom of Table 7. For those chemicals where the RWQCB has issued more protective ESLs; the cumulative risk and HIs are shown in blue font at the bottom of Table 7. Using default RME assumptions and USEPA RSLs, the cumulative risk for all chemicals detected in indoor air was 3×10^{-6} and the HI ranged from 0.8 to 0.9. Using RWQCB ESLs, the cancer risk ranges from 5×10^{-6} to 6×10^{-6} and the HI ranges from 0.8 to 1.

The results from multiple lines of evidence are interpreted to evaluate whether a chemical detected in the indoor air can be attributed to VI. Both TCE and PCE are attributed to VI because the concentrations detected in the sub-slab vapor samples were higher than what was detected in the indoor air. Where sub-slab detections are low or not detected these chemicals are not considered VI related; VC is considered such a chemical at this Site. Although VC was detected at low concentrations in the indoor air, sub-slab concentrations were below reporting limits; and therefore, VC was eliminated as a VI related chemical. Outdoor air concentrations are also considered as a line of evidence that a chemical is or is not VI related; where chemicals are detected ubiquitously throughout the site with similar concentrations in indoor and ambient outdoor air these chemicals are also eliminated as VI related. Chloroform and ethyl benzene had similar concentrations in both indoor and outdoor air and are not considered VI related chemicals at the Site. When only those chemicals attributed to the VI pathway are included to evaluate cancer risk, results range from 2×10^{-6} to 3×10^{-6} using both USEPA RSLs and RWQCB ESLs. The HI values remain unchanged when sub-slab vapor data and outdoor ambient air data are considered because TCE is the primary driver for HI and HQ values for all other chemicals are less than 0.1.

5.0 INTERPRETATION, UNCERTAINTIES, AND RECOMMENDATIONS

5.1 Interpretation of Results

A comparison of results to USEPA RSLs and RWQCB ESLs suggest TCE presents risk above a 1×10^{-6} exposure level in the existing building under the industrial exposure scenario. This conclusion is further supported by results from the screening level risk evaluation for all chemicals detected and those chemicals attributed to the VI pathway. These results are within the low end of the CERCLA risk management range (1×10^{-4} to 1×10^{-6}) with HI approaching 1. Concentrations of TCE slightly exceed the short-term TCE prompt response action level recommended by USEPA Region 9 of $7 \mu\text{g}/\text{m}^3$ for 10-hour workday exposures; however no

response is currently warranted as the building is unoccupied. Current building conditions at the time of sampling suggest this sampling event represents a worst-case scenario for VI due to 1) sampling performed during wintertime conditions, 2) an unfinished building interior with many exposed conduits for VI, and 3) the absence of mechanical ventilation.

The interpretation of calculated cancer risks and non-cancer hazards is part of a process called risk management. The USEPA has provided guidance for interpreting these risk results within the CERCLA framework by considering cancer risks less than 1×10^{-6} to be acceptable and non-cancer hazards less than 1 as acceptable. However, in consideration of the complexities offered by different sites and the inherent conservative nature of the risk assessment process, cancer risks which fall between 1×10^{-4} and 1×10^{-5} are considered to be within the range of risk management. This means that features present at a site that could mitigate the potential impact of residual chemicals on potential receptors, or assumptions made during the risk assessment process that would tend to over-estimate the magnitude of the actual risk, can be given consideration when evaluating whether the level of risk at a site is or is not considered acceptable. Uncertainties associated with these site features and assumptions are discussed below.

5.2 Uncertainties

Inherent in the screening level evaluation of potential indoor air risk included in this report are uncertainties associated with the various processes that contribute to the final risk result. Understanding the major uncertainties assists with the interpretation of the risk characterization results. In general, the risk assessment process operates in a "cascade" fashion, whereby each phase relies on information generated in the previous phase. If uncertainty is introduced, for example, during the data collection phase, it will be carried through each successive risk assessment phase. When successive uncertainties introduce biases, the final health risk estimates may overestimate or underestimate actual risks and hazards.

5.2.1 Uncertainties Introduced by Sampling Design

The assumptions used in this screening level risk evaluation are intended to approximate actual conditions. However, these conditions are often difficult to represent and entail uncertainties in the choice of specific values to represent many of the parameters used to calculate potential risk. These choices include, but are not limited to, the location of the sampling device, how long to collect air samples, and how often to collect the samples.

At the request of the USEPA and RWQCB, indoor air samples were targeted to be collected over a 12-hour period (a 12-hour sample collection time was targeted but sample times varied between 10 and 11 hours due to the variability of the laboratory calibrated canister regulators). This sample duration is representative of an extended work day (i.e., 10 to 12-hour work day), but the actual work shift duration is unknown for the building as it is not occupied or equipped for occupancy although it is zoned for commercial/industrial use. In general, sampling locations were

selected to represent potential occupied spaces throughout the facility with some sampling locations, such as the elevator sample and the sample collected near the Eductor, positioned near a potential conduit for VI rather than exposure at an actual work space. The incomplete construction within the building introduces additional conduits for VI. Many open conduits through the concrete slab were observed throughout the building that likely contribute to indoor air concentrations; most of these conduits would be eliminated during completion of the building for occupancy. The presence of these conduits likely contributes to VOCs detected in the indoor air and overestimates the risk to receptors who may potentially occupy the building in future.

A contingency to evaluate the potential impact on indoor VOC levels resulting from sample collection during different times of the year (i.e., effects on vapor intrusion from climatic differences), was included in the work plan. However, as explained in Section 3.2, the current sampling event represents wintertime conditions, considered in VI guidance to represent a worst-case scenario for assessing the VI pathway. Note from Table 3 that pressure differentials measured inside building rooms relative to the outside air were slightly to moderately negative, suggesting that building pressure conditions support the use of this sampling event as a worst-case scenario for exposure.

5.2.2 Uncertainties Introduced by Exposure Assumptions

The exposure assumptions (frequency, time and duration) used to calculate potential intake rates are another source of uncertainty. For example, the screening risk evaluation used the RME industrial exposure parameters described in Section 4.1 (8 hours per day, 250 days per year for 25 years); the cumulative RME risk based on an 8-hour work day is at the low end of the CERCLA risk management range (10^{-4} to 10^{-6}) while the HI is below 1 for all buildings (using ESLs the HI rounds to 1 at one location). However, the data was collected using sample durations from 10 to 11 hours which may overestimate risk.

5.2.3 Uncertainties as to Sources of Chemicals Detected in the Indoor Air

Additional uncertainties are introduced when evaluating the contribution from a VI source for chemicals detected in indoor air. Although the building is unoccupied and no chemicals are in use or observed to be located onsite, the indoor air can be impacted by background sources including outdoor sources and regional and global sources. As an example, chloroform found ubiquitously in both indoor and outdoor samples at the site is known to have a global atmospheric distribution. A report on chloroform by the World Health Organization in 2004 (WHO 2004) identified mean concentrations of 0.17– 43.9 $\mu\text{g}/\text{m}^3$ (maximum 210 $\mu\text{g}/\text{m}^3$) have been reported for indoor air in the USA (USEPA 1992) and mean concentrations in 248 homes in Los Angeles, California, in 1987 ranged from 0.9 to 1.5 $\mu\text{g}/\text{m}^3$ (maximum 13 $\mu\text{g}/\text{m}^3$) (Wallace, 1997). Statewide in California, the 90th percentile concentration of chloroform was 0.25 $\mu\text{g}/\text{m}^3$ in 2012 as reported by the California Air Resources Board (CARB) (<http://www.arb.ca.gov/adam/toxics/statepages/ccl4state.html>) based on results from air monitoring samples located throughout the state. This average is similar to the chloroform concentrations in the indoor

(0.18 $\mu\text{g}/\text{m}^3$ to 0.25 $\mu\text{g}/\text{m}^3$) and outdoor (0.25 $\mu\text{g}/\text{m}^3$) air at the Site. Therefore, chloroform was not identified as a VI-related chemical.

Professional judgment was used in assessing whether chemicals were VI-related, using the multiple lines of evidence approach. Where chemicals were detected in the indoor air but not in the sub-slab (such as VC) the chemical was eliminated as VI-related and where similar concentrations were detected in outdoor air as detected in indoor air (such as chloroform and ethyl benzene) the chemical was not considered to be VI-related. Note that total cumulative risks for all chemicals detected in the indoor air were similar to the risk calculated when only VI-related chemicals were included thus reducing uncertainty.

5.2.4 Uncertainties Inherent in Toxicity Values

Uncertainty is also inherent in toxicity values established to evaluate cancer risks and non-cancer HIs. Such uncertainty is chemical-specific and incorporated into the toxicity value during its development. Application of uncertainty factors is expected to overestimate risks. Uncertainties related to the selection of toxicity criteria used to calculate RSLs were minimized by the inclusion of the more protective CA-ESLs in evaluating risk.

5.3 Conclusions and Recommendations

Based on the results of this sampling event, TCE is the only VI-related chemical that presents risk slightly above a 1×10^{-6} exposure level at 3×10^{-6} in the existing building under the industrial exposure scenario. These results are within the low end of the CERCLA risk management range (1×10^{-4} to 1×10^{-6}) with HI approaching 1.

Considering where these results fall in the risk management range, the timing of the sampling event under worst-case scenario conditions, and the uncertainties outlined above, the following actions are recommended to adequately mitigate VI risk to building occupants:

1. To the extent possible, remove conduits that are suspected to contribute to the VI pathway. This includes abandonment of the Eductor and groundwater monitoring wells located within the building and the elimination of other open conduits to VI that currently exist in the unfinished building (but will likely be addressed once the building interior is completed) such as the incomplete drain lines, electrical conduits, and other cut-outs in the concrete slab foundation of the building.
2. As part of completing the building construction, work with the property owner to ensure that a mechanical ventilation system will be installed and operated at the typical air exchange rate of 1 building volume of air per hour. Based on the previous evaluation of this mitigation measure conducted by CDM (refer to Section 2.2 above), installation and operation of a standard mechanical ventilation system is expected to mitigate the updated VI risk discussed in this report.

3. Following installation and operation of mechanical ventilation, collect samples of indoor air prior to occupancy in potential work areas and near potential conduits for VI (i.e., near the elevator) to assess whether VI risk (both long- and short-term) has been mitigated.

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Tables

TABLE 1. CHEMICALS OF CONCERN INCLUDED IN THE VI EVALUATION AND PROJECT ACTION LEVELS

(Page 1 of 2)

Analyte	2013 Maximum Indoor Air Concentration ($\mu\text{g}/\text{m}^3$)	2013 Maximum Concentration in Groundwater ($\mu\text{g}/\text{L}$)	USEPA Region 9 Screening Level for Industrial Exposure in Air ^(a) ($\mu\text{g}/\text{m}^3$)
1,1-dichloroethane	ND	0.78	7.7
1,1-dichloroethene	ND	0.70	880
1,2-dichlorobenzene	ND	19	880
1,1,1-trichloroethane	0.15	0.5	22,000
cis-1,2-dichloroethene (cDCE)*	2.0	340	260
trans-1,2-dichloroethene (tDCE)	ND	86	260
tetrachloroethene (PCE)*	0.56	2.3	47
trichloroethene (TCE)	7.7	250	3
Freon 113	0.98	1.4	130,000
vinyl chloride*	0.52	430	2.8
1,4-dichlorobenzene	ND	2.4	1.1
chlorobenzene	ND	85	220
chloroform	0.25	ND	0.53
Freon 11	1.6	ND	3,100
Freon 12	2.7	ND	440

TABLE 1. CHEMICALS OF CONCERN INCLUDED IN THE VI EVALUATION AND PROJECT ACTION LEVELS

(Page 2 of 2)

Notes:

All analytes shown in bold are chemicals of concern (COCs) in the groundwater at the site identified in the Record of Decision (ROD). All groundwater COCs meet volatility requirements for the vapor intrusion pathway (VIP) and are also considered as potentially posing a risk via the VIP. Chemicals shown in italics are not groundwater COCs but were included in this VI investigation because they were detected in air during previous indoor air sampling events or identified during recent groundwater sampling at the site. TCE is the primary risk driver for VIP.

*More restrictive Environmental Screening Levels (ESLs) for industrial exposure were derived by the San Francisco Regional Water Quality Control Board in December 2013 (RWQCB 2013) for those analytes noted with an asterisk. These screening levels are listed below:

cDCE – 31 $\mu\text{g}/\text{m}^3$

PCE – 2.1 $\mu\text{g}/\text{m}^3$

vinyl chloride – 0.16 $\mu\text{g}/\text{m}^3$

⁽¹⁾ Source: USEPA (USEPA, 2013a).

$\mu\text{g}/\text{m}^3$ micrograms per cubic meter

ND not detected

TABLE 2. PREVIOUS INDOOR AIR SAMPLING RESULTS
FORMER TRW MICROWAVE FACILITY
(Page 1 of 2)

Sample Location ID	Purpose	Date	Infl Pressure (inches Hg)	Final Pressure (inches Hg)	Reporting Limit Multiplier	(µg/m ³)						Chloroform	
						Freon 11	Freon 12	Freon 113	PCE	TCE	VC		1,1,1-TCA
October 30, 2003 sampling event													
AI-01	Indoor Random	10/30/2003	-29.0	-8.0	1.83	5.4	3.3	1.3	0.60	4.6	0.097	0.25	0.59
AI-02	Indoor Random	10/30/2003	-29.0	-8.3	1.87	4.4	3.3	1.2	0.59	3.9	0.10	0.24	0.54
AI-03	Indoor Random	10/30/2003	-29.0	-8.0	1.83	3.6	3.2	1.0	0.41	2.9	0.11	0.22	0.36
AI-04	Indoor Random	10/30/2003	-29.0	-8.0	1.83	4.9	3.2	1.3	0.67	5.2	0.13	0.24	0.54
AI-05	Indoor Random	10/30/2003	-29.0	-7.5	1.79	3.4	3.1	1.0	0.40	2.8	0.15	0.22	0.36
AI-06	Over Educator Vault	10/30/2003	-29.0	-7.5	1.79	4.3	3.1	1.1	0.45	3.5	0.13	0.22	0.42
AI-06	Over Educator - Duplicate	10/30/2003	-29.0	-8.0	1.91	4.1	3.3	1.2	0.46	3.4	0.16	0.23	0.43
AA-01	Outdoor Location	10/30/2003	-29.0	-8.5	1.87	1.5	2.9	0.65	ND <0.26	ND <0.20	ND <0.048	ND <0.21	ND <0.18
--	Trip Blank	--	-29.0	-29.0	1.00	ND <0.11	ND <0.10	ND <0.16	ND <0.14	ND <0.11	ND <0.026	ND <0.11	ND <0.099
April 15, 2004 sampling event													
AI-07	Indoor Random	4/5/2004	-29.0	-7.0	1.75	6.6	3.2	1.2	0.49	2.2	ND <0.045	0.21	ND <0.17
AI-08	Indoor Random	4/5/2004	-29.0	-6.0	1.68	6.3	3.1	1.1	0.42	2.3	ND <0.044	0.22	ND <0.17
AI-08	Indoor Random - Duplicate	4/5/2004	-29.0	-6.0	1.68	6.2	3.0	1.1	0.38	2.2	ND <0.044	0.21	ND <0.17
AI-09	Indoor Random	4/5/2004	-29.0	-7.0	1.75	4.6	3.4	1.2	0.42	2.5	0.067	0.23	ND <0.17
AI-10	Over Educator Vault	4/5/2004	-29.0	-6.0	1.68	4.9	3.4	1.2	0.41	2.6	0.067	0.23	0.22
AI-10	Over Educator - Duplicate	4/5/2004	-29.0	-6.0	1.68	5.0	3.3	1.3	0.52	2.7	0.065	0.25	0.20
AA-02	Outdoor Location	4/5/2004	-29.0	-6.0	1.68	1.8	3.2	0.88	ND <0.23	ND <0.18	ND <0.044	ND <0.19	ND <0.17
--	Trip Blank	--	-29.0	-29.0	1.00	ND <0.11	ND <0.10	ND <0.16	ND <0.14	ND <0.11	ND <0.026	ND <0.11	ND <0.099
April 8, 2004 sampling event - under temporary ventilation													
AI-07	Indoor Random	4/8/2004	-29.0	-6.0	1.68	1.3	3.0	0.44	0.36	ND <0.18	ND <0.044	ND <0.19	ND <0.17
AI-08	Indoor Random	4/8/2004	-29.0	-6.0	1.68	1.3	3.0	0.44	0.23	ND <0.18	ND <0.044	ND <0.19	ND <0.17
AI-08	Indoor Random - Duplicate	4/8/2004	-29.0	-6.0	1.68	1.2	2.8	0.40	ND <0.23	ND <0.18	ND <0.044	ND <0.19	ND <0.17
AI-09	Indoor Random (see Note 1)	4/8/2004	-29.0	-5.0	1.61	-	-	-	-	-	-	-	-
AI-10	Over Educator Vault	4/8/2004	-29.0	-6.5	1.71	1.3	2.8	0.42	0.24	ND <0.19	ND <0.044	ND <0.19	ND <0.17
AI-10	Over Educator - Duplicate	4/8/2004	-29.0	-7.0	1.75	1.3	2.8	0.42	0.24	ND <0.19	ND <0.045	ND <0.19	ND <0.17
AA-03	Outdoor Location	4/8/2004	-29.0	-7.5	1.79	1.2	2.8	0.47	0.30	ND <0.20	ND <0.046	ND <0.20	ND <0.18
--	Trip Blank	--	-29.0	-29.0	1.00	ND <0.11	ND <0.10	ND <0.16	ND <0.14	ND <0.11	ND <0.026	ND <0.11	ND <0.099
October 4, 2004 sampling event													
AI-11	Indoor Random	10/4/2004	-29.0	-6.5	1.71	3.8	2.4	0.96	0.46	4.3	ND <0.044	0.18	0.17
AI-12	Indoor Random	10/4/2004	-29.0	-6.5	1.71	5.4	2.5	1.0	0.73	5.1	ND <0.044	0.19	0.17
AI-13	Indoor Random	10/4/2004	-29.0	-5.5	1.64	7.0	2.5	1.0	0.65	4.5	ND <0.042	0.19	0.18
AA-04	Outdoor Location	10/4/2004	-29.0	-6.5	1.71	1.1	2.4	0.60	ND <0.23	ND <0.18	ND <0.044	ND <0.19	ND <0.17
--	Trip Blank	--	-29.0	-29.0	1.00	ND <0.11	ND <0.099	ND <0.15	ND <0.14	ND <0.11	ND <0.026	ND <0.11	ND <0.098

**TABLE 2. PREVIOUS INDOOR AIR SAMPLING RESULTS
FORMER TRW MICROWAVE FACILITY**
(Page 2 of 2)

Sample Location ID	Purpose	Date	In final Pressure (inches Hg)	Final Pressure (inches Hg)	Reporting Limit Multiplier	Freon 11	Freon 12	Freon 113	PCE	TCE	VC	1,1,1-TCA	Chloroform
Threshold Levels													
USEPA Region 9 Screening Levels - Industrial Exposure (November 2013)													
Environmental Screening Levels (RWQCB 2013)													
						3,100	440	130,000	47	3	2.8	22,000	0.53
						-	-	-	2.1	-	0.16	-	2.3

Note:
Sampling locations are shown on Figure 3.
Only detections are summarized in this table. Table includes comparison to industrial air USEPA Region 9 Screening Levels current as of February 2014 (USEPA 2013a).
- = Value above one or more screening levels.
(1) Results from the 4/8/04 sample not deemed to be representative of indoor air conditions and are not included in the table. PCE was detected at 2.5 µg/m³ in this sample, which is significantly higher than PCE concentrations detected in other samples from that day or previous/subsequent sampling events.

- not established
- µg/m³ micrograms per cubic meter
- ND=0.20 non detect/less than stated reporting limit (e.g. 0.20)
- 1,1,1-TCA 1,1,1-trichloroethane
- Freon 11 trichlorofluoromethane
- Freon 12 dichlorodifluoromethane
- Freon 113 1,1,2-trichloro-1,2,2-trifluoroethane
- inches Hg inches mercury
- PCE tetrachloroethene
- RWQCB Regional Water Quality Control Board
- TCE trichloroethane
- USEPA United States Environmental Protection Agency
- VC vinyl chloride

TABLE 4. SUB-SLAB VAPOR RESULTS WITH COMPARISONS TO SOIL VAPOR SCREENING LEVELS
(Page 1 of 2)

		Volatile Organics											
		acetone	benzene	2-butanone (MEK)	carbon disulfide	chloroform	chloroethane	dichlorodifluoromethane	cis-1,2-dichloroethene	trans-1,2-dichloroethane	ethylbenzene	1,4-dichlorobenzene	1-methyl-2-pentanone (MTBK)
	Units	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3
J6038-SS-1	12/09/2013	170 B	11	37	0.99 J	2.1	0.82 J	2.4	6.2	1.2 J	4.6	4.8	<1.6
	USEPA SVSL ^(a) 12/09/2013 ^(b)	4,666,666	53	733,333	103,333	17	13,000	14,666	NP	8,666	163	NP	433,333
J6038-SS-2	12/09/2013	290 B	11 J	34 J	<44	<26	<29	<35	<28	<28	<30	<34	69
	USEPA SVSL ^(a) 12/09/2013	370 B	6.9	48	0.40 J	<1.5	<1.7	3.2	<1.6	<1.6	28	35	<1.6
J6038-SS-4	12/09/2013	130 B	14	24	1.5 J	0.79 J	1.3 J	2.8	<1.6	0.43 J	6.3	8.2	<1.6
	ESL-SVSL ^(c)	2,800,000	32	440,000	62,000	10.6	7,800	8,800	NP	5,300	98	NP	260,000

TABLE 4. SUB-SLAB VAPOR RESULTS WITH COMPARISONS TO SOIL VAPOR SCREENING LEVELS
(Page 2 of 2)

		Volatile Organics (continued)											
	Units	1,1-dichloroethane (PCE)	1,1,1-trichloroethane	1,1,2-trichloroethane	1,2-dichloroethane (TCE)	1,2-dichloroethane	1,1,2-trichloroethane	1,2,4-trimethylbenzene	1,3,5-trimethylbenzene	Vinyl chloride	m- & p-xylene	o-xylene	xylene, total
	USEPA SVSL ^(a)	1,566	733,333	440,000	100	103,333	4,333,333	NP	NP	93	NP	14,666	14,666
	CA-SVSL ^(b)	940	440,000	60	60	62,000	2,600,000	NP	NP	56	NP	8,800	8,800
	ESL-SVSL ^(c)	70								5			
36038-SS-1	12/09/2013	0.95 J	15	4.4	82	1.6 J	10	2.1 J	5.8	<1.0	22	7.1	29.1
	12/09/2013 ^(d)	2.6	15	4.3	84	1.6 J	11	1.5 J	5.2	<1.0	20	6.4	26.4
36038-SS-2	12/09/2013	7.6 J	62	6.2	1,900	<3.9	310	<72	<69	<18	12 J	<10	12 J
36038-SS-3	12/09/2013	2.8	15	11	110	2.7	42	-4.1	33	<1.0	100	34	134
36038-SS-4	12/09/2013	2.9	10	2.3	60	1.9 J	2.5	0.79 J	8.7	0.38 J	29	8.5	37.5

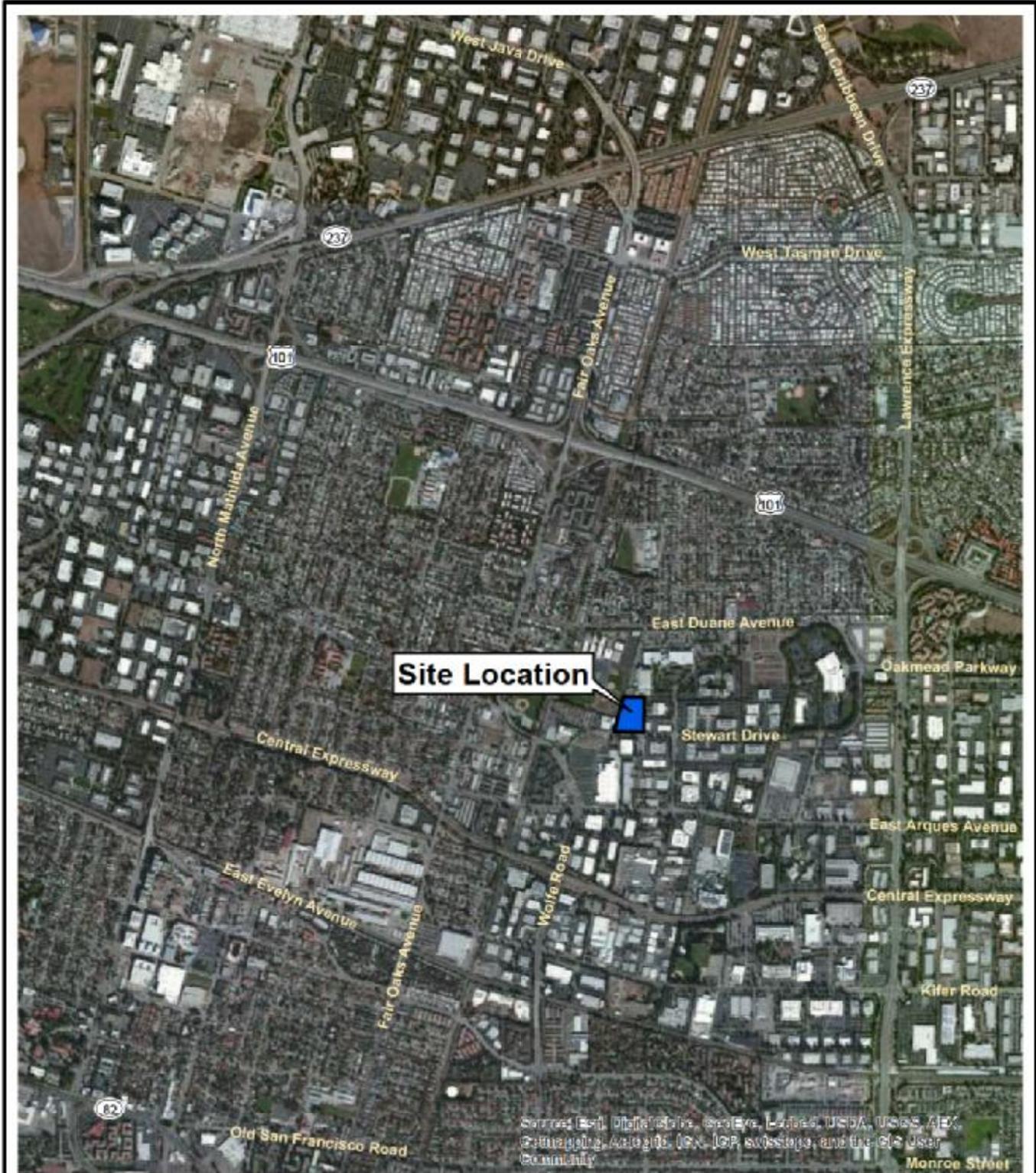
Goal Comparison
 Exceeds SVSL derived using EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites - Region 9 (11/2013) - Industrial RSLs / (0.03 AF)
 Exceeds CA-SVSL derived using EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites - Region 9 (11/2013) - Industrial RSLs / (0.05 AF)
 Exceeds Both Goals

Notes:

- (a) SVSL derived using USEPA RSLs/0.03.
- (b) SVSL derived using USEPA RSL/0.05.
- (c) Value shown in italics exceed ESL/0.03.
- (d) Duplicate sample.

- J Estimated Value
- ESL Environmental Screening Level (RWQCB 2013)
- NP Not Promulgated
- RSL Regional Screening Level (USEPA 2013a)
- SVSL Soil Vapor Screening Level

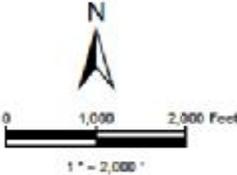
Figures



Source: Esri, DigitalGlobe, GeoEye, Earthstar USA, USDA, USGS, AeroGRID, IGN, IGP, swisstopo, and the GIS User Community

Former TRW Microwave Facility

Site Location



Date: 12-13
Project No.: 60238860



Figure
1

LEGEND

- A-ZONE WELL INSTALLED IN NOVEMBER 2013
- B1-ZONE WELL INSTALLED IN NOVEMBER 2013
- A-ZONE MONITORING WELL
- B1-ZONE MONITORING WELL
- B2-ZONE MONITORING WELL
- B4-ZONE MONITORING WELL
- EDUCTOR
- PROPERTY BOUNDARY
- VAPOR BARRIER

ABBREVIATIONS

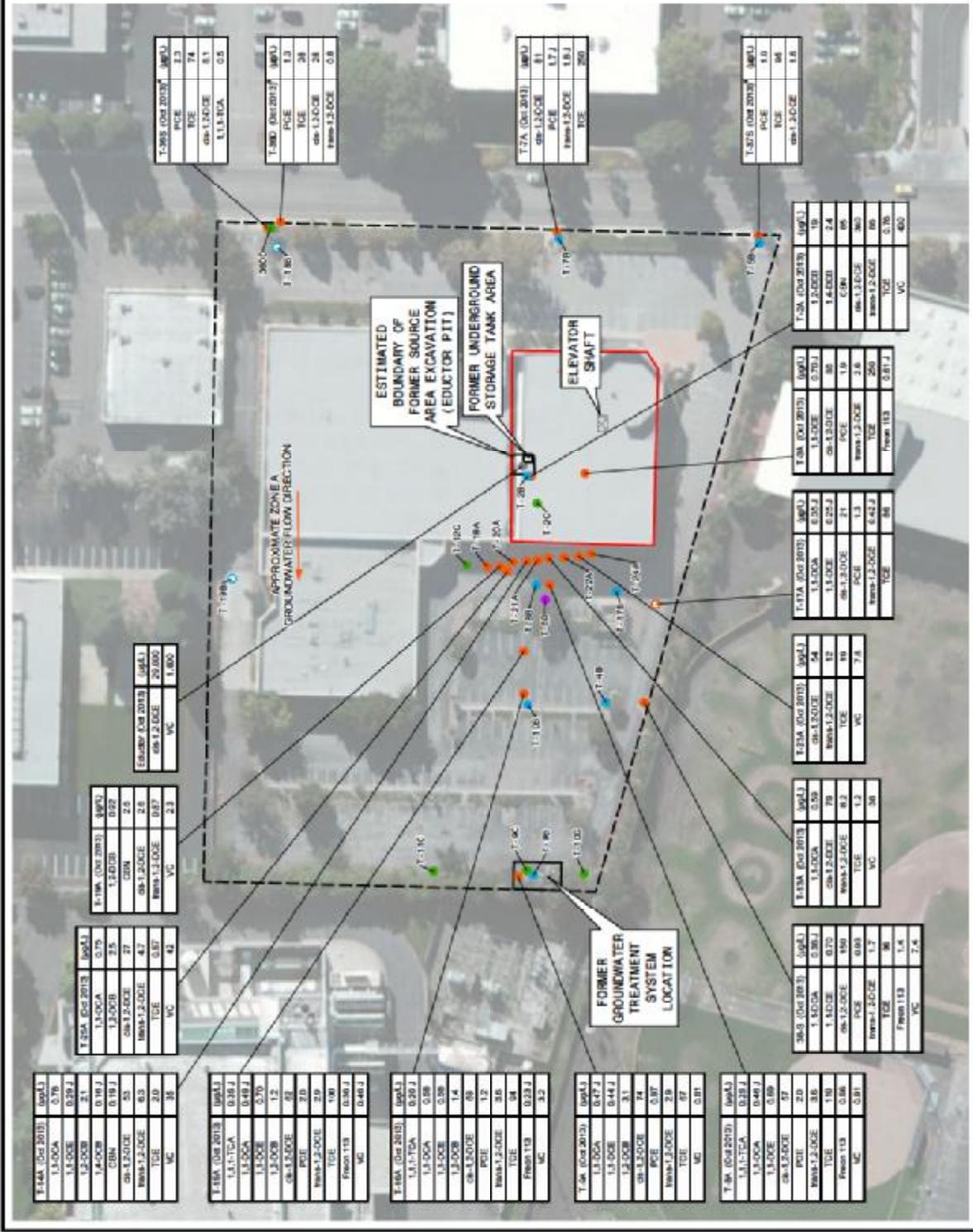
- DCA DIChloroethANE
- DOB DIChloroBENZENE
- DOE DIChloroETHENE
- DCE TETRACHloroETHENE
- PCE TRICHloroETHENE
- VC VINYL ChlorIDE

NOTES

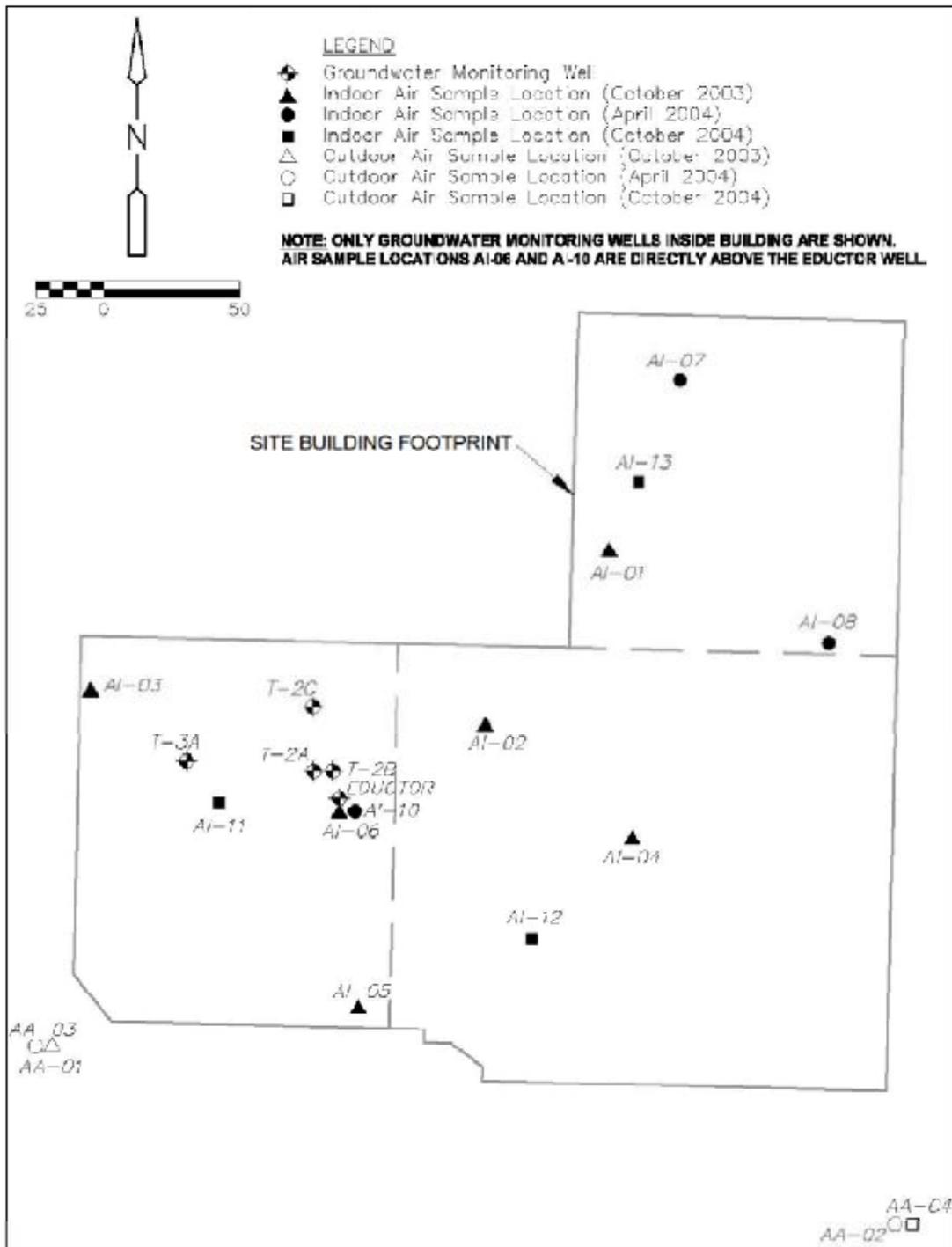
- COMPLETE ANALYTICAL RESULTS ARE INCLUDED IN APPENDIX A.
- * GROUNDWATER ANALYTICAL DATA PROVIDED BY AMD.
- J ESTIMATED VALUE



Site Layout with 2013 Zone A Groundwater Concentrations

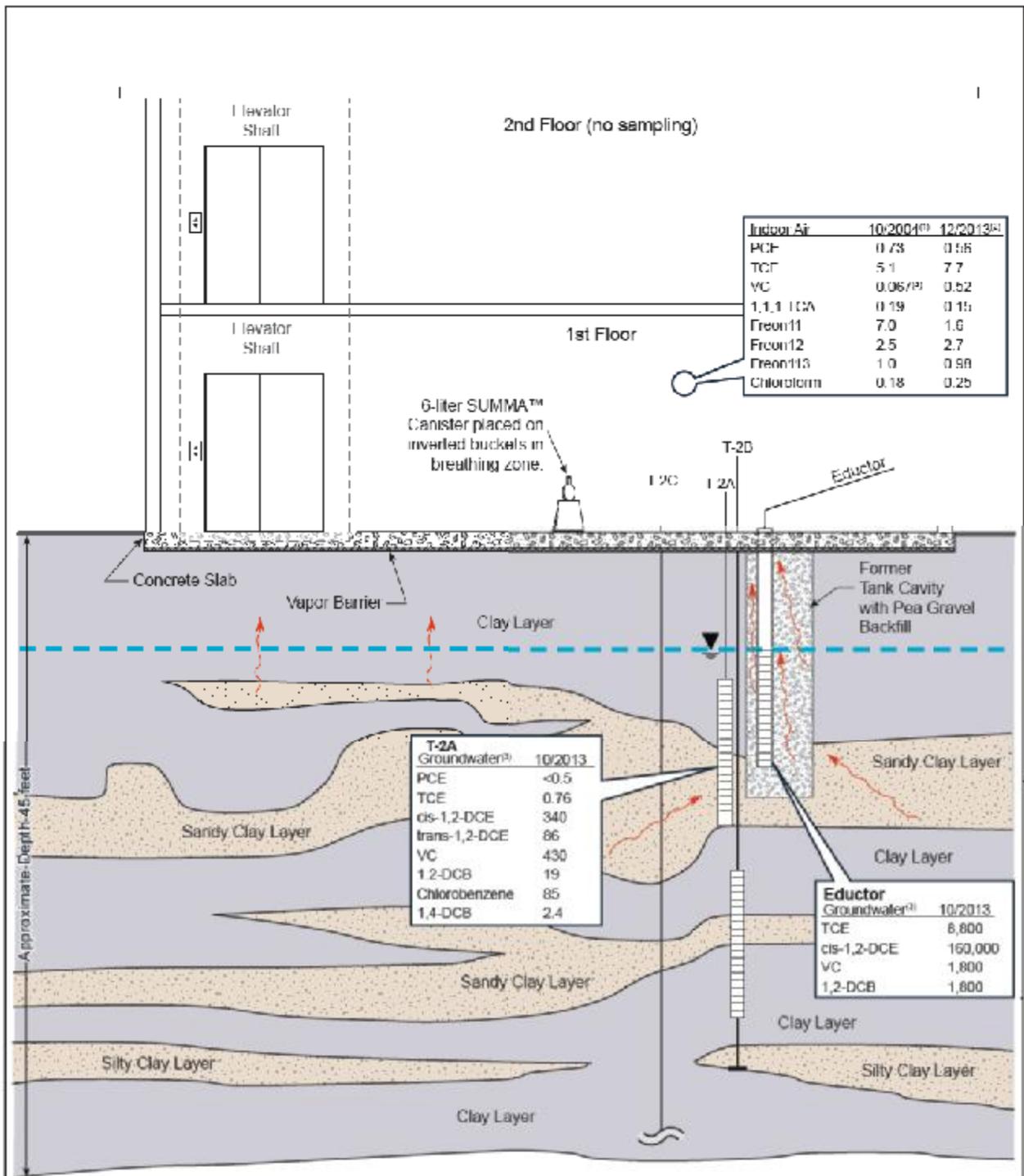


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Adapted from CDM 2009.

	Former TRW Microwave Facility	FIGURE 3
	Previous Indoor Air Sampling Locations	



Explanation

- Approximate Static Water Level (8 feet below ground surface)
- Potential Vapor Contaminant Pathway
- DCB Dichlorobenzene
- DCE Dichloroethene
- PCF Tetrachloroethene
- TCA Trichloroethane
- TCE Trichloroethene
- VC Vinyl Chloride

Notes:

- ⁽¹⁾ Maximum 2004 historical indoor air concentrations detected; shown in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$).
- ⁽²⁾ Maximum indoor air concentration detected during December 2013 sampling event; shown in $\mu\text{g}/\text{m}^3$.
- ⁽³⁾ Groundwater concentrations shown in micrograms per liter ($\mu\text{g}/\text{L}$).
- ⁽⁴⁾ Maximum detected concentration from April 2004.

NOT TO SCALE

Former TRW Microwave Facility

Conceptual Site Model for Vapor Intrusion

Date: 02-14	NORTHROP GRUMMAN	Figure
Project No. 60238880		4

6023-8880-03b Northrop Grumman

LEGEND

- ⊗ INDOOR AIR SAMPLING LOCATION
- SUB-SLAB SAMPLING LOCATION
- ⊕ OUTDOOR AIR SAMPLING LOCATION
- ⊙ BUILDING TEMPERATURE AND PRESSURE READING LOCATION
- PROPERTY BOUNDARY
- - - BUILDING SECTION BOUNDARY
- VAPOR BARRIER

NOTES

- * DUPLICATE SAMPLE LOCATION
- J ESTIMATED VALUE

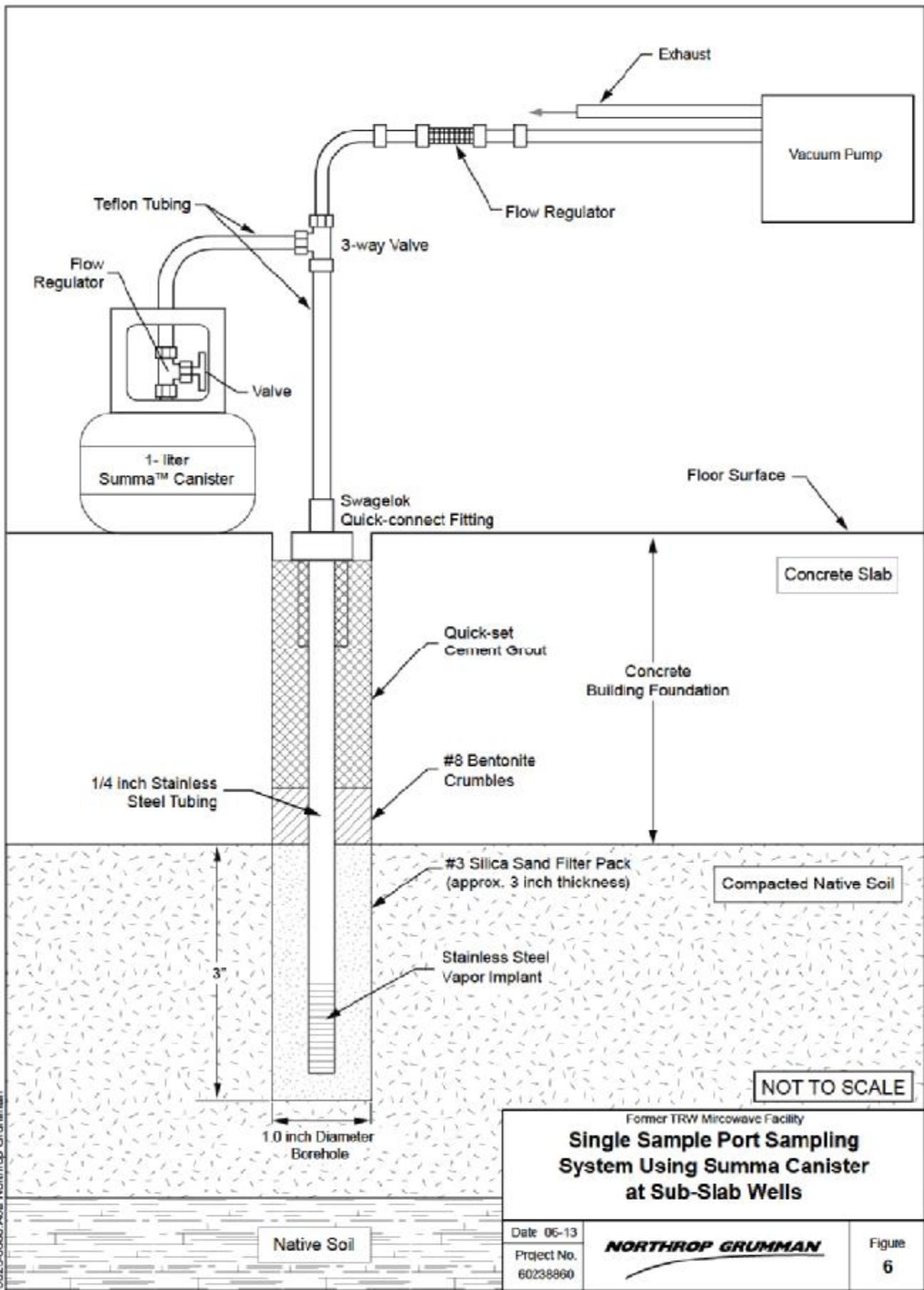


Former TRW Microwave Facility
 Sub-Slab Vapor and
 Air Sampling Locations
 with Chemicals Exceeding
 Project Action Levels

DATE: 2/14/14
 PROJECT: 14030000
 SHEET NO: 6

Page 6

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