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26 March 2015

Ms. Melanie Morash
Remedial Project Manager
U. S. Environmental Protection Agency
Region 9
75 Hawthorne Street, SFD-7-1
San Francisco, CA 94105

Re: Work Plan Addendum for Vapor Intrusion Evaluation Sampling and Analysis
Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California

Dear Ms. Morash:

Northrop Grumman Systems Corporation is submitting the enclosed Work Plan Addendum for Vapor Intrusion Evaluation Sampling and Analysis at the former TRW Microwave site for your review and approval. The addendum was prepared to present the proposed sampling locations and procedures for evaluating the vapor intrusion pathway under current site conditions.

If you have any questions, please do not hesitate to contact me at 703-280-4035, or our project manager, Linda Niemeyer, at 760-944-9490.

Sincerely,

Joseph P. Kwan
Corporate Director, Environmental Remediation
on behalf of Northrop Grumman Systems Corporation

Enclosure: Work Plan Addendum for Vapor Intrusion Evaluation Sampling and Analysis

cc: Rebecca Mora - AECOM
Linda Niemeyer - Watermark

AECOM

WORK PLAN ADDENDUM FOR VAPOR INTRUSION EVALUATION SAMPLING AND ANALYSIS

FORMER TRW MICROWAVE SITE
825 STEWART DRIVE
SUNNYVALE, CALIFORNIA

MARCH 2015

WORK PLAN ADDENDUM FOR VAPOR INTRUSION EVALUATION SAMPLING AND ANALYSIS

FORMER TRW MICROWAVE SITE
825 STEWART DRIVE
SUNNYVALE, CALIFORNIA

March 26, 2015

Prepared by:

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CONTENTS

1.0 INTRODUCTION 1
1.1 Project Objectives 1
1.2 Work Plan Addendum Organization 1
2.0 UPDATED SITE BACKGROUND AND CONCEPTUAL SITE MODEL 2
2.1 Previous Vapor Intrusion Evaluation Sampling 2
2.2 Conceptual Site Model 3
2.3 Indoor Air Sampling Locations Rationale 4
2.4 Sub-Slab Sampling Locations Rationale 4
2.5 Outdoor Air Sampling Location 4
3.0 SAMPLING AND ANALYSIS PLAN 4
3.1 HVAC-Off Sampling Event 5
3.2 HVAC-On Sampling Event 5
4.0 QUALITY ASSURANCE PLAN 5
5.0 HEALTH AND SAFETY PLAN 6
6.0 DATA VALIDATION, EVALUATION, AND REPORTING 6
7.0 SCHEDULE 6
8.0 REFERENCES 6

TABLES

1 2013 Sub-Slab Vapor Results with Comparisons to Soil Vapor Screening Levels
2 2013 Indoor and Outdoor Ambient Air Results with Comparison to Project Action Levels
3 Summary of Cumulative Cancer Risk and Non-Cancer Hazard
4 Updated Screening Criteria Comparison

FIGURES

1 Proposed Sub-Slab and Indoor Air Sampling Locations

APPENDICES

Appendix A Vapor Intrusion Evaluation Sampling and Analysis Work Plan
(on CD with hard copy)

1.0 INTRODUCTION

This work plan addendum (Addendum) for the Vapor Intrusion Evaluation Sampling and Analysis Work Plan (AECOM, 2013; VI Work Plan) has been prepared by AECOM on behalf of Northrop Grumman Systems Corporation (Northrop Grumman) for the former TRW Microwave Site (the Site) located at 825 Stewart Drive in Sunnyvale, California (refer to Figure 1 in the VI Work Plan [Appendix A]). At the time the original VI Work Plan was prepared, the building had been unoccupied and without mechanical ventilation since 2001. As summarized below, conditions at the Site have changed significantly over the past year:

- The lead regulatory agency for the Site was transferred from the Regional Water Quality Control Board (RWQCB) to the United States Environmental Protection Agency (USEPA), per notification from USEPA in a letter dated August, 7, 2014 (USEPA, 2014);
- The property changed ownership in early 2014 from Pacific Landmark LLC to 825 Stewart Acquisition Partners LLC. The new owner started property redevelopment activities in late 2014 that will be ongoing into the second quarter of 2015; and
- Significant remediation efforts were performed including: 1) installation of a passive soil vapor collection (SVC) system under the Site building, 2) source area soil removal, and 3) removal of potential vapor intrusion (VI) pathways (described in Section 2.0).

The purpose of this Addendum is to provide updated sampling locations and procedures for evaluating the VI pathway under current Site conditions. The results of this sampling effort will be used to assess whether the building is suitable for human occupancy and if so, obtain a certificate of occupancy from the City of Sunnyvale.

The VI Work Plan is included in Appendix A of this Addendum for reference.

1.1 Project Objectives

The primary objectives of the sampling described in this Addendum are:

- Assess the VI pathway under current Site conditions;
- Evaluate the efficacy of the passive SVC system; and
- Support attainment of a certificate of occupancy from the City of Sunnyvale after evaluation of analytical results.

1.2 Work Plan Addendum Organization

This Addendum is organized as follows:

- Section 1. Introduction – presents the project objectives and organization for this Addendum.
- Section 2: Updated Site Background and Conceptual Site Model – summarizes Site activities conducted after the previous VI sampling event and the resulting updated conceptual Site model and proposed sampling locations.

- Section 3: Sampling and Analysis Plan – presents the updated sampling methods proposed based on changed Site conditions.
- Section 4: Quality Assurance Project Plan (QAPP) – presents updates to the QAPP included in the previous VI Work Plan.
- Section 5: Health and Safety Plan (HASP) – presents updates to the current HASP.
- Section 6: Data Validation, Evaluation, and Reporting – presents how the data will be evaluated and reported.
- Section 7: Schedule – presents the proposed schedule for implementation of this Addendum.
- Section 8: References – lists the documents cited in this Addendum.

2.0 UPDATED SITE BACKGROUND AND CONCEPTUAL SITE MODEL

This section provides updated background information for the Site including the results of the 2013 VI evaluation sampling and recent remedial activities at the Site.

Based on results of groundwater sampling conducted in October 2014 at the Site, chemicals of concern (COCs) in the groundwater that could potentially impact indoor air include chlorinated volatile organic compounds (VOCs): trichloroethene (TCE), tetrachloroethene (PCE), and their degradation products (primarily cis-1,2-dicholoroethene and vinyl chloride).

2.1 Previous Vapor Intrusion Evaluation Sampling

Indoor air, outdoor air, and sub-slab sampling were performed in December 2013 to evaluate the extent of VI into the building. Tables 1 and 2 summarize the December 2013 sub-slab vapor and indoor/outdoor air sampling results and Table 3 summarizes the resulting calculated risk. The results of this sampling indicated that TCE was the only VI-related chemical that presented 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 Comprehensive Environmental Restoration, Compensation, and Liability Act risk management range (1×10^{-4} to 1×10^{-6}) with a hazard index (HI) approaching 1.

Based on these results, the following recommendations were presented in the Vapor Intrusion Evaluation Report (AECOM, 2014a) (approved by both RWQCB and USEPA) 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 Camp Dresser & McKee (CDM) (CDM, 2004), installation and operation of a standard mechanical ventilation system is expected to mitigate VI risk.

3. Following installation and operation of mechanical ventilation, collect samples of indoor air prior to building 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.

2.2 Conceptual Site Model

The conceptual Site model described in the VI Work Plan has changed significantly since the previous sampling event due to both remedial activities and property owner improvements. These activities included installation of a passive SVC system, removal of source material located under the Site building, and removal of all known potential VI conduits within the building.

At the request of the property owner and as a conservative, proactive measure, Northrop Grumman agreed to install a passive SVC system. In August and September 2014, the passive SVC system was installed beneath the concrete floor of the entire building in accordance with the Passive Sub-Slab Vapor Collection System Installation Work Plan (AECOM, 2014b). The purpose of the passive SVC system is to passively collect vapors below the building slab and vent them to the atmosphere as a protective measure against vapor intrusion. The layout of the passive SVC system is shown on Figure 1.

In October and November 2014, a targeted excavation of the former source area was performed in accordance with the Well Destruction and Source Removal Work Plan (AECOM, 2014c). The excavation was performed using large-diameter augers to remove residual contaminated material. The extent of the excavation was guided by the results of a membrane interface probe investigation, as well as additional confirmation soil borings. Based on the results of confirmation soil borings, the extent of the excavation was expanded, as explained in the Work Plan Addendum for Source Area Removal Activities (AECOM, 2014d). The final area that was excavated is shown on Figure 1. A total of approximately 590 tons of soil and semi-solids and approximately 9,000 gallons of water were removed from the source area. A detailed description of excavation activities at the Site is provided in the Source Area Soil Removal Report (Orion Environmental Inc., 2015).

Concurrently with source area excavation activities, the Eductor and all wells within the building (T-2A, T-2B, T-2C, and T-3A) were destroyed via overdrilling per the Well Destruction and Source Removal Work Plan (AECOM, 2014c). These wells were removed to prevent them from serving as a potential VI pathway once the building is occupied following the redevelopment activities currently being conducted by the new owner.

On January 21, 2015, the building was inspected for potential VI conduits by AECOM and the property owner, including the area around pipes, seams, and/or cracks in the concrete slab, and

unsealed spaces between the three sections of the buildings. Potential conduits identified during the walkthrough included inadequate seals where pipes penetrate the slab, narrow gaps between each part of the building where soil is exposed directly to the atmosphere, contraction joints in the concrete slab, and the elevator shaft. These potential conduits will be sealed prior to implementation of this Addendum.

2.3 Indoor Air Sampling Locations Rationale

In general, indoor air samples are collected in the vicinity of potential VI conduits; however, as described in Section 2.2, all known potential VI conduits will be sealed prior to this sampling event. Samples will be located within each of the three main areas of the building (IA-1 in the two-story portion, IA-2 in the central large one-story portion, and IA-3 in the smaller northern one-story portion) and near the elevator on both the first (IA-4) and second (IA-5) floors of the two-story portion, for a total of 5 indoor air locations. A duplicate sample will be collected at one of the indoor air locations. Proposed indoor air sampling locations are shown on Figure 1.

2.4 Sub-Slab Sampling Locations Rationale

During the remedial activities described in Section 2.2 and during tenant improvements, some of the sub-slab monitoring points used in the previous sampling event were destroyed. Additional points were installed to help confirm some parameters of the passive SVC system design. Of the points remaining, the three considered to be most representative of the three building areas are points SS-5 in the two-story portion, SS-7 in the large one-story portion, and SS-11 in the northern one-story portion (Figure 1). A duplicate sample will be collected at one of these three locations. The remaining existing sub-slab sampling locations (SS-1 through -4, -6, and -8 through -10) will be abandoned during implementation of the work described in this Addendum by removing the probes and backfilling with concrete.

2.5 Outdoor Air Sampling Location

As in the previous sampling event, one outdoor air sample and one duplicate outdoor air sample will be collected. The samples will be collected from the roof of the building near the intake of the heating, ventilation, and cooling (HVAC) system so that the samples will be representative of the air that would enter the building if the HVAC system was in operation.

3.0 SAMPLING AND ANALYSIS PLAN

The general procedures listed in the VI Work Plan (Appendix A) for both sub-slab and indoor air sampling will be followed. During the previous sampling event, the building did not have a functional HVAC system. As part of the property owner improvements, an HVAC system will be installed prior to implementation of the work described in this Addendum. The initial indoor air samples will be collected with the HVAC system off (HVAC-off). If the results of initial sampling exceed applicable screening levels (Table 4), an additional indoor air sampling event will be performed with the HVAC functioning normally (HVAC-on). If the HVAC-off results are below applicable screening levels, the HVAC-on sampling event will not be performed.

3.1 HVAC-Off Sampling Event

Initial indoor air samples will be collected with the HVAC system off-line. Although not representative of the exposure of a typical commercial building occupant, the results of these samples will serve as the conservative "worst-case" scenario. Prior to sampling, the HVAC system will be turned off for a minimum of 36 hours. Differential pressure readings will be collected to document ambient conditions with the system off-line. Samples will be collected over a 10-hour period using the same methods previously stated in the VI Work Plan (Appendix A).

3.2 HVAC-On Sampling Event

If the results of the HVAC-off sampling event are above applicable screening levels, an additional indoor air sampling event will be performed with the HVAC system in operation, as would be typical when the building is occupied. The HVAC system will be turned on and operated normally for a minimum of 48 hours prior to this sampling event. Differential pressure readings will be collected to document that the HVAC system is maintaining positive pressure relative to outside the building. Samples will be collected from the same sampling locations used during the HVAC-off sampling event and will use the same methods previously stated in the VI Work Plan. Samples will be collected over a 10-hour period.

4.0 QUALITY ASSURANCE PROJECT PLAN

The QAPP included in Appendix A of the VI Work Plan will be used for implementation of this Addendum with the following updates:

- Project Organization: Beth Ainsworth (Project Geologist) will be replaced by Ray Kaminsky (510-879-4536) and Chris Drabandt (Field Staff Geologist) will be replaced by Ben Loebner (510-879-4506).

- Project Action Levels (PALs): PALs were previously based on USEPA Regional Screening Levels (RSLs) updated in May 2013 and Environmental Screening Levels (ESLs) from the RWQCB, updated in February 2013. PALs for the sampling described in this Addendum will use USEPA RSLs last updated in January 2015 or the recommended value from the Department of Toxic Substances Control (DTSC) Office of Human and Ecological Risk (HERO) Note 3, last updated in July 2014. The resulting screening criteria and laboratory reporting limits are shown in Table 4, which replaces Table A-2 from the original QAPP.

- Number and Location of Samples: Sampling locations and rationale for the work described in this Addendum are discussed in Sections 2.2 through 2.5. The number of field duplicates (one indoor air, one outdoor air, and one sub-slab) remains unchanged.

- Project Reporting: As discussed in Section 1.0 of this Addendum, the lead agency for the Site was transferred from the RWQCB to USEPA. Therefore, the results of this sampling event will be reported only to USEPA.

5.0 HEALTH AND SAFETY PLAN

The HASP previously prepared for the Site will be used.

6.0 DATA VALIDATION, EVALUATION, AND REPORTING

Data validation and reporting will follow the procedures listed in Sections 6.1 and 6.3, respectively, of the VI Work Plan. Similar to the 2013 VI sampling effort, data validation will be performed by a third-party. Data will be evaluated using the procedures listed in Section 6.2 of the VI Work Plan; however, the comparison criteria will be updated to reflect updated screening levels issued in 2014 and 2015, as discussed in Section 4.0.

All conclusions made from implementing this Addendum are contingent upon the property owner ensuring that the integrity of the concrete slab will not be compromised after the sampling has been conducted (i.e., during or following completion of the final interior building improvements). Northrop Grumman will request that the property owner provide written certification to USEPA that they will not perform any activities during completion of the final tenant improvements (after the indoor air sampling event) that will affect (e.g., cut and/or penetrate) the concrete slab of the building. If the concrete slab is compromised after implementation of this Addendum, the VI sampling and reporting (as described above) will need to be repeated to document current conditions.

7.0 SCHEDULE

Following USEPA approval of this Addendum, Northrop Grumman will conduct the sealing of potential conduits in the concrete floor slab and will begin preparation for field activities, including coordination with the analytical laboratory and the property owner. Pending availability of all relevant parties and appropriate weather conditions, sampling is expected to be scheduled in May or early June. A 1-day field sampling effort will be needed to complete the HVAC-off sampling event and, if necessary, an additional 1-day field sampling effort will be needed to complete the HVAC-on sampling event. Data validation, compilation, and evaluation will follow sample collection and analysis and a draft version of the report will be submitted for regulatory review. Final validated analytical results will be submitted to USEPA within 48 hours of receipt from the third-party validator. AECOM plans to submit the draft report to the USEPA within 60 days of the completion of field activities.

8.0 REFERENCES

AECOM, 2013. Vapor Intrusion Evaluation Sampling and Analysis Work Plan, Former TRW Microwave Facility, Sunnyvale, California. October 29, 2013.

AECOM, 2014a. Vapor Intrusion Evaluation Report, Former TRW Microwave Facility, 825 Stewart Drive Sunnyvale, California. February 28, 2014.

AECOM, 2014b. Passive Sub-Slab Vapor Collection System Installation Work Plan, Former TRW Microwave Facility, 825 Stewart Drive, Sunnyvale, California. August 13, 2014.

AECOM, 2014c. Well Destruction and Source Removal Work Plan, Former TRW Microwave Facility, 825 Stewart Drive, Sunnyvale, California. September 18, 2014.

AECOM, 2014d. Work Plan Addendum for Source Area Removal Activities, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California. November 12, 2014.

CDM, 2004. Report of Findings – Installation and Operation of a Temporary Mechanical Ventilation System and Indoor Air Sampling. May 11, 2014.

DTSC Office of Human and Ecological Risk (HERO), 2014. Human Health Risk Assessment Note Number 3. July 14, 2014.

Orion Environmental, Inc. 2015. Source Area Soil Removal Report, Former TRW Microwave Site, 825 Stewart Drive, Sunnyvale, California. March 20, 2015.

USEPA, 2014, Notice of Lead Agency Transfer – California Regional Board to USEPA; Triple Site: AMD 901/902 Thompson Place Superfund Site, Philips (formerly Signetics) Site, and TRW Microwave Superfund Site and Off-site Operable Unit, Sunnyvale, California. August 7, 2014.

USEPA, 2015. Regional Screening Levels. January 2015. (Accessed from http://www.epa.gov/region9/superfund/prg/ on February 24, 2015.).

TABLES

TABLE 1. 2013 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	chloromethane	dichlorodifluoromethane	cis-1,2-dichloroethene	trans-1,2-dichloroethene	ethylbenzene	4-ethyltoluene	4-methyl-2-pentanone (MIBK)
	Units	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3
	USEPA SVSL[a]	4,666,666	53	733,333	103,333	17	13,000	14,666	NP	8,666	163	NP	433,333
	CA-SVSL[b]	2,800,000	32	440,000	62,000	10.6	7,800	8,800	NP	5,200	98	NP	260,000
	ESL-SVSL[c]	-	-	-	-	-	-	-	-	-	-	-	-
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
	12/09/2013[d]	**190** B	**9.9**	**33**	**0.93** J	**1.5**	**0.93** J	**2.5**	**5.5**	**1.1** J	**4.1**	**4.3**	<1.6
J6038-SS-2	12/09/2013	**290** B	**11** J	**34** J	<44	<26	<29	<35	<28	<28	<30	<34	**69**
J6038-SS-3	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

TABLE 1. 2013 SUB-SLAB VAPOR RESULTS WITH COMPARISONS TO SOIL VAPOR SCREENING LEVELS

(Page 2 of 2)

		Volatile Organics (continued)													
		methylene chloride	tetrachloroethene (PCE)	toluene	1,1,1-trichloroethane	trichloroethene (TCE)	trichlorofluoromethane	1,1,2-trichlorotrifluoroethane	trihalomethanes, total	1,2,4-trimethylbenzene	1,3,5-trimethylbenzene	vinyl chloride	m- & p-xylene	o-xylene	xylenes, total
	Units	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3
	USEPA SVSL[a]	40,000	1,566	733,333	733,333	100	103,333	4,333,333	NP	1,033	NP	93	NP	14,666	14,666
	CA-SVSL[b]	24,000	940	440,000	440,000	60	62,000	2,600,000	NP	620	NP	56	NP	8,800	8,800
	ESL-SVSL[c]	-	70	-	-	-	-	-	-	-	-	5	-	-	-
J6038-SS-1	12/09/2013	**0.95** J	**15**	**25**	**4.4**	**82**	**1.6** J	**10**	**2.1** J	**5.8**	**3.2**	<1.0	**22**	**7.1**	**29.1**
	12/09/2013[d]	**2.6**	**15**	**23**	**4.3**	**84**	**1.6** J	**11**	**1.5** J	**5.2**	**2.7**	<1.0	**20**	**6.4**	**26.4**
J6038-SS-2	12/09/2013	**7.6** J	**170**[c]	**20** J	**62**	**1,900**	<39	**310**	<72	<69	<34	<18	**12** J	<30	**12** J
J6038-SS-3	12/09/2013	**2.8**	**15**	**69**	**11**	**110**	**2.7**	**42**	<4.1	**33**	**12**	<1.0	**100**	**34**	**134**
J6038-SS-4	12/09/2013	**2.9**	**10**	**35**	**2.3**	**60**	**1.9** J	**25**	**0.79** J	**8.7**	**5.2**	**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] SVSLs derived using USEPA RSLs/0.03.

[b] SVSLs derived using USEPA RSLs/0.05.

[c] Value shown in italics exceed ESLs/0.03.

[d] Duplicate sample.

µg/m^3	micrograms per cubic meter
AF	attenuation factor
CA	California
ESL	Environmental Screening Level (RWQCB 2013)
J	estimated value
NP	not promulgated
RSL	Regional Screening Level
RWQCB	Regional Water Quality Contol Board
SVSL	soil vapor screening level
USEPA	United States Environmental Protection Agency

TABLE 2. 2013 INDOOR AND OUTDOOR AMBIENT AIR RESULTS WITH COMPARISON TO PROJECT ACTION LEVELS

(Page 1 of 1)

		Volatile Organics															
		chloroform	dichlorodifluoromethane	1,1-dichloroethane	cis-1,2-dichloroethene	ethylbenzene	tetrachloroethene (PCE)	toluene	1,1,1-trichloroethane	trichloroethene (TCE)	trichlorofluoromethane	1,1,2-trichlorotrifluoroethane	trihalomethanes, total	vinyl chloride	m- & p-xylene	o-xylene	xylenes, total
	Units	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3
	USEPA AIR RSLS[a]	0.53	440	7.7	260	4.9	47	22,000	22,000	3	3,100	130,000	NP	2.8	NP	440	440
	SF BAY RWQCB - ESLs[b]	0.46	-	-	31	-	2.1	1,300	-	-	-	-	-	0.16	-	-	-
J6038-IA-1	12/10/2013	**0.18**	**2.4**	<0.081	**1.9**	**0.52**	**0.54**	**2.9**	**0.11**	**7.6**	**1.4**	**0.90**	**0.18**	**0.48**	**1.7**	**0.64**	**2.34**
	12/10/2013[c]	**0.23**	**2.4**	<0.081	**1.9**	**0.52**	**0.55**	**3.0**	**0.15**	**7.7**	**1.4**	**0.91**	**0.23**	**0.49**	**1.8**	**0.64**	**2.44**
J6038-IA-2	12/10/2013	**0.23**	**2.5**	<0.081	**1.6**	**0.53**	**0.56**	**3.0**	**0.12**	**7.6**	**1.5**	**0.98**	**0.23**	**0.39**	**1.8**	**0.65**	**2.45**
J6038-IA-3	12/10/2013	**0.25**	**2.5**	<0.081	**1.4**	**0.54**	<0.14	**3.0**	<0.11	**6.8**	**1.5**	**0.90**	**0.25**	**0.35**	**1.8**	**0.66**	**2.46**
J6038-IA-4	12/10/2013	**0.25**	**2.7**	<0.081	**2.0**	**0.34**	<0.14	**3.0**	**0.12**	**7.3**	**1.6**	<0.23	**0.25**	**0.52**	**0.98**	**0.32**	**1.3**
J6038-OA-1	12/10/2013	<0.098 H	**2.4** H	<0.081 H	<0.079 H	**0.64** H	<0.14 H	**3.4** H	<0.11 H	**0.21** H	**1.3** H	**0.62** H	**0.18** H	<0.051 H	**2.3** H	**0.81** H	**3.11** H
	12/10/2013[c]	**0.25** H	**3.0** H	**0.097** H	**0.27** H	**1.1** H	**0.34** H	**8.0** H	<0.11 H	**0.45** H	**1.4** H	**0.64** H	**0.17** H	<0.051 H	**3.4** H	**1.1** H	**4.5** H

Goal Comparison[d]

Exceeds United States Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites - Region 9 (11/2013) - Industrial RSLs

Exceeds San Francisco (SF) Bay Regional Water Quality Control Board (RWQCB) Environmental Screening Levels (ESLs) (12/2013) - Industrial ESLs

Notes:

[a] USEPA Regional Screening Levels for Industrial Exposure (RSLs, USEPA 2013).

[b] SF Bay Environmental Screening Levels (ESLs, RWQCB 2013).

[c] Duplicate sample.

[d] SF Bay RWQCB Industrial ESLs are only shown if lower than USEPA Industrial RSLs

µg/m^3 micrograms per cubic meter

H Data qualifier; sample was reanalyzed on 30 December 2013

NP Not Promulgated

TABLE 3. SUMMARY OF CUMULATIVE CANCER RISK AND NON-CANCER HAZARD
(Page 1 of 1)

Analyte		Toxicity Criteria IUR[a] $(\mu g/m^3)^{-1}$	Toxicity Criteria RfC[b] (mg/m^3)	Risk-Based Screening Concentrations for Carcinogens $(\mu g/m^3)$	Risk-Based Screening Concentrations for Non-Carcinogens $(\mu g/m^3)$	Sample Location IA1 12/10/2013 Concentration[c] $(\mu g/m^3)$	Sample Location IA1 12/10/2013 Cancer Risk[d]	Sample Location IA1 12/10/2013 Hazard Quotient[e]	Sample Location IA2 12/10/2013 Concentration[c] $(\mu g/m^3)$	Sample Location IA2 12/10/2013 Cancer Risk[d]	Sample Location IA2 12/10/2013 Hazard Quotient[e]	Sample Location IA3 12/10/2013 Concentration[c] $(\mu g/m^3)$	Sample Location IA3 12/10/2013 Cancer Risk[d]	Sample Location IA3 12/10/2013 Hazard Quotient[e]	Sample Location IA4 12/10/2013 Concentration[c] $(\mu g/m^3)$	Sample Location IA4 12/10/2013 Cancer Risk[d]	Sample Location IA4 12/10/2013 Hazard Quotient[e]
chloroform	c	2.3E-05	9.8E-02	5.3E-01	4.3E+02	0.23	4.3E-07	<0.1	0.23	4.3E-07	<0.1	0.25	4.7E-07	<0.1	0.25	4.7E-07	<0.1
dichlorodifluoromethane			1.0E-01		4.4E+02	2.4		<0.1	2.5		<0.1	2.5		<0.1	2.7		<0.1
ethylbenzene	c	2.5E-06	1.0E+00	4.9E+00	4.4E+03	0.52	1.1E-07	<0.1	0.53	1.1E-07	<0.1	0.54	1.1E-07	<0.1	0.34	6.9E-08	<0.1
tetrachloroethene (PCE)	c	2.6E-07	4.0E-02	4.7E+01	1.8E+02	0.55	1.2E-08	<0.1	0.56	1.2E-08	<0.1						
tetrachloroethene (PCE)	c	5.9E-06	3.5E-02	2.1E+00	1.5E+02	0.55	2.6E-07	<0.1	0.56	2.7E-07	<0.1						
toluene			5.0E+00		2.2E+04	3		<0.1	3		<0.1	3		<0.1	3		<0.1
toluene			3.0E-01		1.3E+03	3		<0.1	3		<0.1	3		<0.1	3		<0.1
1,1,1-trichloroethane			5.0E+00		2.2E+04	0.15		<0.1	0.12		<0.1				0.12		<0.1
trichloroethene (TCE)	c	4.1E-06	2.0E-03	3.0E+00	8.8E+00	7.7	2.6E-06	0.9	7.6	2.5E-06	0.9	6.8	2.3E-06	0.8	7.3	2.4E-06	0.8
trichlorofluoromethane			7.0E-01		3.1E+03	1.4		<0.1	1.5		<0.1	1.5		<0.1	1.6		<0.1
trichlorotrifluoroethane (Freon113)			3.0E+01		1.3E+05	0.91		<0.1	0.98		<0.1	0.9		<0.1			
vinyl chloride	c	4.4E-06	1.0E-01	2.8E+00	4.4E+02	0.49	1.8E-07	<0.1	0.39	1.4E-07	<0.1	0.35	1.3E-07	<0.1	0.52	1.9E-07	<0.1
vinyl chloride	c	7.8E-05	1.0E-01	1.6E-01	4.4E+02	0.49	3.1E-06	<0.1	0.39	2.5E-06	<0.1	0.35	2.2E-06	<0.1	0.52	3.3E-06	<0.1
cis-1,2-dichloroethene[f]			6.0E-02		2.6E+02	1.9		<0.1	1.6		<0.1	1.4		<0.1	2		<0.1
cis-1,2-dichloroethene			3.5E-02		3.1E+01	1.9		<0.1	1.6		<0.1	1.4		<0.1	2		<0.1
m,p-xylenes			1.0E-01		4.4E+02	1.8		<0.1	1.8		<0.1	1.8		<0.1	0.98		<0.1
o-xylenes			1.0E-01		4.4E+02	0.64		<0.1	0.65		<0.1	0.66		<0.1	0.32		<0.1
Totals for all VOCs detected (USEPA):							3.3E-06	0.9		3.2E-06	0.9		3.0E-06	0.8		3.2E-06	0.9
Totals for all VOCs detected (SF Bay RWQCB):							6.5E-06	1.0		5.8E-06	0.9		5.1E-06	0.8		6.3E-06	0.9

Notes:

Cancer risks and hazard quotient values shown in black font use toxicity criteria based on USEPA's recommended approach to selecting toxicity values for use in Superfund risk assessments; as presented in OSWER Directive 9285.7-53 (dated December 5, 2003), USEPA establishes the IRIS database as the first tier of criteria to be considered. By contrast, cancer risks and HQ values shown in blue font are based on toxicity criteria recommended by SF Bay Regional Water Quality Control Board, using more health protective toxicity criterion between OEHHA and USEPA/IRIS.

[a] The IUR parameter was used to evaluate the potential cancer risk.
[b] The RfC parameter was used to evaluate the potential non-cancer Hazard Quotient.
[c] For the cancer risk and non-cancer hazard calculations, ND data were not used.
[d] Cancer risk was calculated as follows: (concentration x 8 hours/day x 250 days/year x 25 years x IUR) / (24 hours/day x 365 days/year x 70 years).
[e] Hazard Quotient was calculated as follows: (concentration x 8 hours/day x 250 days/year x 25 years) / (RfC x 24 hours/day x 365 days/year x 25 years x 1,000 µg/mg).
[f] Trans-1,2-dichloroethene used as a surrogate.

<	less than
$(\mu g/m^3)^{-1}$	per microgram per cubic meter
$\mu g/m^3$	micrograms per cubic meter
µg/mg	micrograms per milligram
c	chemical is a known or suspected carcinogen
IA	indoor air
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
mg/m^3	milligrams per cubic meter
ND	not detected
OEHHA	Office of Environmental Health Hazard Assessment
OSWER	Office of Solid Waste and Emergency Response
RfC	reference concentration
SF	San Francisco
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

TABLE 4. UPDATED SCREENING CRITERIA COMPARISON

(Page 1 of 1)

Analyte	Previous PALs ($\mu g/m^3$)	USEPA Region 9 Industrial RSLs[a] ($\mu g/m^3$)	DTSC HERO Note 3 [b] ($\mu g/m^3$)	USEPA Region 9 Interim Accelerated Response Action Levels (commercial / industrial) ($\mu g/m^3$)	USEPA Region 9 Interim Urgent Response Action Levels (commercial / industrial) ($\mu g/m^3$)	Laboratory Reporting Limit ($\mu g/m^3$)
1,1-dichloroethane (1,1-DCA)	7.7	7.7	7.7	-	-	0.081
1,1-dichloroethene (1,1-DCE)	880	880	310	-	-	0.079
1,2-dichlorobenzene	880	880	880	-	-	0.30
1,1,1-trichloroethane (1,1,1-TCA)	22,000	22,000	4,400	-	-	0.27
chlorobenzene	220	220	220	-	-	0.092
chloroform	0.53	0.53	0.53	-	-	0.098
cis-1,2-dichloroethene	260	NE	31	-	-	0.079
trans-1,2-dichloroethene	260	NE	NE	-	-	0.079
tetrachloroethene (PCE)	47	47	2.08	-	-	0.14
trichloroethene (TCE)	3.0	3.0	3.0	8[c] / 7 [d]	24 [c] / 21 [d]	0.11
Freon 11 (trichlorofluoromethane)	3,100	3,100	3,100	-	-	0.25
Freon 12 (dichlorodifluoromethane)	440	440	440	-	-	0.049
Freon 113	130,000	130,000	130,000	-	-	0.23
vinyl chloride	2.8	2.8	0.16	-	-	0.051

Notes:

[a] USEPA Regional Screening Levels for Industrial Exposure (RSLs; USEPA, 2015).

[b] DTSC HERO Note 3 Screening Levels for Industrial Exposure (HERO, 2014).

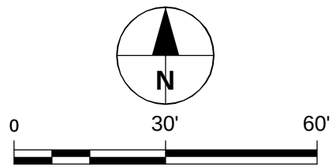
[c] 8-hour work day

[d] 10-hour work day

$\mu g/m^3$	micrograms per cubic meter
DTSC	Department of Toxic Substances Control
HERO	DTSC Office of Human and Ecological Risk
NE	Not established
PALs	project action levels
USEPA	United States Environmental Protection Agency

FIGURE

ANSI B 11" x 17"



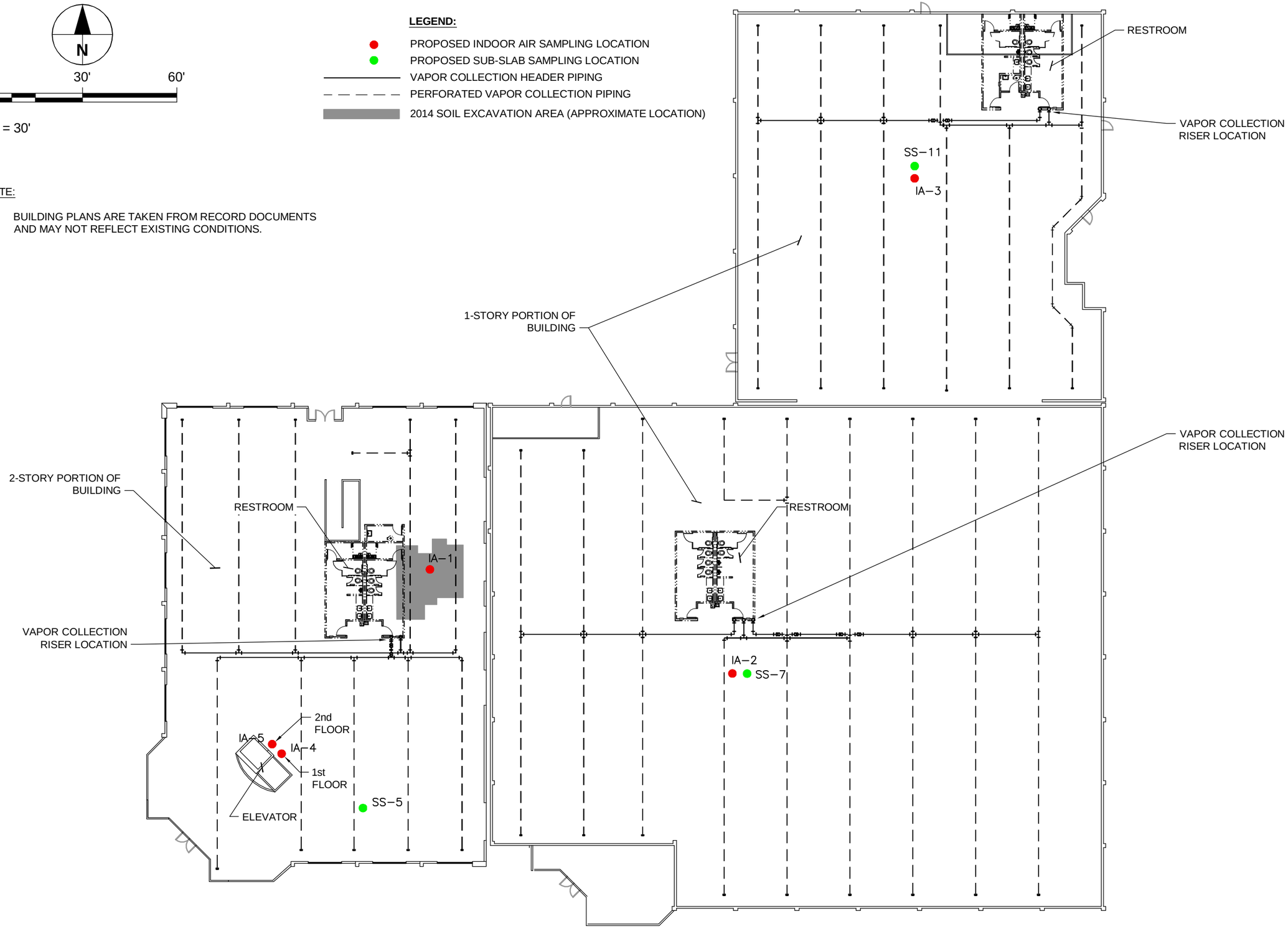
1" = 30'

LEGEND:

- PROPOSED INDOOR AIR SAMPLING LOCATION
- PROPOSED SUB-SLAB SAMPLING LOCATION
- VAPOR COLLECTION HEADER PIPING
- PERFORATED VAPOR COLLECTION PIPING
- 2014 SOIL EXCAVATION AREA (APPROXIMATE LOCATION)

NOTE:

1. BUILDING PLANS ARE TAKEN FROM RECORD DOCUMENTS AND MAY NOT REFLECT EXISTING CONDITIONS.



Issue Status: FINAL

AECOM

Figure: 1

Proposed Sub-Slab and Indoor Air Sampling Locations
Former TRW Microwave Site - Sunnyvale, CA
Northrop Grumman Systems Corporation
Project No.: 60238860 Date: March 2015

Last saved by: MEX1AS(2015-03-20) Last Plotted: 2015-03-20
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APPENDICES

APPENDIX A

VAPOR INTRUSION EVALUATION
SAMPLING AND ANLYSIS WORK PLAN
(Provided on CD with Hard Copy)

AECOM

VAPOR INTRUSION EVALUATION SAMPLING AND ANALYSIS WORK PLAN

FORMER TRW MICROWAVE FACILITY
825 STEWART DRIVE
SUNNYVALE, CALIFORNIA

REVISED FINAL

OCTOBER 2013

VAPOR INTRUSION EVALUATION SAMPLING AND ANALYSIS WORK PLAN

FORMER TRW MICROWAVE FACILITY
825 STEWART DRIVE
SUNNYVALE, CALIFORNIA

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TABLE OF CONTENTS

1.0 INTRODUCTION 1
- 1.1 Project Objectives 1
- 1.2 Work Plan Organization 2

2.0 SITE BACKGROUND AND CONCEPTUAL SITE MODEL 2
- 2.1 Site Background 2
- 2.2 Summary of Previous Indoor Air Sampling Activities 4
- 2.3 Conceptual Site Model and Selection of Sampling Locations 5

3.0 SAMPLING AND ANALYSIS PLAN 7
- 3.1 Pre-Sampling Activities 7
- 3.2 Indoor Air Sampling 7
- 3.3 Sub-slab Sampling 8
- 3.4 Sample Handling, Containers, Analytical Methods, Sample Identification, Sample Custody and Shipping 10

4.0 QUALITY ASSURANCE PLAN 11

5.0 HEALTH AND SAFETY PLAN 11

6.0 DATA VALIDATION, EVALUATION, AND REPORTING 11
- 6.1 Data Validation and Quality Assurance 11
- 6.2 Data Evaluation 12
- 6.3 Reporting 13

7.0 SCHEDULE 14

8.0 REFERENCES 14

TABLES

1 Chemicals of Concern in Groundwater and Indoor Air USEPA Risk Screening Levels
2 Previous Indoor Air Sampling Results

FIGURES

1 Site Location Map
2 Conceptual Site Model for Vapor Intrusion
3 Previous Indoor Air Sampling Locations
4 Site Layout with 2012 Zone A Groundwater Concentrations
5 Proposed Indoor Air Sampling Locations
6 Sub-slab Vapor Well Construction Diagram

APPENDICES

A Quality Assurance Project Plan
B Summary of Historic Groundwater Data
C Site Photographs and Completed Building Survey Form
C.1 Site Photographs
C.2 Completed Building Survey Form – Site Walk
D Field Forms
E TAML - Standard Operating Procedure - TO-15 SIM and Full Scan (Provided on Compact Disk)
F Field Equipment Specifications
G Activity Hazard Analysis
H Responses to Comments

1.0 INTRODUCTION

This *Vapor Intrusion Evaluation Sampling and Analysis Work Plan* (Work Plan) was prepared in response to the 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) and comments issued on 17 May 2013 (revised per input from teleconference on 4 June 2013) by the RWQCB on the draft submittal of this work plan and additional comments issued on 23 August 2013 by the United States Environmental Protection Agency (USEPA) on the final submittal of this work plan. The letter requires 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 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 TCE and related chlorinated volatile organic compounds (VOCs).

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 (CDM 2009).

This Work Plan addresses the 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. Chemicals of concern (COCs) in the groundwater include the chlorinated VOCs trichloroethene (TCE), tetrachloroethene (PCE) and their degradation products (primarily cis-1,2-dicholoroethene [cDCE] and vinyl chloride [VC]). Table 1 lists the groundwater COCs identified in the ROD. The building has been vacant since 2001 and is not equipped with mechanical ventilation, electricity, or plumbing.

1.1 Project Objectives

The primary objective of the activities discussed in this Work Plan is to assess the VI pathway at the current Site building and to evaluate the possible future need for a VI remedy, by collecting indoor and outdoor (ambient) air and sub-slab vapor samples at the Site. Findings of previous VI investigations performed in 2003 and 2004 (CDM 2004a, 2004c, 2004e) concluded that the VI pathway does not pose unacceptable risk to potential Site workers when proper ventilation of the building is maintained. In addition with the installation and operation of a standard ventilation system it is anticipated that the potential risk is further reduced (refer to discussion in Section 2.2 of this Work Plan). Subsequent changes in vapor intrusion evaluation methods and action levels have prompted a reconsideration of the vapor intrusion pathway and additional vapor intrusion-related sampling at the TRW Microwave OU.

This Work Plan presents the methods and procedures for collecting multiple lines of evidence to be used for evaluating the VI pathway and ensure that data obtained are reliable and usable. The USEPA Regional Screening Levels (RSLs) for indoor air industrial exposure, most recently

published in May 2013 (USEPA 2013) and the RWQCB Environmental Screening Levels (ESLs) (RWQCB 2013), most recently published in May 2013 (RWQCB 2013) will be used as the project action levels (PALs). The PALs for groundwater COCs at the Site are listed on Table 1; four additional VI related COCs are included on page 2 of Table 1 and in Table A-2 in the Quality Assurance Project Plan (QAPP, provided in Appendix A to the Work Plan). All COCs will be included in air analyses performed under this project (refer to Work Plan Section 3.2). Data obtained under this Work Plan will be used to assess potential risk to future industrial users.

1.2 Work Plan Organization

This Work Plan is organized as follows:

- Section 1 provides an introduction and project objectives.
- Section 2 provides a brief site background and summary of previous indoor air sampling activities at the Site along with a conceptual site model relating to VI.
- Section 3 describes the sampling and analysis plan, identifies pre-sampling activities, sampling media, defines the sampling area, and describes the field sampling and analysis plan.
- Section 4 introduces the QAPP, which as stated above is provided in Appendix A.
- Section 5 introduces the health and safety plan (HASP) for this investigation.
- Section 6 describes data validation, evaluation, and reporting.
- Section 7 addresses the work schedule.
- Section 8 provides references.

2.0 SITE BACKGROUND AND CONCEPTUAL SITE MODEL

2.1 Site Background

The Site is located in an industrial area and is occupied by one 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) was accomplished between 1993 and 1998. The SVE system removed approximately 140 pounds of TCE and was removed in 1998 following demonstration that the criteria for closure had been met (CDM 1998). Groundwater treatment was initiated in 1985 with groundwater extraction and treatment (GWET), which was approved for suspension in 2001. In 2000, an enhanced anaerobic bioremediation (EAB) program was initiated and has continued to the present day. A summary of historic groundwater results associated with the groundwater remediation is included in Appendix B.

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; this new structure overlies the former UST excavation (see red outline on Figure 4). Per building drawings (available at 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 C, Photograph 1). 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.

A chronology of major events associated with Site VI investigations and actions is presented below and discussed in Section 2.2:

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.
May 2004	Northrop Grumman submitted a *Report of Findings – Installation and Operation of a Temporary Mechanical Ventilation System and Indoor Air Sampling* 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 *Report of Findings – October 2004 Indoor Air Sampling* report to the RWQCB (CDM 2004e).
December 2004	RWQCB approved the October 2004 Indoor Air Sampling Report (RWQCB 2004d).

Date	Event
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 *Letter of Requirement for Vapor Intrusion Sampling and Analysis Work Plan and Report*.

2.2 Summary of Previous Indoor Air Sampling Activities

The VI risk posed by VOCs was evaluated as part of a Baseline Public Health Evaluation (BPHE) and summarized in the ROD issued for the Site by the USEPA in 1991. Risk estimates presented in the BPHE were based on modeling transport of vapors from groundwater into hypothetical residences and used 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}. However, 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 2013) for industrial exposure and ESLs (RWQCB 2013). 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 Northrop Grumman installed and operated 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.

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 1.0. This conclusion remains valid when results are compared to current threshold values.

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 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 most recently (in October 2004), ranging from 4.3 micrograms per meter cubed ($\mu g/m^3$) to 5.1 $\mu g/m^3$ and was the only analyte that exceeded its current indoor air RSL for industrial exposure of 3 $\mu g/m^3$. It should be noted that these concentrations are marginally above industrial RSLs.

2.3 Conceptual Site Model and Selection of Sampling Locations

Figure 2 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 4) constructed in 2002. Figure 4 also shows groundwater monitoring well locations and contaminant concentrations detected in groundwater in October 2012.

There is no evidence of contaminant sources remaining in the shallow vadose zone beneath or surrounding the building; vadose zone contamination was addressed by earlier soil vapor extraction (SVE) and source removal actions (CDM 1998). However, concentrations of VOCs previously detected in the indoor air (see concentrations listed on Table 2) may be attributed to volatilization from groundwater.

AECOM staff performed a building survey on 22 January 2013 to (1) identify the current condition of the building and potential conduits for VI into the building; and (2) select potential sampling locations (shown as black circles enclosing an X on Figure 5). An indoor air building survey and sampling form adapted from Appendices K and L of the *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (DTSC 2011) was completed and is included in Appendix C along with photographs that document the locations of potential VI pathways including the elevator shaft (Photograph 1) and Eductor located in the former UST source area (Photograph 2). The building's interior construction is not complete (refer to Photograph 1) and the portion of the building overlying the former Site source area is a two story building with concrete slab and steel I-beam construction (refer to Photographs 1 and 2) and is presently not equipped with any heating, ventilation and air conditioning (HVAC) system, electricity, or plumbing.

The Eductor and surrounding backfilled excavation, groundwater monitoring wells located within the building, and elevator shaft all were identified as potential pathways for VI into the Site building. Indoor air sample location IA-1 will be collected at the Eductor to evaluate VOC concentrations in the area of the Eductor pit and near groundwater monitoring Well T-2A and indoor air sample IA-4 will be collected in the elevator shaft and approximately 25 feet from groundwater monitoring Well T-3A. Proposed sampling locations are shown on Figure 5. Refer to Figure 4 for groundwater monitoring well locations. Based on inspection of the remaining building interior, the third (IA-2) and fourth (IA-3) sampling locations are proposed near the center of each of the other two building rooms, which are not underlain by a vapor barrier (note also that these rooms do not overlie the former source area). Obtaining one sample in each room will achieve a spacing pattern of 50- to 100-feet between samples. Results from all samples will be compared with results from previous samples also collected in each of the three building rooms (refer to Figure 3 and Table 2). An outdoor (ambient) air sample will be collected at an upwind location approximately 25 feet away from the building (this sampling location will be finalized on the sampling date and is therefore not shown on Figure 5). Sub-slab vapor monitoring wells will be co-located with the indoor air sampling locations with the exception of the sample located in the elevator shaft. An additional un-paired sub-slab vapor well will be installed south of the Educator and upgradient of the former on-site source area. These wells

will be used to help gain an understanding of potential VI sources to indoor air and to evaluate site specific building attenuation factors.

3.0 SAMPLING AND ANALYSIS PLAN

3.1 Pre-Sampling Activities

As desired and if required, Northrop Grumman will visit the Site with the USEPA and RWQCB to review and get approval of final sampling locations included in this work plan. Geophysical clearances will be performed prior to the commencement of well installations to avoid any utilities, conduits, or rebar located within the concrete slab foundation of the building.

A pre-sampling building survey was performed on 22 January 2013 (refer to Appendix C.2 for completed building survey form). During the pre-sampling survey a drum of hydraulic fluid and a liquid sprayer were observed in the building (refer to Photograph 3 in Appendix C.1). Approximately one week prior to sampling, the Site will be visited to remove any potential VOC sources from inside the building including the drum of hydraulic fluid and sprayer if they are still present.

Note that samples will not be collected within 48 hours of a significant rain event (1/2 inch of rainfall or greater).

3.2 Indoor Air Sampling

Indoor and outdoor air samples will be collected over a 12-hour period using individually-certified clean SUMMA™ canisters supplied by the analytical laboratory. Samples will be analyzed by Test America Laboratories (TAML) in West Sacramento for VOCs by USEPA Method TO-15 using selective ion monitoring (SIM). Table E-1 in Appendix E provides TAML's list of the requested TO-15 SIM analytes and reporting limits (RLs); Table A-2 in the QAPP also lists the 14 VOCs selected for analysis of indoor air samples collected under this Work Plan. These VOCs include the 10 groundwater COCs listed in Table 1; three chemicals (Freon 11, Freon 12, and chloroform) consistently detected in previous indoor air samples at the Site (refer to Table 2); and chlorobenzene, which was detected in groundwater at relatively high concentrations beneath the building during the most recent annual site monitoring event conducted in October 2012 (refer to Figure 4). The USEPA RSLs and the RWQCB ESLs for industrial exposure to indoor air will be used as PALs. The reporting limits for the TO-15 SIM analyses meet these PALs.

A second building survey will be completed on the day of sampling using the form included in Appendix D, which is adapted from Appendices K and L in the *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (DTSC 2011). This survey will include real-time screening level measurement of total organic vapors inside the building using a low-level photoionization detector (PID) with a reporting limit of 1 part per billion (ppb). Atmospheric pressure and temperature measurements will be taken inside and outside of the building prior to and after indoor air sampling as described below.

The overall strategy for air sampling is as follows:

1. Conduct a pre-sampling survey during which the following measurements will be recorded: temperature (indoors and outside on sampling date); pressure differential measurements (readings taken throughout the building and at each sample location inside the Site building relative to the outside air pressure); total VOCs detected using a PID; and outside weather conditions during sample collection. These readings will be recorded on the form prior to and at the conclusion of the sampling described below. In addition, any changes to observations made in January 2013 regarding preferential flow pathways, onsite chemical storage, or changes to the building floor plan or ventilation system will be recorded on the form; if significant changes are observed, sample locations may be modified. As noted previously, there is currently no HVAC system in the building so air intake is not anticipated to be a factor in the sampling program.

2. Collect indoor air samples over a 12-hour period for analysis of VOCs by USEPA Method TO-15 SIM using individually certified-clean canisters. The 6-liter sample canisters will be located on the first floor of the building in close proximity to the Eductor (Sample IA-1), elevator shaft (Sample IA-4), and near the center of each room in the portion of the original building that does not overlie a vapor barrier (Samples IA-2 and IA-3) (Figure 5). Each SUMMA™ canister will be placed at a height of approximately 3 to 5 feet above the floor level (i.e., the breathing zone). Sampling locations will be photographed and documented in the report. All windows and doors in the facility will be closed prior to initiating sampling and remain closed throughout the period of sampling. If the initial vacuum gauge reads less than 26 inches of Hg, the canister will be replaced prior to sample collection; if the final vacuum gauge reads greater than 20 inches of Hg, the sample will be rejected. Vacuum pressures will be monitored throughout the 12-hour sampling period to identify potential problems with flow regulators.

3. Collect an outside air sample (Sample OA-1) at least 25 feet upwind of the Site building. The upwind sample will be placed in a container for stability and for protection from direct sunlight with the inlet extending out of the container. The sample will be collected over a 12-hour period concurrent with indoor air sampling and will be collected into an individually certified clean canister for analysis of VOCs by USEPA Method TO-15 SIM.

4. Sample start and end times as well as start and end vacuum gauge readings will be included on the sample label and on field forms (field forms included in Appendix D). The samples will be sent to an off-site laboratory for analysis by USEPA Method TO-15 SIM (analytes listed in QAPP Table A-2).

5. A tee will be used to collect duplicate samples into co-located SUMMA™ canisters at the locations of Sample IA-1, located by the Eductor (where concentrations are anticipated to be highest), and Sample OA-1, at the outdoor sample location.

3.3 Sub-slab Sampling

Sub-slab vapor monitoring wells will be installed using a hand-held hammer drill. Well installations will follow the following procedures. A 1-inch diameter borehole will be drilled to

a depth of 3 inches below the concrete foundation of the building. A pilot borehole will be completed to determine the thickness of the building foundation if needed. A 0.5-inch-long stainless steel tip (vapor implant) attached to ¼-inch Nylaflow® tubing will be inserted into the bottom of the borehole and will be connected to ¼-inch stainless steel tubing and inserted into the bottom of the borehole so that the top of screen is 1 inch below the building foundation. Filter pack sand (#3) will be placed around and extending 1 inch above the implant (approximately level with the building foundation), followed by 2 to 3 inches of bentonite, hydrated to ensure proper sealing, and topped by a quick-set cement to the surface. The well will be completed with the terminal end of the ¼-inch stainless steel tubing connected to a threaded fitting in a compression cap that is flush with the building floor. A diagram of the typical construction of a sub-slab vapor well and sampling setup is presented on Figure 6. The protocol for sub-slab vapor well construction and sampling will follow guidelines in the *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (DTSC 2011) and the *Advisory - Active Soil Gas Investigations* (Cal-EPA 2012).

Following well installation the overall strategy for sub-slab sampling is as follows:

1. All wells will be leak tested to verify that each well is properly installed and that indoor air is not drawn into the well thus diluting VOC concentrations in the samples. Leak testing will be conducted prior to sampling of the well and no sooner than 2 hours after vapor well installation to allow time for the cement to cure and subsurface conditions to equilibrate prior to testing.

   The leak tests will involve the use of helium as a tracer compound introduced into the atmosphere immediately surrounding the well. An on-site helium tester will be used (similar to a MGD-2002 helium detector, refer to Appendix F for specifications on helium testing equipment). Prior to leak tests, an overturned plastic tub (shroud) is placed over the well head, and the helium tracer is introduced into the air beneath the shroud. A PID is used to purge vapor from the well and field screen for VOCs; followed by measurement of helium in the well vapor. Detection of helium (using the helium tester) at 5 percent (%) of the concentration measured in the inverted tub surrounding the well head will trigger an investigation into the potential cause of the leakage. If a potential cause is identified, corrective action will be taken to eliminate the leak before conducting a second leak test to confirm the initial result. If the tracer compound is not detected at a concentration in excess of failure criteria, the vapor well will be considered properly sealed.

   If the well again fails the leak test, then a replacement well will be installed at least 5 ft away from the original well. The tubing and implant will be removed from the original well, and the borehole will be backfilled with concrete and finished flush with the building floor.

2. Prior to sampling, a shut-in test is performed to check for leaks in the above-ground sample train (e.g., fittings, lines, and valves located above-ground). The objective is to ensure that leaks in the sample train are detected. Valves to the probe and sample container are shut and the lines will be evacuated inducing a measured vacuum of about 100 inches of water. Once all the external valves to the sampling line are shut,

the vacuum is observed for at least a minute. The vacuum gauge should remain steady, indicating no leakage at any of the fittings. If there is an observable loss of vacuum (indicating leakage), the fittings are adjusted until the line can hold a vacuum.

3. Collect samples from the sub-slab wells immediately after purging using a 1-L SUMMA™ canister fitted with a flow regulator that limits the flow rate to less than (<) 200 mL/min. Sub-slab Samples SS-1, SS-2, and SS-3 will be co-located with indoor air Samples IA-1, IA-2, and IA-3; an additional sub-slab sample (SS-4) will be located upgradient of the former Site source area south of the Eductor. Sub-slab samples will be collected within 24 hrs of indoor air samples.

4. Sample start and end times as well as start and end vacuum gauge readings will be included on the sample label and on field forms (field forms included in Appendix D). The samples will be sent to an off-site laboratory for analysis by USEPA Method TO-15 in full scan mode (analytes listed in Appendix E Table E-2).

5. A tee will be used to collect a duplicate sample into co-located SUMMA™ canisters at the location of SS1, located by the Eductor (where concentrations are expected to be highest).

3.4 Sample Handling, Containers, Analytical Methods, Sample Identification, Sample Custody and Shipping

3.4.1 Sample Handling, Containers and Analytical Methods

The analytical laboratory will supply seven individually certified 6-liter SUMMA™ canisters and five batch certified 1-liter SUMMA™ canisters equipped with vacuum pressure gauges and flow regulators. Prior to collection of a sample, each canister will be vacuum tested to confirm that it has been properly evacuated. Each SUMMA™ canister is received from the laboratory with a clean certification that will be scanned and saved in the project file. Indoor air and ambient air samples will be collected in 6-liter SUMMA ™ canisters and analyzed using USEPA Method TO-15 modified for selective ion monitoring (SIM) mode; vapor samples collected from sub-slab wells will be collected in 1-liter SUMMA™ canisters and analyzed using USEPA Method TO-15 in full scan mode. No sample preservation is required for TO-15 analysis; however, to preserve sample integrity, air samples will be protected from temperature extremes.

3.4.2 Sample Identification

Samples will be identified using the Site identifier (J6038) follow by the location identifier SS (sub-slab), IA (indoor air) or OA (outdoor air), then the sample number (sequential number of the sample, i.e., 1-4 for sub-slab wells, 1-4 for indoor air and 1 for outdoor air), the sampling date (mmddyyyy), and finally -1 for an original sample or -2 for a duplicate sample. For example the first indoor air sample obtained on November 15, 2013 would be identified as J6038-IA-1-11152013-1. A duplicate sample from this same location would be identified as J6038-IA-1-11152013-2. Completed sample labels will be attached to each sample container. The location of each sample will be photographed and identified in the field notebook and site map.

3.4.3 Sample Custody and Shipping

The SUMMA™ sample canisters will be labeled, packed, and shipped to TAML, which is air-certified by the National Environmental Laboratory Accreditation Program (NELAP). The analytical method is described in the standard operating procedure (SOP) for TO-15 full scan and SIM provided by TAML (Appendix E).

Filled and labeled sample containers will be placed into boxes for transport to the analytical laboratory. Sample labels and the air sampling log will identify the basic project information (business address and project name and number), sample identification (ID), sample type, date, start/stop time, sample canister number, flow controller number, sampler name, and initial and final vacuum pressures. A canister field data record form furnished by the analytical laboratory will accompany each canister and include the canister serial number, date cleaned, flow regulator identification number and flow setting, field sample ID, and vacuum readings (initial vacuum check, initial field vacuum and final field vacuum). This form accompanies the canister along with the chain-of-custody form. The chain-of-custody form will also document the canister serial number in the remarks column of the form. The field manager will coordinate delivery with the laboratory to ensure timely and safe delivery of shipped samples. Samples will be transferred under chain-of-custody procedures. The chain-of-custody form will be signed by the sampler and relinquished to the sample custodian. All samples will be transported to the laboratory within 24 hours of the time sample collection is completed. Sampling field data sheets and chain-of-custody form are included in Appendix D along with the building survey form.

4.0 QUALITY ASSURANCE PLAN

A QAPP has been prepared for this investigation and is provided in Appendix A. The purpose of the QAPP is to ensure that the appropriate type, quality, and quantity of data are collected to meet all of the project objectives.

5.0 HEALTH AND SAFETY PLAN

A HASP previously prepared for the Site is included in the project files. The field crew will have on-site access to the HASP on the day of sampling. An AECOM activity hazard analysis (AHA) form has been prepared specifically for the sampling and well installation activities proposed in this Work Plan and is included in Appendix G. This AHA will be provided to the field crew before mobilization to the Site.

6.0 DATA VALIDATION, EVALUATION, AND REPORTING

The following sections discuss the process for validation of the indoor air data, reporting the results of the VI investigation, and the anticipated schedule of field work and reporting.

6.1 Data Validation and Quality Assurance

Following completion of the field investigation and upon receipt of the analytical data, the data will be validated by a third-party validator, Conestoga-Rover Associates (CRA). Data validation will be performed in accordance with the *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (USEPA 2008).

Assessment will include checks on data consistency by looking for comparability of duplicate analyses, comparability to previous data from the same sampling location (as available), adherence to accuracy and precision control criteria detailed in the project QAPP, and anomalously high or low parameter values. The results of these data validations will be reported to the Project Manager and the contract laboratory, noting any discrepancies and their effect upon acceptability of the data.

Raw data from field measurements and sample collection activities that are used in project reports will be appropriately identified and appended to the report. Where data have been reduced or summarized, the method of reduction will be documented in the report. Field data will be audited for anomalously high or low values that may appear to be inconsistent with other data.

6.2 Data Evaluation

Indoor air sample results will be compared to the USEPA May 2013 indoor air RSLs for industrial exposure and to RWQCB May 2013 indoor air ESLs for commercial/industrial exposure. The RSLs and ESLs are long-term, health-based risk criteria. Sub-slab vapor sample results will be compared to soil vapor screening levels (SVSLs) developed using the indoor air RSLs and ESLs for industrial exposure divided by a default attenuation factor of 0.05 for existing commercial buildings as per California Environmental Protection Agency Department of Toxic Substances Control VI Guidance (DTSC 2011). TCE and its degradation products are the primary Site contaminants contributing to the VI pathway, other Site COCs identified for groundwater are included on Table 1. In addition, three VOCs, Freon 11 (trichlorofluoromethane), Freon 12 (dichlorofluoromethane), and chloroform, detected in previous indoor air samples at the Site (refer to Table 2) as reported by CDM (2004) will be included in air and vapor analyses. Finally, chlorobenzene detected at relatively high concentrations beneath the building during the most recent annual groundwater monitoring event at the site conducted in October 2012 (refer to Figure 4) will also be included in TO-15 analyses. Table A-2 in Appendix A presents the complete list of project analytes for indoor and outdoor air analysis, as well as the May 2013 RSLs and ESLs selected as the PALs; and laboratory RLs for the TO-15 SIM mode. For sub-slab vapor samples the complete TO-15 full scan mode analyte list will be performed. This list includes all indoor air project analytes and additional VOCs included in the standard list for TO-15 full scan mode analysis. The complete list of analytes included in the TO-15 full scan mode analysis is included in Appendix E, Table E-2 which also lists the RLs for these analytes and the SVSLs to be used as PALs for the soil vapor samples.

The concentrations of VOCs detected in the indoor air samples will be compared to outdoor air concentrations to assess the likelihood that individual chemicals detected in the indoor air are affected by sources unassociated with VI from groundwater. Indoor air concentrations will also be compared to sub-slab vapor concentrations to further evaluate chemicals that can be attributed to a VI source and if possible evaluate the contribution from onsite and upgradient sources. The estimated risk to workers under a commercial/industrial exposure scenario will be calculated for: (1) all chemicals detected in the indoor air; and (2) that subset of chemicals detected in indoor air considered likely to have entered the building from the subsurface via the VI pathway. This subset of chemicals detected in indoor air will be identified based on interpretation of several lines of evidence including:

- Detection in the groundwater;
- Detection in sub-slab vapor wells;
- Indoor air concentrations are higher than concentrations in the outdoor (ambient) air (i.e., the chemical is not ubiquitously present in the indoor or outdoor atmosphere); and
- Historic data indicating use and potential release of this chemical to the subsurface.

The entire suite of chemicals detected in indoor air samples and that subset of detected chemicals identified as likely attributable to the VI pathway will be used to calculate a cumulative cancer risk and non-cancer hazard index (HI) for each indoor air sampling location. The procedure to be used is as follows:

1. Risks and hazards will be calculated on a sample-by-sample basis.

2. For carcinogens, a ratio will be calculated by dividing the concentration of each individual chemical by its RSL, and multiplying that ratio by 10^{-6}. These risks will be summed to give an estimate of cumulative risk for that location.

3. For non-carcinogens, the simple ratio of each chemical concentration to the RSL will give the HQ for that chemical. These HQs will be summed to give the HI for the VIP at that location.

4. Cumulative risks and HIs based on using the more restrictive February 2013 ESLs for PCE and VC will also be estimated and reported.

As a starting point for risk management decisions, Northrop Grumman proposes that no action is appropriate unless the screening-level risk evaluation indicates a cumulative risk exceeding a level of 10^{-6} for a commercial/industrial scenario. Based on this screening level risk evaluation, a conclusion will be provided regarding whether the cumulative cancer risk attributed to the VI is below the risk level of 10^{-6} and a non-cancer HI of 1, in which case no further action will be recommended. If sampling results indicate a cumulative screening-level cancer risk attributed to the VI between 10^{-4} and 10^{-6} and/or an HI greater than 1, Northrop Grumman will discuss and document appropriate risk management decisions with the regulatory agencies. Based on these discussions, additional sampling events and/or VI mitigation measures may be required. Risk decisions may be supported by risk calculated using a building wide exposure point concentration rather than a location specific risk. Previously (refer to Work Plan Section 2.2 and Table 2), CDM (2004e) demonstrated a reduction in indoor air concentrations to below levels of concern under the condition of mechanical ventilation (i.e., operation of fans) at an AER of 1 building volume per hour. Note that risks calculated from previous indoor air sampling results collected in 2003 and 2004 without operational mechanical ventilation were in the 10^{-5} risk management range and are considered protective of the building occupants.

6.3 Reporting

Following completion of the field investigation and upon receipt and validation of the analytical data, a report of the VI investigation will be prepared. This report will include descriptions of field methods, field observations, laboratory analytical data validation, and results. Laboratory

data will be tabulated and presented on figures. Copies of laboratory analytical reports and chain-of-custody records will also be included.

In addition to the field forms, all field descriptions and observations will be entered into the field notebook. This notebook and all field forms will serve as a record of field activities and will be retained as a permanent project record.

7.0 SCHEDULE

Following RWQCB approval of this Work Plan (Note: responses to RWQCB and USEPA comments on the Work Plan are included in Appendix H), preparation for field activities will begin that will include scheduling of drilling crew for sub-slab vapor well installations and coordination with the analytical laboratory. Pending availability of all relevant parties, tenant activities, and appropriate weather conditions sampling dates will be scheduled. Prior to sampling the Site will be visited to clear sampling locations and perform a pre-sampling building survey. A 2-day field sampling effort will be needed to install and sample sub-slab vapor wells and collect indoor and outdoor (ambient) air samples. Data validation, compilation, and evaluation will follow sample collection and analyses and a draft version of the report will be submitted for regulatory review. Final analytical results will be submitted to the RWQCB and USEPA within 48 hours of receipt from the analytical laboratory. Upon approval of the draft report a final report will be issued. AECOM plans to submit the draft investigation report to the RWQCB and USEPA within 60 days after all field activities are concluded.

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TABLES

TABLE 1. CHEMICALS OF CONCERN IN GROUNDWATER AND INDOOR AIR USEPA RISK SCREENING LEVELS

Analyte	2004 Maximum Indoor Air Concentration ($\mu g/m^3$)	2012 Maximum Concentration in Groundwater ($\mu g/L$)	USEPA Region 9 Screening Level for Industrial Exposure in Air[(a)] ($\mu g/m^3$)
1,1-dichloroethane	ND	0.71	7.7
1,1-dichloroethene	ND	0.57	880
1,2-dichlorobenzene	ND	2.3	880
1,1,1-trichloroethane	0.19	ND	22,000
cis-1,2-dichloroethene (cis-1,2-DCE)	ND	73	260
trans-1,2-dichloroethene (trans-1,2-DCE)	ND	3.8	260
tetrachloroethene (PCE)*	0.73	1.3	47
trichloroethene (TCE)	5.1	130	3
Freon 113	1.0	0.62	130,000
vinyl chloride*	ND	12	2.8

Notes:

All analytes listed in the table 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. 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 May 2013 (RWQCB 2013) for those analytes noted with an *. These screening levels are listed below:

PCE – 2.1 $\mu g/m^3$
Vinyl chloride – 0.16 $\mu g/m^3$

[(a)] Source: USEPA (USEPA 2013)
ND not detected
< less than
$\mu g/m^3$ micrograms per cubic meter

TABLE 1. CHEMICALS OF CONCERN IN GROUNDWATER AND INDOOR AIR USEPA RISK SCREENING LEVELS

Four other VOCs identified during previous indoor air sampling events or identified during recent groundwater sampling at the site are listed below and will be evaluated for VI risk.

Analyte	2004 Maximum Indoor Air Concentration ($\mu g/m^3$)	2012 Maximum Groundwater Concentration ($\mu g/L$)	USEPA Region 9 Screening Level for Industrial Exposure ($\mu g/m^3$)
chlorobenzene	ND	78	220
chloroform	0.30	ND	0.53
Freon 11	7.0	ND	3,100
Freon 12	3.4	ND	440

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

Sample Location ID	Purpose	Date	Initial Pressure (inches Hg)	Final Pressure (inches Hg)	Reporting Limit Multiplier	Freon 11	Freon 12	Freon 113	PCE	TCE	VC	1,1,1-TCA	Chloroform
						($\mu g/m^3$)							
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	-8.5	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 Eductor 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 Eductor - Duplicate	10/30/2003	-29.0	-9.0	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 5, 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 Eductor 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 Eductor - Duplicate	4/5/2004	-29.0	-6.0	1.68	**5.0**	**3.3**	**1.3**	**0.52**	**2.7**	**0.055**	**0.25**	**0.30**
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 Eductor 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 Eductor - 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**	**0.66**	**4.3**	ND <0.044	**0.18J**	**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

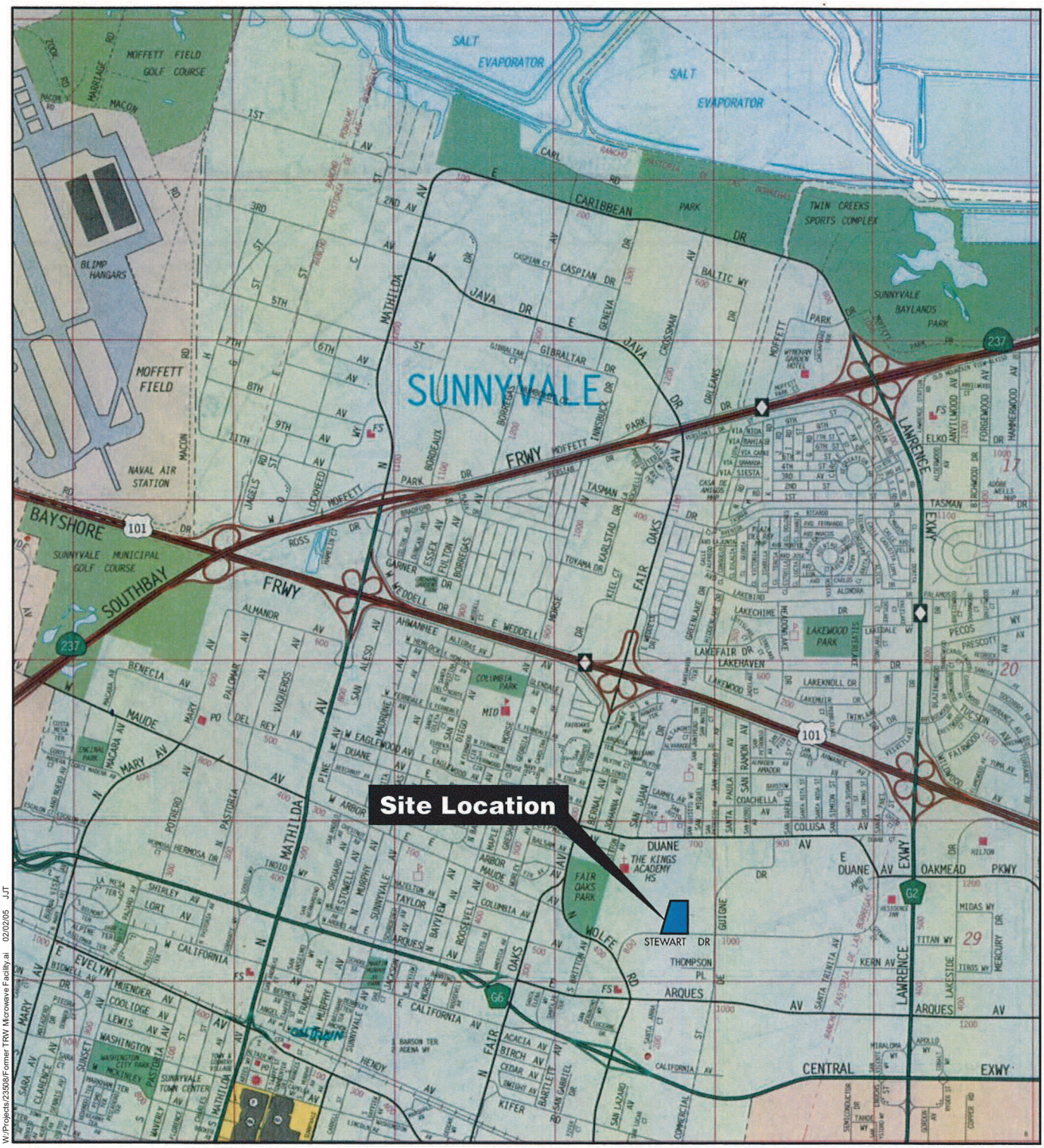
TABLE 2. PREVIOUS INDOOR AIR SAMPLING RESULTS
FORMER TRW MICROWAVE FACILITY
(Page 2 of 2)

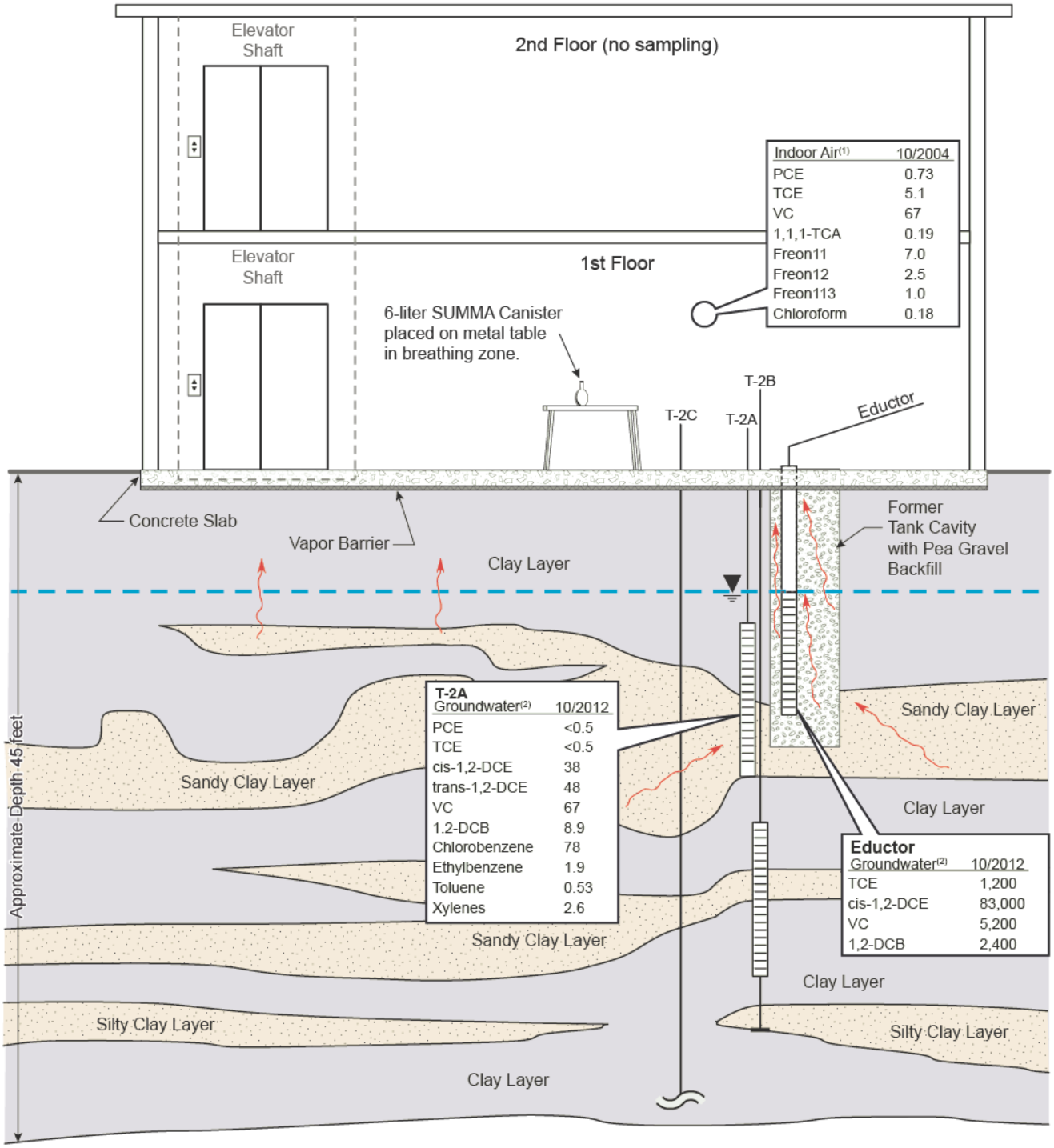
Sample Location ID	Purpose	Date	Initial Pressure (inches Hg)	Final Pressure (inches Hg)	Reporting Limit Multiplier	Freon 11	Freon 12	Freon 113	PCE	TCE	VC	1,1,1-TCA	Chloroform
						(µg/m^3)							
Threshold Levels													
USEPA Region 9 Screening Levels - Industrial Exposure (May 2013)						3,100	440	130,000	47	3	2.8	22,000	0.53
Environmental Screening Levels (RWQCB 2013)						-	-	-	2.1	-	0.160	-	-

Notes:
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 June 2013 (USEPA 2013).
= 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 ug/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
ug/m^3	micrograms per cubic meter
ND<0.020	non detect less than stated reporting limit (e.g. 0.020)
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
J	estimated value below reporting limit
PCE	tetrachloroethene
RWQCB	Regional Water Quality Control Board
TCE	trichloroethene
USEPA	United States Environmental Protection Agency
VC	vinyl chloride

FIGURES


Site Location
SUNNYVALE
STEWART DR
SALT EVAPORATOR
SALT EVAPORATOR
MOFFETT FIELD GOLF COURSE
BLIMP HANGARS
MOFFETT FIELD
NAVAL AIR STATION
SUNNYVALE MUNICIPAL GOLF COURSE
TWIN CREEKS SPORTS COMPLEX
SUNNYVALE BAYLANDS PARK
LAKEWOOD PARK
FAIR OAKS PARK
THE KINGS ACADEMY HS
BAYSHORE
SOUTHBAY
FRWY
101
237
MATHILDA
LAWRENCE
EXWY
CENTRAL
OAKMEAD PKWY
CALIFORNIA
EVELYN
WOLFE RD
FAIR OAKS
MOFFETT
CARIBBEAN
JAVA DR
GIBRALTAR
CASPIAN DR
BALTIC WY
TASMAN
E WEDDELL
DUANE
ARQUES
THOMPSON PL
KERN AV
COLUSA AV
COACHELLA
LAKEFAIR DR
LAKEHAVEN
LAKEMOOR
LAKEMOUNT
LAKEMOUNT
LAKEMOUNT



Explanation

Approximate Static Water Level (8 feet below ground surface)

Potential Vapor Contaminant Pathway

DCB	Dichlorobenzene
DCE	Dichloroethene
PCE	Tetrachloroethene
TCA	Trichloroethane
TCE	Trichloroethene
VC	Vinyl Chloride

Notes:

(1) Maximum 2004 historical indoor air concentrations detected; shown in mircograms per cubic meter (µg/m³).

(2) Groundwater concentrations shown in micrograms per liter (µg/L).

NOT TO SCALE

Former TRW Mircowave Facility

Conceptual Site Model for Vapor Intrusion

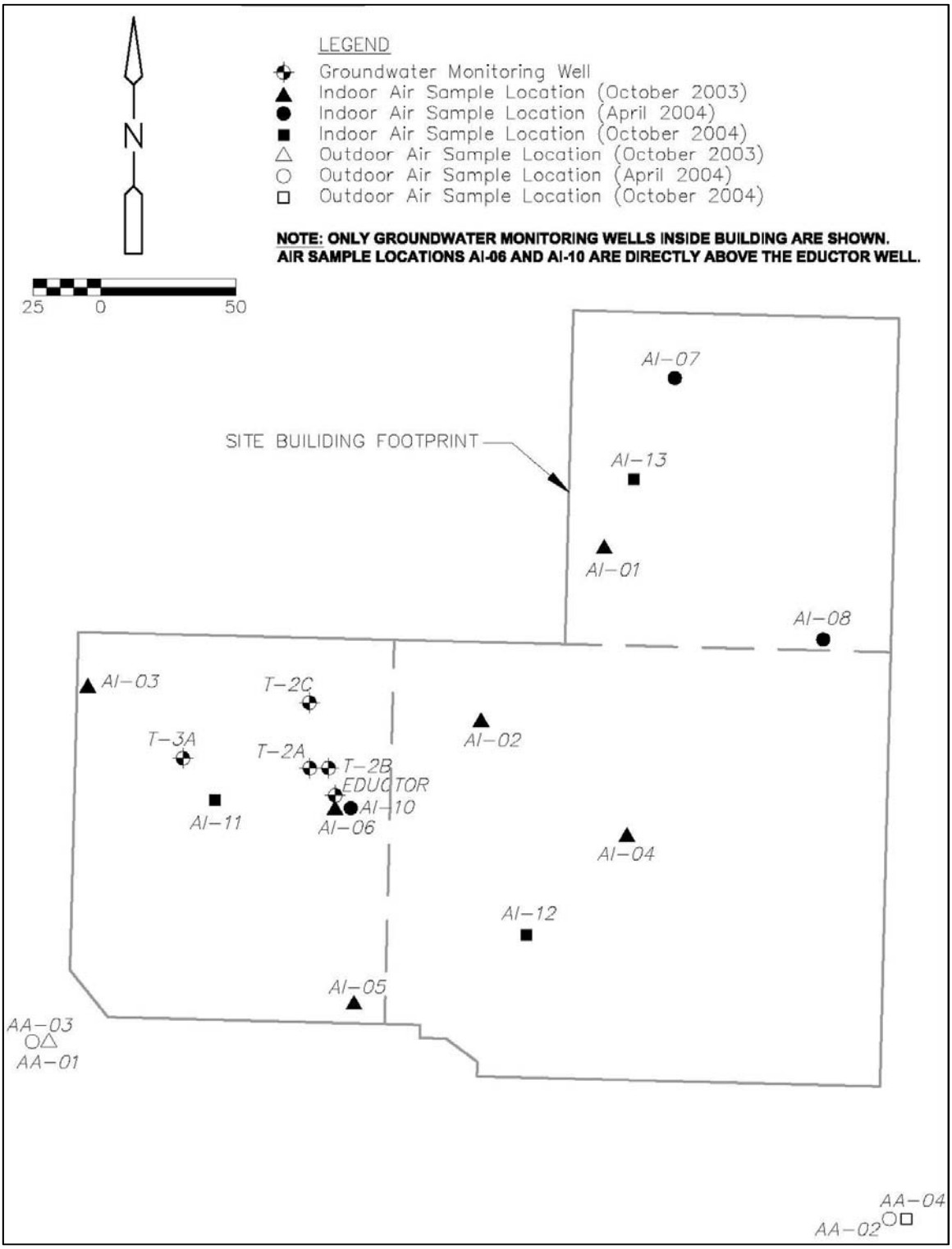
Date 02-13

Project No. 60238860

NORTHROP GRUMMAN

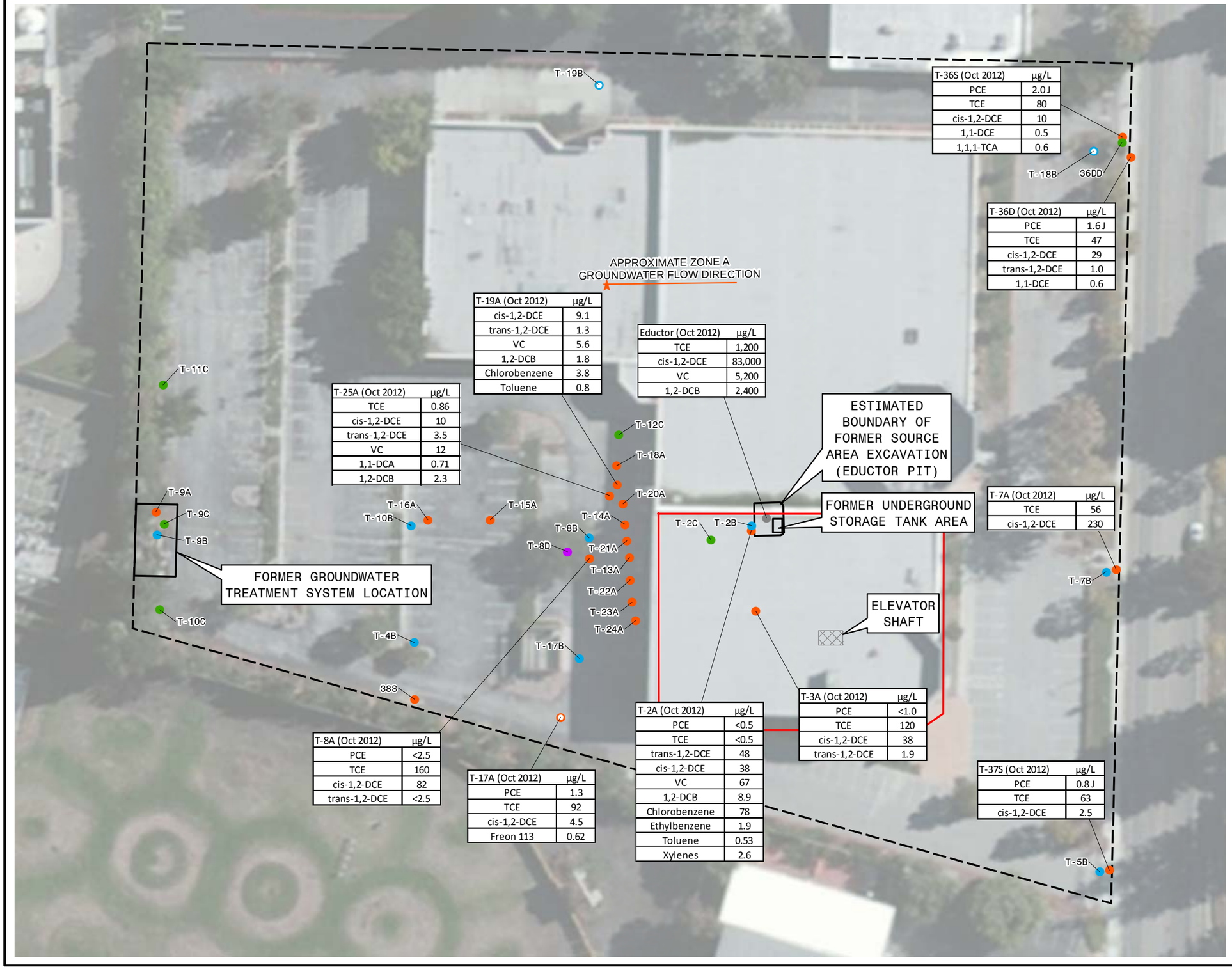
Figure 2

6023-8860.A6a Northrop Grumman



Adapted from CDM 2009.

NORTHROP GRUMMAN	Former TRW Microwave Facility **Previous Indoor Air Sampling Locations**	**FIGURE 3**



T-36S (Oct 2012)	µg/L
PCE	2.0 J
TCE	80
cis-1,2-DCE	10
1,1-DCE	0.5
1,1,1-TCA	0.6

T-36D (Oct 2012)	µg/L
PCE	1.6 J
TCE	47
cis-1,2-DCE	29
trans-1,2-DCE	1.0
1,1-DCE	0.6

T-19A (Oct 2012)	µg/L
cis-1,2-DCE	9.1
trans-1,2-DCE	1.3
VC	5.6
1,2-DCB	1.8
Chlorobenzene	3.8
Toluene	0.8

Eductor (Oct 2012)	µg/L
TCE	1,200
cis-1,2-DCE	83,000
VC	5,200
1,2-DCB	2,400

T-25A (Oct 2012)	µg/L
TCE	0.86
cis-1,2-DCE	10
trans-1,2-DCE	3.5
VC	12
1,1-DCA	0.71
1,2-DCB	2.3

T-7A (Oct 2012)	µg/L
TCE	56
cis-1,2-DCE	230

T-3A (Oct 2012)	µg/L
PCE	<1.0
TCE	120
cis-1,2-DCE	38
trans-1,2-DCE	1.9

T-2A (Oct 2012)	µg/L
PCE	<0.5
TCE	<0.5
trans-1,2-DCE	48
cis-1,2-DCE	38
VC	67
1,2-DCB	8.9
Chlorobenzene	78
Ethylbenzene	1.9
Toluene	0.53
Xylenes	2.6

T-8A (Oct 2012)	µg/L
PCE	<2.5
TCE	160
cis-1,2-DCE	82
trans-1,2-DCE	<2.5

T-17A (Oct 2012)	µg/L
PCE	1.3
TCE	92
cis-1,2-DCE	4.5
Freon 113	0.62

T-37S (Oct 2012)	µg/L
PCE	0.8 J
TCE	63
cis-1,2-DCE	2.5

LEGEND

- A-ZONE WELL INSTALLED IN NOVEMBER 2012
- B1-ZONE WELL INSTALLED IN NOVEMBER 2012
- A-ZONE MONITORING WELL
- B1-ZONE MONITORING WELL
- B2-ZONE MONITORING WELL
- B4-ZONE MONITORING WELL
- EDUCTOR
- PROPERTY BOUNDARY

ABBREVIATIONS

DCA	DICHLOROETHANE
DCB	DICHLOROBENZENE
DCE	DICHLOROETHENE
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
VC	VINYL CHLORIDE

NOTES

J ESTIMATED VALUE

N

0 25 50 Feet

1 " = 50 '

Former TRW Microwave Facility

Site Layout with 2012 Zone A Groundwater Concentrations

Date 3-13

Project No. 60238860

NORTHROP GRUMMAN

Figure 4

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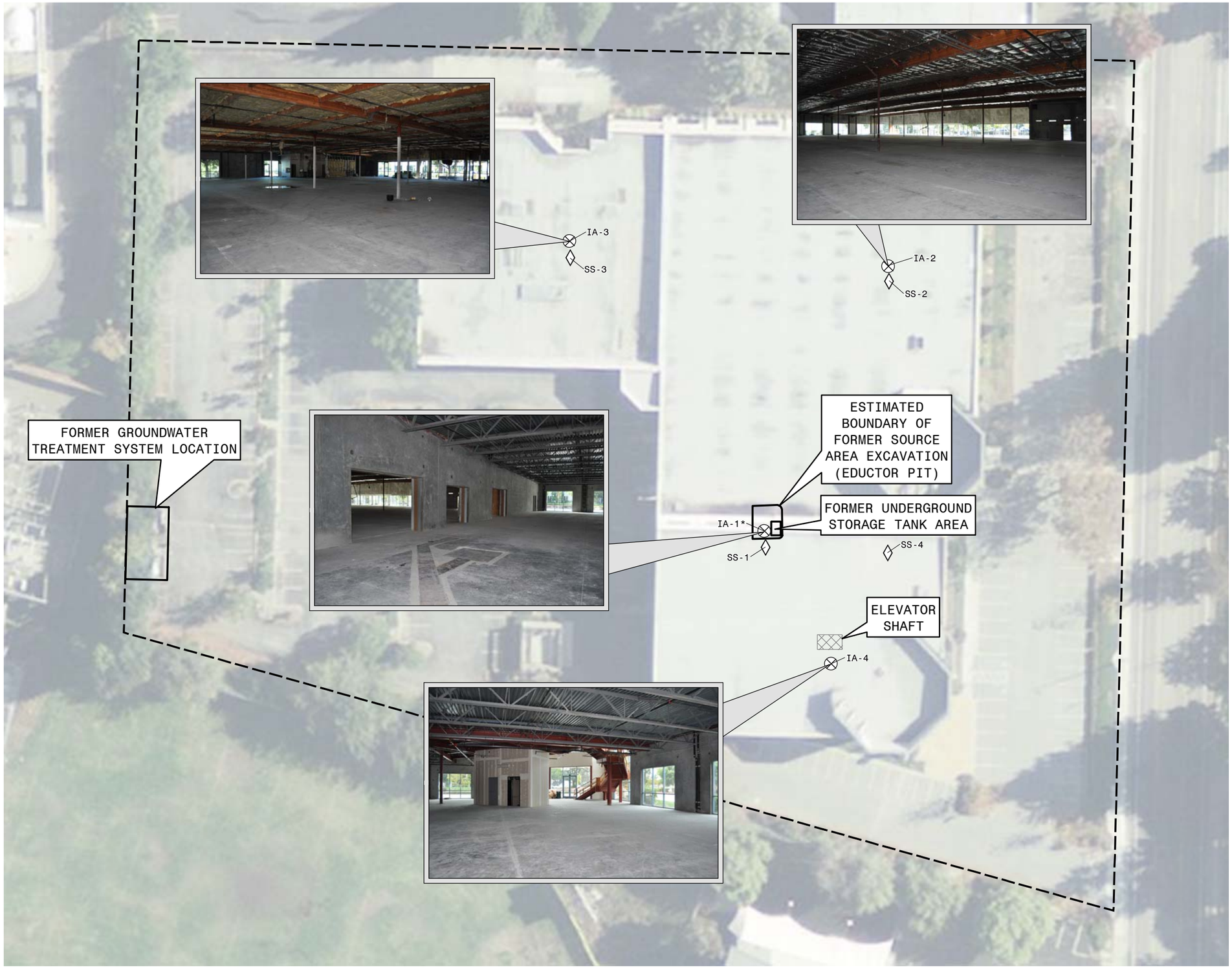

LEGEND

- ⊗ PROPOSED INDOOR AIR SAMPLING LOCATION
- ◊ PROPOSED SUB-SLAB SAMPLING LOCATION
- PROPERTY BOUNDARY

NOTES

* DUPLICATE SAMPLE LOCATION

N

0 25 50 Feet

1 " = 50 '

Former TRW Microwave Facility

Proposed Sampling Locations

Date 06-13	NORTHROP GRUMMAN	Figure
Project No. 60238860		5

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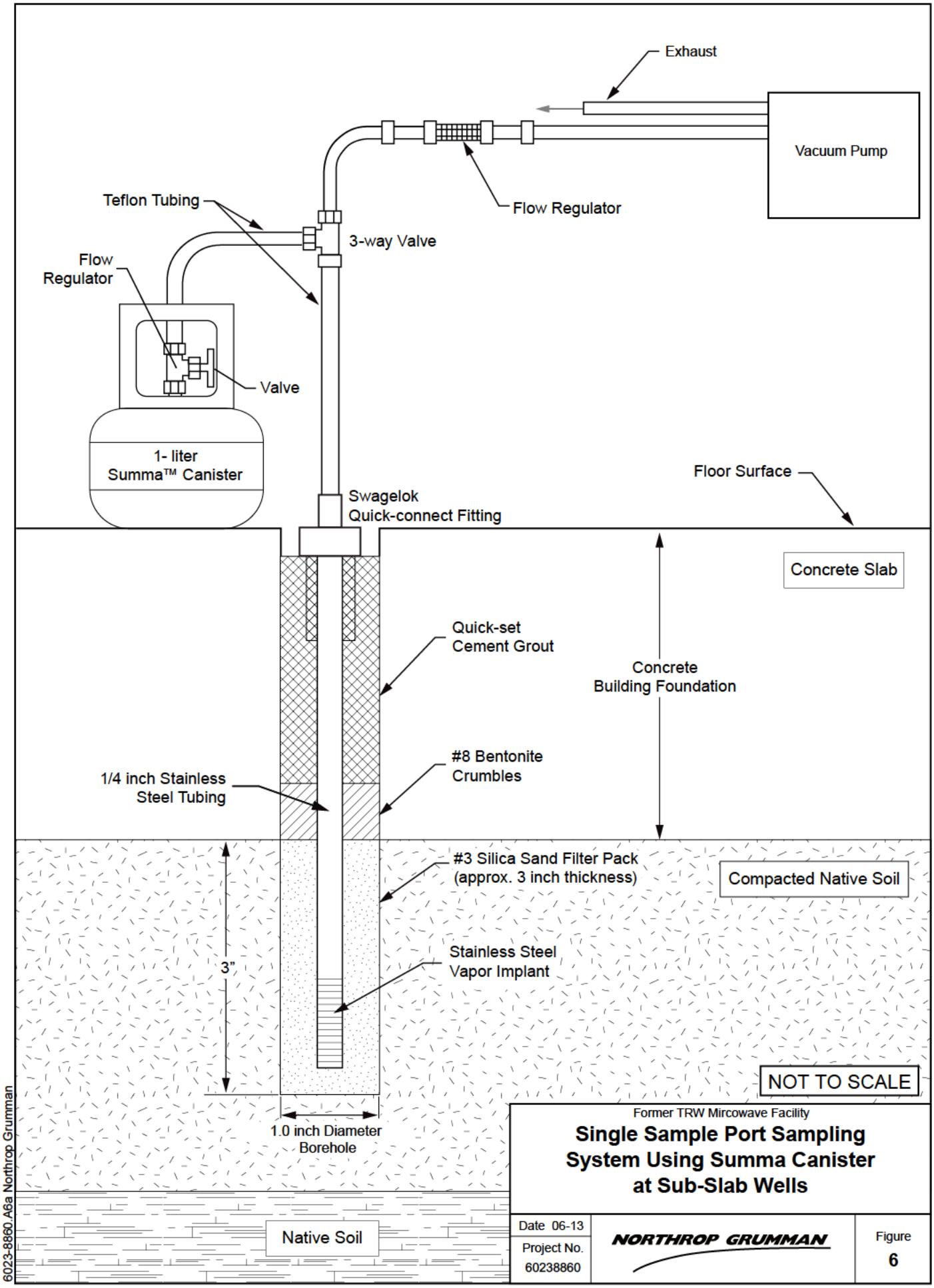

Former TRW Mircowave Facility

Single Sample Port Sampling System Using Summa Canister at Sub-Slab Wells

Date 06-13	NORTHROP GRUMMAN	Figure
Project No. 60238860		6

6023-8860.A6a Northrop Grumman

APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

This appendix presents the quality assurance project plan (QAPP) for vapor intrusion (VI) sampling and analysis to be conducted at the Former TRW Microwave Operable Unit (OU) (the "Site") located in Sunnyvale, California. The *Vapor Intrusion Evaluation Sampling and Analysis Work Plan* (Work Plan) and this QAPP were prepared in response to a 6 December 2012 letter from the San Francisco Regional Water Quality Control Board (RWQCB) titled *Requirement for Vapor Intrusion Sampling and Analysis Work Plan and Report* and comments received from RWQCB on the draft submittal of this Work Plan and additional comments issued on 23 August 2013 by the United States Environmental Protection Agency (USEPA) on the final submittal of this work plan. The RWQCB regulates the site under Order No. 91-103. As explained in Section 1.0 of the Work Plan, the USEPA has (since 1990) also been involved in overseeing remedial investigation and cleanup at the Site under a 1991 Record of Decision (ROD) selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process.

A.1 PROJECT MANAGEMENT

A.1.1 Quality Assurance Project Plan Identification and Approval

Individuals listed in Table A-1 agree to this Quality Assurance Project Plan (QAPP) for the indoor air investigation at the former TRW Microwave OU, located at 825 Stewart Drive in Sunnyvale, California, and commit to their responsibilities for following the procedures described and referenced in this plan to ensure that the requirements specified in the plan are met.

A.1.2 Distribution List

The personnel listed in Table A-1 will receive copies of the approved Work Plan, which includes this QAPP for the VI investigation at the site.

A.1.3 Project Organization

The RWQCB is the lead agency for remedial activities at the site. The USEPA Region 9 Superfund Division provides technical guidance and support to the RWQCB. AECOM is performing the tasks described in the Work Plan at the request of Northrop Grumman. Test America Laboratories, which is certified by the National Environmental Laboratory Accreditation Program (NELAP), will provide analytical services for the air/vapor samples collected as part of this sampling effort. Conestoga-Rovers and Associates will provide data validation.

Table A-1. Personnel Roles, Responsibilities and Communication Pathways			
Personnel	**Role**	**Responsibility/Communication**	**Contact**
Rick Cramer, P.G.	Project Director	Overall responsibility for project budget and staffing, including communication of roles and responsibilities. Review and sign documents.	(714) 689-7264
Rebecca Mora	Senior Engineer/Project Manager	Review documents and technical approach. Overall responsibility for project management, field operations, adherence to schedule, and deliverables. Approves qualified subcontractors as required. Directs and approves all communications to Northrop Grumman, including notification of field changes, significant corrective action, or modification within 2 business days.	(714) 689-7254
Beth Ainsworth	Project Geologist	Prepares work plan and report; assists in interpretation of data	(714) 689-7217
Holly Holbrook	Field Coordinator/Staff Engineer	Assists in preparation of documents and field coordination. Communicates daily with field geologist and project manager during fieldwork.	(714) 689-7215
Chris Drabandt, P.G.	Field (Staff) Geologist	Performs field work. Reports any field changes to Field Coordinator and/or project manager during same field day.	(916) 284-0029
Sue Scrocchi, QA/QC Chief, Conestoga-Rovers and Associates (CRA)	Third-party data validation	Data review and validation in accordance with the QAPP and program requirements.	(716) 297-6150
Laura Turpen, Project Manager, Test America Laboratories	Laboratory Analysis	Provides testing of samples for requested analytes in accordance with the QAPP using approved standard methods. Ensures that reported data meet the project required standards for accuracy and precision.	(916) 374-4414

A.1.4 Problem Definition/Background

As described in the Work Plan, the RWQCB in a letter dated 6 December 2012 required Northrop Grumman to submit a work plan for conducting VI sampling and analysis at the Site; and to submit a report on results of the VI sampling and analysis tasks and the potential for VI risk.

Section 2.1 of the Work Plan describes the site background and includes a chronology of major events associated with Site VI investigations and actions. Vadose zone treatment using soil vapor extraction (SVE) was accomplished between 1993 and 1998 following removal of the UST and surrounding soil. Groundwater treatment was initiated in 1985 with groundwater extraction and treatment (GWET), which was approved for suspension in 2001. In 2000, an enhanced anaerobic bioremediation (EAB) program was initiated and has continued to the present day. A vertical polyvinyl chloride perforated pipe installed within the backfilled

excavation is referred to as the Eductor (refer to Figure 2 in the Work Plan) and has been used for injections during EAB treatments.

The VI investigations listed below are also discussed in Section 2.2 of the Work Plan. As summarized in a November 17, 2004 *Report of Findings – October 2004 Indoor Air Sampling, Former TRW Microwave Facility in Sunnyvale, California* prepared by Camp Dresser & McKee Inc. (CDM 2004), previous indoor air sampling was conducted in:

- October 2003 (involving the collection of six indoor and one outdoor air sample);
- April 2004 (four indoor air plus a duplicate and one outdoor air sample), both prior to and during operation of a mechanical ventilation unit designed to mitigate the VI pathway; and
- October 2004 (three indoor air and one outdoor air sample) under conditions without mechanical ventilation; this sampling was performed to meet an RWQCB request (via letter dated 1 July 2004) that, "if the (Site) building has not been occupied by October 2004, another round of indoor air samples be collected without mechanical ventilation to determine if improvements in groundwater quality have reduced vapor intrusion to a level that does not require further monitoring."

Of the 29 chemicals for which air samples in each of these events was analyzed, the following eight were detected: Freon 11, Freon 12, Freon 113, tetrachloroethene (PCE), trichloroethene (TCE), vinyl chloride (VC), 1,1,1-trichloroethane (1,1,1-TCA), and chloroform. Of these eight chemicals, four (PCE, TCE, VC, and chloroform) were detected in one or more indoor air samples at concentrations above one or more of the following threshold values: environmental screening levels (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).

Based on its comparison of sampling results to these threshold levels as presented in Table 2 of the Work Plan, CDM (2004) did not consider Freon 11, Freon 12, Freon 113, or 1,1,1-TCA to present unacceptable risk in indoor air; moreover, each of the freons was detected in outdoor air samples as well as in the indoor air, suggesting that their presence inside the Site building was not attributable to VI.

Of the four chemicals detected in the indoor air at concentrations exceeding one or more threshold levels (over all sampling rounds), only three (PCE, TCE, and VC) were also detected in groundwater samples collected from wells screened in the shallow Zone A groundwater zone

(refer to Work Plan Figure 4). With regard to VC, CDM noted that this chemical was not detected in the October 2004 indoor air samples and had decreased in each consecutive sampling round, citing this as "evidence that improving Zone A groundwater quality under the Site building is benefiting indoor air quality. VC is a biodegradation product of PCE and TCE; the only source of VC to the indoor air is the groundwater. Therefore changes in VC levels provide a better reflection on the dynamics between indoor air and groundwater quality than the other VOCs detected in indoor air."

Since 2004, both toxicological research and the guidance for VI evaluations have continued to advance. Currently, USEPA Region 9 recommends use of "evergreen" USEPA Regional Screening Levels (RSLs) developed jointly by Regions 3, 6, and 9; the RSLs, most recently updated in May 2013, are the project action levels (PALs) selected for this project. In February 2013 the RWQCB updated its ESLs, which included revising the commercial/industrial ESLs to reflect an exposure frequency of 8 hours per day rather than 24 hours per day (used for residential screening levels). This change brought the indoor air industrial ESLs more in line with USEPA's indoor air industrial RSLs, with the exception that the ESLs for some chemicals are based on more restrictive toxicity criteria published by California's Office of Environmental Health Hazard Assessment (OEHHA) than criteria published in USEPA's Integrated Risk Information Service (IRIS) database. For this project, sampling results (where applicable) will be compared to ESLs as well as RSLs, both of which were most recently updated in May 2013. Screening levels (both RSLs and ESLs) available at the time the data are evaluated will be used during preparation of the report.

A.1.5 Project Description

The tasks to be completed under this QAPP include:

- Installation and sampling of four sub-slab vapor monitoring wells co-located with indoor air samples;
- Collection of 12-hour (12-hr) integrated air samples at four indoor and one outdoor location inside/outside the unoccupied building at the Site;
- Laboratory analysis of the sub-slab vapor and air samples for VOCs previously detected in the indoor air and/or considered to be chemicals of concern (COCs) in the groundwater;
- Validation of the vapor and air sampling results by Conestoga-Rovers & Associates (CRA), a third-party validator;
- Comparing the concentrations of detected VOCs to USEPA May 2013 RSLs (and to May 2013 ESLs as applicable) for a commercial/industrial exposure as a screening level evaluation of Site risk;
- Evaluating the likelihood that each VOC detected in the indoor air entered the building via VI from the subsurface;
- Calculating cumulative risks for each individual sampling location: (1) based on all VOCs detected in the indoor air; and (2) based on that subset of chemicals attributed to the VI pathway;

- Determining whether the cumulative risk posed by VOCs attributed to the VI pathway falls below 10^{-6} (and thus may require no further action) or within the 10^{-4} to 10^{-6} range requiring a CERCLA risk management decision;
- Summarizing these activities, results, and evaluation in a report for the RWQCB.

A.1.6 Data Quality Objectives

Process

The primary objective is to comply with the RWQCB requirement cited in Section A.1.4, to evaluate the VI pathway at the Site.

To generate data that will meet the primary project objective, it is necessary to define the types of decisions that will be made, identify the intended use of the data, and design an appropriate data collection program. Data quality objectives (DQOs) are an integrated set of thought processes that define data quality requirements based on the intended use(s) of the data. DQOs are necessary in order to ensure that data users obtain sufficient data of known defensible quality which fulfill the primary objective. AECOM has followed the seven-step DQO process, described in the USEPA *Guidance on Systematic Planning using the Data Quality Objectives Process* (USEPA 2006), to determine the quantification, detection, and reporting limits; analytical methods; and sample handling procedures appropriate for this project. The following is a brief description of the seven-step DQO process.

Step 1 – Identification of the problem

Please see Section A.1.4 above.

Step 2 – Identification of decision

Results for sub-slab vapor, indoor and ambient air samples will be evaluated to assess:

- The types and concentrations of VOCs detected in and beneath the Site building;
- Whether sampling results indicate that VOCs present in the building are attributable to the VI pathway and have a likely groundwater source; and
- Whether the cumulative health risk posed by VOCs present in the indoor air and attributable to the VI pathway is within the range that requires a risk management decision regarding further action.

Based on results of the screening evaluation, Northrop Grumman in conjunction with USEPA and the RWQCB will reach a risk management decision as to whether further actions are required, such as additional sampling, further monitoring and/or mitigation including engineering controls (e.g., operation of a mechanical ventilation system) and/or additional remedial action.

Step 3 – Identify the inputs to the decision

The following inputs will be used for decision-making:

- Sampling locations will take into account structural information such as cracks in floors, or conduits penetrating the concrete slab foundation such as the Eductor and the elevator shaft;
- Sampling conditions will include recording weather conditions, particularly wind and precipitation.
- Analysis of indoor and ambient air samples for VOCs will use laboratory methods designed to achieve the PALs, which in turn are based on chemical toxicity data. The most recent May 2013 RSLs (USEPA 2013) and May 2013 ESLs (RWQCB 2013) have been selected as the PALs for this project. Air samples will be analyzed by the USEPA TO-15 method using selective ion monitoring (SIM) modified to achieve the lower reporting limits (RLs) required to meet the PALs.
- Analysis of sub-slab vapor samples for VOCs will be analyzed by USEPA TO-15 method in full scan mode which has RLs that achieve the PALs. The PALs for vapor samples use the 2013 RSLs and ESLs divided by a default attenuation factor of 0.05 for existing commercial buildings as per California Environmental Protection Agency Department of Toxic Substances Control VI Guidance (DTSC 2011).

Typically the amount of time that potential receptors spend in the building on an annual and lifetime basis is a consideration in the decision-making; however this site-specific factor is not cited here as the building has been unoccupied since January 2001. The RSLs used as PALs for this project assume for the commercial/industrial scenario an exposure frequency (EF) of 8 hours per day, 250 days per year and an exposure duration (ED) of 25 years.

Step 4 – Definition of study boundaries

Indoor and outdoor (ambient) air samples will be collected as 12-hour (hr) composites for analysis of a total of 14 chemicals, including the following 10 VOCs listed in the ROD for the Site as groundwater COCs (refer to Table 1 in the Work Plan):

- TCE
- PCE
- cis-1,2-DCE
- trans-1,2-DCE
- 1,2-dichlorobenzene
- 1,1-dichloroethane
- 1,1-dichloroethene
- Freon 113
- 1,1,1-trichloroethane
- vinyl chloride.

In addition, the following three VOCs detected in previous indoor air samples at the Site (refer to Table 2 in the Work Plan) as reported by CDM (2004) will be included:

- Freon 11
- Freon 12
- Chloroform

Finally, chlorobenzene detected in groundwater beneath the Site building during the most recent annual monitoring event conducted in October 2012 (refer to Figure 4 in the Work Plan) will also be included in TO-15 SIM analyses. Table A-2 presents the complete list of project analytes, as well as the May 2013 RSLs and ESLs (as applicable) selected as the PALs;, and laboratory RLs.

Table A-2. Project Analytes and Project Action Levels

Analyte	USEPA Region 9 Screening Level for Air[(a)] (µg/m3)	TAML TO15 SIM Reporting Limit[(b)] (µg/m3)
1,1-dichloroethane	7.7	0.081
1,1-dichloroethene	880	0.079
1,2-dichlorobenzene	880	0.30
1,1,1-trichloroethane	22,000	0.27
chlorobenzene	220	0.092
chloroform	0.53	0.098
cis-1,2-dichloroethene (cis-1,2-DCE)	260	0.079
trans-1,2-dichloroethene (trans-1,2-DCE)	260	0.079
tetrachloroethene (PCE)*	47	0.14
trichloroethene (TCE)	3	0.11
Freon 11 (trichlorofluoromethane)	3,100	0.25
Freon 12 (dichlorodifluoromethane)	440	0.049
Freon 113	130,000	0.23
vinyl chloride*	2.8	0.051

Notes:

Environmental Screening levels (ESLs, RWQCB 2013) for those analytes noted with an * are more protective than the USEPA Region 9 Screening Levels. For these analytes the ESLs will be used as project action levels. These ESLs are listed below.

PCE – 2.1 µg/m^3
Vinyl chloride – 0.16 µg/m^3

[(a)] Source: USEPA (USEPA 2013)
[(b)] Refer to Appendix E

<	less than
-	not included in TO15 SIM analyses
µg/m3	micrograms per cubic meter
COC	chemical of concern
RWQCB	Regional Water Quality Control Board
USEPA	United States Environmental Protection Agency
VIP	vapor intrusion pathway
VOC	volatile organic compound

Sub-slab vapor samples will be collected for analysis that includes the project analytes included in Table A-2 and additional VOCs included in the TAML full scan mode for TO-15 analysis. The list of analytes included in the TO-15 full scan mode analysis is included in Appendix E, Table E-2 which also lists the RLs for these analytes and the SVSLs to be used as PALs for the vapor samples.

The proposed indoor air and sub-slab vapor sampling locations are shown on Figure 5 of the Work Plan, and the rationale for these locations is discussed in Section A.2.1 of this QAPP. The ambient air sample will be collected from a location upwind of the building as determined by the prevailing wind direction on the sampling day.

Step 5 – Development of decision rules

Decision rules have been broken into two categories: (1) sampling/data collection and (2) health risks. Decision rules are further discussed below.

1. Sampling/Data Collection

- If the initial vacuum gauge reads less than 26 inches of Hg, the canister will be replaced prior to sample collection,
- If the final vacuum gauge reads greater than 20 inches of Hg, the sample will be rejected, and
- If sample field duplicate pair results fall within a relative percentage difference (RPD) of 25 percent (%), the results will be considered representative.

2. Health Risks

- Indoor air sample results will be compared to outdoor air concentrations to assess the likelihood that individual chemicals detected in the indoor air are affected by sources unassociated with VI from groundwater.
- Indoor air sample results will be compared to the USEPA May 2013 indoor air RSLs for industrial exposure and to RWQCB May 2013 indoor air ESLs for commercial/industrial exposure. The RSLs and ESLs are long-term, health-based risk criteria.
- The entire suite of chemicals detected in indoor air samples and that subset of detected chemicals identified as likely attributable to the VI pathway (i.e., detected in groundwater or sub-slab vapor, indoor air concentrations higher than outdoor air, or historic data use) will be used to calculate a cumulative cancer risk and non-cancer hazard index (HI) for each indoor air sampling location. This is a screening level risk evaluation. Refer to Section 6.2 in the Work Plan for the procedure to be used for calculating cumulative risk/HI.
- Based on these evaluations, a conclusion will be provided regarding whether the cumulative cancer risk attributed to the VI is below 10^{-6} and a non-cancer HI of 1, in which case no further action will be recommended. If sampling results indicate a

cumulative cancer risk attributed to the VI between 10^{-4} and 10^{-6} and/or an HI greater than 1, the report will recommend that Northrop Grumman and the regulatory agency stakeholders discuss and document the appropriate risk management decision regarding potential next steps. Based on these discussions, additional sampling events and/or VI mitigation measures may be required. Risk decisions may be supported by risk calculated using a building wide exposure point concentration rather than a location specific risk. Previously (refer to QAPP Section A.1.4 and Work Plan Table 2), CDM (2004) demonstrated a reduction in indoor air concentrations to below levels of concern under the condition of mechanical ventilation (i.e., operation of fans) at an air exchange rate of 1 building volume per hour.

Step 6 – Specification of limits on decision errors

Decision Errors: There are two possible decision errors:

- Type I Error (False Positives): Determining that a sample contains contaminants exceeding screening levels when it does not, and
- Type II Error (False Negatives): Determining that a sample does not contain contaminants exceeding screening levels when it does.

Decision Error Mitigation: If there actually is a health risk, but inadequate or incorrect data indicate exposure is below risk criteria, exposure to future workers could exceed levels considered safe. This error could allow threats to go unmitigated. In contrast, if there is no health risk, but inadequate or incorrect data indicate there is unacceptable risk, additional data would be collected and/or risk would be mitigated without sufficient cause.

A decision error resulting in an unmitigated health hazard has more severe consequences, and thus outweighs the consequences of economic costs related to air sampling. Field duplicates (one indoor/one outdoor) will be collected to reduce this decision error; however, additional sampling may be needed to reduce the potential for error. Raw data for all samples will be made available for further independent review as required.

Step 7 – Optimization of sampling design for obtaining data

The pre-sampling site walk with regulatory approval for the selection of sample locations will allow optimization of the sampling design described in Section A.2 of this QAPP.

Data Quality Objectives Criteria

The analytical method to be used for this investigation is Method TO-15 described in the *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air* (USEPA 1999). The analytical method is also described in the standard operating procedures (SOPs) for the selected analytical laboratory (see Appendix E of the Work Plan). The method will be operated in the SIM mode to achieve RLs that meet the PALs as listed in Table A-2 for indoor and ambient air samples and full scan mode for sub-slab vapor samples. Specific criteria

for RLs, accuracy, precision, and completeness will be used during this project. The laboratory criteria are based on the SOPs provided by the analytical laboratory performing the TO-15 analysis. The analytical completeness goal for this project is 95 %. The completeness goal for the holding time is 100 %.

A.1.7 Special Training/Certification

All AECOM field personnel responsible for data collection are 40-hour Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) trained. Field personnel are experienced in the collection of indoor air and sub-slab vapor samples and daily calibration of field equipment. Field equipment is calibrated by the rental company according to manufacturer guidelines prior to initial use. The proposed sampling requires two days of field work and onsite calibration by field personnel will be performed prior to each day of sampling. The laboratory selected for sample analysis is NELAP-certified for TO-15 analysis.

A.1.8 Documentation Records

A project file will be established for storing original data, historical data, written documents, and data collected or generated during this work. AECOM maintains an electronic central project folder in which the project file will be located. AECOM also maintains a quality management system (QMS) that incorporates a technical review process and project file maintenance. The format for the file will, at a minimum, include the following:

- Correspondence
- Project contact information
- Contracts
- Field data and notes
- Figures and maps
- Permits
- Laboratory data and quality assurance/quality control (QA/QC) documents
- Chain-of-custody records
- Photographs
- Work Plans and Reports
- Schedules

The Project Manager maintains overall responsibility for the project file and provides that appropriate documents are saved in the project file.

A.2 DATA GENERATION AND ACQUISITION

A.2.1 Sampling Rationale and Sampling Locations

The primary objective of this work is to evaluate the potential for future VI risk. A building survey was previously conducted at the one Site building as documented on the photos and form in Work Plan Appendix C.

As part of pre-sampling activities, a second survey will be conducted including field screening to evaluate indoor air and potential preferential vapor migration pathways using a photoionization detector (PID) appropriate for detecting total VOCs to 1 part per billion (ppb) (ppb RAE PID calibrated to 10 parts per million [ppm] isobutylene gas, see Appendix F of the Work Plan). During the site walk, features of the building with the potential to be a preferential vapor intrusion pathway will be noted and photographed.

Because the Site building interior is not occupied, samples will not be specific to office use areas. In the unfinished, southwestern part of the building, one sample (IA-1) will be collected near the Eductor identified as a potential point of vapor entry and another (IA-4) adjacent to the elevator shaft, a potential conduit identified during the initial building survey, (refer to Work Plan, Figure 5). In the older portion of the building, samples IA-2 and IA-3 will be collected from the center of each room. Sample IA-2 in the southeastern room is at the approximate location of previous sample AI-04 (refer to Work Plan Figure 3); while Sample IA-3 in the northern room is closest to previous sampling location AI-13. Refer to Work Plan Table 2 for previous sampling results at these and other locations previously sampled. The outdoor (ambient) air sample OA-1 will be collected from a location upwind of the building as determined by the prevailing wind direction on the sampling day. Sub-slab vapor monitoring wells will be co-located with three of the four indoor air samples IA-1, IA-2, and IA-3. The indoor air sample IA4 located in the elevator shaft will not have a companion sub-slab vapor well because the shaft extends approximately 5 feet below grade. A fourth sub-slab vapor monitoring well will be located south of the Eductor to monitor potential vapor sources from upgradient offsite groundwater contamination.

A.2.2 Quality Control Samples

Field duplicate samples (one indoor, one outdoor, and one sub-slab) will be collected to serve as a check on the precision of field sampling and analytical methods. Other QC will be performed as a check on instrumentation and potential contamination that may occur during laboratory sample preparation and analyses. The following table indicates the number of field duplicates to be collected as quality assurance samples during this investigation.

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of Trip Blanks	Total No. of Samples to Lab
Air	VOCs TO-15, SIM	4 for IA; 1 for OA	1 for IA; 1 for OA	None	7
Vapor	VOCs TO-15, full scan mode	4 for SS	1 for SS	None	5

Notes:

IA = indoor air
OA = ambient (outdoor) air
SS = sub-slab

A.2.3 Sampling Methods

Sampling methods are discussed in Section 3.0 of the Work Plan, and are briefly summarized below:

Northrop Grumman proposes to collect five indoor air samples (includes one duplicate sample). Each sample will be collected from a height of approximately 3 to 5 feet above floor level (i.e., breathing zone of a worker (DTSC 2011). To measure the concentrations of VOCs in the ambient air, two outdoor air samples (including one duplicate sample) will be collected outside the building and analyzed for the same constituents as the indoor air samples. The outdoor samples will be placed upwind of the building as determined by the prevailing wind direction on the sampling day. Each sample will be collected over a 12-hr period into an individually certified 6-liter SUMMA™ canister. This exposure duration is typical of an extended work day. The canisters are equipped with laboratory-supplied pre-calibrated flow controllers. At the time of set-up canister vacuum pressures must exceed 26 inches of Hg and vacuum pressures will be monitored throughout the 12-hr sampling period to identify any potential problems with the flow regulators. Canisters should achieve vacuum pressures of approximately 5 inches of Hg by the end of the 12-hr sampling period and any canister with a vacuum pressure above 20 inches Hg at the end of the sampling day will be rejected. Because the building is not yet equipped with an HVAC unit no provisions for HVAC use will be needed during sampling.

Three sub-slab vapor monitoring wells will be co-located with indoor air samples with one sub-slab vapor well located south of the Eductor. Sub-slab vapor monitoring wells will be installed and sampled as described in Section 3.3 of the Work Plan. Following installation the wells will be subjected to leak testing and prior to sample collection shut in testing will be performed on the sample train to check for leakage. The procedures for both leak testing and shut in testing are described in Work Plan Section 3.3. Samples will be collected in batch certified 1-Liter SUMMA™ canisters using laboratory supplied flow regulators adjusted to a flow rate of 200 mL/min.

A.2.4 Sample Handling and Custody Requirements

Once the air/vapor sampling is complete, the maximum allowable holding time is 14 days. The analytical laboratory turnaround time to report sample results once samples are received is also 14 days. Samples will be preserved under ambient temperature and without direct exposure to sunlight. The assignment of sample identification labels, sample handling and custody requirements are discussed in Section 3.3 of the Work Plan.

QC review for sample handling and custody procedures includes a review of sample labels, container initial pre-sample and final post-sample vacuums, and chain-of-custody forms before sample are transferred to the laboratory. This QC review includes checks to make sure that the final vacuum gauge readings are less than 20 inches of Hg and that sample labels and chain-of-custody forms are complete and accurate.

A.2.5 Analytical Method

Chemical analysis is scheduled to be performed by TestAmerica Laboratories (TAML) located in West Sacramento, CA. Should TAML be unable to provide services indicated in the Work Plan, samples will be shipped to Air Technologies Laboratory in Folsom, California. Air samples will be transferred under chain-of-custody procedures. The analytical method to be used for this investigation is Method TO-15 using both SIM and full scan mode described in *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air - Second Edition* (USEPA 1999). The analytical method is also described in the SOP provided by TAML (see Appendix E of the Work Plan). The method will be operated in the SIM mode for air samples to achieve lower RLs. Calibration procedures, internal QC checks (including analytical batch and laboratory QC samples), data quality indicators, preventive maintenance, and corrective actions for the analytical method used for this project will be consistent with USEPA protocols.

A.2.6 Quality Control

QC measures for field data collection are provided in the field sampling procedures described above. Quality control measures for laboratory procedures are described in Work Plan Appendix E, which contains the SOPs for the desired analytical method, qualifier definitions, and QC limits.

A.3 DATA MANAGEMENT

A.3.1 Data Recording

Observations made and measurements taken in the field will be recorded on an Indoor Air Sampling Form (a sample form is provided in Appendix D of the Work Plan). Copies of field forms including building survey forms, indoor and outdoor ambient air field data sheet, sub-slab vapor well field data sheet, and chain-of-custody will be attached to the project report as appendices. Data used for analysis, presentation, and reporting will be stored in electronic files. These data files will facilitate:

- Tracking chain-of-custody and sample identification data;
- Reviewing and evaluating analytical data against project-specific criteria; and
- Producing data tables and figures.

Analytical data will be provided by the laboratory in both hard-copy and as a complete and single electronic data deliverable (EDD). CRA will check the EDD against the hard copy for all detected analytes. The EDD will be submitted on a compact disk or via e-mail, with the disk label or email including the laboratory delivery group, submittal date, laboratory name, and site description. If an EDD is resubmitted to CRA, the EDD will be labeled "Revised."

A.3.2 Data Transformation

Transforming data by converting individual data point values into related values or symbols using conversion formulas or a system of replacement is not currently proposed for data evaluation for the project at this time. If data transformation is required at a later date, then conversion procedures will be described in detail in the associated data report.

A.3.3 Data Transmittal

Assigning data entry personnel to input the data from field forms into a spreadsheet format will complete the integration of field data. A staff geologist or engineer will review the spreadsheet for completeness and accuracy by comparing the electronic spreadsheet to the original field data. The reviewed spreadsheet will then be uploaded into a designated electronic project folder.

A.3.4 Data Tracking

The Project Manager is responsible for data management. The Project Manager has the authority to enforce proper procedures as outlined in this QAPP and to implement corrective procedures to provide for the accurate and timely flow and transfer of data. The Project Manager will review final data reports.

Data will be generated from environmental sampling and analysis, field analyses, and field readings. The individuals who generate data (geologists, engineers, samplers, and chemical analysts) will be responsible for accurate and complete documentation of required data, and for assuring that those data are provided to their supervisor in a timely manner.

The Field Geologist/Engineer is responsible for the day-to-day monitoring of data collected in the field. He/She will ensure that data are collected in the format specified in the Work Plan, assign sample designations, and route data to the Field Coordinator for review and transfer of data to the project files. At least one copy of all project documents will be retained for project use during the work activity. Original documents will be maintained in the project file.

The Field Coordinator and QA Manager are responsible for the day-to-day monitoring of activities related to the generation and reporting of chemical data. The QA Manager will ensure that samples are analyzed according to the specified procedures; that data are validated; and that

the data are properly coded, checked for accuracy, and entered into a spreadsheet. The Field Coordinator will then ensure that the data are routed to the Project folder.

A project file will be established for storing original data, historical data, written documents, and data collected or generated, as described in this QAPP, Section A.1.8.

A.4 ASSESSMENT AND OVERSIGHT

A.4.1 Assessments and Response Actions

Following completion of the field investigation and upon receipt of the analytical data, the data validation process will begin. If the validated analytical results for any sample are outside the anticipated range of the suspected constituents, the RWQCB and USEPA will be contacted for discussion of results and to determine whether additional analyses may be warranted. Indoor air results will be compared to USEPA (2013) RSLs and RWQCB (2013) ESLs to preliminarily screen potential health risks to site workers and possible future receptors. The cumulative Site risk based on all VOCs detected in the indoor air and that subset attributed to the VI pathway will also be calculated in accordance with DQOs established in QAPP Section A.1.6 and Work Plan section 6.2.

A.4.2 Reports to Management

A report of the indoor air results will be prepared. This report will include descriptions of field methods, field observations, laboratory analytical results, and data validation findings. The comparison between the indoor air sampling results and USEPA RSLs (and RWQCB ESLs, as applicable) will be included. Laboratory data will be tabulated and presented on figures; copies of laboratory analytical reports will be provided as appendices. The final investigation report will be submitted to the RWQCB and USEPA.

A.5 DATA VALIDATION AND USEABILITY

A.5.1 Data Review, Verification, and Validation

Data validation processes, which are an integral part of the QA program, consist of reviewing and assessing the quality of data. Data validation provides assurance that the data as reported are of acceptable quality. For validity, the characteristics of importance are precision, accuracy, representativeness, comparability, and completeness. Data usability describes whether a dataset is sufficiently complete and of sufficient quality to support a decision or action in terms of the specific DQOs.

All analytical data submitted by the laboratory will be validated by a third-party validator (CRA), and, if necessary, exception reports will be produced. Final validated (and qualified, if required) results will be saved to the Project folder. Data validation will follow the USEPA *Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (USEPA 2008). The data validation process includes:

- Evaluating against criteria for laboratory blanks;
- Evaluating against accuracy criteria including holding times and laboratory control samples;
- Evaluating against precision criteria by assessing RPDs for field and laboratory duplicates; and
- Confirming that data qualifiers are assigned appropriately.

Assessment will include checks on data consistency by looking for comparability of duplicate analyses, comparability to previous data from the same sampling location (as available), adherence to accuracy and precision control criteria where detailed in this QAPP, and anomalously high or low parameter values. The results of these data validations will be reported to the Project Manager and the contract laboratory, noting any discrepancies and their effect upon acceptability of the data.

Raw data from field measurements and sample collection activities that are used in project reports will be appropriately identified and appended to the report. Where data have been reduced or summarized, the method of reduction will be documented in the report. Field data will be audited for anomalously high or low values that may appear to be inconsistent with other data.

Table A-3 describes the processes that will be followed to verify project data and how each item will be verified, when the activity will occur, what documentation is necessary, and which person and organization is responsible.

Table A-3. Planned Project Assessments

Verification Input	**Description**	**Internal/External**	**Responsible for Verification** (name, organization)
Chain-of-Custody	The Chain-of-Custody Form will be internally reviewed upon completion and verified against field logs and the laboratory report. Review will be conducted upon completion of each report or project phase.	Internal	Project Engineer, AECOM
Field Notes	Field notes will be reviewed internally and placed in the project file.	Internal	Field Personnel, AECOM
Analytical Data Packages	Laboratory data packages will be used to verify the reported results. Information, such as reporting limits and method references, will be verified against QAPP requirements.	Internal and External	Internal: Laboratory PM/ Test America External: CRA Data Validator and AECOM Project Engineer

A.6 REFERENCES

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APPENDIX B

SUMMARY OF HISTORIC
GROUNDWATER DATA

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
T-1A ZA																			
Per Water Board approval, well T-1A was abandoned in February 2004.																			
Oct-02	<0.5	404,000	--	--	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<1.0	<0.5	<2.0	<0.5	<0.5	NA	NA	NA	NA
Oct-01	<0.5	28	--	--	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<2.0	<2.0	<0.5	<0.5	NA	NA	NA	NA
Oct-00	<2.0	34	--	--	<2.0	<2.0	<2.0	<2.0	<2.0	ND	ND	<2.0	ND	<2.0	<2.0	NA	NA	NA	NA
Oct-99	<1.0	34	--	--	<1.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-98	<1.0	42	2.0	<1.0	<1.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-97	<1.0	51	--	--	<1.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<2.0	ND	NA	NA	NA	NA
Oct-96	<0.5	48	3.6	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-95	<1.0	61	--	--	<2.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-94	<5.0	74	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-93	<5.0	120	--	--	<10	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Apr-90	<0.5	110	--	--	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-89	<0.5	90	--	--	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5		<0.5	--	--	--	--	--
Aug-89	<0.5	87	--	--	<0.5	<0.5	<0.5	0.9	--	--	--	<0.5		<0.5	--	--	--	--	--
Feb-89	<0.5	86	--	--	<0.5	<0.5	<0.5	1.3	--	--	--	<0.5		<0.5	--	--	--	--	--
Nov-88	<0.5	88	--	--	<0.5	0.5	<0.5	2.7	--	--	--	<0.5		<0.5	--	--	--	--	--
Aug-88	<1.0	60	--	--	<1.0	0.9	<1.0	<1.0	--	--	--	<1.0		<1.0	--	--	--	--	--
Jun-88	<0.5	56	--	--	<0.5	1.5	<0.5	<0.5	--	--	--	10		<0.5	--	--	--	--	--
Jan-88	<1.0	200	--	--	<1.0	3.1	<1.0	1.5	--	--	--	9.1		<1.0	--	--	--	--	--
Oct-87	<2.5	160	--	--	<2.5	8.6	<2.5	<2.5	--	--	--	<2.5		<2.5	--	--	--	--	--
Jun-87	<1.0	190	--	--	<1.0	7.0	<1.0	<1.0	--	--	--	<1.0		<1.0	--	--	--	--	--
Apr-87	<2.5	160	--	--	<2.5	<2.5	<2.5	<2.5	--	--	--	<2.5		<2.5	--	--	--	--	--
Jan-87	<10	140	--	--	<10	<10	<10	<10	--	--	--	<10		<10	--	--	--	--	--
Sep-86	<2.0	420	--	--	<2.0	5	<2.0	<2.0	--	--	--	<2.0		<2.0	--	--	--	--	--
Jul-86	<1.0	140	--	--	<1.0	<1.0	<1.0	<1.0	--	--	--	<1.0		<1.0	--	--	--	--	--
Apr-86	<2.0	340	--	--	<2.0	<2.0	<2.0	<2.0	--	--	--	<2.0		<2.0	--	--	--	--	--
Jan-86	<5.0	630	--	--	<5.0	<5.0	<5.0	<5.0	--	--	--	NA		<5.0	--	--	--	--	--
Oct-85	10	640	--	--	<5.0	30	<5.0	<5.0	--	--	--	<5.0		<5.0	--	--	--	--	--
Nov-84	4	930	--	--	NA	5	NA	NA	--	--	--	NA		NA	--	--	--	--	--
Aug-84	5	950	--	--	ND	7	ND	ND	--	--	--	ND		ND	--	--	--	--	--
Mar-84	NA	680	--	--	NA	NA	NA	NA	--	--	--	NA		NA	--	--	--	--	--
Sep-83	7	1,000	--	--	NA	5	ND	<1.0	--	--	--	ND		NA	--	--	--	--	--
Sep-83	3	540	--	--	NA	3	ND	<1.0	--	--	--	ND		NA	--	--	--	--	--
Aug-83	<1.0	660	--	--	ND	4	<1.0	<1.0	--	--	--	<1.0		ND	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
T-2A ZA																			
Oct-12	<0.50	<0.50	120	48	67	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	8.9	78	<0.50	1.9	0.53	2.6
Apr-12	<0.50	0.84	34	16	27	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	6.1	47	<0.50	1.1	0.57	1.8
Oct-11	<0.50	<0.50	12	6	11	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	3.4	74	<0.50	1.7	0.94	5.3
May-11	<0.50	0.52	3	2.3	5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	2.7	39	<0.50	<0.50	<0.50	<0.50
Mar-11	<0.50	0.68	7	2.5	31	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	3.2	57	<0.50	1.7	<0.50	4.8
Nov-10	<50	<50	3,200	<50	2,700	<50	<50	<50	<50	<100	<50	<50	<100	57	120	--	--	--	--
Oct-10	<20	<20	8,700	75	5,400	<20	<20	<20	<20	<40	<20	<20	<40	23	140	<20	<20	<20	<40
Oct-09	<20	<20	--	--	1,100	<20	<20	<20	<20	<40	<20	<20	<40	<20	46	<20	<20	<20	<40
Oct-08	<1	2.4	--	--	52	<1	<1	<1	<1	<2	<1	<1	<2	9.4	31	<1	<1	<1	<2
Oct-07	<5.0	<5.0	650	280	200	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	48	<5.0	<5.0	<5.0	<15
Apr-07	<5.0	25	180	<5.0	65	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-06	<5.0	<5.0	580	270	140	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	41	<5.0	<5.0	<5.0	<15
Apr-06	<5.0	<5.0	170	110	35	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	14	<5.0	<5.0	<5.0	<15
Jan-06	<5.0	<5.0	220	190	120	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	39	<5.0	<5.0	<5.0	<15
Oct-05	<5.0	<5.0	45	49	22	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	18	<5.0	<5.0	<5.0	<15
Jul-05	<5.0	<5.0	110	96	50	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	60	<5.0	<5.0	<5.0	<15
Apr-05	<5.0	9.4	13	9.0	23	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	13	<5.0	<5.0	<5.0	<15
Jan-05	<5.0	<5.0	150	100	49	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	30	<5.0	<5.0	<5.0	<15
Oct-04	<5.0	<5.0	200	69	100	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	46	<5.0	<5.0	<5.0	<15
Apr-04	<1.0	4.4	59	<1.0	30	<1.0	<1.0	<1.0	NA	<1.0	<1.0	NA	<1.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0
Jan-04	<5.0	<5.0	<5.0	<5.0	9.7	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<5.0
Oct-03	<5.0	6.3	66	<5.0	130	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	24	<5.0	<5.0	<5.0	<10
Jul-03	<1.0	2.5	17	<1.0	48	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	14	NA	19	<1.0	3.8
Apr-03	<1.0	15	7.3	<1.0	13	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	6.6	NA	<1.0	<1.0	<2.0
Jan-03	<1.0	16	12	1.1	24	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	16	NA	NA	NA	NA
Oct-02	1.2	28	31	2	37	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	28	<1.0	<1.0	<1.0	3.9
Jul-02	<1.0	32	94	6.7	140	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	NA	NA	7.1	NA	<1.0	<1.0	<2.0
Apr-02	<1.0	4.2	45	<1.0	76	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	ND	NA	76	NA	<1.0	<1.0	<2.0
Jan-02	<13	110	210	<13	240	<13	<13	<13	ND	<25	<13	NA	ND	20	<13	NA	NA	NA	NA
Nov-01	10	140	180	6.7	460	<5.0	<5.0	<5.0	ND	<5.0	<5.0	<5.0	<5.0	<5.0	ND	<5.0	<5.0	<5.0	<10
Oct-01	<50	480	230	<50	310	<50	<50	<50	<50	<100	<100	<100	<50	NA	<50	NA	<50	<50	<100
Aug-01	19	88	400	8.6	690	<1.0	<1.0	1.1	ND	<2.0	<2.0	NA	ND	NA	2.9	NA	1.8	<1.0	5.4
Jun-01	1.1	5.4	57	5.2	620	<1.0	1.2	1.9	ND	4.0	<2.0	NA	ND	NA	<1.0	NA	<1.0	<1.0	<2.0
Mar-01	13	110	360	5.3	400	1.6	1.2	<1.0	ND	<2.0	<2.0	NA	ND	NA	<1.0	NA	<1.0	<1.0	<2.0
Jan-01	11	120	330	4.2	86	2.3	1.3	<1.0	ND	<2.0	<2.0	NA	ND	NA	<1.0	NA	<1.0	<1.0	<2.0
Oct-00	<20	160	520	<20	330	<20	<20	<20	<20	ND	ND	<20	ND	<20	<20	NA	NA	NA	NA
Oct-99	27	270	220	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	<10	NA	NA	NA	NA
Apr-99	20	210	160	<10	<10	<10	<10	<10	ND	ND	ND	<10	ND	<10	<25	NA	NA	NA	NA
Oct-98	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Apr-98	20	440	150	<10	<10	<10	<10	<10	ND	ND	ND	<40	ND	<10	<25	NA	NA	NA	NA
Oct-97	71	470	320	<25	<25	<25	<25	<25	ND	ND	ND	<25	ND	<50	<50	NA	NA	NA	NA
Apr-97	37	330	250	4.4	3.1	<1.7	2.1	<1.7	ND	ND	ND	1.8	ND	<1.7	ND	NA	NA	NA	NA
Oct-96	3.3	71	97	1.0	9.5	<0.5	0.6	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-95	14	190	--	--	13	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	ND	NA	NA	NA	NA
Apr-95	18	280	--	--	<10	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-94	<25	320	--	--	<25	<25	<25	<25	ND	ND	ND	<25	ND	<25	ND	NA	NA	NA	NA
Apr-94	3.9	1,600	--	--	120	<0.5	21	<0.5	ND	ND	ND	<0.5	ND	2.2	ND	NA	NA	NA	NA
Feb-94	6.3	1,900	--	--	260	<0.5	32	1.1	ND	ND	ND	1.9	ND	9.6	ND	NA	NA	NA	NA
Oct-93	16	5,800	--	--	300	<5.0	49	<5.0	ND	ND	ND	<5.0	ND	23	ND	NA	NA	NA	NA
Apr-93	18	1,300	--	--	14	<0.5	13	<0.5	ND	ND	ND	NA	ND	<0.5	ND	NA	NA	NA	NA
Oct-92	10	640	--	--	80	<0.5	<0.5	<0.5	ND	ND	ND	NA	ND	2.1	ND	NA	NA	NA	NA
Apr-92	30	4,400	--	--	120	<20	<20	<20	ND	ND	ND	<20	ND	<20	ND	NA	NA	NA	NA
Jan-92	0.8	42	--	--	4.0	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Apr-91	12	120	--	--	<1	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Jul-90	40	100	--	--	3.3	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	3.4	ND	NA	NA	NA	NA
Apr-90	40	160	--	--	7.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-89	84	230	--	--	220	<1.0	3	<1.0	--	--	--	<1.0	ND	79	--	--	--	--	--
Aug-89	41	2,300	--	--	<10	<10	<10	<10	--	--	--	18	ND	<10	--	--	--	--	--
May-89	140	470	--	--	340	<5.0	<5.0	<5.0	--	--	--	<5.0	ND	<5.0	--	--	--	--	--
Feb-89	220	620	--	--	<10	<10	<10	<10	--	--	--	380	ND	<10	--	--	--	--	--
Nov-88	260	1,300	--	--	18,000	<100	<100	<100	--	--	--	<100	ND	<100	--	--	--	--	--
Nov-88	<10	1,300	--	--	3,600	<10	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Aug-88	250	1,400	--	--	11,000	<100	<100	<100	--	--	--	<100	ND	<100	--	--	--	--	--
Jun-88	610	4,000	--	--	4,600	<50	<50	<50	--	--	--	<50	ND	<50	--	--	--	--	--
Jun-88	530	3,200	--	--	4,000	1.6	15	1.4	--	--	--	<5.0	ND	32	--	--	--	--	--
Oct-87	190	980	--	--	40	7.5	<5.0	<5.0	--	--	--	<5.0	ND	46	--	--	--	--	--
Jan-87	380	2,900	--	--	<50	<50	<50	<50	--	--	--	<50	ND	610	--	--	--	--	--
Jul-86	980	6,400	--	--	540	<50	<50	<50	--	--	--	<50	ND	650	--	--	--	--	--
Apr-86	1,700	10,000	--	--	740	<100	<100	<100	--	--	--	<100	ND	<100	--	--	--	--	--
Apr-86	3,700	15,000	--	--	650	<100	<100	<100	--	--	--	NA	ND	<100	--	--	--	--	--
Mar-86	<100	9,800	--	--	<100	<100	<100	<100	--	--	--	NA	ND	<100	--	--	--	--	--
Oct-85	4,600	12,000	--	--	<50	<50	<50	<50	--	--	--	<50	ND	<50	--	--	--	--	--
Nov-84	5,400	520,000	--	--	NA	<500	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--
Aug-84	8,600	190,000	--	--	300	ND	600	ND	--	--	--	ND	ND	ND	--	--	--	--	--
Mar-84	NA	13,000	--	--	NA	NA	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--
Sep-83	4,000	730,000	--	--	NA	ND	ND	ND	--	--	--	ND	ND	NA	--	--	--	--	--
Sep-83	7,000	890,000	--	--	NA	ND	ND	ND	--	--	--	ND	ND	NA	--	--	--	--	--
Aug-83	86,000	6,100,000	--	--	<5.0	130	<5.0	<5.0	--	--	--	<5.0	ND	<5.0	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
T-3A ZA																			
Oct-12	<1.0	120	38	1.9	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0
Oct-11	1.8	120	38	1.6	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-10	1.1	120	42	1.4	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	1.7	170	44	2.2	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-08	<2	140	8.0	<2	<2	<2	<2	<2	<2	<4	<2	<2	<4	<2	<2	<2	<2	<2	<4
Oct-07	<5.0	210	15	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-06	3.7	230	49	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<4.0	<2.0	<2.0	<2.0	<2.0	NA	NA	NA	NA
Oct-05	4.1	180	48	1.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	NA	NA	NA	NA
Oct-04	2.3	130	41	1.7	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<4.0	<1.0	<1.0	NA	NA	NA	NA
Oct-03	<5.0	150	43	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10
Oct-02	<2.0	180	17	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<4.0	<4.0	<2.0	<8.0	<2.0	<2.0	NA	NA	NA	NA
Oct-01	<5.0	130	48	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<10	<5.0	<5.0	<5.0	NA	NA	NA	NA
Oct-00	<10	140	71	<10	<10	<10	<10	<10	<10	ND	ND	<10	ND	<10	<10	NA	NA	NA	NA
Oct-99	2.1	95	78	<2.0	9	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	ND	NA	NA	NA	NA
Oct-98	<5.0	140	84	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-97	<5.0	180	100	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<10	ND	NA	NA	NA	NA
Oct-96	2.0	110	52	0.6	<0.5	0.9	<0.5	<0.5	ND	ND	ND	0.8	ND	<0.5	ND	NA	NA	NA	NA
Oct-95	2.9	180	--	--	<2.0	3.1	<1.0	1.1	ND	ND	ND	1.9	ND	<1.0	ND	NA	NA	NA	NA
Oct-94	<5.0	170	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Feb-94	3.7	130	--	--	<1.0	4.6	<0.5	1.2	ND	ND	ND	1.7	ND	<0.5	ND	NA	NA	NA	NA
Oct-93	<5.0	280	--	--	<10	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-92	1.1	3.0	--	--	<1.0	1.7	<0.5	<0.5	ND	ND	ND	NA	ND	<0.5	ND	NA	NA	NA	NA
Apr-92	4.7	17	--	--	<0.5	5.9	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Jan-92	2.0	11	--	--	<0.5	2.3	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-91	5.8	25	--	--	<0.5	5.4	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Jul-91	3.2	19	--	--	<0.5	6.2	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Apr-91	2.1	10	--	--	<0.5	3.1	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Jan-91	1.4	7.4	--	--	<0.5	0.7	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-90	1.4	11	--	--	<0.5	4.2	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Jul-90	<0.5	4.6	--	--	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Apr-90	<0.5	1.5	--	--	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Jan-90	<0.5	8.2	--	--	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-89	<0.5	4	--	--	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5	ND	<0.5	--	--	--	--	--
Aug-89	0.7	5	--	--	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5	ND	<0.5	--	--	--	--	--
May-89	<1.0	2	--	--	<1.0	<1.0	<1.0	<1.0	--	--	--	<1.0	ND	<1.0	--	--	--	--	--
Feb-89	<0.5	<0.5	--	--	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5	ND	<0.5	--	--	--	--	--
Nov-88	<0.5	4	--	--	<0.5	<0.5	<0.5	<0.5	--	--	--	<0.5	ND	<0.5	--	--	--	--	--
Aug-88	0.5	5	--	--	<0.5	1.1	<0.5	<0.5	--	--	--	<0.5	ND	<0.5	--	--	--	--	--
May-88	0.4	2	--	--	<0.1	0.2	<0.1	<0.1	--	--	--	<0.1	ND	<0.2	--	--	--	--	--
May-88	0.4	2	--	--	<0.1	0.2	<0.1	<0.1	--	--	--	<0.1	ND	<0.1	--	--	--	--	--
Jan-88	0.7	4	--	--	<0.5	0.6	<0.5	<0.5	--	--	--	<0.5	ND	<0.5	--	--	--	--	--
Jan-88	0.5	2	--	--	<0.1	0.2	<0.1	<0.1	--	--	--	<0.1	ND	<0.2	--	--	--	--	--
Oct-87	15	460	--	--	<2.5	16	<2.5	<2.5	--	--	--	<2.5	ND	<2.5	--	--	--	--	--
Jun-87	24	900	--	--	<10	72	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Apr-87	20	920	--	--	<10	100	12	<10	--	--	--	86	ND	<10	--	--	--	--	--
Jan-87	<10	3,000	--	--	<10	<10	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Sep-86	15	560	--	--	<2.0	15	<2.0	<2.0	--	--	--	<2.0	ND	<2.0	--	--	--	--	--
Jul-86	180	1,800	--	--	<10	<10	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Apr-86	91	1,500	--	--	<1.0	12	<1.0	<1.0	--	--	--	<1.0	ND	<1.0	--	--	--	--	--
Oct-85	<25	2,700	--	--	<25	<25	<25	<25	--	--	--	<25	ND	<25	--	--	--	--	--
Oct-85	170	3,100	--	--	<50	95	<50	<50	--	--	--	480	ND	<50	--	--	--	--	--
Nov-84	260	1,300	--	--	NA	42	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--
Aug-84	210	530	--	--	ND	13	ND	2	--	--	--	ND	ND	ND	--	--	--	--	--
Mar-84	NA	240	--	--	NA	NA	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--
Sep-83	560	300	--	--	NA	16	ND	<1.0	--	--	--	52	ND	NA	--	--	--	--	--
Sep-83	580	290	--	--	NA	16	NA	<1.0	--	--	--	35	ND	NA	--	--	--	--	--
Aug-83	1,100	1,600	--	--	<5.0	0.2	<5.0	<5.0	--	--	--	<5.0	ND	<5.0	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
T-6A ZA																			
Oct-07	<0.5	22	17	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	0.62	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0
Oct-06	<0.5	24	22	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA
Oct-05	<0.5	21	28	0.51	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA
Oct-04	<0.5	14	30	0.92	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<1.0	<0.5	<2.0	<0.5	<0.5	NA	NA	NA	NA
Oct-03	0.61	8.5	2.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<1.0	<0.5	<2.0	<0.5	<0.5	NA	NA	NA	NA
Oct-02	0.72	9.3	2.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<1.0	<0.5	<2.0	<0.5	<0.5	NA	NA	NA	NA
Oct-01	<0.5	9.2	1.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<2.0	<2.0	<0.5	<0.5	NA	NA	NA	NA
Oct-00	<1.0	7.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	ND	ND	<1.0	ND	<1.0	<1.0	NA	NA	NA	NA
Oct-99	<1.0	9.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-98	<1.0	9.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-97	<0.5	7.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	0.6	ND	<1.0	ND	NA	NA	NA	NA
Oct-96	<0.5	7.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	0.8	ND	<0.5	ND	NA	NA	NA	NA
Oct-95	<1.0	6.5	--	--	<2.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-94	<5.0	19	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-93	<0.5	6.3	--	--	<1.0	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-92	<0.5	5.6	--	--	<1.0	<0.5	<0.5	<0.5	ND	ND	ND	NA	ND	<0.5	ND	NA	NA	NA	NA
Oct-91	<0.5	7.8	--	--	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-90	<0.5	9.0	--	--	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Aug-89	<0.5	14	--	--	<0.5	0.6	<0.5	<0.5	--	--	--	0.7	ND	<0.5	--	--	--	--	--
May-88	<0.5	13	--	--	<0.5	2.5	<0.5	<0.5	--	--	--	2.1	ND	<0.5	--	--	--	--	--
Jan-88	<0.5	21	--	--	<0.5	2.6	<0.5	<0.5	--	--	--	2.1	ND	<0.5	--	--	--	--	--
Jan-87	<10	52	--	--	<10	<10	<10	<10	--	--	--	37	ND	<10	--	--	--	--	--
Oct-85	<0.5	68.5	--	--	<0.5	12	<0.5	<0.5	--	--	--	21	ND	<0.5	--	--	--	--	--
Mar-84	NA	27	--	--	NA	NA	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
T-7A ZA																			
Oct-12	<2.5	56/63	230	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<2.5	<2.5	<5.0	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0
Oct-11 Dup	<2.5	140	170	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<2.5	<2.5	<5.0	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0
Oct-11	0.67	140	180	2.1	1.8	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-10 Dup	<5.0	190	51	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0	<10
Oct-10	<5.0	220	56	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0	<10
Oct-09 Dup	1.6	180	54	1.9	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	1.6	180	52	2.4	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-08 Dup	<4	330	75	<4	<4	<4	<4	<4	<4	<8	<4	<4	<8	<4	<4	<4	<4	<4	<8
Oct-08	<4	370	79	4.2	<4	<4	<4	<4	<4	<8	<4	<4	<8	<4	<4	<4	<4	<4	<8
Oct-07	<5.0	370	80	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-07 Dup	<5.0	380	81	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
May-07	<5.0	290	100	<5.0	NA	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	5.4	<5.0	<5.0	<5.0	<15
Jan-07	NA	430	120	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-06	<4.0	330	85	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<8.0	<4.0	<4.0	<8.0	<4.0	<4.0	NA	NA	NA	NA
Oct-06 Dup	<2.0	320	76	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<4.0	<2.0	<2.0	<4.0	<2.0	<2.0	NA	NA	NA	NA
Jul-06	<5.0	450	140	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-06	<5.0	360	180	9.9	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-05	<2.0	340	130	3.3	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<4.0	<2.0	<2.0	<2.0	<2.0	NA	NA	NA	NA
Oct-04	<2.0	370	110	4.6	<2.0	<2.0	<2.0	<2.0	<2.0	<4.0	<4.0	<2.0	<8.0	<2.0	<2.0	NA	NA	NA	NA
Apr-04	2.0	340	170	4.4	<1.0	<1.0	<1.0	<1.0	NA	<1.0	<1.0	NA	<1.0	NA	<1.0	<1.0	<1.0	<1.0	<2.0
Oct-03 (1)	<5.0	480	268	8.7	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<10
Apr-03	<1.0	430	210	2.6	<1.0	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	<1.0	NA	<1.0	<1.0	<2.0
Oct-02	<5.0	510	190	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<10	<5.0	<20	<5.0	<5.0	NA	NA	NA	NA
Apr-02	<10	350	160	<10	<10	<10	<10	<10	ND	<20	<10	<10	ND	<10	<10	NA	NA	NA	NA
Jan-02	<10	290	120	<10	<10	<10	<10	<10	ND	<20	<10	<10	ND	<10	<10	NA	NA	NA	NA
Oct-01	<5.0	260	71	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<10	<5.0	<5.0	<5.0	NA	NA	NA	NA
Jun-01	1.6	220	76	1.4	<2.0	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	ND	NA	<1.0	NA	<1.0	1.2	<2.0
Oct-00	<10	120	87	<10	<10	<10	<10	<10	<10	ND	ND	<10	ND	<10	<10	NA	NA	NA	NA
Oct-99	<2.0	130	21	<2.0	<2.0	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	<2.0	NA	NA	NA	NA
Oct-99 Dup	<2.0	140	20	<2.0	<2.0	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	ND	NA	NA	NA	NA
Oct-98	<5.0	200	18	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	<25	NA	NA	NA	NA
Oct-97	<10	270	33	<10	<10	<10	<10	<10	ND	ND	ND	<10	ND	<20	<50	NA	NA	NA	NA
Oct-96	1.8	260	32	<1.0	<1.0	<1.0	<1.0	<1.0	ND	ND	ND	1.5	ND	<1.0	ND	NA	NA	NA	NA
Oct-95	<5.0	400	--	--	<10	<5.0	<5.0	<5.0	ND	ND	ND	5.9	ND	<5.0	ND	NA	NA	NA	NA
Nov-94	<25	410	--	--	<25	<25	<25	<25	ND	ND	ND	<25	ND	<25	ND	NA	NA	NA	NA
Oct-94	450	1,700	--	--	<250	<250	<250	<250	ND	ND	ND	<250	ND	<250	ND	NA	NA	NA	NA
Oct-93	<5.0	480	--	--	<10	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-92	2.4	670	--	--	<1.0	2	<0.5	1	ND	ND	ND	NA	ND	<0.5	ND	NA	NA	NA	NA
Apr-92	5.0	980	--	--	<0.5	3	1	2	ND	ND	ND	1	ND	<0.5	ND	NA	NA	NA	NA
Jan-92	<10	1,200	--	--	<10	<10	<10	<10	ND	ND	ND	<10	ND	<10	ND	NA	NA	NA	NA
Jul-91	10	720	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	14	ND	<5.0	ND	NA	NA	NA	NA
Apr-91	<5.0	720	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-90	<5.0	820	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Jul-90	<20	810	--	--	<20	<20	<20	<20	ND	ND	ND	<20	ND	<20	ND	NA	NA	NA	NA
Apr-90	<10	1,300	--	--	<10	<10	<10	<10	ND	ND	ND	<10	ND	<10	ND	NA	NA	NA	NA
Jan-90	<10	1,300	--	--	<10	<10	<10	<10	ND	ND	ND	<10	ND	<10	ND	NA	NA	NA	NA
Oct-89	<5.0	1,000	--	--	<5.0	<5.0	<5.0	<5.0	--	--	--	<10	ND	<5.0	--	--	--	--	--
Oct-89	6	820	--	--	<2.0	5	<2.0	<2.0	--	--	--	<2.0	ND	<2.0	--	--	--	--	--
Aug-89	<10	1,400	--	--	<10	38	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
May-89	5.7	1,300	--	--	<5.0	<5.0	<5.0	<5.0	--	--	--	<5.0	ND	<5.0	--	--	--	--	--
Feb-89	<25	1,200	--	--	<25	<25	<25	<25	--	--	--	<25	ND	<25	--	--	--	--	--
Feb-89	<25	1,100	--	--	<25	<25	<25	<25	--	--	--	<25	ND	<25	--	--	--	--	--
Nov-88	<10	1,200	--	--	<10	<10	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Aug-88	<10	970	--	--	<10	<10	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Jun-88	<25	1,200	--	--	<25	<25	<25	<25	--	--	--	360	ND	<25	--	--	--	--	--
Jan-88	<50	3,200	--	--	<50	<50	<50	<50	--	--	--	<50	ND	<50	--	--	--	--	--
Oct-87	<25	2,700	--	--	<25	<25	<25	<25	--	--	--	<25	ND	<25	--	--	--	--	--
Jun-87	<25	3,000	--	--	<25	<25	<25	<25	--	--	--	<25	ND	<25	--	--	--	--	--
Apr-87	<25	2,800	--	--	<25	<25	59	<25	--	--	--	<25	ND	<25	--	--	--	--	--
Jan-87	<10	3,000	--	--	<10	<10	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Sep-86	<12	2,200	--	--	<12	<12	<12	<12	--	--	--	<12	ND	<12	--	--	--	--	--
Jul-86	<25	3,300	--	--	<25	<25	<25	<25	--	--	--	<25	ND	<25	--	--	--	--	--
Apr-86	<10	1,400	--	--	<10	<10	1,800	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Jan-86	<25	2,500	--	--	<25	<25	<25	<25	--	--	--	NA	ND	<25	--	--	--	--	--
Oct-85	28	3,800	--	--	340	87	<50	<50	--	--	--	<50	ND	<50	--	--	--	--	--
Oct-85	<50	3,600	--	--	<50	<50	<50	<50	--	--	--	690	ND	<50	--	--	--	--	--
Nov-84	15	3,100	--	--	NA	22	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--
Aug-84	120	6,800	--	--	ND	ND	ND	ND	--	--	--	ND	ND	ND	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
T-8A ZA																			
Oct-12	<2.5	160	82	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<2.5	<2.5	<5.0	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0
Apr-12	1.1	110	67	1.1	0.88	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-11	1.6	140	69	2.1	1.3	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-10	0.99	87	65	2.8	4.6	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-10	<0.50	43	26	2.1	3.7	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	0.54	36	33	3.2	21	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Feb-09	<0.50	21	23	1.4	9.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	NA	NA	NA	NA
Oct-08	0.76	84	28	1.1	4.9	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5	<1
Oct-07	<5.0	59	71	<5.0	36.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-07	<5.0	170	63	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-07	8.2	180	81	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-06	<5.0	57	34	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jul-06	<5.0	210	94	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-06	<5.0	86	83	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-06	<5.0	63	44	<5.0	5.8	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-05	<5.0	200	130	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jul-05	<5.0	170	58	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-05	<5.0	140	44	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-04	2.8	130	39	2.3	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<4.0	<1.0	<1.0	NA	NA	NA	NA
Jul-04	<5.0	150	50	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<10
Apr-04	3.2	120	45	2.5	<1.0	<1.0	<1.0	<1.0	NA	<1.0	<1.0	NA	<1.0	NA	<1.0	<1.0	<1.0	<1.0	<2.0
Jan-04	<5.0	110	33	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<10
Oct-03	<5.0	140	48	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<10
Jul-03	2.0	150	41	1.2	<2.0	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	<1.0	NA	<1.0	<1.0	<2.0
Mar-03	1.9	150	45	<1.0	<2.0	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	<1.0	NA	<1.0	<1.0	<2.0
Jan-03	3.3	140	49	1.2	<2.0	<1.0	<1.0	<1.0	<2.0	<2.0	<2.0	<2.0	<1.0	NA	<1.0	NA	NA	NA	NA
Oct-02	2.4	130	54	1.4	14	1.2	2.8	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	<1.0	1.3	<1.0	1.2	<2.0
Jul-02	<1.0	120	44	<1.0	<2.0	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	ND	NA	<1.0	NA	<1.0	<1.0	<2.0
Mar-02	2.4	140	41	1.3	<2.0	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	ND	NA	<1.0	NA	<1.0	<1.0	<2.0
Jan-02	2.0	170	62	1.5	<2.0	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	ND	NA	<1.0	NA	<1.0	6.8	2.7
Nov-01	<5.0	140	62	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	ND	NA	<5.0	NA	<5.0	<5.0	<10
Oct-01	2.8	190	68	1.4	<2.0	1.5	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	<1.0	NA	<1.0	<1.0	<2.0
Aug-01	5.9	180	72	1.4	<2.0	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	ND	NA	<1.0	NA	<1.0	<1.0	<2.0
Jun-01	2.6	150	64	1.4	<2.0	1.6	<1.0	<1.0	NA	<2.0	<2.0	NA	ND	NA	<1.0	NA	<1.0	2.2	<2.0
Oct-00	<10	150	64	<10	<10	<10	<10	<10	<10	ND	ND	<10	ND	<10	<10	NA	NA	NA	NA
Oct-00 Dup	<10	140	62	<10	<10	<10	<10	<10	<10	ND	ND	<10	ND	<10	<10	NA	NA	NA	NA
Oct-99	2.6	130	77	<2.0	<2.0	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	<2.0	NA	NA	NA	NA
Apr-99	<10	110	72	<10	<10	<10	<10	<10	ND	ND	ND	<10	ND	<10	<10	NA	NA	NA	NA
Oct-98	3.0	110	120	<2.0	<2.0	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	<2.0	NA	NA	NA	NA
Apr-98	<5.0	170	110	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<20	ND	<5.0	<5.0	NA	NA	NA	NA
Oct-97	<10	210	170	<10	<10	<10	<10	<10	ND	ND	ND	<10	ND	<20	<10	NA	NA	NA	NA
Apr-97	3.8	200	160	12	<1.0	2.9	<1.0	1.3	ND	ND	ND	2.7	ND	2.2	ND	NA	NA	NA	NA
Oct-96	2.4	160	160	3.7	<0.5	2.3	0.8	1.1	ND	ND	ND	1.5	ND	2.2	ND	NA	NA	NA	NA
Apr-96	4.0	230	--	--	<2.5	3	<2.5	<2.5	ND	ND	ND	<2.5	ND	<2.5	ND	NA	NA	NA	NA
Oct-95	4.4	260	--	--	<4.0	4.9	2.1	<2.0	ND	ND	ND	4	ND	<2.0	ND	NA	NA	NA	NA
Apr-95	<5.0	230	--	--	<10	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-94	<25	300	--	--	<25	<25	<25	<25	ND	ND	ND	<25	ND	<25	ND	NA	NA	NA	NA
Apr-94	4.9	280	--	--	<0.5	8	3	<0.5	ND	ND	ND	3	ND	1	ND	NA	NA	NA	NA
Oct-93	<5.0	250	--	--	<10	7	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Apr-93	2.6	160	--	--	<5.0	4	<2.5	<2.5	ND	ND	ND	<2.5	ND	<2.5	ND	NA	NA	NA	NA
Oct-92	7.3	260	--	--	2	4	<0.5	<0.5	ND	ND	ND	NA	ND	1	ND	NA	NA	NA	NA
Apr-92	8.0	400	--	--	<2.0	19	<2.0	<2.0	ND	ND	ND	21	ND	<2.0	ND	NA	NA	NA	NA
Jul-91	4.6	110	--	--	<0.5	2	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Apr-91	<2.0	160	--	--	<2.0	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	ND	NA	NA	NA	NA
Jan-91	1.0	100	--	--	<1.0	1	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-90	2.8	100	--	--	<0.5	4	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Jul-90	<2.0	120	--	--	<2.0	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	ND	NA	NA	NA	NA
Apr-90	3.0	99	--	--	<0.5	1	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Feb-90	2.6	76	--	--	<0.5	1	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-89	7	250	--	--	2	7	2	<1.0	--	--	--	3	ND	8	--	--	--	--	--
Aug-89	14	340	--	--	<1.0	10	4	1	--	--	--	5	ND	<1.0	--	--	--	--	--
Feb-89	<10	200	--	--	<10	<10	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Nov-88	7	260	--	--	<2.0	7	<2.0	<2.0	--	--	--	4	ND	9	--	--	--	--	--
Aug-88	9.0	370	--	--	<5.0	10	<5.0	<5.0	--	--	--	25	ND	<5.0	--	--	--	--	--
Jan-88	23	570	--	--	<5.0	18	<5.0	<5.0	--	--	--	27	ND	<5.0	--	--	--	--	--
Oct-87	9.8	690	--	--	<5.0	17	<5.0	<5.0	--	--	--	<5.0	ND	<5.0	--	--	--	--	--
Oct-87	<0.5	830	--	--	<1.0	<0.5	<0.5	<0.5	--	--	--	<1.0	ND	NA	--	--	--	--	--
Jul-87	<10	1,700	--	--	<10	25	<10	<10	--	--	--	12	ND	<10	--	--	--	--	--
Jan-87	23	1,200	--	--	<5.0	24	<5.0	<5.0	--	--	--	<5.0	ND	53	--	--	--	--	--
Jul-86	<10	1,400	--	--	<10	<10	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Apr-86	20	1,100	--	--	<10	<10	<10	<10	--	--	--	<10	ND	800	--	--	--	--	--
Oct-85	44	2,200	--	--	<25	77	<25	<25	--	--	--	320	ND	<25	--	--	--	--	--
Nov-84	37	2,200	--	--	NA	9.8	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--
Aug-84	130	2,800	--	--	ND	ND	ND	ND	--	--	--	ND	ND	ND	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
T-9A ZA																			
Oct-12	0.9	50	82	3.3	0.91	<0.5	0.54	<0.5	<0.5	<1.0	<0.5	<0.5	<1.0	3	<0.5	<0.5	<0.5	<0.5	<1.0
Oct-11	1.6	73	100	2.9	2.2	<0.50	0.55	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	3.7	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-10	0.83	48	88	2.2	3.5	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	2.6	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	1.5	66	82	3.0	2.0	<0.50	0.58	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	4.0	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-08	1.3	50	98	2.7	1.2	<1	<1	<1	<1	<2	<1	<1	<2	3.1	<1	<1	<1	<1	<2
Oct-07	<5.0	120	130	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
May-07	<5.0	98	92	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-07	<5.0	130	120	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-06	<5.0	100	100	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jul-06	<5.0	60	130	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-06	<5.0	47	190	8.1	6.8	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-06	<5.0	56	140	<5.0	21	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-05	<5.0	56	170	<5.0	7.3	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jul-05	<5.0	140	90	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-05	<5.0	7.5	320	<5.0	8.2	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-05	<5.0	120	92	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-04	<5.0	110	74	<5.0	5.3	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-04	2.9	85	81	2.3	7.2	<1.0	<1.0	<1.0	NA	<1.0	<1.0	NA	<1.0	NA	<1.0	<1.0	<1.0	<1.0	<2.0
Jan-04	<5.0	92	56	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<10
Oct-03	<5.0	120	81	<5.0	24	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<10
Apr-03	1.8	120	87	1.4	<2.0	1.1	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	<1.0	NA	<1.0	<1.0	<2.0
Oct-02	<5.0	110	66	<5.0	8.1	<5.0	<5.0	<5.0	<5.0	<10	<10	<5.0	<20	<5.0	<5.0	NA	NA	NA	NA
Jul-02	<2.5	120	95	<2.5	7.3	<2.5	<2.5	<2.5	ND	<5.0	<2.5	<2.5	ND	<2.5	<2.5	NA	NA	NA	NA
Apr-02	3.0	130	100	<2.5	9.0	<2.5	<2.5	<2.5	ND	<5.0	<2.5	<2.5	ND	3.0	<2.5	NA	NA	NA	NA
Jan-02	3.0	140	110	<2.5	11	<2.5	<2.5	<2.5	ND	<5.0	<2.5	<2.5	ND	3.9	<2.5	NA	NA	NA	NA
Oct-01	<5.0	110	87	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<20	<20	<5.0	<5.0	NA	NA	NA	NA
Aug-01	<5.0	120	110	<5.0	<5.0	<5.0	<5.0	<5.0	ND	<5.0	<5.0	<25	ND	NA	<5.0	<5.0	<5.0	<5.0	<5.0
Oct-00	<10	140	110	<10	<10	<10	<10	<10	<10	ND	ND	<10	ND	<10	<10	NA	NA	NA	NA
Oct-00 Dup	<10	140	110	<10	<10	<10	<10	<10	<10	ND	ND	<10	ND	<10	<10	NA	NA	NA	NA
Oct-99	3.5	130	100	2.2	<2.0	2.4	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	<2.0	NA	NA	NA	NA
Apr-99	<10	140	140	<10	<10	<10	<10	<10	ND	ND	ND	<10	ND	<10	<10	NA	NA	NA	NA
Oct-98	3.4	130	150	2.1	<2.0	2.6	<2.0	<2.0	ND	ND	ND	<2.0	ND	6.0	<2.0	NA	NA	NA	NA
Apr-98	<5.0	150	170	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<20	ND	<5.0	<5.0	NA	NA	NA	NA
Oct-97	<10	210	290	<10	<10	<10	<10	<10	ND	ND	ND	<10	ND	<20	<10	NA	NA	NA	NA
Apr-97	5.0	200	250	16	1.4	3.9	1.9	1.7	ND	ND	ND	3.3	ND	9.8	ND	NA	NA	NA	NA
Oct-96	4.2	190	270	3.5	<1.0	4.4	2.7	1.7	ND	ND	ND	2.8	ND	11	ND	NA	NA	NA	NA
Apr-96	6.2	240	--	--	<2.5	5.3	2.7	<2.5	ND	ND	ND	<2.5	ND	12	ND	NA	NA	NA	NA
Oct-95	5.7	210	--	--	<5.0	5.4	3.2	<2.5	ND	ND	ND	3.5	ND	14	ND	NA	NA	NA	NA
Apr-95	4.7	180	--	--	<6.0	3.8	<3.0	<3.0	ND	ND	ND	<3.0	ND	12	ND	NA	NA	NA	NA
Oct-94	<25	260	--	--	<25	<25	<25	<25	ND	ND	ND	<25	ND	<25	ND	NA	NA	NA	NA
Apr-94	9.2	270	--	--	6.7	12	9.1	2.3	ND	ND	ND	<0.5	ND	22	ND	NA	NA	NA	NA
Oct-93	7.0	330	--	--	<10	8.0	<5.0	<5.0	ND	ND	ND	8.0	ND	17	ND	NA	NA	NA	NA
Apr-93	8.0	420	--	--	30	8.0	<5.0	<5.0	ND	ND	ND	5.0	ND	16	ND	NA	NA	NA	NA
Oct-92	13	470	--	--	8.7	9.3	5.8	3.2	ND	ND	ND	NA	ND	21	ND	NA	NA	NA	NA
Apr-92	16	740	--	--	<5.0	18	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Jan-92	22	850	--	--	<5.0	24	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Jul-91	26	720	--	--	<5.0	17	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Apr-91	20	1,000	--	--	<10	<10	<10	<10	ND	ND	ND	<10	ND	22	ND	NA	NA	NA	NA
Jan-91	30	1,700	--	--	<10	10	10	<10	ND	ND	ND	<10	ND	<10	ND	NA	NA	NA	NA
Oct-90	20	1,400	--	--	<10	<10	<10	<10	ND	ND	ND	<10	ND	<10	ND	NA	NA	NA	NA
Jul-90	45	1,100	--	--	64	8.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	11	ND	NA	NA	NA	NA
Apr-90	30	2,600	--	--	120	<20	<20	<20	ND	ND	ND	<20	ND	<20	ND	NA	NA	NA	NA
Feb-90	<50	2,800	--	--	<50	<50	<50	<50	ND	ND	ND	<50	ND	<50	ND	NA	NA	NA	NA
Oct-89	69	820	--	--	200	14	3	<2.0	--	--	--	<2.0	ND	110	--	--	--	--	--
May-88	25	1,000	--	--	170	26	13	<5.0	--	--	--	24	ND	63	--	--	--	--	--
Jan-88	<25	1,700	--	--	230	<25	<25	<25	--	--	--	<25	ND	<25	--	--	--	--	--
Oct-87	44	770	--	--	220	22	<5.0	<5.0	--	--	--	55	ND	<5.0	--	--	--	--	--
Jul-87	<10	1,000	--	--	390	13	<10	<10	--	--	--	18	ND	36	--	--	--	--	--
Jul-86	21	1,100	--	--	540	<10	<10	<10	--	--	--	<10	ND	82	--	--	--	--	--
Apr-86	<10	1,100	--	--	780	<10	<10	<10	--	--	--	<10	ND	<10	--	--	--	--	--
Mar-86	<10	2,500	--	--	<10	<10	<10	<10	--	--	--	NA	ND	<10	--	--	--	--	--
Mar-86	<10	1,700	--	--	<10	<10	<10	<10	--	--	--	NA	ND	<10	--	--	--	--	--
Mar-86	120	1,100	--	--	710	<10	<10	<10	--	--	--	NA	ND	<10	--	--	--	--	--
Oct-85	320	5,600	--	--	<50	60	<50	<50	--	--	--	1,200	ND	<50	--	--	--	--	--
Nov-84	31	1,800	--	--	NA	12	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--
Aug-84	280	2,000	--	--	3,500	ND	47	ND	--	--	--	ND	ND	ND	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
T-13A ZA																			
Oct-12	<0.50	1.2	20	2.3	17	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-12	<0.50	0.74	18	1.6	5.8	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.52	<0.50	<0.50	<0.50	0.56	<1.0
Oct-11	0.84	70	66	2.8	10.0	<0.50	0.54	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-10	0.52	72	51	2.2	6.9	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-10	<0.50	57	31	1.4	4.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	<0.50	26	40	2.40	8.0	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.52	1.2	<0.50	<0.50	<0.50	<1.0
Feb-09	<0.50	30	32	2.1	8.3	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	2.1	2.9	NA	NA	NA	NA
Oct-08	<25	38	<25	<25	<25	<25	<25	<25	<25	<50	<25	<25	<50	<25	<25	<25	<25	3100	<50
Oct-07	<5.0	48	260	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jul-07	<5.0	180	64	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-07	<5.0	200	75	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-07	6.2	300	120	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-06	<5.0	210	99	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jul-06	<5.0	200	120	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-06	<5.0	180	140	6.2	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-06	<5.0	210	98	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Nov-05	<5.0	200	98	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
T-14A ZA																			
Oct-12	<0.50	0.96	27	3.8	26	<0.50	<0.50	0.71	<0.50	<1.0	<0.50	<0.50	<1.0	2	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-12	<0.50	3.0	42	3.1	16	<0.50	<0.50	0.51	<0.50	<1.0	<0.50	<0.50	<1.0	2.3	0.86	<0.50	<0.50	<0.50	<1.0
Oct-11	<0.50	28	38	2.8	6.7	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.0	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-10	<0.50	36	42	2.4	9.0	<0.50	<0.50	0.60	<0.50	<1.0	<0.50	<0.50	<1.0	1.9	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-10	<0.50	28	37	2.2	9.7	<0.50	<0.50	0.51	<0.50	<1.0	<0.50	<0.50	<1.0	1.7	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	<0.50	9.0	16	1.9	7.4	<0.50	<0.50	0.53	<0.50	<1.0	<0.50	<0.50	<1.0	1.8	1.9	<0.50	<0.50	0.54	<1.0
Feb-09	<0.50	6.2	15	2.0	7.8	<0.50	<0.50	0.59	<0.50	<1.0	<0.50	<0.50	<1.0	2.4	2.2	NA	NA	NA	NA
Oct-08	<20	<20	45	<20	<20	<20	<20	<20	<20	<40	<20	<20	<40	<20	<20	<20	<20	1300	<40
Oct-07	<5.0	54	200	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jul-07	<5.0	120	51	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-07	<5.0	160	58	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-06	<5.0	200	57	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-06	6.8	140	92	8	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-06	<5.0	150	63	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Nov-05	<5.0	130	59	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
T-15A ZA																			
Oct-12	<2.5	130	62	3.8	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<2.5	<2.5	<5.0	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0
Apr-12	2.2	130	58	3.2	<0.50	<0.50	0.64	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.1	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-11	3	130	61	3.8	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<2.5	<2.5	<5.0	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0
Oct-10	1.3	110	48	2.2	0.50	<0.50	0.54	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.91	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	<0.50	92	37	2.4	0.61	<0.50	0.64	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.90	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-08	1.6	140	53	2.2	1.5	<1	<1	<1	<1	<2	<1	<1	<2	<1	<1	<1	<1	<1	<2
Oct-07	<5.0	160	75	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jul-07	<5.0	130	63	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
May-07	<5.0	140	66	<5.0	8.2	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-07	5.2	170	87	<5.0	7.4	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-06	<5.0	140	66	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jul-06	<5.0	130	91	<5.0	8.2	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-06	<5.0	51	140	11	29	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-06	<5.0	<5.0	110	<5.0	83	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Nov-05	<5.0	8.2	160	<5.0	37	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
T-16A ZA																			
Oct-12	1	68	63	3.2	2.1	<0.50	0.57	0.5	<0.50	<1.0	<0.50	<0.50	<1.0	1.1	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-11	1.6	91	67	2.9	0.53	<0.50	0.7	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.5	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-10	0.81	72	64	2.2	0.76	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.89	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	0.59	40	44	2.2	0.84	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.61	<0.5	0.6	<0.50	0.56 B	<1.0
Oct-08	0.9	63	77	2.3	2.6	<0.5	0.53	<0.5	<0.5	<1	<0.5	<0.5	<1	1.4	<0.5	<0.5	<0.5	<0.5	<1
Oct-07	<5.0	79	160	<5.0	8.8	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.1	NA	<5.0	<5.0	<5.0	<5.0	<15
May-07	<5.0	120	71	<5.0	7.3	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Oct-06	<5.0	80	100	<5.0	8.2	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Apr-06	<5.0	17	160	9.5	26	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Jan-06	<5.0	20	120	<5.0	45	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Nov-05	<5.0	24	160	<5.0	32	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
T-17A ZA																			
Oct-12	1.3	92	4.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	0.62	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-12	1.3	96	5.8	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Nov-11	1.7	110	6.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
T-19A ZA																			
Oct-12	<0.50	<0.50	9.1	1.3	5.6	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.8	3.8	<0.50	<0.50	0.8	<1.0
Apr-12	<0.50	<0.50	2.1	1.2	0.92	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.60	4.3	<0.50	<0.50	0.77	<1.0
Oct-11	<0.50	4.1	16	1.60	10	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.80	1.3	<0.50	<0.50	<0.50	1
Oct-10	<0.50	0.89	7.7	0.72	10	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.87	1.2	<0.50	<0.50	<0.50	<1.0
Apr-10 Dup	<0.50	0.89	1.6	<0.50	0.81	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.56	1.1	<0.50	<0.50	<0.50	<1.0
Apr-10	<0.50	0.98	1.6	<0.50	0.88	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.65	1.3	<0.50	<0.50	<0.50	<1.0
Oct-09	<0.50	<0.50	4.6	0.84	2.8	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.3	3.9	<0.50	<0.50	<0.50	<1.0
Feb-09 Dup	<0.50	<0.50	2.6	0.78	1.4	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.2	6.3	NA	NA	NA	NA
Feb-09	<0.50	<0.50	1.9	0.65	1.0	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.0	6.0	NA	NA	NA	NA
Oct-08	<50	<50	<50	<50	<50	<50	<50	<50	<50	<100	<50	<50	<100	<50	<50	<50	<50	3500	<100
Oct-07	<5.0	53	140	<5.0	8	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Sep-07	<5.0	140	55	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
T-23A ZA																			
Oct-12	<0.50	36	73	2.4	6.6	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-12	<0.50	2.0	58	2.0	3.2	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.1	0.79	<0.50	<0.50	3.5	<1.0
Apr-12 Dup	<0.50	2.0	61	1.9	3.0	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.0	0.76	<0.50	<0.50	3.3	<1.0
Oct-11	0.62	62	39	4.2	2.0	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-10	0.60	51	37	4.3	3.5	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.56	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-10	<0.50	41	19	2.8	2.0	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.54	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	<0.50	11	14	2.0	3.1	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	0.55	ND	<0.50	<0.50	<0.50	<1.0
Feb-09	<0.50	17	29	2.1	9.7	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.5	1.8	NA	NA	NA	NA
Oct-08	<10	16	12	<10	<10	<10	<10	<10	<10	<20	<10	<10	<20	<10	<10	<10	<10	890	<20
Oct-07	<5.0	130	120	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Sep-07	7.7	210	21	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
T-25A ZA																			
Oct-12	<0.50	0.86	10	3.5	12	<0.50	<0.50	0.71	<0.50	<1.0	<0.50	<0.50	<1.0	2.3	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-12	<0.50	1.1	19	2.7	7.3	<0.50	<0.50	0.52	<0.50	<1.0	<0.50	<0.50	<1.0	3.1	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-11	1.5	63	50	3.0	2.1	<0.50	0.51	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.8	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-10	0.8	47	50	2.5	7.3	<0.50	<0.50	0.55	<0.50	<1.0	<0.50	<0.50	<1.0	2.1	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-10	1.0	39	34	2.3	6.8	<0.50	<0.50	<0.50	<0.50	<1.0	0.5	<0.50	<1.0	2.5	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	ND	26	17	2.0	3.3	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	1.3	<0.50	<0.50	<0.50	<0.50	<1.0
Feb-09	1.3	41	42	2.3	9.7	<0.50	<0.50	0.55	<0.50	<1.0	<0.50	<0.50	<1.0	3.3	<0.50	NA	NA	NA	NA
Oct-08	1.0	42	38	2.2	7.6	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<1	4.2	<0.5	<0.5	<0.5	<0.5	<1
Oct-07	<5.0	66	160	<5.0	9.6	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15
Sep-07	5.5	160	52	<5.0	<5.0	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	<5.0	<5.0	<5.0	<5.0	<15

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
36S ZA																			
Oct-12	2.0J	1	10	<0.5	<0.5	0.6	0.5	<0.5	NA	NA	NA	<2.0	NA	<5.0	NA	NA	NA	NA	NA
Oct-11	1.8 J	73	8	<0.5	<0.5	0.7	0.5	<0.5	NA	NA	NA	<2.0	NA	<5.0	NA	NA	NA	NA	NA
Oct-10+	2.0	75	11	0.6	<0.5	0.7	0.5	<0.5	NA	NA	NA	<2.0	NA	<0.5	NA	NA	NA	NA	NA
Oct-09+	2.2	80	9.3	<0.5	<0.5	0.6	<0.5	<0.5	NA	NA	NA	<2.0	NA	<0.5	NA	NA	NA	NA	NA
Oct-08+	2.4	98	13	0.6	<0.5	0.7	<0.5	<0.5	NA	NA	NA	<2.0	NA	<0.5	NA	NA	NA	NA	NA
Oct-07+	1.5	70	15	0.9	<0.7	<0.7	0.8	<0.7	ND	ND	ND	<0.7	ND	<0.7	<0.7	NA	NA	NA	NA
Oct-06+	2.6	98	20	0.9	<0.5	0.9	0.6	<0.5	ND	ND	ND	0.8	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-05+	2.1	91	22	0.8	<1.0	1.1	0.6	<0.5	ND	ND	ND	0.6	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-04+	1.8	91	34	1.1	<0.5	1.1	0.6	0.5	ND	ND	ND	1.9	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-03+	1.7	100	53	1.6	1.1	1.2	0.7	0.7	ND	ND	ND	<1.0	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-02+	1.8	140	70	1.9	<0.5	1.7	0.8	0.7	ND	ND	ND	1.2	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-01+	2.1	140	110	2.8	<0.5	2.5	1.1	1.0	ND	ND	ND	1.8	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-00+	1.3	83	100	5.6	<1.0	1.6	1.2	0.9	ND	ND	ND	1.8	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-99	1.2	50	83	4.4	<1.0	1.7	<1.0	<1.0	ND	ND	ND	1.0	ND	<1.0	<1.0	NA	NA	NA	NA
Oct-97+	<0.5	20	16	5.2	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-96	0.7	25	6.1	3.0	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-95	<1.0	21	--	--	<2.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	<1.0	NA	NA	NA	NA
Oct-94	<5.0	19	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	<5.0	NA	NA	NA	NA
Oct-93	<2.5	66	--	--	<5.0	<2.5	<2.5	<2.5	ND	ND	ND	<2.5	ND	<2.5	<2.5	NA	NA	NA	NA
Oct-92	2.1	35	--	--	<1.0	<0.5	<0.5	<0.5	ND	ND	ND	NA	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-89	4	130	--	--	<0.5	5.7	0.8	<0.5	--	--	--	2	ND	<0.5	--	--	--	--	--
May-88	3.9	140	--	--	<1.0	20	3.3	1.6	--	--	--	13	ND	1.8	--	--	--	--	--
Jan-88	5.8	170	--	--	<1.0	23	3.8	1.3	--	--	--	14	ND	<1.0	--	--	--	--	--
Oct-87	3.5	160	--	--	<1.0	20	2.5	1.7	--	--	--	14	ND	<1.0	--	--	--	--	--
Jun-87	<1.0	170	--	--	<1.0	15	1.6	<1.0	--	--	--	8.2	ND	<1.0	--	--	--	--	--
Apr-87	4	200	--	--	<2.5	34	6	<2.5	--	--	--	19	ND	<2.5	--	--	--	--	--
Jan-87	<10	140	--	--	<10	34	<10	<10	--	--	--	28	ND	<10	--	--	--	--	--
Sep-86	5.3	200	--	--	<1.0	27.5	2.9	2.1	--	--	--	16.5	ND	7.95	--	--	--	--	--
Jul-86	3.3	59	--	--	<0.5	32	3.2	1.6	--	--	--	15	ND	<0.5	--	--	--	--	--
Apr-86	3.4	130	--	--	<0.5	36	3.5	1.5	--	--	--	<0.5	ND	<0.5	--	--	--	--	--
Jan-86	11	190	--	--	<2.0	42	3.4	<2.0	--	--	--	<2.0	ND	<2.0	--	--	--	--	--
Oct-85	<5.0	250	--	--	<5.0	65	<5.0	<5.0	--	--	--	90	ND	ND	--	--	--	--	--
Nov-84	4.7	150	--	--	NA	19	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--
Aug-84	8	230	--	--	ND	23	2	ND	--	--	--	40	ND	ND	--	--	--	--	--
Mar-84	NA	360	--	--	NA	NA	NA	NA	--	--	--	NA	ND	NA	--	--	--	--	--
Aug-83	19	470	--	--	ND	36	16	<1.0	--	--	--	<1.0	ND	ND	--	--	--	--	--
May-83	ND	82	--	--	ND	ND	ND	ND	--	--	--	ND	ND	ND	--	--	--	--	--
Apr-83	13	400	--	--	ND	16	ND	ND	--	--	--	12	ND	ND	--	--	--	--	--
Aug-82	10	590	--	--	ND	19	<2.0	<2.0	--	--	--	2	ND	ND	--	--	--	--	--
Jun-82	18	710	--	--	ND	42	<10	<10	--	--	--	19	ND	ND	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
36D ZA																			
Oct-11	1.6 J	47	29	1.0	<0.5	<0.5	0.6	<0.5	NA	NA	NA	<2.0	NA	<5.0	NA	NA	NA	NA	NA
Oct-11	0.7 J	29	34	1.2	<0.5	<0.5	0.7	<0.5	NA	NA	NA	<2.0	NA	<5.0	NA	NA	NA	NA	NA
Oct-10+	1.4	47	34	1.2	<0.5	<0.5	0.7	<0.5	NA	NA	NA	<2.0	NA	<0.5	NA	NA	NA	NA	NA
Oct-09+	<0.5	19	40	1.1	<0.5	<0.5	0.5	<0.5	NA	NA	NA	<2.0	NA	<0.5	NA	NA	NA	NA	NA
Oct-08+	0.7	27	5.8	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	<2.0	NA	<0.5	NA	NA	NA	NA	NA
Oct-07+	<0.5	17	6.1	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	ND	ND	<0.5	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-06+	2.1	92	42	1.6	0.6	0.9	1.0	0.7	ND	ND	ND	1.2	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-05+	<0.5	4.6	1.5	<0.5	0.5	<0.5	<0.5	<0.5	ND	ND	ND	<1.0	ND	<0.5	ND	NA	NA	NA	NA
Oct-04+	1.6	85	46	1.7	2.4	1.1	0.8	0.6	ND	ND	ND	1.7	ND	0.8	ND	NA	NA	NA	NA
Apr-04	<1.0	45	27	2.5	12	<1.0	<1.0	<1.0	NA	<1.0	<1.0	NA	<1.0	NA	<1.0	<1.0	<1.0	<1.0	<2.0
Oct-03+	1.7	110	57	1.5	0.9	1.3	0.9	0.8	ND	ND	ND	1.1	ND	0.8	ND	NA	NA	NA	NA
Apr-03	<1.0	69	40	<1.0	8.2	<1.0	<1.0	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	<1.0	NA	<1.0	<1.0	<2.0
Oct-02+	1.8	150	90	2.3	<0.5	1.7	1.2	1.0	ND	ND	ND	1.9	ND	1.1	ND	NA	NA	NA	NA
Oct-01+	0.9	67	48	1.1	<0.5	1.2	0.6	<0.5	ND	ND	ND	1.4	<1.0	<0.5	ND	NA	NA	NA	NA
Oct-00+	1.6	110	97	2.2	<1.0	1.9	1.0	0.8	ND	ND	ND	1.6	ND	0.7	ND	NA	NA	NA	NA
Oct-00 Dup+	1.6	100	91	2.5	<1.0	1.8	1.1	0.7	ND	ND	ND	1.5	ND	0.7	ND	NA	NA	NA	NA
Oct-99	<2.0	85	120	2.7	<2.0	2.6	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	ND	NA	NA	NA	NA
Apr-98+	<5.0	81	130	<5.0	<5.0	NA	<5.0	<5.0	ND	ND	ND	<20	ND	<5.0	ND	NA	NA	NA	NA
Oct-97+	<0.5	52	91	1.2	<0.5	2.1	<0.5	0.9	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Oct-96	1.2	48	34	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	0.6	ND	NA	NA	NA	NA
Oct-95	<1.0	25	--	--	<2.0	<1.0	<1.0	<1.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-94	<5.0	66	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-93	<5.0	94	--	--	<10	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-92	2.1	92	--	--	<1.0	1.0	<0.5	<0.5	ND	ND	ND	NA	ND	1.6	ND	NA	NA	NA	NA
Apr-92	4.0	180	--	--	<1.0	3.0	1.0	2.0	ND	ND	ND	<1.0	ND	<1.0	ND	NA	NA	NA	NA
Jan-92	1.6	170	--	--	<1.0	2.9	<1.0	<1.0	ND	ND	ND	<1.0	ND	1.6	ND	NA	NA	NA	NA
Oct-91	2.5	120	--	--	<0.5	2.2	1.8	1.2	ND	ND	ND	0.6	ND	2.3	ND	NA	NA	NA	NA
Jul-91	2.0	130	--	--	<1.0	1.0	<1.0	1.0	ND	ND	ND	1.0	ND	3.0	ND	NA	NA	NA	NA
Apr-91	<2.0	180	--	--	<2.0	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	ND	NA	NA	NA	NA
Jan-91	2.0	120	--	--	<1.0	1.0	1.0	1.0	ND	ND	ND	<1.0	ND	3.0	ND	NA	NA	NA	NA
Oct-90	2.6	120	--	--	<0.5	2.7	<0.5	<0.5	ND	ND	ND	<0.5	ND	2.1	ND	NA	NA	NA	NA
Jul-90	2.7	110	--	--	<0.5	2.7	1.3	0.9	ND	ND	ND	1.3	ND	5.0	ND	NA	NA	NA	NA
Apr-90	3.0	170	--	--	<1.0	2.0	1.0	<1.0	ND	ND	ND	<1.0	ND	4.0	ND	NA	NA	NA	NA
Jan-90	3.0	170	--	--	<1.0	4.0	2.0	<1.0	ND	ND	ND	1.0	ND	4.0	ND	NA	NA	NA	NA
Oct-89	4.3	120	--	--	<0.5	9.6	2.7	0.8	--	ND	--	7.4	ND	<0.5	--	--	--	--	--
Aug-89	4	200	--	--	<2.0	10	6	<2.0	--	ND	--	7	ND	8	--	--	--	--	--
May-89	<2.5	<2.5	--	--	<2.5	<2.5	<2.5	<2.5	--	ND	--	<2.5	ND	<2.5	--	--	--	--	--
Feb-89	<5.0	180	--	--	<5.0	8	<5.0	<5.0	--	ND	--	12	ND	<5.0	--	--	--	--	--
Feb-89	<2.0	61	--	--	<2.0	4	<2.0	<2.0	--	ND	--	<2.0	ND	5	--	--	--	--	--
Feb-89	<2.0	51	--	--	<2.0	3	<2.0	<2.0	--	ND	--	<2.0	ND	3	--	--	--	--	--
Nov-88	3.2	180	--	--	<1.0	14	3.5	1.6	--	ND	--	16	ND	13	--	--	--	--	--
Aug-88	5	150	--	--	<1.0	30	5.6	2.8	--	ND	--	34	ND	11	--	--	--	--	--
May-88	4.2	170	--	--	<1.0	31	5.5	2.6	--	ND	--	20	ND	11	--	--	--	--	--
Jan-88	4.1	100	--	--	<1.0	34	3.5	1.9	--	ND	--	30	ND	9.4	--	--	--	--	--
Oct-87	3.3	68	--	--	<0.5	29	3.4	2.3	--	ND	--	22	ND	14	--	--	--	--	--
Jun-87	5.9	170	--	--	<1.0	22	2.9	1.9	--	ND	--	21	ND	24	--	--	--	--	--
Apr-87	3	160	--	--	<1.0	25	4.7	1.7	--	ND	--	16	ND	18	--	--	--	--	--
Jan-87	<10	170	--	--	<10	28	<10	<10	--	ND	--	54	ND	<10	--	--	--	--	--
Sep-86	20	170	--	--	<1.0	40	5.1	3.5	--	ND	--	17	ND	18	--	--	--	--	--
Jul-86	3.6	60	--	--	<0.5	43	4.8	2.3	--	ND	--	25	ND	<0.5	--	--	--	--	--
Apr-86	3	130	--	--	<0.5	39	4.3	1.9	--	ND	--	<0.5	ND	<0.5	--	--	--	--	--
Oct-85	16	220	--	--	<5.0	77	<5.0	<5.0	--	ND	--	120	ND	<5.0	--	--	--	--	--
Nov-84	4.2	160	--	--	NA	26	NA	NA	--	ND	--	NA	ND	NA	--	--	--	--	--
Aug-84	6	180	--	--	ND	19	2	ND	--	ND	--	30	ND	ND	--	--	--	--	--
Mar-84	NA	260	--	--	NA	NA	NA	NA	--	ND	--	NA	ND	NA	--	--	--	--	--
Aug-83	15	600	--	--	NA	36	13	16	--	ND	--	<1.0	ND	NA	--	--	--	--	--
Jul-83	8	650	--	--	ND	18	2	2	--	ND	--	ND	ND	ND	--	--	--	--	--
May-83	14	9,200	--	--	ND	18	ND	ND	--	ND	--	ND	ND	ND	--	--	--	--	--
Aug-82	6.8	500	--	--	ND	19	<2.0	<2.0	--	ND	--	<2.0	ND	ND	--	--	--	--	--
Jul-82	<5.0	210	--	--	ND	<5.0	<5.0	<5.0	--	ND	--	<5.0	ND	ND	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
37S ZA																			
Oct-12	0.8 J	63	2.5	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	<2.0	NA	<5.0	NA	NA	NA	NA	NA
Oct-11	0.8 J	63	2.3	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	<2.0	NA	<5.0	NA	NA	NA	NA	NA
Oct-10+	0.9	60	3.7	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	<2.0	NA	<0.5	NA	NA	NA	NA	NA
Oct-09+	1.4	91	2.2	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	<2.0	NA	<0.5	NA	NA	NA	NA	NA
Oct-08+	1.1	81	3.6	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	<2.0	NA	<0.5	NA	NA	NA	NA	NA
Oct-07+	1.0	81	2.4	<0.5	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	1.8	ND	<0.5	<0.5	NA	NA	NA	NA
Oct-05+	1.0	91	5.2	<0.7	<0.7	<0.7	<0.7	<0.7	ND	ND	ND	<1.4	ND	<0.7	ND	NA	NA	NA	NA
Oct-04+	1.2	11	3.3	<0.7	<0.7	<0.7	<0.7	<0.7	ND	ND	ND	1.9	ND	<0.7	ND	NA	NA	NA	NA
Oct-03+	1.3	160	2.9	<0.6	<0.6	<0.6	<0.6	<0.6	ND	ND	ND	<1.3	ND	<0.6	ND	NA	NA	NA	NA
Oct-02+	0.9	170	3.7	<0.7	<0.7	<0.7	<0.7	<0.7	ND	ND	ND	<1.4	ND	<0.7	ND	NA	NA	NA	NA
Oct-01	<5.0	140	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<20	ND	<5.0	ND	NA	NA	NA	NA
Oct-00+	1.2	200	9.7	<0.5	1.8	<0.5	<0.5	<0.5	ND	ND	ND	2.1	ND	<0.5	ND	NA	NA	NA	NA
Oct-99	<5.0	180	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-97+	<2.5	260	12	<2.5	<2.5	<2.5	<2.5	<2.5	ND	ND	ND	<2.5	ND	<2.5	ND	NA	NA	NA	NA
Oct-96	1.2	270	6.3	<1.0	<1.0	<1.0	<1.0	<1.0	ND	ND	ND	2.0	ND	<1.0	ND	NA	NA	NA	NA
Oct-95	<1.0	380	--	--	<2.0	<1.0	<1.0	<1.0	ND	ND	ND	3.8	ND	<1.0	ND	NA	NA	NA	NA
Oct-94	<5.0	330	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-93	<5.0	400	--	--	<10	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Jun-88	<1.0	150	--	--	<1.0	5.8	<1.0	<1.0	--	--	ND	<1.0	ND	<1.0	--	--	--	--	--
Jan-88	<10	1,100	--	--	<10	<10	<10	<10	--	--	ND	95	ND	<10	--	--	--	--	--
Jan-87	<5.0	600	--	--	<5.0	<5.0	<5.0	<5.0	--	--	ND	52	ND	<5.0	--	--	--	--	--
Nov-84	6.6	1,300	--	--	NA	3.2	NA	NA	--	--	ND	NA	ND	NA	--	--	--	--	--
Aug-84	8	760	--	--	ND	4	ND	ND	--	--	ND	ND	ND	ND	--	--	--	--	--
Mar-84	NA	1,400	--	--	NA	NA	NA	NA	--	--	ND	NA	ND	NA	--	--	--	--	--
Sep-83	37	4,200	--	--	NA	4	ND	ND	--	--	ND	190	ND	NA	--	--	--	--	--
Sep-83	47	3,500	--	--	NA	5	ND	ND	--	--	ND	14	ND	NA	--	--	--	--	--
Aug-83	34	41,000	--	--	5	13	2.0	1.6	--	--	ND	<1.0	ND	ND	--	--	--	--	--
May-83	ND	270	--	--	ND	ND	ND	ND	--	--	ND	ND	ND	ND	--	--	--	--	--
Apr-83	10	330	--	--	ND	ND	ND	ND	--	--	ND	120	ND	ND	--	--	--	--	--
Aug-82	9	1,400	--	--	ND	13	<2.0	<2.0	--	--	ND	78	ND	ND	--	--	--	--	--
Jun-82	<10	2,600	--	--	ND	<10	<10	<10	--	--	ND	370	ND	ND	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
38S ZA																			
Oct-12	0.84	91	200	2.5	11	<0.50	0.84	<0.50	<0.50	<1.0	<0.50	1.8	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Apr-12	<0.50	32	120	1.4	11	<0.50	0.60	<0.50	<0.50	<1.0	<0.50	0.80	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-11	<2.5	130	140	<2.5	6.7	<2.5	<2.5	<2.5	<2.5	<5.0	<2.5	<2.5	<5.0	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0
Oct-10	1.3	150	130	1.8	5.7	<0.50	0.50	<0.50	<0.50	<1.0	<0.50	1.5	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-09	1.5	150	120	2.8	6.3	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	1.1	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0
Oct-08	0.65	50	82	2.4	30	<0.5	<0.5	<0.5	<0.5	<1	<0.5	1.0	<1	<0.5	<0.5	<0.5	<0.5	<0.5	<1
Oct-07	1.3	85	50	0.82	16	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5	0.61	<1.0	<0.5	<1.0	<0.5	<0.5	<0.5	<1.0
Oct-06	1.5	130	33	<1.0	5.8	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	NA	NA	NA	NA
Oct-05	2.0	140	68	1.5	14	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	NA	NA	NA	NA
Oct-04	<5.0	190	190	<5.0	6.9	<5.0	<5.0	<5.0	<5.0	<10	<10	<5.0	<20	<5.0	<5.0	NA	NA	NA	NA
Oct-03	<1.0	51	110	1.2	21	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<4.0	<1.0	<1.0	NA	NA	NA	NA
Oct-02	2.6	240	200	6.3	8.6	<2.0	<2.0	<2.0	<2.0	<4.0	<4.0	3.5	<8.0	<2.0	<2.0	NA	NA	NA	NA
Oct-01	<5.0	170	120	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<20	<20	<5.0	<5.0	NA	NA	NA	NA
Oct-00	<20	240	240	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	NA	NA	NA	NA
Oct-99	<5.0	270	240	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-97+	<5.0	160	520	<5.0	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Oct-96	<1.7	440	540	4.0	<1.7	<1.7	2.7	<1.7	ND	ND	ND	2.9	ND	<1.7	ND	NA	NA	NA	NA
Oct-95	<10	1,100	--	--	<20	<10	<10	<10	ND	ND	ND	<10	ND	<10	ND	NA	NA	NA	NA
Oct-94	<5.0	910	--	--	<5.0	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
May-88	<25	3,400	--	--	<25	<25	<25	<25	--	ND	--	95	ND	<25	--	--	--	--	--
Jan-88	<50	2,900	--	--	<50	<50	<50	<50	--	ND	--	<50	ND	<50	--	--	--	--	--
Oct-87	<25	2,400	--	--	<25	<25	<25	<25	--	ND	--	100	ND	<25	--	--	--	--	--
Jun-87	260	2,200	--	--	<10	13	<10	<10	--	ND	--	83	ND	<10	--	--	--	--	--
Apr-87	26	2,700	--	--	<10	74	<10	<10	--	ND	--	91	ND	<10	--	--	--	--	--
Jan-87	<10	2,500	--	--	<10	<10	<10	<10	--	ND	--	180	ND	<10	--	--	--	--	--
Sep-86	<25	4,600	--	--	<25	<25	<25	<25	--	ND	--	150	ND	<25	--	--	--	--	--
Jul-86	<5.0	2,800	--	--	<5.0	<5.0	<5.0	<5.0	--	ND	--	250	ND	<5.0	--	--	--	--	--
Oct-85	45	3,700	--	--	<25	33	<25	<25	--	ND	--	590	ND	<25	--	--	--	--	--
Nov-84	28	3,200	--	--	NA	20	NA	NA	--	ND	--	NA	ND	NA	--	--	--	--	--
Aug-84	28	1,400	--	--	ND	5	3	ND	--	ND	--	ND	ND	ND	--	--	--	--	--
Mar-84	NA	3,500	--	--	NA	NA	NA	NA	--	ND	--	NA	ND	NA	--	--	--	--	--
Sep-83	59	2,700	--	--	ND	<2.0	<4.0	1	--	ND	--	140	ND	ND	--	--	--	--	--
Sep-83	72	6,300	--	--	ND	<2.0	4	3	--	ND	--	120	ND	ND	--	--	--	--	--
May-83	23	2,000	--	--	ND	ND	ND	ND	--	ND	--	ND	ND	ND	--	--	--	--	--
Aug-82	17	2,200	--	--	ND	<2.0	<2.0	<2.0	--	ND	--	35	ND	ND	--	--	--	--	--
Aug-82	76	40,000	--	--	3	6.4	2	2.6	--	ND	--	<1.0	ND	ND	--	--	--	--	--
Jun-82	<10	1,250	--	--	ND	<10	<10	<10	--	ND	--	103	ND	ND	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750
EDUCTOR ZA																			
Oct-12	<1,000	1,200	83,000	<1,000	5,200	<1,000	<1,000	<1,000	<1,000	<2,000	<1,000	<1,000	<2,000	2,400	<1,000	<1,000	<1,000	<1,000	<2,000
Apr-12	<50	620	93,000	74	6,400	<50	110	<50	<50	<100	<50	<50	<100	880	190	<50	120	<50	430
Oct-11	<50	54	8,000	<50	1,100	<50	<50	<50	<50	<100	<50	<50	<100	<50	<50	<50	<50	<50	<100
May-11	<500	3,600	100,000	<500	11,000	<500	<500	<500	<500	<500	<500	<500	<500	1,500	<500	<500	<500	<500	<500
Mar-11	<500	1,100	94,000	<500	5,900	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500
Nov-10	<500	670	29,000	<500	2,700	<500	<500	<500	<500	<1,000	<500	<500	<1,000	1,300	660	--	--	--	--
Oct-10	<200	2,100	78,000	<200	67,000	<200	<200	<200	<200	<400	<200	<200	<400	1,900	6900	<200	<200	<200	<400
Oct-09	<200	<200	34,000	<200	9,300	<200	<200	<200	<200	<400	<200	<200	<400	1,600	840	<200	230	<200	<400
Oct-08	<2000	100,000	23,000	<2000	28,000	<2000	<2000	<2000	<2000	<4000	<2000	<2000	<4000	3100	5200	<2000	<2000	<2000	<4000
Oct-07	55	3,500	8,300	120	15,000	<5.0	30	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	4,200	<5.0	<500	13	1,300
Apr-07	<5.0	5.1	29,000	200	28,000	<5.0	57	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	14	<5.0	<200	9.2	960
Oct-06	<100	<100	25,000	<100	9,800	<100	<100	<100	NA	<100	<100	NA	<100	NA	2,200	<100	290	<100	880
Apr-06	<5.0	<5.0	20,000	<500	8,500	<5.0	37	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	1,500	<5.0	160	5.7	200
Jan-06	150	4,800	2,300	30	12,000	<5.0	12	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	3,000	<5.0	<500	9.9	<1500
Oct-05	<250	<250	3,600	<250	3,900	<250	<250	<250	NA	<250	<250	NA	<250	NA	1,000	<250	<250	<250	<750
Sep-05	<250	<250	27,000	<250	18,000	<250	<250	<250	<250	<250	<500	<250	<250	420	2,900	NA	NA	NA	NA
Jul-05	82	2,200	27,000	150	15,000	<5.0	130	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	3,600	<5.0	<500	11	1,200
Jul-05-Dup	92	2,100	27,000	180	14,000	<5.0	140	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	3,500	<5.0	<500	11	1,100
Apr-05	23	490	19,000	160	33,000	<5.0	57	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	2,900	<5.0	340	8.7	1,180
Apr-05 Dup	23	430	19,000	160	35,000	<5.0	66	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	2,800	<5.0	330	9.6	1,180
Jan-05	<0.5	<0.5	4,700	180	4,400	<5.0	9.3	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	1,900	<5.0	200	<5.0	650
Oct-04	<5.0	<5.0	<5.0	9.3	28	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	1,200	<5.0	120	<5.0	380
Apr-04	<1.0	<1.0	<1.0	7	<1.0	<1.0	<1.0	<1.0	NA	<1.0	<1.0	NA	<1.0	NA	<1.0	<1.0	<1.0	<1.0	<1.0
Jan-04	<10	<10	<10	<10	<10	<10	<10	<10	NA	<10	<10	NA	<10	NA	<10	<10	<10	<10	<20
Oct-03	14	75	34	9.6	560	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	340	<5.0	32	<5.0	113
Oct-03 Dup	20	110	53	12	550	<5.0	<5.0	<5.0	NA	<5.0	<5.0	NA	<5.0	NA	300	<5.0	39	<5.0	144
Jul-03	870	15,000	3,800	210	24,000	<1.0	120	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	97	NA	460	5.9	1,020
Jul-03 Dup	880	32,000	4,000	200	27,000	<1.0	120	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	98	NA	490	7.2	1,030
Apr-03	<1.0	11	570	12	4,500	<1.0	1.2	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	130	NA	35	1.9	63
Apr-03 Dup	<1.0	7.6	790	12	5,500	1.4	1.8	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	110	NA	46	1.8	56
Jan-03	21	670	9,400	34	5,700	7.2	27	<1.0	<1.0	<2.0	<2.0	<1.0	<1.0	<1.0	60	NA	NA	NA	NA
Jan-03 Dup	32	1,200	9,600	28	5,600	2.9	24	1.3	<1.0	<2.0	<2.0	<1.0	<1.0	<1.0	62	NA	NA	NA	NA
Oct-02	120	17,000	20,000	38	21,000	<1.0	32	<1.0	NA	<2.0	<2.0	NA	<1.0	NA	40	2.9	62	4.0	249
Jul-02	62	2,600	6,400	30	2,400	<1.0	19	<1.0	NA	<2.0	<2.0	NA	ND	NA	13	NA	<50	<50	<100
Mar-02	170	3,800	8,000	<50	540	<50	NA	<50	NA	<50	<50	NA	ND	NA	<50	NA	<50	<50	<100
Jan-02	1,400	80,000	17,000	110	1,200	<50	<50	<50	NA	<50	<50	NA	ND	NA	400	NA	<50	<50	1,170
Nov-01	150	5,000	5,600	48	750	<5.0	8.0	<5.0	NA	<5.0	<5.0	NA	ND	NA	11	<5.0	42	<5.0	169
Oct-01	1,200	53,000	18,000	<1,000	<2,000	<1,000	<1,000	<1,000	NA	<2,000	<2,000	NA	<1,000	NA	<1,000	NA	<1,000	<1,000	<2,000
Aug-01	140	5,100	7,700	44	710	1.2	43	<1.0	NA	<2.0	<2.0	NA	ND	NA	39	NA	36	<1.0	100
Jun-01	7.9	230	15,000	140	6,100	15	66	3.3	NA	5.6	<2.0	NA	ND	NA	72	NA	63	3.8	97
Mar-01	19	310	14,000	110	1,500	12	2.0	35	NA	<2.0	<2.0	NA	ND	NA	20	NA	13	<1.0	179
Oct-00	<400	8,400	680	<400	<400	<400	<400	<400	<400	ND	ND	<400	ND	<400	<400	NA	NA	NA	NA
Oct-99	470	13,000	650	<250	<250	<250	<250	<250	ND	ND	ND	<250	ND	<250	<250	NA	NA	NA	NA
Apr-99	<1,000	11,000	<1,000	<1,000	<1,000	<1,000	<1,000	<1,000	ND	ND	ND	<1,000	ND	<1,000	<1,000	NA	NA	NA	NA
Oct-98	<500	17,000	740	<500	<500	<500	<500	<500	ND	ND	ND	<500	ND	<500	<500	NA	NA	NA	NA
Apr-98	520	20,000	810	<100	<100	<100	<100	<100	ND	ND	ND	<400	ND	<100	<100	NA	NA	NA	NA
Oct-97	<500	16,000	<500	<500	<500	<500	<500	<500	ND	ND	ND	<500	ND	<1000	<500	NA	NA	NA	NA
Apr-97	120	6,700	450	<31	<31	<31	<31	<31	ND	ND	ND	<31	ND	<31	ND	NA	NA	NA	NA
Oct-96	140	9,800	1,100	<50	<50	<50	<50	<50	ND	ND	ND	<50	ND	<50	ND	NA	NA	NA	NA
Apr-96	440	23,000	--	--	100	<5.0	6.7	<5.0	ND	ND	ND	<5.0	ND	370	ND	NA	NA	NA	NA
Oct-95	670	46,000	--	--	<500	<250	<250	<250	ND	ND	ND	<250	ND	380	ND	NA	NA	NA	NA
Apr-95	<200	13,000	--	--	<400	<200	200	200	ND	ND	ND	<200	ND	<200	ND	NA	NA	NA	NA
Oct-94	260	12,000	--	--	<250	<250	<250	<250	ND	ND	ND	<250	ND	<250	ND	NA	NA	NA	NA
Apr-94	810	63,000	--	--	49	<5.0	<5.0	<5.0	ND	ND	ND	<5.0	ND	<5.0	ND	NA	NA	NA	NA
Feb-94	520	28,000	--	--	1.0	1.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	10	ND	NA	NA	NA	NA
Oct-93	730	100,000	--	--	<100	<50	<50	<50	ND	ND	ND	<50	ND	<50	ND	NA	NA	NA	NA
Aug-93	730	29,000	--	--	<100	<50	<50	<50	ND	ND	ND	<100	ND	<50	ND	NA	NA	NA	NA
Apr-93	1,200	26,000	--	--	3.5	1.9	2.2	<0.5	ND	ND	ND	NA	ND	15	ND	NA	NA	NA	NA
Jul-90	3.0	53	--	--	<0.5	<0.5	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Apr-90	<0.5	12	--	--	<0.5	1.2	<0.5	<0.5	ND	ND	ND	<0.5	ND	<0.5	ND	NA	NA	NA	NA
Jan-90	<2.0	240	--	--	<2.0	<2.0	<2.0	<2.0	ND	ND	ND	<2.0	ND	<2.0	ND	NA	NA	NA	NA
Oct-89	3.3	60	--	--	<0.5	<0.5	<0.5	<0.5	--	ND	--	<0.5	ND	3.3	--	--	--	--	--
May-89	51	970	--	--	<10	<10	<10	<10	--	ND	--	<10	ND	<10	--	--	--	--	--
Feb-89	3.6	62	--	--	<0.5	<0.5	<0.5	<0.5	--	ND	--	<0.5	ND	<0.5	--	--	--	--	--
Dec-87	130	62	--	--	<50	<50	<50	<50	--	ND	--	<50	ND	<50	--	--	--	--	--
Oct-87	3,400	8,400	--	--	<1,000	<1,000	<1,000	<1,000	--	ND	--	<1,000	ND	<1,000	--	--	--	--	--
Jan-87	2,700	230,000	--	--	<500	<500	<500	<500	--	ND	--	<500	ND	6,700	--	--	--	--	--
Jul-86	2700	75,000	--	--	2,000	<250	<250	<250	--	ND	--	<250	ND	7,700	--	--	--	--	--
Apr-86	4200	24,000	--	--	530	<100	<100	<100	--	ND	--	<100	ND	9,200	--	--	--	--	--
Oct-85	13000	32,000	--	--	<250	<250	<250	<250	--	ND	--	<250	ND	<250	--	--	--	--	--

Historic Groundwater Volatile Organic Compound Results
Former TRW Microwave Facility
825 Stewart Drive, Sunnyvale, California

Well Number/ Dates	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	VC (µg/L)	1,1,1-TCA (µg/L)	1,1-DCE (µg/L)	1,1-DCA (µg/L)	CDM (µg/L)	Freon 11 (µg/L)	Freon 12 (µg/L)	Freon 113 (µg/L)	BFM (µg/L)	1,2-DCB (µg/L)	CBN (µg/L)	BEN (µg/L)	EBN (µg/L)	TOL (µg/L)	XYL (µg/L)
Drinking Water Standard	5	5	6	10	0.5	200	6	5	100	150	NE	1200	100	600	70	1	300	150	1750

Notes:
Drinking water standards are Maximum Contaminant Levels (MCLs) as established by the California Department of Health Services, or if no California MCLs have been established, then USEPA MCLs were used.

-- = Data reported as total 1,2-DCE prior to 1996.
^ = Data not previously reported due to low levels.
< = Not detected at the detection limit shown.
+ = Data provided by AMD.
** = Well resampled in July 1998 due to potential labeling error.
B = Compound was found in the blank and sample.
NA = Not Analyzed
ND = Not Detected
NE = Not Established
µg/L = microgram per liter
Water Board = California Regional Water Quality Control Board - San Francisco Bay Region
(1) - Initial results of 268 µg/L for cis-1,2-DCE was higher than standard of 200 µg/L. When rerun with dilution of 50, the result was <250 µg/L. Initial result reported in table.

1,1,1-TCA = 1,1,1-trichloroethane
1,1-DCA = 1,1-dichloroethane
1,1-DCE = 1,1-dichloroethene
1,2-DCB = 1,2-dichlorobenzene
1,2-DCE = 1,2-dichloroethene
BEN = Benzene
BFM = Bromoform
CBN = Chlorobenzene
CDM = Chlorodibromomethane

EBN = Ethylbenzene
Freon 11 = Trichlorofluoromethane
Freon 12 = Dichlorodifluoromethane
Freon 113 = 1,1,2-trichloro-1,2,2-trifluoroethane
PCE = Tetrachloroethene
TCE = Trichloroethene
TOL = Toluene
VC = Vinyl Chloride
XYL = Total Xylenes

APPENDIX C

SITE PHOTOGRAPHS AND COMPLETED BUILDING SURVEY FORM

C.1 Site Photographs
C.2 Completed Building Survey Form – Site Walk

Photograph 1 – Building Interior of Two-Story Area (Recent Renovation)

Photograph 2 - Metal Plate Covering Eductor with Adjacent Plate Covering Wells T-2A and T-2B (One Indoor Air Sample Will be Located near the Metal Plate)

Photograph 3 - Sprayer Potentially used for Weed Abatement – To Be Removed Prior to Sampling

AECOM
10461 Old Placerville Road, Suite 170
Sacramento, CA 95827-2508

916.362.7100 tel
916.362.8100 fax

Indoor Air Building Survey & Sampling Form

Preparer's Name: CHRIS DRABANDT Date: 1/22/13

Preparer's Office Location: SACRAMENTO Project No: 60238860

Site Name: NGC TRW MICROWAVE

Part I Occupants

Building Address:

825 STEWART DRIVE, SUNNYVALE, CA

Property Contact: _____ Owner/Renter/Other: _____

Contact's Phone: Work ( ) _____ Cell ( ) _____ Home ( ) _____

# of Building occupants: Ø Hours Building Occupied: ~~INTERMITTANT~~ 3/14 NOT OCCUPIED

Occupants Interviewed: Y / N

Occupants present during sampling: Y / N

Part II – Building Characteristics

Building type: Residential / Multi-family / Office / Strip Mall / Commercial / Industrial

Sensitive Population: Day care / nursing home / hospital / school / NA / other (specify): NA

Describe Building: 2 STORY, VACANT, BARE STRUCTURE

Year Constructed: 2003 Number of floors at or above grade: 2 below grade: Ø

Depth of Basement below grade surface: — ft. Basement size: — ft^2

Basement floor construction: concrete / dirt / floating / stone / NA / other specify: _____

Describe basement floor condition and, if observed, locations of cracks or penetrations:

—

Foundation walls: poured concrete / cinder blocks / stone / other (specify):

Basement windows and bulkheads observed? Y / N How many and Where (show on sketch):

—

Basement Sump observed? Y / N Sump pump? Y / N Water in Sump? Y / N

Type of heating system (circle all that apply):

hot air circulation	hot air radiation	wood	steam radiation
heat pump	hot water radiation	kerosene heater	electric
baseboard	None	Other (specify): _____	

Type of ventilation system (circle all that apply):
central air conditioning | mechanical fans | bathroom ventilation fans
Individual air conditioning units | Kitchen range hood fan | outside air intake
None | other (specify): _____

Type of fuel utilized (circle all that apply):
Natural gas / electric / fuel oil / wood / coal / solar / kerosene / none

Wood stove observed in basement? Y / N If yes, describe numbers and locations of vent registers:

_____

Are the basement walls or floors sealed with water proof paint or epoxy coatings? Y / N 3/14 CD NO BASEMENT

Is there a whole house fan? Y / N Septic System? Y / N If, yes in use? Y / N

Irrigation/private well? Y / N If, yes in use? Y / N

Type of ground cover outside of building: grass / concrete / asphalt / other (specify): _____

Existing subsurface depressurization (radon) system in place? Y / N active / passive

Sub-slab vapor/moisture barrier in place? Y / N Type of barrier: 10MIL PE

Description and location of utilities and depth below grade for utility conduits: ELEVATOR SHAFT ~5' BELOW GRADE, WELL BOXES IN BUILDING BELOW GRADE

Is basement / lowest level occupied? Full-time / occasionally / seldom / almost never

Describe general use of each floor / room:

Basement: NA

First Floor: NOT OCCUPIED / OFFICE + WAREHOUSE AREA

Second Floor: NOT OCCUPIED / OFFICE SPACE

Third Floor: 3/14 CD NA

Describe areas of the structure which were not access or viewed for this sampling event (janitor's closet, supply rooms, adjacent operations or activities within structure, etc.): NA

Can the Owner, Owner's representative, and/or occupant describe the contents or activities within the spaces?

3/14 CD UNOCCUPIED SINCE JANUARY 2001

Part III – Outside Contaminant Sources

Evidence of monitoring wells or previous test borings or test pits observed on or near the property:

ALL WELLS INSIDE BUILDING KNOWN

Contaminated site (1,000-ft. radius: ON SITE, BELOW BUILDING

Other stationary sources nearby (gas stations, emission stacks, etc.):

UPGRADIENT VOLATILE PLUMES

Heavy vehicular traffic nearby (or other mobile sources):

—

Part IV – Indoor Contaminant Sources

Identify all potential indoor sources observed in the building (including attached garages), the location of the source (floor and room), and whether the item was removed from the building 48 hours prior to indoor air sampling event. List item separately. To the extent possible, product labeling information should be examined and documented for items known or suspected to contain target compounds. Any ventilation implemented after removal of the items should be completed at least 24 hours prior to the commencement of the indoor air sampling event.

Potential Source	Location	Removed (Yes/No/NA)
Gasoline storage cans	NONE	NA
Gas-powered equipment		
Kerosene storage cans		
Paints / thinners / strippers		
Automotive aerosol products		
Cleaning solvents		
Carpet / upholstery cleaners		
Other house cleaning products		
Moth balls		
Dry-cleaned items		
Insecticides		
Furniture / floor polish		
Nail polish / polish remover		
Hairspray		
Cologne / perfume		
Air fresheners		
Fuel tank (inside building)		
New furniture / upholstery		
New carpeting / flooring		
Hobbies: glues, paints, etc.		
Other: HYDRAULIC FLUID	FRONT DOOR	NO 3/14 CD 55-GAL DRUM (STEEL) CLOSED/SEALED
3/14 CD SPRAYER	FRONT DOOR	NO / UNKNOWN CONTENTS 1.5 GAL SPRAYER/PLASTIC

Part V – Miscellaneous Items

Do any occupants of the building smoke Y / N How often? _____

Last time someone smoked in the building? _____ hours / days ago

Are kerosene heaters present? Y / N

Have any pesticides / herbicides been applied around the building or area outside? Y / N

If yes, when and which chemicals: _____

Has there ever been a fire in the building? Y / N If yes, when? _____

Has painting or staining been done in the building in the last 6 months? Y / N

If yes, when? _____ Where? _____

Provide Digital pictures and/or Drawing of Sample Location(s) in Building

3/14 CD NOT SAMPLED DURING SURVEY

Part VI – Sampling Information

Sample Technician: _____ Phone No. ( ) _____

Sample Source: Indoor Air / Sub-Slab / Near Slab Soil Gas / Exterior Soil Gas

Sampler type: Tedlar bag / Sorbent / Canister / Other (specify): _____

Analytical Method: TO-15 / TO-17 / other: _____ Cert. Lab: _____

Sample identifications and locations (floor, room):

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Part VII – Meteorological Conditions

Supplemental local weather data should be obtained for a minimum interval which includes the period 24 hours prior to sampling through the completion of sampling, including hourly details, temperature, wind speed/direction, barometric pressure, relative humidity, and precipitation.

Was there no significant precipitation within 12 hours prior to (or during) the sampling event? Y / N

Describe the general weather conditions throughout the sampling: _____

_____

Part VIII – General Observations

Provide any additional information that may be pertinent to the sampling event and may assist in the data interpretation process:

_____

_____

_____

_____

APPENDIX D

FIELD FORMS

AECOM
10461 Old Placerville Road, Suite 170
Sacramento, CA 95827-2508

916.362.7100 tel
916.362.8100 fax

Indoor Air Building Survey & Sampling Form

Preparer's Name: _____ Date: _____

Preparer's Office Location: _____ Project No: _____

Site Name: _____

Part I Occupants

Building Address:

_____

Property Contact: _____ Owner/Renter/Other: _____

Contact's Phone: Work ( )_____ Cell ( )_____ Home ( )_____

# of Building occupants: _____ Hours Building Occupied: _____

Occupants Interviewed: Y / N

Occupants present during sampling: Y / N

Part II – Building Characteristics

Building type: Residential / Multi-family / Office / Strip Mall / Commercial / Industrial

Sensitive Population: Day care / nursing home / hospital / school / NA / other (specify): _____

Describe Building: _____

Year Constructed: _____ Number of floors at or above grade: _____ below grade: _____

Depth of Basement below grade surface: _____ ft. Basement size: _____ ft^2

Basement floor construction: concrete / dirt / floating / stone / NA / other specify: _____

Describe basement floor condition and, if observed, locations of cracks or penetrations:

_____

Foundation walls: poured concrete / cinder blocks / stone / other (specify):
_____

Basement windows and bulkheads observed? Y / N How many and Where (show on sketch):

_____

Basement Sump observed? Y / N Sump pump? Y / N Water in Sump? Y / N

Type of heating system (circle all that apply):

hot air circulation	hot air radiation	wood	steam radiation
heat pump	hot water radiation	kerosene heater	electric
baseboard	None	Other (specify): _____	

Type of ventilation system (circle all that apply):

central air conditioning	mechanical fans	bathroom ventilation fans
Individual air conditioning units	Kitchen range hood fan	outside air intake
None	other (specify): _____	

Type of fuel utilized (circle all that apply):
Natural gas / electric / fuel oil / wood / coal / solar / kerosene / none

Wood stove observed in basement? Y / N If yes, describe numbers and locations of vent registers:

_____

Are the basement walls or floors sealed with water proof paint or epoxy coatings? Y / N

Is there a whole house fan? Y / N Septic System? Y / N If, yes in use? Y / N

Irrigation/private well? Y / N If, yes in use? Y / N

Type of ground cover outside of building: grass / concrete / asphalt / other (specify): _____

Existing subsurface depressurization (radon) system in place? Y / N active / passive

Sub-slab vapor/moisture barrier in place? Y / N Type of barrier: _____

Description and location of utilities and depth below grade for utility conduits: _____

_____

Is basement / lowest level occupied? Full-time / occasionally / seldom / almost never

Describe general use of each floor / room:

Basement: _____

_____

First Floor: _____

_____

Second Floor: _____

_____

Third Floor: _____

_____

Describe areas of the structure which were not access or viewed for this sampling event (janitor's closet, supply rooms, adjacent operations or activities within structure, etc.): _____

_____

Can the Owner, Owner's representative, and/or occupant describe the contents or activities within the spaces? _____

_____

Part III – Outside Contaminant Sources

Evidence of monitoring wells or previous test borings or test pits observed on or near the property:

_____

Contaminated site (1,000-ft. radius: _____

Other stationary sources nearby (gas stations, emission stacks, etc.):

_____

Heavy vehicular traffic nearby (or other mobile sources):

_____

Part IV – Indoor Contaminant Sources

Identify all potential indoor sources observed in the building (including attached garages), the location of the source (floor and room), and whether the item was removed from the building 48 hours prior to indoor air sampling event. List item separately. To the extent possible, product labeling information should be examined and documented for items known or suspected to contain target compounds. Any ventilation implemented after removal of the items should be completed at least 24 hours prior to the commencement of the indoor air sampling event.

Potential Source	Location	Removed (Yes/No/NA)
Gasoline storage cans		
Gas-powered equipment		
Kerosene storage cans		
Paints / thinners / strippers		
Automotive aerosol products		
Cleaning solvents		
Carpet / upholstery cleaners		
Other house cleaning products		
Moth balls		
Dry-cleaned items		
Insecticides		
Furniture / floor polish		
Nail polish / polish remover		
Hairspray		
Cologne / perfume		
Air fresheners		
Fuel tank (inside building)		
New furniture / upholstery		
New carpeting / flooring		
Hobbies: glues, paints, etc.		
Other:		

Part V – Miscellaneous Items

Do any occupants of the building smoke Y / N How often? _____

Last time someone smoked in the building? _____ hours / days ago

Are kerosene heaters present? Y / N

Have any pesticides / herbicides been applied around the building or area outside? Y / N

If yes, when and which chemicals: _____

Has there ever been a fire in the building? Y / N If yes, when? _____

Has painting or staining been done in the building in the last 6 months? Y / N

If yes, when? _____ Where? _____

Provide Digital pictures and/or Drawing of Sample Location(s) in Building

Part VI – Sampling Information

Sample Technician: _____ Phone No. ( )_____

Sample Source: Indoor Air / Sub-Slab / Near Slab Soil Gas / Exterior Soil Gas

Sampler type: Tedlar bag / Sorbent / Canister / Other (specify):_____

Analytical Method: TO-15 / TO-17 / other: _____ Cert. Lab: _____

Sample identifications and locations (floor, room):

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Field ID # _____ – _____

Part VII – Meteorological Conditions

Supplemental local weather data should be obtained for a minimum interval which includes the period 24 hours prior to sampling through the completion of sampling, including hourly details, temperature, wind speed/direction, barometric pressure, relative humidity, and precipitation.

Was there no significant precipitation within 12 hours prior to (or during) the sampling event? Y / N

Describe the general weather conditions throughout the sampling: _____

_____

Part VIII – General Observations

Provide any additional information that may be pertinent to the sampling event and may assist in the data interpretation process:

_____

_____

_____

_____

Sub Slab Vapor Well Field Data Sheet

PID Used: _____

He Detector: _____

PA Meter: _____

Building: _____

Page _____ of _____

Location	Sample ID	Cannister	Controller	Date	Shut In Test (Hg/min)	Differential Pressure (Pa)	Purge Time	PID Measurement (pp____)	Sample Time	Shroud Leak Test (Helium)	Well Leak Test (Helium)	Temp (°F)
						Initial:		**Initial:**	**Start:**			**Initial:**
Notes:					**Initial Vacuum:**				**Mid:**			
					Final Vacuum:	**Post:**		**Post:**	**Stop:**			**Post:**

Location	Sample ID	Cannister	Controller	Date	Shut In Test (Hg/min)	Differential Pressure (Pa)	Purge Time	PID Measurement (pp____)	Sample Time	Shroud Leak Test (Helium)	Well Leak Test (Helium)	Temp (°F)
						Initial:		**Initial:**	**Start:**			**Initial:**
Notes:					**Initial Vacuum:**				**Mid:**			
					Final Vacuum:	**Post:**		**Post:**	**Stop:**			**Post:**

Location	Sample ID	Cannister	Controller	Date	Shut In Test (Hg/min)	Differential Pressure (Pa)	Purge Time	PID Measurement (pp____)	Sample Time	Shroud Leak Test (Helium)	Well Leak Test (Helium)	Temp (°F)
						Initial:		**Initial:**	**Start:**			**Initial:**
Notes:					**Initial Vacuum:**				**Mid:**			
					Final Vacuum:	**Post:**		**Post:**	**Stop:**			**Post:**

Location	Sample ID	Cannister	Controller	Date	Shut In Test (Hg/min)	Differential Pressure (Pa)	Purge Time	PID Measurement (pp____)	Sample Time	Shroud Leak Test (Helium)	Well Leak Test (Helium)	Temp (°F)
						Initial:		**Initial:**	**Start:**			**Initial:**
Notes:					**Initial Vacuum:**				**Mid:**			
					Final Vacuum:	**Post:**		**Post:**	**Stop:**			**Post:**

Sampler Name(s): _____

Date: _____

Project Number: _____

Project Name: _____

Analytical Methods: _____

Comments: _____

Indoor and Outdoor Ambient Air Field Data Sheet

Building: _____

Page _____ of _____

Location	Sample ID	Cannister	Controller ID	Sample Date	Sample Start Time	Sample End Time	PID Measurement (pp___)	Initial Vacuum	Initial Temp	Final Vacuum	Final Temp	Comments

Sampler Name(s): _____

Date: _____

Project Number: _____

Project Name: _____

Analytical Methods: _____

Comments: _____

Chain of Custody Record

Lab job no.: _____

Date _____

Page _____ of _____

Laboratory _____
Address _____
_____
_____
Client _____
Address _____
_____
Project Name _____
Project Number _____

Method of Shipment _____
Shipment No. _____
Airbill No. _____
Cooler No. _____
Project Manager _____
Telephone No. _____
Fax. No. _____
Samplers: (Signature) _____

Field Sample ID	Matrix	Sample Depth Interval	Sampling Date	Sampling Time	Type/Size of Container	Preservation		Filtered	No. of Containers	Analysis Required									Remarks
						Temp.	Chemical												
		/																	
		/																	
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Relinquished by:	Date	Received by:	Date	Relinquished by:	Date	Received by:	Date
Signature _____		Signature _____		Signature _____		Signature _____	
Printed _____	Time	Printed _____	Time	Printed _____	Time	Printed _____	Time
Company _____		Company _____		Company _____		Company _____	
Reason _____				Reason _____			

Comments: _____	Relinquished by:	Date	Received by:	Date
	Signature _____		Signature _____	
	Printed _____	Time	Printed _____	Time
	Company _____		Company _____	
	Reason _____			

DISTRIBUTION: White to Project File, Canary to Laboratory, Pink to Courier, Goldenrod to Field File

F-1000
04/11

AECOM

APPENDIX E

TAML - STANDARD OPERATING PROCEDURE – TO-15 SIM AND FULL SCAN MODE
(Provided on Compact Disk)
TABLE E-1 LIST ANALYTES INCLUDED IN TAML TO-15 SIM MODE

TABLE E-2 LIST ANALYTES INCLUDED IN TAML TO-15 FULL SCAN MODE

TABLE E-1. METHOD TO-15 SIM

Analyte	MDL (ppbv)	RL (ppbv)	MDL ($\mu g/m^3$)	RL ($\mu g/m^3$)
1,1-Dichloroethane	0.005	0.02	0.02	0.081
1,1-Dichloroethene	0.008	0.02	0.032	0.079
1,2-Dichlorobenzene	0.02	0.05	0.12	0.3
1,4-Dichlorobenzene	0.02	0.1	0.12	0.6
Chlorobenzene	0.008	0.02	0.037	0.092
Chloroform	0.005	0.02	0.024	0.098
cis-1,2-Dichloroethene	0.008	0.02	0.032	0.079
ethylbenzene	0.008	0.02	0.035	0.087
Freon 11	0.01	0.045	0.056	0.25
Freon 12	0.005	0.01	0.025	0.049
Freon 113	0.008	0.03	0.061	0.23
trans-1,2-Dichloroethene	0.008	0.02	0.032	0.079
Tetrachloroethene	0.008	0.02	0.054	0.14
1,1,1-Trichloroethane	0.008	0.02	0.044	0.11
toluene	0.008	0.02	0.03	0.075
Trichloroethene	0.005	0.02	0.027	0.11
Vinyl chloride	0.005	0.02	0.013	0.051
1,1,2-trichloro1,2,2trifluoroethane	0.008	0.03	0.061	0.23
m,p-xylenes	0.016	0.04	0.069	0.17
o-xylenes	0.008	0.02	0.035	0.087

Notes:

$\mu g/m^3$ micrograms per cubic meter
MDL method detection limit
ppbv parts per billion by volume
RL reporting limit

TABLE E-2 LIST OF ANALYTES INCLUDED IN TAML TO-15 FULL SCAN MODE

Analyte	Soil Vapor Screening Levels (SVSLs) in ug/m3	MDL_ugm3	RL_ugm3	LCL	UCL
Acetone	280,000	2.1	24	70	130
Benzene	32	1.3	6.4	70	130
Benzyl chloride	5	4.2	21	70	130
Bromodichloromethane	6.6	2.2	10	70	130
Bromoform	220	3.6	21	70	130
Bromomethane	44	6.5	16	70	130
2-Butanone (MEK)	44,000	2.9	12	70	130
Carbon disulfide	6,200	1.2	12	70	130
Carbon tetrachloride	40	2	25	70	130
Chlorobenzene	440	1.5	6.9	70	130
Dibromochloromethane	9	3.4	17	70	130
Chloroethane	-	4.1	11	70	130
Chloroform	10.6	2.3	7.3	70	130
Chloromethane	780	2	8.3	70	130
1,2-Dibromoethane (EDB)	0.4	2.9	31	70	130
1,2-Dichlorobenzene	1,760	3.9	12	70	130
1,3-Dichlorobenzene	-	3.3	12	70	130
1,4-Dichlorobenzene	22	4.5	12	70	130
Dichlorodifluoromethane	880	3.6	9.9	70	130
1,1-Dichloroethane	154	1.5	6.1	70	130
1,2-Dichloroethane	9.4	1.8	16	70	130
1,1-Dichloroethene	1,760	1.4	16	70	130
cis-1,2-Dichloroethene	520	1.8	7.9	70	130
trans-1,2-Dichloroethene	520	2	7.9	70	130
1,2-Dichloropropane	24	5.5	9.2	70	130
cis-1,3-Dichloropropene	-	2.4	9.1	70	130
trans-1,3-Dichloropropene	-	2	9.1	70	130
1,2-Dichloro-1,1,2,2-tetrafluoroethane	-	5.4	14	70	130
Ethylbenzene	98	1.4	8.7	70	130
4-Ethyltoluene	-	4.6	9.8	70	130
Hexachlorobutadiene	11.2	23	110	70	130
2-Hexanone	260	1.8	8.2	70	130
Methylene Chloride	5,200	1.3	6.9	70	130
4-Methyl-2-pentanone (MIBK)	26,000	2.8	8.2	70	130
Styrene	8,800	1.3	8.5	70	130
1,1,2,2-Tetrachloroethane	4.2	2.4	14	70	130
Tetrachloroethene	940	1.7	14	70	130
Toluene	44,000	0.96	7.5	70	130
1,2,4-Trichlorobenzene	17.6	16	74	70	130
1,1,1-Trichloroethane	44,000	1.8	8.2	70	130
1,1,2-Trichloroethane	2	1.8	11	70	130
Trichloroethene	60	2.8	11	70	130
Trichlorofluoromethane	6,200	5.5	11	70	130
1,1,2-Trichloro-1,2,2-trifluoroethane	260,000	6.2	15	70	130
1,2,4-Trimethylbenzene	62	4	20	70	130
1,3,5-Trimethylbenzene	62	3.1	9.8	70	130
Vinyl acetate	1,760	2.6	14	70	130
Vinyl chloride	56	1.5	5.1	70	130
m,p-Xylene	880	2.2	17	70	130
o-Xylene	880	1.2	8.7	70	130

Notes:

LCL lower confidence limit
MDL method detection limit
RL reporting limit
TAML Test America Los Angeles
UCL upper confidence limit
ugm3 micrograms per cubic meter

Title: DETERMINATION of LOW-LEVEL VOLATILE ORGANICS in AMBIENT / INDOOR WHOLE AIR SAMPLES using GC/MS-SIM MODE

[Method EPA TO-15]

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Approvals (Signature/Date):

12-07-09 Dave Kammerer — Date Air Lab Department Manager	12/07/2009 William Nash — Date Environmental Health & Safety Coordinator
12-8-2009 Maria Friedman — Date Quality Assurance Manager	12/8/09 Elizabeth Winger — Date Laboratory Director

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TABLE OF CONTENTS

1. SCOPE AND APPLICATION 3
2. SUMMARY OF METHOD 3
3. DEFINITIONS 3
4. INTERFERENCES 5
5. SAFETY 6
6. EQUIPMENT AND SUPPLIES 8
7. REAGENTS AND STANDARDS 9
8. SAMPLE COLLECTION, PRESERVATION, SHIPMENT, AND STORAGE 11
9. QUALITY CONTROL 11
10. PROCEDURE 21
11. CALCULATIONS / DATA REDUCTION 25
12. METHOD PERFORMANCE 29
13. POLLUTION CONTROL 30
14. WASTE MANAGEMENT 30
15. REFERENCES / CROSS-REFERENCES 31
16. METHOD MODIFICATIONS 31
17. ATTACHMENTS 32
18. REVISION HISTORY 36

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1. SCOPE AND APPLICATION

1.1. This standard operating procedure (SOP) is applicable to the analysis of low-level volatile organic compounds (VOCs) in ambient/indoor air samples, collected in passivated canisters, using Gas Chromatography/Mass Spectrometry (GC/MS) technique.

1.2. Analytes, Matrix, and Reporting Limits (RLs)

1.2.1. Target analytes and RLs are listed in Attachments 1 and 2. Note that RLs are subject to change based on annual method detection limit (MDL) studies.

1.2.1.1. The target analytes in Attachment 2 are not routinely analyzed and are termed "add-ons." They are only analyzed and reported when requested by a client/project/contract.

1.2.2. Applicable matrices – ambient air, indoor air

1.3. On occasion, clients may request modifications to this SOP. These modifications are handled following the procedures outlined in the facility Quality Assurance Manual (QAM) in the section that discusses Service to the Client.

2. SUMMARY OF METHOD

2.1. An air sample and internal standards are metered through a mass flow controller and concentrated onto a cryogenically cooled glass bead trap. The trap is heated and the contents are transferred to a Tenax trap to remove water. The Tenax trap is heated and the analytes are transferred to a cryofocusing module. The cryofocuser is heated to transfer the analytes to the gas chromatographic column for separation and detection by a mass spectrometer operated in the selected ion monitoring (SIM) mode.

3. DEFINITIONS

3.1. Note that *"must"* and *"shall"* in this SOP denote required activities.

3.2. Batch – A batch is defined as a set of up to 20 client samples (reportable or not) of the same matrix processed using the same procedures and the same lot(s) of reagents within the same time period. A batch must contain a Laboratory Control Sample (LCS), LCS duplicate (LCSD), and a method blank, but they do not count towards the maximum 20 samples in a batch.

3.2.1. Rerun of the same client sample is counted as part of the 20 in a batch (i.e., a client sample analyzed twice in the same batch must be counted as two client samples).

3.2.2. Field quality control (QC) samples (e.g., trip blanks, equipment blanks, and field duplicates) count as client samples; therefore, they add to the batch count.

3.2.3. The batch must be analyzed sequentially using the same instrument and instrument configuration within the same calibration event. That is, the same calibration curve, calibration factors, or response factors must be in effect throughout the analysis.

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3.3. Internal Standard (IS) – The IS is a known amount of standard that is added to a test portion of a sample and carried through the entire measurement process as a reference for evaluating and controlling precision and bias of the applied analytical test method.

3.4. Laboratory Control Samples – LCSs are laboratory-generated samples used to monitor the laboratory's day-to-day performance. The LCS/LCSD is used to monitor the accuracy of the analytical process, independent of matrix effects. Ongoing monitoring of the LCS/LCSD results provides evidence that the laboratory is performing the method within accepted QC guidelines for accuracy and precision. The LCS/LCSD is prepared from a source independent of the calibration standards.

3.5. Method Blank – The method blank, consisting of all reagents added to the samples, is analyzed with each batch and is processed in the same manner as samples. The method blank is used to identify any background interference or contamination of the analytical system that may lead to the reporting of elevated concentration levels or false positive data.

3.6. Part per billion volume to volume (ppbv or ppb v/v) – Concentration expressed as part of gaseous (vapor) volume of pure target compound contained in a billion part of gaseous volume of sample.

Note: This reporting unit is NOT equivalent to the common ppb unit used in soil or water analysis.

3.7. Passivated canister – Commonly referred to as SUMMA canister, SilcoCan, or T.O.-Can in 1.0-liter, 1.8-liter, 6-liter, or 15-liter volume.

3.7.1. SUMMA – A nickel electropolish passivation process in which the interior of a stainless steel sample container is deactivated and rendered inert to most VOCs

3.7.2. SilcoCan – A sampling canister manufactured by Restek Corporation using the Restek Silcosteel® process to coat the interior of the canister with fused silica, rendering it inactive to most VOCs

3.7.3. T.O.-Can – A stainless steel container (which is the equivalent of a SUMMA canister) that is manufactured by Restek using a proprietary

electropolishing process and extensively cleaned using an ultrasonic method that ensures a high-quality, passivated surface that maintains the stability of VOCs during storage

3.8. Standard pressure is defined as 1.0 atmosphere, 14.6 psia (pounds per square inch absolute), 0 inch of mercury, and 0 psig (pounds per square inch gauge), based on laboratory elevation and average barometric pressure.

Note: Full vacuum (0 psia) = -30 inches of mercury vacuum

3.9. Standard molar volume is defined as 24.5 L/mol at room temperature of 25°C and standard pressure of 1 atmosphere.

3.10. Surrogates – Surrogates are organic compounds which are similar to the target analytes in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples. Surrogate compounds are chosen to represent the various chemistries of the target analytes in the method. Although not required in the EPA TO-15 method, each client and QC sample is spiked with surrogate standards via the analytical trap. Surrogate spike recoveries may be evaluated against project-specific requirements by determining whether the concentration (measured as percent recovery) falls within the required limits.

3.11. Vacuum/Pressure Gauge – Device used to measure the vacuum or pressure in a passivated canister. Units of measure range from -30 to 0 inch of mercury (for vacuum) to 0 to 30 psig (for positive pressure). All units used to express vacuum or pressure are converted to psia.

3.12. Refer to the Appendix of the facility QAM for all other definition of terms used in this SOP.

4. INTERFERENCES

4.1. Gas regulators are cleaned by the manufacturer using Freon 113, a target analyte in this SOP. Before using ultra high purity nitrogen (UHP N_2), hydrocarbon-free air, IS mix, or target compound standard mix cylinders, each regulator should be purged with the appropriate gas.

4.2. Contamination may occur in the sampling system if canisters are not properly cleaned prior to use. Canisters should not be used for the collection of samples until a batch blank analysis indicates that no target compounds are present above the RL, or a level previously agreed upon between the laboratory and the client. Further information regarding the cleaning and certification of canisters may be found in SOP LA-SRA-002. All other sampling equipment including pumps, flow controllers, and filters must be thoroughly cleaned to ensure that the filling apparatus will not contaminate samples.

4.2.1. Canisters may also be individually certified clean as required by and at an additional cost to the client.

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4.2.2. Canisters will be certified clean down to the MDL of the target analytes of interest if sample results need to be evaluated down to those limits. However, the laboratory must be provided advanced notification of the requirement. Canister order must be placed with at least 7-day advanced notice or certification requirement may not be guaranteed.

4.2.2.1. Common laboratory contaminants like acetone and methylene chloride may be present above the MDL.

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4.3. Carry-over may occur when samples with high levels of contaminants are analyzed. The sample immediately following a high-level sample should be re-analyzed if carry-over is suspected.

4.4. Only compounds having both similar mass spectrum and GC retention time (RT) would be expected to interfere in the method. This situation most commonly occurs with structural isomers.

4.5. Large concentrations of water, methane, or carbon dioxide may limit the size of the sample aliquot that can be effectively cryo-trapped. This may elevate the RLs for samples of this type.

4.6. Matrix interferences may be caused by non-target contaminants that are present in the sample. The extent of matrix interference will vary considerably from source to source depending upon the nature and diversity of the site being sampled.

5. SAFETY

5.1. Employees must abide by the policies and procedures in the Corporate Environmental Health and Safety Manual (CW-E-M-001). This procedure may involve hazardous materials, operations, and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal, and health practices under the assumption that all samples and reagents are potentially hazardous. The minimum Personal Protective Equipment required when handling these samples are safety glasses, gloves, laboratory coats, and closed-toe/non-absorbent shoes.

5.2. Specific Safety Concerns or Requirements

5.2.1. Gas pressurized equipment is used in this procedure. Be sure all valves and gauges are operating properly and that no equipment is over-pressurized. After changing cylinders, check all gas line connectors for leaks, with soapy water.

5.2.2. Passivated canisters must never be pressurized over 40 psig.

5.2.3. When pressurizing canisters or changing cylinders, safety glasses must be worn. If pressure from a canister or cylinder must be released during this process, a face shield must also be worn.

5.2.4. Pressurized gas cylinders must be securely retained. The use of a face shield is recommended when changing regulators.

5.2.5. The preparation of standards and reagents will be conducted in a fume hood with the sash set at the level indicated on the side of the hood.

5.2.6. Temperature appropriate gloves must be worn when working with hot or cold items.

5.2.7. Latex and vinyl gloves provide no protection against the organic solvents used in this method. Nitrile or similar gloves must be used.

5.2.8. The effluents from the sample splitters for the GC and the roughing pumps for the MS must be vented to a fume hood or at a minimum, must pass through a charcoal filter.

5.2.9. Both the GC and the MS contain elevated temperature zones. These zones must be cooled prior to an analyst or technician working on the unit.

5.2.10. The MS is under deep vacuum and must be brought to atmospheric pressure before working on the source.

5.2.11. Due to high voltage risk, power to the GC and/or MS must be turned off or disconnected before work can be done on the instrument.

5.3. Primary Materials Used

5.3.1. The following is a list of the materials used in this method, which have a serious or significant hazard rating. **NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the Material Safety Data Sheet (MSDS) for each of the materials listed in the table.** A complete list of materials used in the method can be found in the Reagents and Standards section of this SOP. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Helium	Simple Asphyxiant	NA – Keep oxygen levels at 19.5%	Oxygen Deficient atmosphere may cause headaches, ringing in ears, dizziness, drowsiness, unconsciousness, nausea, vomiting and depression of all the senses.

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Material (1)	Hazards	Exposure Limit (2)	Signs and symptoms of exposure
Liquid Nitrogen	Simple Asphyxiant Cryogenic liquid	NA – Keep oxygen levels at 19.5%	Oxygen Deficient atmosphere may cause headaches, ringing in ears, dizziness, drowsiness, unconsciousness, nausea, vomiting and depression of all the senses. Contact with skin may cause frostbite-changes in skin color to white or grayish-yellow.
Benzene	Flammable Poison Carcino-genic	1 ppm TWA	Toxic by ingestion, inhalation and absorption. Causes headache, nausea, dizziness, weakness and breathing difficulties. This material is irritating on contact with the skin and eyes and may cause permanent eye damage.
Chloroform	Carcinogen Irritant	50 ppm Ceiling	Acts as a relatively potent anesthetic. Irritates respiratory tract and causes central nervous system effects, including headache, drowsiness, and dizziness. Causes skin irritation resulting in redness and pain and may be absorbed. Removes natural oils. Vapors cause pain and irritation to eyes. Splashes may cause severe irritation and possible eye damage.
Carbon Tetrachlo-ride	Carcino-genic Poison	10ppm – TWA 200ppm STEL	Toxic by ingestion, inhalation and absorption. Causes headache, nausea, dizziness and narcosis. Contact with skin or eyes may cause irritation. Consumption of alcohol may increase toxic effects.
Methylene Chloride	Carcinogen Irritant	25 ppm-TWA 125 ppm-STEL	Causes irritation to respiratory tract. Has a strong narcotic effect with symptoms of mental confusion, light-headedness, fatigue, nausea, vomiting and headache. Causes irritation, redness and pain to the skin and eyes. Prolonged contact can cause burns. Liquid degreases the skin. May be absorbed through skin.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			

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6. EQUIPMENT AND SUPPLIES

6.1. Instrumentation

6.1.1. Gas chromatograph – capable of sub-ambient temperature programming and electronic pressure control (Agilent 6890)

6.1.2. Mass-selective detector – equipped with computer and appropriate software (Hewlett Packard 5973 with Chemstation data system and Target report generation software)

6.1.3. Sample concentrator – equipped with a cryogenic trap and appropriate systems for the control of moisture (EnTech 7100 or equivalent)

6.1.4. Electronic mass flow controller – device used to accurately meter gas flow in sample concentrators (part of EnTech 7100)

6.1.5. Diaphragm-type vacuum pump to draw sample through mass flow controller

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6.2. Supplies

6.2.1. Chromatographic grade stainless steel or nickel tubing and stainless steel plumbing fittings

6.2.2. Chromatographic column – Rtx-Volatiles, 0.32 mm ID, 1.5 μm df, 60 m length, methyl polysilicate liquid phase (Restek Corporation or equivalent)

6.2.3. High precision vacuum/pressure gauge or process meter for preparing daily standards (Cole-Parmer Pressure Transmitter No. P-07356-12 with Cole-Parmer Process Meter No. 94785-00, or equivalent)

6.2.3.1. The vacuum/pressure gauge must be calibrated quarterly, at a minimum, against the master gauge. See SOP LA-SRA-002.

6.2.4. Pressure regulators for carrier gas and standards – 2-stage, stainless steel diaphragm (single stage acceptable for standards)

6.2.5. Passivated canister (SUMMA, Silco, or TO-can) – 1.0-L, 1.8-L, 6-L, 15-L (S.I.S., Restek, or equivalent)

6.2.6. Stainless steel vacuum/pressure gauge capable of measuring from -30 inches of mercury to 40 psig (Span Instruments or equivalent)

7. REAGENTS AND STANDARDS

7.1. Reagents

7.1.1. UHP N_2 – used for method blanks and preparing dilutions of samples and standards

7.1.2. UHP Helium – used as the gas chromatograph carrier gas

7.1.3. Pressurized air source for EnTech 7100 heater gas

7.1.4. Liquid N_2

7.1.5. De-ionized (DI) or NANOpure water

7.2. Standards

7.2.1. Gas calibration stock standards containing the target compounds are purchased from commercial sources or prepared from neat in passivated canisters. Suppliers are required to provide certification of the analyte concentrations.

7.2.2. IS and surrogate stock standard mix at 250 ppbv. See Attachments 5 and 6, respectively.

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7.3. Expiration dates for standards and reagents are based on vendor specification. If no vendor expiration date is assigned, the laboratory assigns an expiration date of two years from the date of receipt. Refer to SOP LA-QAS-002 for further information on standards and expiration dates. Expiration dates must be documented on the gas cylinders.

7.4. Standard Preparation

7.4.1. Static dilutions of the stock standard gas mixtures are made in 6- or 15-L passivated canisters to create working standards. A high precision vacuum gauge is flushed with UHP N_2 and attached to the top valve of a clean, evacuated canister, and the absolute pressure is recorded.

7.4.1.1. DI or NANOpure water (100 µL) is added to calibration standards prior to mixing.

7.4.1.2. The IS mix does not contain water.

7.4.2. Depending on the concentration of each stock standard gas mixture, a particular pressure of each is added to the canister to achieve the desired concentration in the working standard.

7.4.3. Care should be taken to flush each regulator and transfer line with standard prior to transfer to the canister. After all of the stock standard mixes are added, the standard canister is pressurized with UHP N_2 to achieve the appropriate concentration.

7.4.4. Currently, the daily standard has a nominal concentration of 1.25 ppbv and is created by adding 2 psia of the 25 ppbv low-level scan standard mix and adding UHP N_2 to the canister to achieve a final pressure of 40 psia.

7.4.4.1. Other preparation techniques may be used to obtain the desired standard concentration, provided these techniques do not compromise the integrity of the standards used.

7.4.4.2. Detailed standard preparation steps are documented in the Laboratory Information Management System (LIMS).

8. SAMPLE COLLECTION, PRESERVATION, SHIPMENT, AND STORAGE

8.1. Sample container, preservation techniques, and holding times may vary and are dependent on sample matrix, method of choice, regulatory compliance, and/or specific contract or client requests. Listed below are the holding times and the references that include preservation requirements.

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Sample Container	Minimum Sample Size	Preservation	Holding Time	Reference
Passivated Canister	2000 mL	None	30 days	EPA/625/R-96/010b, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air
Passivated Canister	2000 mL	None	72 hours	Advisory – Active Soil Gas Investigations, January 28, 2003 (DTSC and LARWQCB)

8.2. Canisters used for sample collection must be certified clean (see Section 4.2). A 7-micron filter should be placed on the inlet of the canister to protect the valve from particulates. Canisters should never be pressurized over 40 psig.

8.3. The pressure of the canister should be recorded before and after sample collection. See Section 10.1 for sample preparation.

8.4. Samples should be protected from extreme temperatures.

9. QUALITY CONTROL

9.1. Sample QC – The following QC samples are prepared with each batch of samples:

9.1.1. Laboratory Control Sample/Laboratory Control Sample Duplicate – For each batch, an LCS/LCSD pair must be analyzed. The LCS/LCSD is analyzed after the calibration standards and before the method blank and client samples. The LCS/LCSD is spiked with the target analytes in Attachments 1 and 2, from which a sub-list may be reported, as defined by the National Environmental Laboratory Accreditation Conference (NELAC) 2003 Standards (see below). Client-specific requirements may require additional analytes or even the full list of analytes to be spiked into the LCS/LCSD.

9.1.1.1. Requirements on LCS/LCSD composition (NELAC Quality Systems, June 5, 2003, Appendix D, D.1.1.2.1c, page 250 of 324) – The following criteria shall be used for determining the minimum number of analytes to be spiked into the LCS/LCSD. However, all targeted components shall be included in the spike mixture over a two-year period:

9.1.1.1.1. For projects that include 1 – 10 targets, spike all analytes.

9.1.1.1.2. For projects that include 11 – 20 targets, spike at least 10 or 80%, whichever is greater.

9.1.1.1.3. For projects with more than 20 targets, spike at least 16 analytes.

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9.1.1.2. Requirements on LCS/LCSD acceptance (NELAC Quality Systems, June 5, 2003, Appendix D, D.1.1.2.1e, pages 251 and 252 of 324) – The number of allowable exceedences is based on the number of analytes in the LCS/LCSD. Upper and lower marginal exceedence (ME) limit is established for each analyte to determine when corrective action is necessary. ME is defined as being beyond the LCS/LCSD control limit but within the ME limit:

9.1.1.2.1. 71 – 90 analytes in LCS/LCSD, 4 analytes allowed in the ME limits

9.1.1.2.2. 51 – 70 analytes in LCS/LCSD, 3 analytes allowed in the ME limits

9.1.1.2.3. 31 – 50 analytes in LCS/LCSD, 2 analytes allowed in the ME limits

9.1.1.2.4. 11 – 30 analytes in LCS/LCSD, 1 analyte allowed in the ME limits

9.1.1.2.5. <11 analytes in LCS/LCSD, no analyte allowed in the ME limits

9.1.1.3. If any analyte is outside established LCS/LCSD control limits but is <u>within</u> established ME limits, no further corrective action is necessary but failed analytes in the LCS/LCSD must be qualified and a Corrective Action Report (CAR) using the CAR program in the LIMS must be generated in order to determine the randomness of the exceedence (NELAC Quality Systems, June 5, 2003, Appendix D, D.1.1.2.1e, page 252 of 324).

9.1.1.3.1. All failed LCS/LCSD must be documented in a CAR because if the same analyte exceeds the LCS/LCSD control limits repeatedly, it is an indication of a systematic problem that must be corrected immediately. The corrective action performed must also be documented in the CAR generated.

9.1.1.4. If the LCS/LCSD is deemed acceptable based on the criteria specified in Section 9.1.1.2 and if any recoveries are above the upper control limit, and the same analytes were not detected (ND) in all of the client samples, then the CAR must state that the positive bias is not expected to impact ND results.

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9.1.1.5. Exceedence outside the ME limits require corrective action, regardless of whether the associated result is positive or ND. See Section 9.1.1.6.

9.1.1.5.1. For failures that exceeded the ME at the high end, the ND analyte may be flagged and reported only if the program (e.g., Department of Defense, EPA, etc.) or project-specific Quality Assurance Project Plan allows.

9.1.1.5.2. For all other ND results that failed the ME requirements, the client must approve to flag and report the data since the nonconformance does not meet the NELAC Standard.

9.1.1.5.3. Note that even if the data are flagged, the root cause of the QC failure must be investigated, corrected, and documented in a CAR.

9.1.1.6. If more analytes exceed the LCS/LCSD control limits than is allowed (as specified in Section 9.1.1.2), or if <u>any one</u> analyte exceeds the ME limits, then the LCS/LCSD fails and corrective action must be performed. Corrective action will normally be re-analysis of the batch, as follows:

9.1.1.6.1. Evaluate the analytical run for errors and anomalies. Re-analyze the LCS.

9.1.1.6.2. Check the standard for appropriate pressure. Low pressure will often cause failure. Re-pressurize or prepare a new standard and re-analyze the LCS/LCSD.

9.1.1.6.3. Evaluate the instrument status and perform maintenance. Re-analyze the continuing calibration verification (CCV) standard and LCS/LCSD, or recalibrate.

9.1.1.7. Current LCS/LCSD control limits are stored in the LIMS. Control and ME limits are subject to change based on annual evaluation of LCS/LCSD control charts. See SOP LA-QAS-001 for determining control and ME limits. The QA Manager, or designee, notifies the laboratory, via email or other means, of updates to both the control and ME limits.

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9.1.2. Method Blank – For each batch, an acceptable method blank must be analyzed. The method blank is analyzed after the calibration standards and LCS/LCSD and prior to client samples. The method blank is a 6-L "screen can" (see SOP LA-SRA-002) humidified with 100 µL of DI or NANOpure water, pressurized to 40 psia with UHP N_2, and then analyzed with each batch.

9.1.2.1. The method blank must not contain any analyte of interest above the RL (except common laboratory contaminants, see Section 9.1.2.2). Otherwise, the method blank is further evaluated and corrective actions are performed as stated below:

9.1.2.1.1. Re-analyze the method blank once to determine if an anomaly occurred during sample analysis. If the re-analysis is acceptable, then the method blank can be considered in control.

9.1.2.1.2. If there are no results greater than the RL in the samples or if the results in the samples are greater than 10X the method blank level, the data may be reported with qualifiers. In this case, the elevated method blank result is not believed to impact data quality. The anomaly must be reported in a CAR.

9.1.2.1.3. If there are results greater than the RL in the samples and if these results are less than 10X the method blank level, the samples must be re-prepared and re-analyzed.

9.1.2.1.4. If re-analysis is not possible due to limited sample volume or other constraints, the method blank is reported and all associated samples are flagged. The anomaly must be reported in a CAR.

9.1.2.2. If the analyte detected in the method blank is a common laboratory contaminant (methylene chloride, acetone, 2-butanone), the data may be reported with qualifiers if the concentration of the analyte is less than 5X times the RL. Otherwise, corrective actions, as stated in Section 9.1.2.1, must be performed. The anomaly must be reported in a CAR.

9.1.2.3. If surrogates are a project-specific requirement, then the method blank must have acceptable surrogate recoveries. If surrogate recoveries are unacceptable, the data must be evaluated to determine if the method blank has served the purpose of demonstrating that the analysis is free of contamination. If surrogate recoveries are low and there are reportable analytes in the associated samples, re-analysis of the method blank and affected samples must be performed.

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9.1.3. Surrogate Standards – Surrogates are not a method requirement. The laboratory routinely adds surrogates to all QC and client samples via the analytical trap and will report these results only if defined in a project/contract or at client's request. The surrogate compounds used in this SOP are listed in Attachment 6.

9.1.3.1. Surrogate recoveries in client and QC samples may be assessed to ensure that recoveries are within laboratory control limits. If any surrogates are outside these limits and if surrogates are a project-specific requirement, the following corrective actions must be performed:

9.1.3.1.1. Check all calculations for error.

9.1.3.1.2. Ensure that instrument performance is acceptable.

9.1.3.1.3. Recalculate data and/or re-analyze if either of the above checks reveal a problem.

9.1.3.1.4. Re-analyze the sample or flag the data as "Estimated Concentration" if neither of the above resolves the problem.

9.1.3.2. It is only necessary to re-analyze a sample once to demonstrate that poor surrogate recovery is due to matrix effect, unless the analyst has reason to believe that the repeated out of control results are due to problems other than matrix effect.

9.1.3.3. Surrogate control limits are stored in the LIMS and are subject to change based on annual evaluation of surrogate control charts. See SOP LA-QAS-001 for determining surrogate control limits. The QA Manager, or designee, notifies the laboratory, via email or other means, of updates to the control limits.

9.1.4. Internal standard - IS compounds are added to each calibration standard, LCS/LCSD, method blank, and client sample via the analytical trap. IS compounds are monitored for each shift by comparing the IS areas and RTs in each client and QC sample against those of the associated CCV standard. The IS compounds used in this SOP are listed in Attachment 5.

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9.1.4.1. IS evaluation criteria for the initial calibration (ICAL) may be found in Section 9.2.2.6.

9.1.4.2. For all other QC and client sample, IS areas are considered acceptable if they fall between 60% and 140% of the CCV IS areas. The RTs are considered acceptable if they fall within ±20 seconds (0.33 minutes) of the RT of the IS in the associated CCV.

9.1.4.3. Any QC or client sample exceeding the acceptance criteria listed in Sections 9.1.4.1 and 9.1.4.2 must be re-analyzed. If the IS area fails upon re-analysis, the failure must be documented in a CAR. All other corrective actions performed must also be documented in the CAR generated.

9.1.5. Sample Duplicate Analysis

9.1.5.1. A client sample duplicate is analyzed and reported with the batch, only if requested.

9.1.5.2. The acceptance criterion for the duplicate analysis is a relative percent difference (RPD) ≤25 for target analytes detected >5X the RL. No criterion is established for duplicate results <5X the RL. The calculation is provided in Section 11.4.

9.2. Instrument QC

9.2.1. Initial/Daily Tuning of the Instrument

9.2.1.1. At instrument's initial setup, the GC/MS is tuned using the Standard Spectrum Tune function of the instrument to generate a perfluorotributylamine (PFTBA) tune report. Thereafter, the acceptability of the GC/MS tune is checked daily by printing the saved Standard Spectrum Tune file.

The tune report is evaluated against the acceptance criteria specified in Attachment 4.

9.2.1.2. If any of the key ions fail the abundance criteria listed in Attachment 4, the system is considered out of tune and any subsequent sample/standard analysis should be considered unacceptable. The following corrective actions must be followed. Section 10.6 may also be consulted for troubleshooting guidelines:

9.2.1.2.1. Reprint the tune report one more time. Typically, it takes a few minutes for the GC/MS system to stabilize.

9.2.1.2.2. If the reprinted tune report still showed failed abundances, a new Standard Spectrum Tune, as was done during the initial setup, must be performed.

9.2.1.2.3. If the new tune still does not meet acceptance criteria, the source must be cleaned.

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9.2.2. Initial Calibration

9.2.2.1. Instruments are calibrated at initial setup and as needed thereafter, and at least annually.

9.2.2.2. An ICAL curve consisting of a minimum of five points is analyzed to determine the linear working range of the analytical system for each compound. An average response factor (RF), or sometimes called the relative response factor (RRF), and the percent relative standard deviation (%RSD) are calculated for each target analyte using the equations in Section 11.4.

9.2.2.3. The ICAL is considered acceptable if at least 90% of the target analytes have a %RSD $\leq$30, including the surrogates. If the ICAL fails acceptance criteria, corrective actions must be performed and a new ICAL generated. Consult Section 10.6 for troubleshooting guidelines.

9.2.2.3.1. Client- or project-specific requirements may dictate that the laboratory adhere to the following TO-15 criteria: The %RSD for the RFs for <u>all</u> target analytes in the ICAL must be $\leq$30, with up to two target analytes that may have a %RSD of $\leq$40.

9.2.2.4. Linear calibration using least squares regression or non-linear calibration (second-order curves) may be used with the appropriate number of calibration points. Details regarding their use and the calculations involved may be found in TestAmerica Corporate QA SOP CA-Q-S-005. This Corporate SOP must be consulted prior to using these curves. The analyst must read and understand the topics regarding Forcing Through Zero and Curve Weighting.

9.2.2.4.1. Additionally, the reason for using these curves in place of the Ave RF calibration technique must be documented and explained in the instrument maintenance logbook.

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9.2.2.5. The nominal concentrations of the ICAL standards are typically 0.0050, 0.0070, 0.020, 0.10, 0.50, 1.25, 2.5, 5.0, and 10 ppbv, but these may vary depending on the certified mix used to prepare the standards or the volume trapped. The low standard must be at or below the RL. The standards are analyzed by preparing stock standards at the required concentration or by using the appropriate volume of a working standard. For example, the 0.0050, 0.0070, and 0.020 ppbv standards can be analyzed by trapping 125 mL, 175 mL, and 500 mL, respectively, of the 0.020 ppbv working standard.

9.2.2.6. Internal Standards in the ICAL

9.2.2.6.1. The IS response at each calibration level must fall between 60% and 140% of the IS response in the mid-point calibration standard.

9.2.2.6.2. The RT shift for each of the IS at each calibration level must be within ±20 seconds (0.33 minutes) of the RT of the IS in the mid-point calibration standard.

9.2.2.6.3. Any calibration level exceeding the above acceptance criteria must be re-analyzed.

9.2.2.7. The analyst may elect to drop points from the calibration curve to improve subsequent quantitation. The following rules apply:

9.2.2.7.1. Points below the RL may be dropped as long as there is a point remaining at or below the RL.

9.2.2.7.2. High points may be dropped but at the expense of decreasing the linear range.

9.2.2.7.3. Calibration points in between the low and high ends may NOT be dropped.

9.2.3. Initial Calibration Verification (ICV)

9.2.3.1. Each new ICAL must be verified using a second-source standard. Since the regulatory agencies have not provided guidance on second-source verification, the following acceptance criteria are used: ± 30 percent difference (%D) for target analytes, except for the poor performers identified below to be at ±55 %D. The %D calculation is provided in Section 11.4:

9.2.3.1.1. 1,4-Dioxane

9.2.3.1.2. Benzyl chloride

9.2.3.2. The limits specified in Section 9.2.3.1 are provided as guidance. If these criteria are not met, the following corrective actions must be performed. Consult Section 10.6 for troubleshooting guidelines:

9.2.3.2.1. Rerun the second source check standard.

9.2.3.2.2. Re-prepare or acquire a new standard.

9.2.3.2.3. Evaluate instrument conditions.

9.2.3.2.4. Regenerate a new ICAL.

9.2.3.3. Due to the limited availability of second-source manufacturers for the air standard mixes and some neat compounds, the following options may be considered as second-source:

9.2.3.3.1. Use of a certified different lot from the same manufacturer.

9.2.3.3.2. Preparation of an independent standard using the same source as the first standard but by another analyst. This procedure is particularly applied when the air standard was prepared from a neat liquid.

9.2.4. Continuing Calibration Verification

9.2.4.1. Unless the QC batch follows a new ICAL and an ICV, for every 24 hours of operation, a CCV standard is analyzed to verify the ICAL average RF. The %D of the CCV RF from

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the ICAL average RF is calculated for each target analyte. The %D calculation is provided in Section 11.4.

9.2.4.2. The CCV is considered acceptable if at least 90% of the target analytes have a %D ±30, including the surrogates. If the CCV fails acceptance criteria, corrective actions must be performed. Consult Section 10.6 for troubleshooting guidelines.

9.2.4.3. The following NELAC requirements (NELAC Quality Systems, June 5, 2003, 5.5.5.10e, page 217 of 324) apply only when the acceptance criteria in Section 9.2.4.2 are not met. If they are met and specific analytes are outside the ±30 %D criteria, no further corrective action is required, but a hit reported in the analytes that are outside the ±30 %D criteria must be flagged (see Section 11.2.3).

9.2.4.3.1. If routine corrective action procedures fail to produce a second consecutive (immediate) CCV within acceptance criteria, then either the laboratory has to demonstrate acceptable performance after corrective action with two consecutive CCVs, or a new ICAL must be generated.

9.2.4.3.2. When the acceptance criteria for an analyte in the CCV are exceeded high (i.e., high bias), and the analyte was ND in the sample, the ND analyte may be reported with a flag. A CAR must also be generated to document the high bias.

9.2.4.3.3. When the acceptance criteria for an analyte in the CCV are exceeded high (i.e., high bias), and the analyte was detected at a positive hit in the sample, the sample must be re-analyzed after a passing CCV or after a new ICAL has been established, evaluated, and accepted.

9.2.4.3.4. When the acceptance criteria for an analyte in the CCV are exceeded low (i.e., low bias), sample results may be reported if they exceed a maximum regulatory limit/decision level (if any). Otherwise, the samples affected must be re-analyzed after a passing CCV or after a new ICAL has been established, evaluated, and accepted. A CAR must also be generated to document the low bias.

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9.2.4.4. CCVs may be analyzed more frequently depending on documented client requirements.

9.3. Calibration standards and other QC samples (e.g., instrument tuning, LCS/LCSD, method blank, etc.) may not be analyzed more than twice without documented corrective action. If the initial run fails acceptance criteria, re-inject calibration standard or QC sample. If second run passes, analysis may proceed. Otherwise, conduct instrument maintenance or perform corrective action. Completely document failure, corrective action performed, and return to control in the instrument maintenance logbook. Section 10.6 lists troubleshooting guidelines.

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10. PROCEDURE

10.1. Sample Preparation

10.1.1. The initial pressure and the final pressure of samples in canisters must be recorded in the pressurization logbook and in the individual canister field data sheet.

10.1.1.1. The initial pressure is checked and recorded by attaching a vacuum/pressure gauge to the canister. The gauge should be rinsed before use with UHP N_2 by physically holding against the gas outlet and flushing for 10 seconds.

10.1.1.2. Samples received above ambient pressure (14.6 psia) do not require pressurization unless additional volume is needed to perform multiple analyses. If samples are received below ambient pressure, UHP N_2 should be added. The default final pressure is 24.6 psia (+/- 2 psia), however, the final pressure should be above ambient but not more than 3X the initial pressure.

10.1.2. When the canister vacuum/pressure is increased, a dilution factor (DF) is calculated and is applied to the raw results:

$$DF = \frac{Ya}{Xa}$$

where,

Xa = absolute initial canister pressure (before dilution, psia)
Ya = absolute final canister pressure (after dilution, psia)

10.1.3. Canisters received as trip blanks (without sample collected) are humidified with 100 µL of DI or NANOpure water and then pressurized to 25 psia. These samples are considered to have a DF =1.0.

10.1.4. Samples are screened to check for contamination before analysis or if suspected to contain significant contamination, using GC/Flame Ionization Detector analysis or other screening methods. Screening is performed to determine a proper dilution or the optimum volume of sample for the calibrated range, and to prevent overloading the analytical instrument. The screening instrument is generally calibrated at a single-point for common analytes of interest. Screening result printouts are called "screen reports." The following screening procedure is followed:

10.1.4.1. Check out sample from its home storage location using the Internal Chain of Custody program in the LIMS.

10.1.4.2. Attach the sample to an active sample line on the screening instrument.

10.1.4.3. Start the screen sequence in the instrument data system.

10.1.4.4. Push START on the instrument.

10.1.4.5. Open sample container valve.

10.1.4.6. Collect data report and determine the dilution required for the analysis.

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10.2. Water Addition

10.2.1. The analyst should be aware that humidity plays an important role in the recovery of certain target compounds, particularly polar compounds, and should be prepared to add humidity to canisters where appropriate. The addition of water helps to stabilize the behavior of these compounds, which might otherwise interact with the interior surface of the canister or with the stainless-steel lines of the sample manifold.

10.2.1.1. Low humidity is often indicated by low area counts (recovery) for internal standards Chlorobenzene-d5 and 4-Bromofluorobenzene.

10.2.2. Since it is not practical to know the relative humidity of all canisters received at the laboratory, the analyst should assume that canisters are received at approximately 80 percent relative humidity. When preparing canister dilutions, the analyst should attempt to preserve the relative humidity of canisters at a level that will minimize recovery loss due to low canister relative humidity.

10.3. Tuning

10.3.1. Refer to Section 9.2.1 for details regarding instrument tuning.

10.4. Calibration

10.4.1. Before any instrument is used as a measurement device, the instrument response to known reference materials must be determined. The manner in which various instruments are calibrated depends on the particular type of instrument and its intended use. All sample measurements must be made within the calibration range of the instrument. Preparation of all reference materials used for calibration must be documented.

10.4.2. Refer to Sections 9.2.2 through 9.2.4 for details regarding instrument calibration.

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10.5. Sample Analysis

10.5.1. The calibration standards and the sample QC are analyzed in the same manner as client samples. After the calibration standards are analyzed and evaluated (Section 9.2.2 through 9.2.4), the LCS/LCSD are analyzed and evaluated (Section 9.1.1), and then the method blank is analyzed and evaluated (see Section 9.1.2), all prior to client sample analysis.

10.5.2. Each canister is attached to the autosampler (A/S) and recorded in the instrument sequence. A sequence is created in the GC/MS software to prepare the instrument for data acquisition. The sequence information controls the GC/MS method, data file creation, sample parameters, and report output. A second sequence must be created in the A/S control software to control the sampling process such as line position, sample volume, trap temperatures, flow rates, and times.

10.5.3. The valves are opened on all canisters and the A/S and GC/MS sequences are started.

10.5.4. The pressure DF applied to a sample must be compensated for by trapping more than the default volume of 500 mL. For example, a sample received at 12.0 psia and pressurized to 24.6 psia has a pressure DF of 2.05. If the default volume is 500 mL, then 1030 mL should be trapped (the recorded volume is rounded up to three significant figures).

10.5.4.1. A sample that requires only a small dilution can be analyzed by trapping a volume less than the standard volume. The minimum volume that can be trapped is 20 mL. The maximum volume that can be trapped is 1500 mL.

10.5.5. For routine analysis, the A/S will follow the sequence of events below (parameters may be modified based on instrument performance):

10.5.5.1. Glass bead trap (Module 1) cooled to –150 ^{o}C.

10.5.5.2. Trap internal standard.

10.5.5.3. Trap sample.

10.5.5.4. The Tenax trap (Module 2) is cooled to –10°C and the glass bead trap is heated to 20°C. The sample is transferred to Module 2 by passing Helium through Module 1. This step is designed to remove water from the sample.

10.5.5.5. When GC is ready, the cryofocuser (Module 3) is cooled to –150°C. Module 2 is heated to 180°C. The sample is transferred to Module 3.

10.5.5.6. Module 3 is heated and the GC/MS column flow is routed through Module 3 to inject the sample and begin the run.

10.5.5.7. The system is pre-flushed with the next sample and the system is baked to limit carry-over.

10.5.6. Upon completion of the analytical sequence, the Entech 7100 software generates a QA/QC report that records data from the sampling event (i.e. actual volume trapped, temperature at the time of trapping, sample pressure, etc.).

10.6. Troubleshooting

10.6.1. Many problems encountered during analysis are due to low standard pressures or carrier/detector gas supply issues. Always confirm that adequate pressure remains in the standards and that the instrument gas supplies are sufficient before working on the instrument hardware.

10.6.2. Low response – typically caused by leaking sample lines or valves or contaminated/dirty sources. Instrument software can perform automated leak checks of the system. Specific components can be checked by isolating the component in question from the system (disconnect and cap or plug the ends) and then performing a leak test using a pressure gauge and canister at positive pressure. Leaking components will not hold pressure when the canister is closed. Low internal standard areas may be caused by degradation of the MS performance and increasing the electron multiplier (EM) voltage may solve this concern.

10.6.3. Baseline noise – check for supply gas contamination and leaking fittings. Carrier gas filters may need to be changed, including the pencil filters inside the GC. Sample carry-over or contamination may also be an issue and baking the system while flushing sample lines will remove most carry-over. A dirty source or leaking MS may also cause issues. The use of automated leak check routines in the MS software

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can indicate if a leak is present. Source-cleaning should be performed according to the manufacturer's instructions.

10.6.4. Instrument issues – if the current tune file will not meet acceptance criteria, a new Standard Spectrum Tune must be performed. If the new tune still does not meet acceptance criteria, the source should be cleaned according to the manufacturer's instructions.

10.7. Instrument Maintenance and/or Repair

10.7.1. All instrument maintenance and/or repair must be documented in the instrument maintenance logbook.

10.7.2. A new ICAL must be generated following major maintenance such as changing the column, cleaning or repairing the source, replacing filaments, changing electronics, replacing the multiplier, or changing the concentrator.

10.7.3. Minor maintenance includes cleaning the injector port, replacing filters, changing the pump oil, autotuning, switching filaments (instrument contains two filaments under vacuum), replacing the syringe or injector tower, changing/refilling the calibration vial, changing seals and o-rings, ballasting pump, replacing fuses, replacing roughing pumps or transfer lines.

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11. CALCULATIONS / DATA REDUCTION

11.1. Qualitative Analyses

11.1.1. Three criteria must be satisfied to verify positive identification:

11.1.1.1. Elution of sample component at the same GC relative or absolute RT as those of the standard component.

11.1.1.1.1. The sample component relative retention time (RRT) must compare within ± 0.06 RRT units of the RRT of the standard component.

11.1.1.1.2. As an option, RT must compare within 0.33 minutes of the standard component absolute RT. For reference, the RT standard must be run within the same 24-hour shift as the sample.

11.1.1.2. Correspondence of the sample component and the standard component mass spectra.

11.1.1.2.1. All ions present in the standard mass spectra at a relative intensity greater than 10% (most

abundant ion in the spectrum equals 100%) must be present in the sample spectrum.

11.1.1.2.2. The relative intensities of ions specified in Section 11.1.1.2.1 must agree within ±30% between the standard reference and sample spectra. For example, for an ion with an abundance of 50% in the reference spectra, the corresponding sample abundance must be between 20 and 80%. Standard reference mass spectra must be obtained on each individual GC/MS system.

11.1.1.3. All monitored ions of each analyte must be present at the same RT (within + one scan).

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11.1.2. If an analyte cannot be verified by all of the criteria in the above sections but in the technical judgment of the analyst the identification is correct, then the analyte may be reported with a flag to indicate that the amount reported is an estimated concentration.

11.1.3. Tentatively Identified Compounds (TICs) are unavailable in the SIM mode.

11.2. Quantitative Analysis

11.2.1. When an analyte has been identified, the quantification of that analyte will be based on the integrated abundance from the extracted ion current profile (EICP) of the primary characteristic ion. Quantitation will take place using the IS technique.

11.2.2. A sample must be analyzed and reported at a dilution if one or more target analytes have an on-column amount above the upper calibration level. Dilutions are acceptable if at least one of the following criteria are met:

11.2.2.1. Any target analyte in the diluted sample is at or above the mid-point calibration standard (1.25 ppbv on-column).

11.2.2.2. The peak height of any non-target analyte in the diluted sample exceeds the largest peak height of the highest calibration standard.

11.2.3. When an analyte that failed acceptance criteria in a reportable ICAL and/or in a CCV (i.e., at least 90% of analytes met acceptance criteria) is detected in any client sample, the analyte must be flagged.

11.2.4. Analyte quantitation must be performed from the ICAL and not from the CCV analysis. Test results must be qualified in reports when analyte quantitation is based on the CCV at the client's request.

11.3. All manual or re-integration of chromatograms must be documented in accordance with TestAmerica Corporate SOP CA-Q-S-002. Documentation includes, at a minimum, before and after copies of the chromatograms with a reference to the reason for re-integration, dated, and initialed. All manual integrations must undergo a secondary-level review. See Section 11.8.

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11.4. Calculations

11.4.1. Calculation for RPD

$$RPD = \frac{Value\ A - Value\ B}{Average\ of\ Values} X\ 100$$

11.4.2. Calculation for RRF

$$RRF = \frac{Area\ cpd\ in\ Std.}{Area\ I.S.} X\ \frac{Conc.I.S.}{Conc.cpd\ in\ Std.}$$

The area of the primary quantitation ion is used in the calculation.
I.S. = Internal Standard

11.4.3. Calculation for %RSD

$$\%RSD = \frac{Std.Dev.of\ RRFs}{Mean\ of\ RRFs} X\ 100$$

11.4.4. Calculation for %D

$$\%D = \frac{Average RRF\ from\ IC - RRF\ CCV.}{Average RRF\ from\ IC} X 100$$

11.4.5. The data system automatically quantitates the sample results based on a standard sample size of 500 mL. The default result units are in ppbv. If a sample size other than 500 mL was used and/or a canister sample was pressurized, the result must be adjusted as shown below:

$$\text{Final result ppbv = raw } result ppbv X \frac{250mL}{sample volume injected} X \frac{final\ psia}{initial\ psia}$$

11.4.6. Calculation for Determining Concentration of Compounds

$$Conc.Cpd(ppbv) = \frac{Areacpd\,insample}{Area\,I.S.insample} X \frac{Conc.I.S.}{RRFICAL.} X\ Dil.Factor$$

The area of the primary quantitation ion is used in the calculation.
I.S. = Internal Standard

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11.4.7. Calculation for Percent Recovery (%Rec)

$$\%\,Rec = \frac{Amount\ cpd.\ recovered}{Amount\ cpd.\ spiked} X\ 100\%$$

11.4.8. Standard reporting units are ppbv (also ppb v/v). If results are to be reported in ng/L or ug/m^3, use the following equation:

$$result\ ppbv\ X \frac{Molecular\ weight\ of\ compound}{24.5} = results\ ng/L\ or\ ug/m^3$$

Note: 24.5 is the molar volume of ideal gas in liters at 25°C and 1 atmosphere.

11.5. Estimates of uncertainty are based upon LCS historical control limits.

11.6. "J" values (results below the RL but above the MDL) are reported on request only.

11.7. No conversion of the analytical results to standard conditions is made.

11.8. Technical Data Review

11.8.1. Primary

11.8.1.1. Per the facility QAM, the primary review of analytical data is often referred to as a "bench-level" review. In most cases, the analyst who generates the data (prepares and/or analyzes the sample/reduces the data) is the primary reviewer. In some cases, an analyst may be reducing data for samples run by an autosampler that was set up by a different analyst. In this case, the identities of both analysts must be indicated, at a minimum, in the injection or run log.

11.8.2. Secondary

11.8.2.1. Per the facility QAM, the secondary review is a complete technical review of a data set. The secondary review is documented and the secondary reviewer is identified. If problems are found during the secondary review, the reviewer must work with the appropriate personnel to resolve them. If changes are made to the data, such as alternate qualitative identifications, identifications of additional target analytes, re-quantitation, or reintegration, the secondary reviewer must contact the analyst and/or primary reviewer of the data so that the primary analyst and/or reviewer may be aware of the changes made.

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11.9. Completeness/Project Management Review

11.9.1. Per the facility QAM, the completeness review includes the generation of a report narrative and/or cover letter that outlines anomalous data and nonconformances using notes and non-conformance reports generated during the primary and secondary review. The completeness review focuses on the accuracy of final client reporting forms.

11.9.2. The PM signs the final report package submitted to the client.

12. METHOD PERFORMANCE

12.1. Method Detection Limit Study – The MDL is the lowest concentration that can be detected for a given analytical method and sample matrix with 99% confidence that the analyte is present. The MDL is determined according to the laboratory's MDL procedure in the section of the facility QAM that discusses Test Methods and Method Validation. MDLs reflect a calculated (statistical) value determined under ideal laboratory conditions in a clean matrix, and may not be achievable in all environmental matrices. At initial set-up and subsequently once per 12-month period, an MDL study must be performed and verified immediately thereafter for each target analyte in each test method.

12.1.1. An MDL must be determined prior to the analysis of any sample.

12.1.2. The laboratory must generate a valid MDL for each analyte of interest.

12.1.3. The MDL must be below the RL for each analyte.

12.1.4. The MDL established for each analyte may be higher than the calculated MDL determined annually. The MDL used and recorded in the LIMS must not exceed 10X the calculated MDL.

12.1.5. MDL verification will be performed for each target analyte in the method and in every analytical instrument where the method is analyzed. Verification will be performed at 1X to 4X the established MDL recorded in the LIMS.

12.1.6. Additional information regarding MDL studies may be found in the TestAmerica Corporate SOP CA-Q-S-006.

12.1.7. For add-on or non-standard analytes, an MDL study is required by NELAC. Additionally, a calibration curve must be generated before analyzing any samples, unless lesser requirements (e.g., a single-point calibration, which should be at the RL) are previously agreed to with the client. Any such agreed deviation from the method must be clearly documented in the report narrative.

12.2. Demonstration of Capability (DOC)

12.2.1. For a method – Refer to the Test Methods and Method Validation section of the facility QAM for the general procedures to follow in order to meet DOC (initial and ongoing) requirements for a method.

12.2.2. For an analyst – The training certification in Attachment 7 is required to complete an analyst's initial DOC. Annual (ongoing) DOCs require that the analyst demonstrate acceptable results on four replicates of the LCS.

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13. POLLUTION CONTROL

13.1. It is TestAmerica's policy to evaluate each method and look for opportunities to minimize waste generated (i.e., examine recycling options, ordering chemicals based on quantity needed, and preparation of reagents based on anticipated usage and reagent stability). Employees must abide by the policies in Section 13 of the Corporate Environmental Health and Safety Manual for "Waste Management and Pollution Prevention."

14. WASTE MANAGEMENT

14.1. Waste management practices are conducted consistent with all applicable rules and regulations. Excess reagents, samples, and method process wastes are disposed of in an accepted manner. Waste description rules and land disposal restrictions are followed. Waste disposal procedures are incorporated by reference to SOP LA-EHS-0001. The following waste streams are produced when this method is carried out.

14.2. Waste Streams Produced

14.2.1. Expired standards in cylinders are returned to the manufacturer.

14.2.2. Expired neat standards will be part of the Lab Pack waste stream. They will be identified as expired, stored under the manufacturer's recommended conditions, and then packed for disposal as outlined in SOP LA-EHS-0001.

15. REFERENCES / CROSS-REFERENCES

15.1. EPA/625/R-96/010b, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, 2nd edition, January 1999

15.1.1. Compendium Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)

15.2. TestAmerica Los Angeles QAM, current revision

15.3. TestAmerica Los Angeles SOP LA-SRA-002, Releasing and Cleaning of Sample Canisters and Cleaning, Calibration, and Setting of Flow Regulators and Vacuum Gauges, current revision

15.4. TestAmerica Corporate Environmental Health and Safety Manual CW-E-M-001, current revision

15.5. TestAmerica Los Angeles SOP LA-QAS-002, Standards Preparation, Traceability, and Verification, current revision

15.6. Advisory – Active Soil Gas Investigations, January 28, 2003 (DTSC and LARWQCB)

15.7. National Environmental Laboratory Accreditation Conference (NELAC), EPA/600/R-04/003, June 2003.

15.8. TestAmerica Los Angeles SOP LA-QAS-001, Statistical Evaluation of Quality Control Data and Development of Control Charts, current revision

15.9. TestAmerica Corporate SOP CA-Q-S-005, Calibration Curves (General), current revision

15.10. TestAmerica Corporate SOP CA-Q-S-002, Manual Integrations, current revision

15.11. TestAmerica Corporate SOP CA-Q-S-006, Detection Limits, current revision

15.12. TestAmerica Los Angeles Safety SOP LA-EHS-0001, Sample and Chemical Waste Characterization, Collection, Storage and Disposal, current revision

16. METHOD MODIFICATIONS

16.1. Nitrogen is used for dilution/pressurization purposes.

16.2. Method TO-15 describes a shelf life of thirty days for primary working standards. TestAmerica Los Angeles maintains these standards for longer periods of time according to the manufacturer's recommendation and the results of stability monitoring.

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16.3. Method TO-15 indicates that in order for the ICAL to be acceptable, all target analytes must have a %RSD <30 (with allowance for two that could be up to 40%). For routine analysis, TestAmerica Los Angeles accepts the ICAL if 90% of the target analytes have a %RSD ≤30 and if the average of the %RSD for all target analytes is ≤30%. This modification accounts for analytical issues that arise for poor performing analytes.

16.4. For the continuing calibration criteria, Method TO-15 states that the %D for each target analyte must compare to the ICAL at ±30%. For routine analysis, TestAmerica Los Angeles accepts the CCV if 90% of the target analytes have a %D ±30. This modification accounts for analytical issues that arise for poor performing analytes.

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16.5. Surrogates are not required by the method. This SOP adds surrogates to every QC and client sample to help monitor for matrix effects and method performance. However, surrogates are not reported unless requested.

16.6. Method TO-15 states that the scan time must give 10 scans per peak, not to exceed 1 second per scan. The GC/MS software is set for a sampling rate of 3, which corresponds to approximately 2 to 3 scans per second, depending on the instrument. See the GC/MS operator's manual or "help" on the software for more information about the sampling rate.

17. ATTACHMENTS

17.1. Attachment 1: Standard Analytes and Reporting Limits

17.2. Attachment 2: Add-on Analytes and Reporting Limits

17.3. Attachment 3: GC Operating Conditions

17.4. Attachment 4: BFB Acceptance Criteria

17.5. Attachment 5: Internal Standards

17.6. Attachment 6: Surrogate Standards

17.7. Attachment 7: Los Angeles Laboratory Training Certification

Attachment 1. Standard Analytes and Reporting Limits

Compound	*RL, ppbv*
Benzene	0.047
Chloroform	0.014
1,1-Dichloroethane	0.0080
1,2-Dichloroethane	0.010
cis-1,2-Dichloroethene	0.014
trans-1,2-Dichloroethene	0.014
1,1-Dichloroethene	0.010
Methylene chloride	0.12
Tetrachloroethene	0.020
1,1,1-Trichloroethane	0.020
1,1,2-Trichloroethane	0.018
Trichloroethene	0.0070
Vinyl chloride	0.0070

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Attachment 2. Add-on Analytes and Reporting Limits

Compound	*RL, ppbv*
Benzyl chloride	0.040
Bromodichloromethane	0.011
Carbon tetrachloride	0.010
Chlorobenzene	0.020
Chloroethane	0.045
Chloromethane	0.045
1,2-Dibromoethane (EDB)	0.012
1,2-Dichlorobenzene	0.045
1,3-Dichlorobenzene	0.045
1,4-Dichlorobenzene	0.045
1,2-Dichloropropane	0.020
cis-1,3-Dichloropropene	0.020
trans-1,3-Dichloropropene	0.020
1.4-Dioxane	0.10
Ethylbenzene	0.020
Styrene	0.030

Compound	*RL, ppbv*
1,1,2,2-Tetrachloroethane	0.020
Toluene	0.020
Trichlorofluoromethane	0.045
1,1,2-Trichloro-1,2,2-trifluoroethane	0.030
m-Xylene & p-Xylene	0.040
o-Xylene	0.020

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Attachment 3. GC Operating Conditions

Method file: SIM14WS

METHOD FILE LIST

Method Parameters		GC Type: 6890	Run type: SIM,GC,E1	
		Column: Cap	Splitless: Yes	
Temperature:	Inj.P	Intfc	Source	
	120	280	230	
GC		LEVEL A	LEVEL B	POST RUN
Temp 1	35	35	150	0.0
Time 1	5.5	0.0	0.0	
Rate		11	30	
Temp 2		150	200	
Time		0.0	8.0	
Oven equilibration Time.	0. 0 min			
Run time:	25.6 mins			
Scan Start time	4.20 mins			
Acquisition Mode: SIM				

Attachment 4. SIM Tuning Criteria – PFTBA

Mass	*Ion Abundance Criteria*
69	Plus or minus 0.10 amu, Peak Width 0.40 – 0.60
219	Plus or minus 0.10 amu, Peak Width 0.40 – 0.60
502	Plus or minus 0.10 amu, Peak Width 0.40 – 0.60
70	0.75 to 1.25% of 69
220	3.75 to 6.25% of 219
503	7.50 to 12.5% of 502

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Attachment 5. Internal Standards

Bromochloromethane
1,4-Difluorobenzene
Chlorobenzene-d5

Attachment 6. Surrogate Standards

1,2-Dichloroethane-d4
Toluene-d8
4-Bromofluorobenzene

Attachment 7: Los Angeles Laboratory Training Certification

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Los Angeles Laboratory
Training Certification

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Employee: _____

Department: _____

Procedure(s): _____

SOP Name/Revision: _____

Task	Trainer's Initials / Date Completed
1. Employee has read and understands the published method(s) or procedure(s).	_____/_____
2. Employee has read, understands, and agrees to follow the applicable SOP(s) without deviation.	_____/_____
3. Using the SOP as a ***step-by-step*** reference, the trainer has demonstrated the entire procedure to the Employee. *If any inaccuracies or contradictions in the SOP are discovered at this time, notify the area Supervisor and the QA Manager before proceeding further.*	_____/_____
4. Employee has performed the procedure under the direct supervision of an experienced staff member (**including standard and reagent preparation, and calibration, where applicable**).	_____/_____
5. Employee has independently performed the procedure and results have been reviewed and confirmed by experienced staff member.	_____/_____
6. Employee has demonstrated precision and accuracy by generating acceptable results on four replicates of the LCS/LCSD for all analytes of interest.	_____/_____

The employee named above has been successfully demonstrated proficiency to perform the above mentioned procedure, maintain applicable QA/QC requirements, and report results on his or her own.

Employee Signature:_____ Date:_____

Trainer Signature:_____ Date:_____

Supervisor Signature:_____ Date:_____

QA Approval:_____ Date:_____

18. REVISION HISTORY

18.1. This section has been added beginning with revision 4. Only details of the last two revisions are incorporated into this SOP. Prior revisions are documented in the QA files.

18.2. Changes to revision 5 implemented in revision 6:

18.2.1. Section 2, Summary of Method

18.2.1.1. Moved Section 2.1 to Section 1 for better organization of topic.

18.2.2. Section 3, Definitions

18.2.2.1. Added notation that “must” and “shall” in this SOP are required activities.

18.2.2.2. Expanded definition for surrogates to clarify its purpose in the analysis.

18.2.2.3. Added definition for ppbv and vacuum/pressure gauge.

18.2.2.4. Removed definition for reporting units since this was already presented in Section 11.

18.2.2.5. Amended full vacuum equivalent in inches of mercury from “30” to “-30,” for clarity.

18.2.3. Section 5 Safety, Section 13 Pollution Control, and Section 14 Waste Management

18.2.3.1. Amended sections to meet current requirements in the Corporate Health and Safety manual.

18.2.4. Section 6, Equipment and Supplies

18.2.4.1. Added GC model number used.

18.2.4.2. Added software systems used in the GC/MS instrument, under Section 6.1.

18.2.4.3. Removed references to 7-micron filters and adjustable vacuum flow regulators, under Section 6.2. These supplies are not used in sample analysis.

18.2.5. Section 7, Reagents and Standards

18.2.5.1. Removed statement re. analysis of new UHP N_2 source as method blank prior to use, under Section 7.1.1. Specific cylinders used for analysis are now tracked in a logbook.

18.2.5.2. Amended amount of DI or NANOpure water added to humidify samples and standards, from 50 µL to 100 µL.

18.2.5.3. Noted that details regarding standards preparation steps, as defined in Section 7.4.4.2, are now recorded using the LIMS instead of using logbooks.

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18.2.6. Section 9, Quality Control

18.2.6.1. Added to Section 9.2.2.4 the requirement to consult the Corporate Calibration Curve SOP prior to using calibration techniques other than the average RF technique; reason for the change must also be documented in the instrument maintenance logbook.

18.2.6.2. Updated nominal ICAL concentrations listed in Section 9.2.2.5.

18.2.6.3. Replaced use of an NCM with use of CAR to report nonconformances and associated corrective actions.

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18.2.6.4. Added the requirement to be fulfilled, under Section 9.1.1, prior to reporting ND results analyzed from an LCS/LCSD that exceeded ME limits.

18.2.6.5. Amended amount of DI or NANOpure water added to humidify the method blank, from 50 µL to 100 µL.

18.2.6.6. Removed the CCV criteria re. the averaging of the %D for all target analytes. This procedure is no longer used.

18.2.7. Section 10, Procedure

18.2.7.1. Clarified the requirement when a canister sample may or may not be pressurized prior to analysis, under Section 10.1.1.2.

18.2.7.2. Amended the amount of pressure that may be applied to trip blanks from 40 psia to 25 psia; also amended amount of DI or NANOpure water added to humidify trip blanks, from 50 µL to 100 µL; both are under Section 10.1.3.

18.2.7.3. Replaced “concentrator” with “Entech 7100 software” since it is the software that generates the instrument’s QA/QC report and not the concentrator. See Section 10.5.5.

18.2.7.4. Replaced the terms “moisture or Tenax traps” with “concentrator,” for clarity, in the discussion in Section 10.7.2 regarding major instrument maintenance.

18.2.8. Section 11, Calculations / Data Reduction

18.2.8.1. Removed reference to use of “JA” flag in Section 11.1.1.4 (renumbered as Section 11.1.2 in revision 6); generalized statement.

18.2.9. Section 12, Method Performance

18.2.9.1. Expanded MDL study requirements in Section 12.1.

18.2.9.2. Expanded DOC requirements in Section 12.2.

18.2.10. Section 17, Attachments

18.2.10.1. Added the laboratory's training certification form.

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18.3. Changes to revision 4 implemented in revision 5:

18.3.1. This SOP has been formatted using the TestAmerica Corporate QA SOP template specified in SOP CW-Q-S-002.

18.3.2. All references to "Severn Trent Laboratories, Inc." or "STL" have been changed to "TestAmerica".

18.3.3. The SOP title was revised to specify the applicability of the SOP to the analysis of indoor air samples.

18.3.4. Changes to Section 1, Scope and Application:

18.3.4.1. Section 1.1 was moved to Section 2 (Summary of Method) of revision 5.

18.3.4.2. Section 1.2 (now Section 1.1.1 in revision 5) was revised to add reference to the add-on analytes and to state that RLs are subject to change based on annual MDL studies conducted at the laboratory.

18.3.4.3. Section 1.3 (now Section 1.1.2 in revision 5) was revised for the same reason stated in Section 18.3.3.

18.3.4.4. Section 1.2 in revision 6 was added to define how modifications to the SOP, per client/project/contract, are handled.

18.3.5. Changes to Section 3, Definitions:

18.3.5.1. The definition of the batch was clarified and expanded, based on the TestAmerica Corporate QAM guidelines.

18.3.5.2. The definition of the IS, standard pressure, and standard molar volume was added.

18.3.5.3. Reference to the use of the facility QAM, for the definition of other terms used in the SOP, was added

18.3.6. Changes to Section 4, Interferences:

18.3.6.1. Section 4.2.2.1 was added to clarify that common laboratory contaminants may be present above the MDL in some screen cans.

18.3.6.2. Other possible intereferences to the analysis were added as Sections 4.4, 4.5, and 4.6 in revision 5.

18.3.7. Section 5 (Safety) was revised in order to comply with the TestAmerica Corporate safety requirements.

18.3.8. The requirement to perform a quarterly calibration of the high precision vacuum/pressure gauge used for preparing daily standards was added as Section 6.2.3.1 in revision 5.

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18.3.9. Changes to Section 7, Reagents and Standards:

18.3.9.1. The requirement to first test a UHP N_2 tank for contamination, prior to use as a diluent gas in samples and standards, was added as Section 7.1.1.1 in revision 5. This requirement was previously stated in Section 9.8.

18.3.9.2. DI or NANOpure water was added as a reagent in Section 7.1. of revision 5.

18.3.9.3. The requirement to humidify standards being prepared was added as Section 7.4.1.1 in revision 5.

18.3.9.4. Section 7.4.1.2 was added to clarify that the IS mix is not humidified.

18.3.10. Changes to Section 8, Sample Collection, Preservation, and Storage:

18.3.10.1. The section was renamed “Sample Collection, Preservation, Shipment, and Storage”, as specified in the TestAmerica Corporate QA SOP template.

18.3.10.2. A table that includes holding time references and preservation requirements was added.

18.3.11. Changes to Section 9, Quality Control:

18.3.11.1. The discussions regarding MDLs and DOCs were moved to Section 12 (Method Performance) of revision 5, as specified in the TestAmerica Corporate QA SOP template. Reference to the facility QAM was added to the discussions.

18.3.11.2. Statements regarding the annual evaluation and implementation of surrogate control limits were added as Section 9.1.3.3 in revision 5.

18.3.11.3. The pressure required for a method blank in Section 9.4 (now Section 9.1.2 in revision 5) was corrected from being 40 psig to 40 psia.

18.3.11.4. The data evaluation and reporting procedures to be followed when common laboratory contaminants have been detected in the method blank, were added as Section 9.1.2.2 in revision 5.

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18.3.11.5. Information regarding use of ME when evaluating acceptance of LCS/LCSD was added to Section 9.5 (now Section 9.1.1 in revision 5).

18.3.11.6. Statements regarding the annual evaluation and implementation of LCS/LCSD control and ME limits were added as Section 9.1.1.6 in revision 5.

18.3.11.7. The RT criterion for accepting IS in QC and client samples was added in Section 9.6.1 (now Section 9.1.4.2 in revision 5).

18.3.11.8. Sections 9.9 (Annual Gauge Calibration) and 9.10 (Process Flow Meter Calibration) were deleted. These procedures were already specified in Sample Control SOP LA-SRA-002.

18.3.12. Changes to Section 10, Calibration and Standardization:

18.3.12.1. Section 10 was deleted. The information in this section was incorporated into the QC section, as specified in the TestAmerica Corporate QA SOP template.

18.3.12.2. The requirement to generate a new ICAL annually, at a minimum, was added, as specified in the TestAmerica Corporate QAM template.

18.3.12.3. The requirement to perform corrective action for failed ICAL and the reference to consult the troubleshooting guidelines added as Section 10.6 in revision 5, were added in Section 10.2.1.1 (now Section 9.2.2.3 in revision 5). The troubleshooting guidelines were originally approved as CF2.

18.3.12.4. Details regarding use of linear regression and second-order calibration curves in Section 10.2.2 were deleted. The

TestAmerica Corporate QA SOP CA-Q-S-005 was referenced in its place.

18.3.12.5. The nominal concentration of lowest standard in the ICAL was added to the list in Section 10.2.3 (now Section 9.2.2.5 in revision 5). This addition was previously approved as CF1.

18.3.12.6. The RT acceptance criterion for evaluating IS in the ICAL in Section 10.2.4.1 (now Section 9.2.2.6.2 in revision 5) was corrected from being 0.50 minutes to being 0.33 minutes of the RT of the IS in the mid-point calibration.

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18.3.12.7. Corrective action required for failed IS in any ICAL level was added as Section 9.2.2.6.3.

18.3.12.8. Section 10.2.5 regarding RRT evaluation was deleted, as this criterion was not being used in the laboratory.

18.3.12.9. Two poor performing analytes that may be allowed to exceed the ± 30%D ICV acceptance criteria were added to Section 10.2.7 (see Sections 9.2.3.1.1 and 9.2.3.1.2 of revision 5).

18.3.12.10. Section 10.2.8, regarding analyte quantitation based on ICAL RF, was moved to Section 11.2 of revision 5.

18.3.12.11. The criteria for evaluating acceptance of individual analytes in the CCV were added to Section 10.2.9 (see Section 9.2.4.2 of revision 5).

18.3.12.12. The NELAC requirements for evaluating CCVs were added as Section 9.2.4.3 in revision 5.

18.3.12.13. The requirement to vary the concentration of the ICV and the CCV in Section 10.2.9.2 was deleted.

18.3.13. Changes to Section 11, Procedures:

18.3.13.1. The section was renumbered as Section 10 in revision 5.

18.3.13.2. The requirement to humidify trip blanks (or other field QC) prior to analysis was added to Section 11.2.4 (now Section 10.1.3 in revision 5).

18.3.13.3. Details were added to the screening procedures specified in Section 11.2.5 (see Section 10.1.4 of revision 5).

18.3.13.4. The indication of low humidity in samples was described in Section 10.2.1.1 in revision 6.

18.3.13.5. Section 11.4.3, regarding sample humidity, was deleted. The laboratory already ensures that all samples are humidified, as necessary, prior to analysis.

18.3.13.6. The requirement to record all major and minor instrument repair and maintenance in the instrument maintenance logbook was added as Section 10.7.1 in revision 5.

18.3.13.7. Section 11.6.1 was revised to add the procedure for the Standard Spectrum Tuning and the corrective actions to be performed when acceptance criteria are not met. See Section 9.2.1 of revision 5.

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18.3.13.8. Section 11.7.1 was expanded to describe the general sequence of analyses performed under this SOP. See Section 10.5.1 of revision 5.

18.3.14. Changes to Section 12, Data Interpretation:

18.3.14.1. The section was renamed “Calculations / Data Reduction”, as specified in the TestAmerica Corporate QA SOP template. The section was also renumbered as Section 11 in revision 5.

18.3.14.2. Section 12.1.1 was modified to specify that there are three, and not two, criteria that must be satisfied before a positive identification of a compound is reported. The third acceptance criteria was added as Section 11.1.1.3 in revision 5.

18.3.14.3. The definition of the “JA” flag in Section 12.1.1.3 (now Section 11.1.1.4 in revision 5) was expanded.

18.3.14.4. Discussion regarding quantitative analysis of data results was added as Section 11.2 in revision 5.

18.3.14.5. The requirement to flag positive results for an analyte that failed in a reportable ICAL or CCV was added as Section 11.2.3 in revision 5.

18.3.14.6. Discussions regarding technical data review of analytical results and completeness/PM review of final reports were added as Sections 11.8 and 11.9, respectively, in revision 5.

18.3.15. Changes to Section 13, Reporting:

18.3.15.1. This section was deleted, as specified in the TestAmerica Corporate QA SOP template.

18.3.15.2. Sub-sections 13.1, 13.3, 13.4, and 13.5 were added to Section 11 of revision 5.

18.3.15.3. Section 13.2, regarding annual MDL studies, was deleted since this was already discussed in Section 12 of revision 5.

18.3.16. Changes to Section 15, Pollution Prevention and Waste Management:

18.3.16.1. This section was divided into two sections (Section 13 - Pollution Control and Section 14 - Waste Management in revision 5), as specified in the TestAmerica Corporate QA SOP template. The specific discussions in each section were also revised according to the referenced template.

18.3.16.2. Section 15.2 (now Section 14.2 in revision 6) was retained but without the discussion regarding disposal of Tedlar bags, since Tedlar bags are not used under this SOP.

18.3.17. Changes to Section 16, References:

18.3.17.1. The section was renamed “References / Cross-References”, as specified in the TestAmerica Corporate QA SOP template. The section was also renumbered in revision 6 as Section 15.

18.3.17.2. Additional SOP references were added.

18.3.17.3. Section 16.4 (Deviations from Method) was made a stand-alone section on its own and was renamed “Method Modifications”, as specified in the TestAmerica Corporate QA SOP template. The section was also renumbered as Section 16 in revision 5.

18.3.18. Changes to Section 17, Miscellaneous (Tables, Appendices, etc.):

18.3.18.1. The section was renamed “Attachments”, as specified in the TestAmerica Corporate QA SOP template.

18.3.18.2. The %Rec and RPD limits specified in Table 1 were deleted. Revision 5 referenced that the LCS/LCSD QC limits may be found in the LIMS.

18.3.18.3. The surrogate standards were deleted from the target analyte list in Table 1. The surrogate standards were added into a separate attachment in revision 5 (see Attachment 6).

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18.3.18.4. Attachment 2 (add-ons and corresponding RLs) was added to revision 5.

18.3.18.5. Table 3 (SIM Key Ions) was deleted. If needed, the key ions may be obtained from the GC/MS method stored in the instrument data system.

18.3.19. Other sections were modified for clerical corrections.

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Title: **DETERMINATION of VOLATILE ORGANICS in NON-AMBIENT WHOLE AIR SAMPLES using GC/MS-SCAN MODE**

[Methods EPA TO-14A and EPA TO-15]

Approvals (Signature/Date):

4-2-8 Dave Kammerer — Date Air Lab Department Manager	04/02/08 William Nash — Date Environmental Health & Safety Coordinator
4-3-2008 Maria Friedman — Date Quality Assurance Manager	4/3/08 Elizabeth Winger — Date Laboratory Director

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TABLE OF CONTENTS

UNCONTROLLED

1. SCOPE AND APPLICATION 3
2. SUMMARY OF METHOD 3
3. DEFINITIONS 3
4. INTERFERENCES 5
5. SAFETY 6
6. EQUIPMENT AND SUPPLIES 9
7. REAGENTS AND STANDARDS 10
8. SAMPLE COLLECTION, PRESERVATION, SHIPMENT, AND STORAGE 11
9. QUALITY CONTROL 12
10. PROCEDURE 22
11. CALCULATIONS / DATA REDUCTION 28
12. METHOD PERFORMANCE 33
13. POLLUTION CONTROL 34
14. WASTE MANAGEMENT 34
15. REFERENCES / CROSS-REFERENCES 34
16. METHOD MODIFICATIONS 35
17. ATTACHMENTS 37
18. REVISION HISTORY 45

UNCONTROLLED

1. SCOPE AND APPLICATION

1.1. This standard operating procedure (SOP) is applicable to the analysis of volatile organic compounds (VOCs), having molecular weight in the general range of 40-200 g/mol and vapor pressure greater than 0.10 Torr at 25°C and 760 mm Hg in ambient air, by gas chromatography/mass spectroscopy (GC/MS) technique. This SOP is based on the EPA TO-14A/TO-15 method specifications and is applicable to various air matrices that include soil gas, landfill gas, and vapor treatment gases.

1.1.1. For low-level EPA TO-14A/TO-15 analysis that is applicable to indoor and ambient air samples, refer to SOP LA-MSA-015.

1.2. Analytes, Matrix, and Reporting Limits (RLs)

1.2.1. Target analytes and RLs are listed in Attachments 1 and 2. Note that RLs are subject to change based on annual method detection limit (MDL) studies.

1.2.1.1. The target analytes in Attachment 2 are not routinely analyzed and are termed “add-ons”. They are only analyzed and reported when requested by a client/project/contract.

1.2.2. Applicable matrices – non-ambient air (e.g., soil gas, landfill gas, vapor treatment systems gas)

1.3. On occasion, clients may request modifications to this SOP. These modifications are handled following the procedures outlined in section 7 of the facility Quality Assurance Manual (QAM).

2. SUMMARY OF METHOD

2.1. An air sample and internal standards (IS) are metered through a mass flow controller and concentrated onto a cryogenically cooled or adsorbent trap. After the IS and an appropriate amount of sample have been trapped, a valve is switched and the trap is heated to purge the trap’s contents onto the GC column. The target compounds are analyzed with a mass selective detector operated in the scan mode.

3. DEFINITIONS

3.1. Batch – A batch is defined as a set of up to 20 client samples (reportable or not) of the same matrix processed using the same procedures and the same lot(s) of reagents within the same time period. A batch must contain a Laboratory Control Sample (LCS), LCS duplicate (LCSD), and a method blank (MB), but they do not count towards the maximum 20 samples in a batch.

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3.1.1. Rerun of the same client sample is counted as part of the 20 in a batch (i.e., a client sample analyzed twice in the same batch must be counted as two client samples).

3.1.2. Field quality control (QC) samples (e.g., trip blanks, equipment blanks, and field duplicates) count as client samples; therefore, they add to the batch count.

3.1.3. The batch must be analyzed sequentially using the same instrument and instrument configuration within the same calibration event. That is, the same calibration curve, calibration factors, or response factors must be in effect throughout the analysis.

3.2. Laboratory Control Samples – LCSs are laboratory-generated samples used to monitor the laboratory's day-to-day performance. The LCS/LCSD is used to monitor the accuracy of the analytical process, independent of matrix effects. Ongoing monitoring of the LCS/LCSD results provides evidence that the laboratory is performing the method within accepted QC guidelines for accuracy and precision. The LCS/LCSD is prepared from a source independent of the calibration standards.

3.3. Method Blank – The MB is used to identify any background interference or contamination of the analytical system that may lead to the reporting of elevated concentration levels or false positive data. The MB, consisting of all reagents added to the samples, is analyzed with each batch and is processed in the same manner as samples.

3.4. Internal Standard – The IS is a known amount of standard that is added to a test portion of a sample and carried through the entire measurement process as a reference for evaluating and controlling precision and bias of the applied analytical test method.

3.5. Surrogates – Surrogates are organic compounds which are similar to the target analytes in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples. Although not required by the method, each client and QC sample is spiked with surrogate standards via the analytical trap. Surrogate spike recoveries may be evaluated against project-specific requirements by determining whether the concentration (measured as percent recovery) falls within the required limits.

3.6. Standard pressure is defined as 1.0 atmosphere, 14.6 pounds per square inch absolute (psia), 0 inch of mercury, and 0 pounds per square inch gauge (psig), based on laboratory elevation and average barometric pressure.

Note: Full vacuum (0 psia) = 30 inches of mercury vacuum.

3.7. Standard molar volume is defined as 24.45 L/mol at room temperature of 25°C and standard pressure of 1 atmosphere.

3.8. Passivated canister – Commonly referred to as SUMMA canister, SilcoCan, or T.O.-Can in 1.0-liter, 1.8-liter, 6-liter, or 15-liter volumes.

3.8.1. SUMMA – A nickel electropolish passivation process in which the interior of a stainless steel sample container is de-activated and rendered inert to most volatile organic compounds (VOCs).

3.8.2. SilcoCan - A sampling canister manufactured by Restek Corporation using the Restek Silcosteel® process to coat the interior of the canister with fused silica, rendering it inactive to most VOCs.

3.8.3. T.O.-Can – A spherical stainless steel container (which is the equivalent of a SUMMA canister) that is manufactured by Restek using a proprietary electropolishing process and extensively cleaned using an ultrasonic method that ensures a high-quality, passivated surface that maintains the stability of VOCs during storage.

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3.9. Tedlar – An inert plastic film used to manufacture sample bags for collecting VOCs. Use of Tedlar bags as sample collection medium constitutes a modification to the method (see section 16.7).

3.10. Vacuum Flow Regulator (VFR) – A device which, when connected to a passivated canister, regulates the flow of sample into the canister so that a timed, representative sample can be obtained (also called a composite sample), as opposed to an unregulated, instantaneous sample (grab sample).

3.11. Particulate Filter – A cylindrical stainless steel fitting containing a fritted metal disc, which is connected to the valve of a passivated canister or VFR, to prevent particulate matter from entering and damaging the canister or VFR.

3.12. Pressure Gauge – Device used to measure the vacuum or pressure in a passivated canister. Units of measure range from 30 to 0 inches of mercury (for vacuum) to 0 to 30 psig (for positive pressure). All pressure units are converted to psia.

3.13. Refer to Appendix 5 of the facility QAM for all other definition of terms used in this SOP.

4. INTERFERENCES

4.1. Gas regulators are cleaned by the manufacturer using Freon 113, a target analyte in this SOP. Before using ultra high purity nitrogen (UHP N_2), hydrocarbon-free air, IS mix, or target compound standard mix cylinders, each regulator should be purged with the appropriate gas.

4.2. Contamination may occur in the sampling system if canisters are not properly cleaned prior to use. Canisters should not be used for the collection of samples until a batch blank analysis indicates that no target compounds are present above the RL, or a level previously agreed upon between the laboratory and the

client. Further information regarding the cleaning and certification of canisters may be found in SOP LA-SRA-002. All other sampling equipment including pumps, flow controllers, and filters must be thoroughly cleaned to ensure that the filling apparatus will not contaminate samples.

4.2.1. Canisters may also be individually certified clean as required by and at an additional cost to the client.

4.2.2. Canisters will be certified clean down to the MDL of the target analytes of interest if sample results need to be evaluated down to those limits. However, the laboratory must be provided advanced notification of the requirement. Canister order must be placed with at least 7-day advanced notice or certification requirement may not be guaranteed.

4.2.2.1. Common laboratory contaminants like acetone and methylene chloride may be present above the MDL.

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4.3. Carry-over may occur when samples with high levels of contaminants are analyzed. The sample immediately following a high-level sample should be re-analyzed if carry-over is suspected.

4.4. Tedlar bags may contain low levels of target analytes.

4.5. Only compounds having both similar mass spectrum and GC retention time (RT) would be expected to interfere in the method. This situation most commonly occurs with structural isomers.

4.6. Large concentrations of water, methane, or carbon dioxide may limit the size of the sample aliquot that can be effectively cryo-trapped. This may elevate the RLs for samples of this type.

4.7. Matrix interferences may be caused by non-target contaminants that are present in the sample. The extent of matrix interference will vary considerably from source to source depending upon the nature and diversity of the site being sampled.

5. SAFETY

5.1. Employees must abide by the policies and procedures in the Corporate Safety Manual, Radiation Safety Manual, and this document.

5.2. This procedure may involve hazardous material, operations, and equipment. This SOP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of the method to follow appropriate safety, waste disposal, and health practices under the assumption that all samples and reagents are potentially hazardous. Safety glasses, gloves, lab coats and closed-toe, nonabsorbent shoes are a minimum.

5.3. Specific Safety Concerns or Requirements

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5.3.1. Gas pressurized equipment is used in this procedure. Be sure all valves and gauges are operating properly and that none of the equipment is over-pressurized.

5.3.2. Sampling canisters should never be pressurized over 40 psig.

5.3.3. Tedlar bags should not be pressurized, as seam splitting will result.

5.3.4. Pressurized gas cylinders must be securely retained. The use of a face shield is recommended when changing regulators.

5.3.5. When pressurizing canisters or changing cylinders, safety glasses must be worn. If pressure from a canister or cylinder must be released during this process, a face shield must also be worn.

5.3.6. Temperature appropriate gloves must be worn when working with hot or cold items.

5.3.7. Latex and vinyl gloves provide no protection against the organic solvents used in this method. Nitrile or similar gloves must be used.

5.3.8. The effluents from the sample splitters for the GC and the roughing pumps for the MS must be vented to a fume hood or at a minimum, must pass through a charcoal filter.

5.3.9. Both the GC and the MS contain elevated temperature zones. These zones must be cooled prior to an analyst or technician working on the unit.

5.3.10. The MS is under deep vacuum and must be brought to atmospheric pressure before working on the source.

5.3.11. Due to high voltage risk, power to the GC and/or MS must be turned off or disconnected before work can be done on the instrument.

5.4. Primary Materials Used

5.4.1. The following is a list of the materials used in this method, which have a serious or significant hazard rating. **NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the MSDS for each of the materials listed in the table.** A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the MSDS for each material before using it for the first time or when there are major changes to the MSDS.

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Material (1)	Hazards	OSHA Exposure Limit (2)	Signs and symptoms of exposure/Unusual Hazards
Methylene Chloride	Carcinogen Irritant	25 ppm-TWA 125 ppm-STEL	Causes irritation to respiratory tract. Has a strong narcotic effect with symptoms of mental confusion, light-headedness, fatigue, nausea, vomiting and headache. Causes irritation, redness and pain to the skin and eyes. Prolonged contact can cause burns. Liquid degreases the skin. May be absorbed through skin.
Methanol	Flammable Poison Irritant	200 ppm-TWA	A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Symptoms of overexposure may include headache, drowsiness and dizziness. Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure. Irritant to the eyes.
Acetone	Flammable	1000 ppm-TWA	Inhalation of vapors irritates the respiratory tract. May cause coughing, dizziness, dullness, and headache.
Hexane	Flammable Irritant	500 ppm-TWA	Inhalation of vapors irritates the respiratory tract. Vapors may cause irritation to the skin and eyes. Overexposure may cause lightheadedness, nausea, headache, and blurred vision.
Benzene	Flammable Poison Carcinogenic	1 ppm TWA	Toxic by ingestion, inhalation and absorption. Causes headache, nausea, dizziness, weakness and breathing difficulties. This material is irritating on contact with the skin and eyes and may cause permanent eye damage.
Chloroform	Carcinogen Irritant	50 ppm Ceiling	Acts as a relatively potent anesthetic. Irritates respiratory tract and causes central nervous system effects, including headache, drowsiness, and dizziness. Causes skin irritation resulting in redness and pain and may be absorbed. Removes natural oils. Vapors cause pain and irritation to eyes. Splashes may cause severe irritation and possible eye damage.

Material (1)	Hazards	OSHA Exposure Limit (2)	Signs and symptoms of exposure/Unusual Hazards
Carbon Tetrachloride	Carcinogenic Poison	10ppm – TWA 200ppm STEL	Toxic by ingestion, inhalation and absorption. Causes headache, nausea, dizziness and narcosis. Contact with skin or eyes may cause irritation. Consumption of alcohol may increase toxic effects.
1 – Always add acid to water to prevent violent reactions.			
2 – Exposure limit refers to the OSHA regulatory exposure limit.			

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6. EQUIPMENT AND SUPPLIES

6.1. Instrumentation

6.1.1. Gas chromatograph capable of sub-ambient temperature programming for the oven and with the jet separator option (Hewlett Packard 5890)

6.1.2. Mass-selective detector equipped with computer and appropriate software (Hewlett Packard 5970B with Chemstation data system and Target 4.0 Report Generation Software)

6.1.3. Canister autosampler with adsorbent trap (Tekmar AUTOCan)

6.2. Supplies

6.2.1. Chromatographic grade stainless steel or nickel tubing and stainless steel plumbing fittings

6.2.2. Chromatographic column DB-624 0.53 ID, or DB-VRX 0.45ID, 75 m length (J&W Scientific or equivalent)

6.2.3. Stainless steel vacuum/pressure gauge capable of measuring from 30 inches of mercury to 40 psig (Span Instruments or equivalent)

6.2.4. High precision vacuum/pressure gauge or process meter for preparing daily standards (Cole-Parmer Pressure Transmitter No. P-07356-12 with Cole-Parmer Process Meter No. 94785-00, or equivalent)

6.2.4.1. The vacuum/pressure gauge must be calibrated quarterly, at a minimum, against the master gauge. See SOP LA-SRA-002.

6.2.5. Pressure regulators for carrier gas and standards – 2-stage, stainless steel diaphragm (single stage acceptable for standards)

6.2.6. Passivated canisters (SUMMA, Silco, or TO-can) – 1.0-L, 6-L, 15-L (S.I.S., Restek, or equivalent)

6.2.7. Tedlar bag, 3-L or 1-L (SKC, ESS, or equivalent)

6.2.8. 7-micron filters (Nupro), or equivalent

6.2.9. Adjustable vacuum flow regulators (Valin or equivalent)

7. REAGENTS AND STANDARDS

7.1. Reagents

7.1.1. UHP N_2 and zero-grade air – used for MBs and preparing dilutions of samples and standards.

7.1.1.1. Before a new UHP N_2 or zero-grade cylinder is used, it must first be analyzed as an MB and pass all the criteria specified in section 9.1.2.

7.1.2. UHP helium – used as the gas chromatograph carrier gas

7.1.3. Liquid N_2

7.1.4. De-ionized (DI) or nano-pure water

7.2. Standards

7.2.1. Gas calibration stock standards, at a nominal concentration of 1 ppmv, containing the target compounds are purchased from commercial sources or prepared from neat in passivated canisters. Suppliers are required to provide certification of the analyte concentrations.

7.2.2. Add-on standards, either as neat liquid or as gaseous mix

7.2.3. IS and surrogate stock standard mix at 250 ppbv. See Attachments 8 and 9, respectively.

7.2.3.1. The surrogate mix is also used to tune the mass spectrometer.

7.2.4. Expiration dates for standards and reagents are based on vendor specification. If no vendor expiration date is assigned, the laboratory assigns an expiration date of two years from the date of receipt. Refer to SOP LA-QAS-002 for further information on standards and

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expiration dates. Expiration dates must be documented on the gas cylinders.

7.3. Standard Preparation

7.3.1. Static dilutions of the stock standard gas mixtures are made in 6- or 15-L passivated canisters to create working standards. A high precision vacuum gauge is flushed with UHP N_2 and attached to the top valve of a clean, evacuated canister, and the absolute pressure is recorded.

7.3.1.1. DI or nano-pure water (50 μL) is added to calibration standards prior to mixing.

7.3.1.2. The IS mix does not contain water.

7.3.2. Depending on the concentration of each stock standard gas mixture, a particular pressure of each is added to the canister to achieve the desired concentration in the working standard.

7.3.3. Care should be taken to flush each regulator and transfer line with standard prior to transfer to the canister. After all of the stock standard mixes are added, the standard canister is pressurized with UHP N_2 to achieve the appropriate concentration.

7.3.4. The working standard at a nominal concentration of 50 ppbv is created by adding 1.5 psia of the 1 ppmv stock standard mix and adding UHP N_2 to the canister to achieve a final pressure of 30 psia.

7.3.5. The working standard at a nominal concentration of 200 ppbv is created by adding 6 psia of the 1 ppmv stock standard mix and adding UHP N_2 to the canister to achieve a final pressure of 30 psia.

7.3.6. Other preparation techniques may be used to obtain the desired standard concentration, provided these techniques do not compromise the integrity of the standards used, and that the details of the preparation are properly documented in the standards preparation logbooks.

7.3.7. Detailed standard preparation steps are documented in logbooks NSL (Preparation of Gas Standards from Neat Liquids) and MSL (Preparation of Gas Standards from Gas Mixtures).

8. SAMPLE COLLECTION, PRESERVATION, SHIPMENT, AND STORAGE

8.1. Sample container, preservation techniques, and holding times may vary and are dependent on sample matrix, method of choice, regulatory compliance, and/or specific contract or client requests. Listed below are the holding times and the references that include preservation requirements.

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Sample Container	Minimum Sample Size	Preservation	Holding Time	Reference
Passivated Canister	2000 mL	None	30 days	EPA/625/R-96/010b, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air
Passivated Canister	2000 mL	None	72 hours	Advisory – Active Soil Gas Investigations, January 28, 2003 (DTSC and LARWQCB)
Tedlar Bag	500 mL	None	3 days	N/A

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8.2. Canisters used for sample collection must be certified clean (see section 4.2). A 7-micron filter should be placed on the inlet of the canister to protect the valve from particulates. Canisters should never be pressurized over 40 psig.

8.3. The absolute pressure of the canister should be recorded before and after sample collection. See section 10.1 for sample preparation.

8.4. Samples should be protected from extreme temperatures.

8.5. Tedlar bag samples should be protected from sunlight.

9. QUALITY CONTROL

9.1. Sample QC – The following QC samples are prepared with each batch of samples:

9.1.1. Laboratory Control Sample/Laboratory Control Sample Duplicate – For each batch, an LCS/LCSD pair must be analyzed. The LCS/LCSD is analyzed after the calibration standards and before the MB and client samples. The LCS/LCSD is spiked with the target analytes in Attachments 1 and 2, from which a sub-list may be reported, as defined by the National Environmental Laboratory Accreditation Conference (NELAC) 2003 Standards (see below). Client-specific requirements may require additional analytes or even the full list of analytes to be spiked into the LCS/LCSD.

9.1.1.1. Requirements on LCS/LCSD composition (NELAC Quality Systems, June 5, 2003, Appendix D, D.1.1.2.1c, page 250 of 324) – The following criteria shall be used for determining

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the minimum number of analytes to be spiked into the LCS/LCSD. However, the laboratory shall ensure that all targeted components are included in the spike mixture over a two-year period:

9.1.1.1.1. For projects that include 1 – 10 targets, spike all analytes.

9.1.1.1.2. For projects that include 11 – 20 targets, spike at least 10 or 80%, whichever is greater.

9.1.1.1.3. For projects with more than 20 targets, spike at least 16 analytes.

9.1.1.2. Requirements on LCS/LCSD acceptance (NELAC Quality Systems, June 5, 2003, Appendix D, D.1.1.2.1e, pages 251 and 252 of 324) – The number of allowable exceedences is based on the number of analytes in the LCS/LCSD. Upper and lower marginal exceedence (ME) limit is established for each analyte to determine when corrective action is necessary. ME is defined as being beyond the LCS/LCSD control limit but within the ME limit:

9.1.1.2.1. 71 – 90 analytes in LCS/LCSD, 4 analytes allowed in the ME limits

9.1.1.2.2. 51 – 70 analytes in LCS/LCSD, 3 analytes allowed in the ME limits

9.1.1.2.3. 31 – 50 analytes in LCS/LCSD, 2 analytes allowed in the ME limits

9.1.1.2.4. 11 – 30 analytes in LCS/LCSD, 1 analyte allowed in the ME limits

9.1.1.2.5. <11 analytes in LCS/LCSD, no analyte allowed in the ME limits

9.1.1.3. If any analyte is outside established LCS/LCSD control limits but within established ME limits, no further corrective action is necessary but failed analytes in the LCS/LCSD must be qualified and a nonconformance memo (NCM) must be generated in order to determine the randomness of the exceedence (NELAC Quality Systems, June 5, 2003, Appendix D, D.1.1.2.1e, page 252 of 324).

9.1.1.3.1. All failed LCS/LCSD must be documented in an NCM because if the same analyte exceeds the LCS/LCSD control limits repeatedly, it is an

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indication of a systematic problem that must be corrected immediately. The corrective action performed must also be documented in the NCM.

9.1.1.3.2. If the LCS/LCSD is deemed acceptable based on the criteria specified in section 9.1.1.2 and if any recoveries are above the upper control limit, and the same analytes were not detected (ND) in all of the client samples, then the NCM must state that the positive bias is not expected to impact ND results.

9.1.1.3.3. Exceedence outside the ME limits require corrective action, regardless of whether the associated result is positive or ND. See section 9.1.1.4.

9.1.1.4. If more analytes exceed the LCS/LCSD control limits than is allowed (as specified in section 9.1.1.3), or if <u>any one</u> analyte exceeds the ME limits, then the LCS/LCSD fails and corrective action is required. Corrective action will normally be re-analysis of the batch, as follows:

9.1.1.4.1. Evaluate the analytical run for errors and anomalies. Re-analyze the LCS.

9.1.1.4.2. Check the standard for appropriate pressure. Low pressure will often cause failure. Re-pressurize or prepare a new standard and re-analyze the LCS/LCSD.

9.1.1.4.3. Evaluate the instrument status and perform maintenance. Re-analyze the continuing calibration verification (CCV) standard and LCS/LCSD, or recalibrate.

9.1.1.5. If the batch is not re-analyzed, the reasons for accepting the batch (e.g., insufficient client sample volume for re-analysis) must be clearly stated in the report narrative.

9.1.1.6. Current LCS/LCSD control limits are stored in the LIMS. Control and ME limits are subject to change based on annual evaluation of LCS/LCSD control charts. See SOP LA-QAS-001 for determining control and ME limits. The QA Manager, or designee, notifies the laboratory, via email or other means, of updates to both the control and ME limits.

9.1.2. Method Blank – For each batch, an acceptable MB must be analyzed. The MB is analyzed after the calibration standards and LCS/LCSD and prior to client samples. The MB is a 6-L "screen can" (see SOP LA-SRA-002) humidified with 50 µL of DI or nano-pure water, pressurized to 40 psia with UHP N_2, and then analyzed with each batch.

9.1.2.1. The MB must not contain any analyte of interest above the RL (except common laboratory contaminants, see section 9.1.2.2). Otherwise, the MB is further evaluated and corrective actions are performed as stated below:

9.1.2.1.1. Re-analyze the MB once to determine if an anomaly occurred during sample analysis. If the re-analysis is acceptable, then the MB can be considered in control.

9.1.2.1.2. If there are no results greater than the RL in the samples or if the results in the samples are greater than 10X the MB level, the data may be reported with qualifiers. In this case, the elevated MB result is not believed to impact the data quality. The anomaly must be reported in an NCM and discussed in the report narrative.

9.1.2.1.3. If there are results greater than the RL in the samples and if these results are lesser than 10X the MB level, the samples must be re-prepared and re-analyzed.

9.1.2.1.4. If re-analysis is not possible due to limited sample volume or other constraints, the MB is reported and all associated samples are flagged. The anomaly must be reported in an NCM and discussed in the report narrative.

9.1.2.2. If the analyte detected in the MB is a common laboratory contaminant (methylene chloride, acetone, 2-butanone), the data may be reported with qualifiers if the concentration of the analyte is less than five times the RL. Otherwise, corrective actions, as stated in section 9.1.2.1, must be performed. The anomaly must be reported in an NCM and discussed in the report narrative.

9.1.2.3. If surrogates are a project-specific requirement, then the MB must have acceptable surrogate recoveries. If surrogate recoveries are unacceptable, the data must be evaluated to determine if the MB has served the purpose of demonstrating that the analysis is free of contamination. If surrogate recoveries are low and there are reportable

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analytes in the associated samples, re-analysis of the MB and affected samples is required.

9.1.3. Surrogate Standards – Surrogates are not a method requirement. The laboratory routinely adds surrogates to all quality control (QC) and client samples via the analytical trap and will report these results only if defined in a project/contract or at client's request. The surrogate compounds used in this SOP are listed in Attachment 9.

9.1.3.1. Surrogate recoveries in client and QC samples may be assessed to ensure that recoveries are within laboratory control limits. If any surrogate is outside these limits and if surrogates are a project-specific requirement, the following corrective actions must be performed:

9.1.3.1.1. Check all calculations for error.

9.1.3.1.2. Ensure that instrument performance is acceptable.

9.1.3.1.3. Recalculate data and/or re-analyze if either of the above checks reveal a problem.

9.1.3.1.4. Re-analyze the sample or flag the data as "Estimated Concentration" if neither of the above resolves the problem.

9.1.3.2. It is only necessary to re-analyze a sample once to demonstrate that poor surrogate recovery is due to matrix effect, unless the analyst has reason to believe that the repeated out of control results are due to problems other than matrix effect.

9.1.3.3. Surrogate control limits are stored in the LIMS and are subject to change based on annual evaluation of surrogate control charts. See SOP LA-QAS-001 for determining surrogate control limits. The QA Manager, or designee, notifies the laboratory, via email or other means, of updates to the control limits.

9.1.4. Internal standard - IS compounds are added to each calibration standard, LCS/LCSD, MB, and client sample via the analytical trap. IS compounds are monitored for each shift by comparing the IS areas and RTs in each client and QC sample against those of the associated CCV standard. The IS compounds used in this SOP are listed in Attachment 8.

9.1.4.1. IS evaluation criteria for the ICAL may be found in section 9.2.2.6.

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9.1.4.2. For all other QC and client sample, IS areas are considered acceptable if they fall between 60% and 140% (for TO-15) or –50% and 200% (for TO-14A) of the CCV IS areas. The RTs are considered acceptable if they fall within ±20 seconds (0.33 minutes) of the IS RT of the associated CCV.

9.1.4.3. Any QC or client sample exceeding the acceptance criteria listed in sections 9.1.4.1 and 9.1.4.2 must be re-analyzed. If the IS area fails upon re-analysis, the failure must be documented in an NCM and discussed in the report narrative. All other corrective actions performed must also be documented in the NCM.

9.1.5. Sample Duplicate Analysis

9.1.5.1. A client sample duplicate is analyzed and reported with the batch, only if requested.

9.1.5.2. The acceptance criterion for the duplicate analysis is a relative percent difference (RPD) ≤25 for target analytes detected >5X the RL. No criterion is established for duplicate results <5X the RL. The calculation is provided in section 11.4.

9.2. Instrument QC

9.2.1. Initial/Daily Tuning of the Instrument

9.2.1.1. After a successful autotune per manufacturer's recommendations, each instrument is manually tuned using perfluorotributylamine (PFTBA) so that mass-to-charge ratio (m/z) 69 is 100%, m/z 131 is approximately 34%, and m/z 213 is approximately 36%. The width and axis parameters are set using the routines in the software. This initial tune should remain stable for extended periods of time, and retuning with PFTBA should not be necessary every day.

9.2.1.2. At the beginning of each 24-hour shift, prior to any analytical runs, it must be verified that the GC/MS system meets acceptable tune performance criteria. This is done through the analysis of 50 ng of 4-bromofluorobenzene (BFB), which acceptance criteria are listed in Attachment 5 (for TO-14A) or in Attachment 6 (for TO-15 Med-level).

9.2.1.2.1. With the AUTOCan tune verification, trap 28 mL of the IS canister containing BFB. Use the BFB.mtc method on the AUTOCan for a 30 mL/min flow rate.

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9.2.1.2.2. If any of the key ions fail the abundance criteria listed in the attachments, the system is considered out of tune and any subsequent sample/standard analysis should be considered unacceptable. The BFB is re-analyzed and re-evaluated. If the BFB continues to fail, the GC/MS system is evaluated. Consult section 10.6 for troubleshooting guidelines.

9.2.1.2.3. Adjustments to the mass axis calibration, the electron multiplier voltage, or other tune parameters may be required. All parameter changes must be recorded in the instrument maintenance logbook.

9.2.1.3. BFB tunes may be analyzed more frequently depending on documented client requirements.

9.2.2. Initial Calibration (ICAL)

9.2.2.1. Instruments are calibrated at initial setup and as needed thereafter, and at least annually.

9.2.2.2. An ICAL curve consisting of a minimum of five points is analyzed to determine the linear working range of the analytical system for each compound. An average response factor (RF), or sometimes called the relative response factor (RRF), and the percent relative standard deviation (%RSD) are calculated for each target analyte using the equations in section 11.4.

9.2.2.3. The ICAL is considered acceptable if at least 90% of the target analytes have a %RSD $\leq$ 30 and the average of the %RSDs for all target analytes, including the surrogates, is $\leq$ 30. If the ICAL fails acceptance criteria, corrective actions must be performed and a new ICAL generated. Consult section 10.6 for troubleshooting guidelines.

9.2.2.3.1. Client- or project-specific requirements may dictate that the laboratory adhere to the following TO-15 criteria: The %RSD for the RFs for <u>all</u> target analytes in the ICAL must be $\leq$ 30, with up to two target analytes that may have a %RSD of $\leq$ 40.

9.2.2.4. Linear calibration using least squares regression or non-linear calibration (second-order curves) may be used with the appropriate number of calibration points. Details

regarding their use and the calculations involved may be found in TestAmerica Corporate QA SOP CA-Q-S-005.

9.2.2.5. The nominal concentrations of the ICAL standards are typically 2, 5, 10, 50, 100, and 500 ppbv, but these may vary depending on the certified mix used to prepare the standards or the volume trapped. The low standard must be at or below the RL. The standards are analyzed by varying the trapped volume of the two working standards from the default volume of 500 mL. For example, the 2, 5, and 50 ppbv standards are analyzed by trapping 20, 50, and 500 mL, respectively, of a 50 ppbv working standard.

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9.2.2.6. Internal Standards in the ICAL

9.2.2.6.1. The IS response at each calibration level must fall between 60% and 140% (for TO-15 Med-level) or –50% and 200% (for TO-14A) of the IS response in the mid-point calibration standard.

9.2.2.6.2. The RT shift for each of the IS at each calibration level must be within ± 20 seconds (0.33 minutes) of the RT of the IS in the mid-point calibration standard.

9.2.2.6.3. Any calibration level exceeding the above acceptance criteria must be re-analyzed.

9.2.2.7. The analyst may elect to drop points from the calibration curve to improve subsequent quantitation. The following rules apply. However, for further guidance, see the current revision of TestAmerica Corporate Policy CA-T-P-002, Selection of Calibration Points.

9.2.2.7.1. Points below the RL may be dropped as long as there is a point remaining at or below the RL.

9.2.2.7.2. High points may be dropped but at the expense of decreasing the linear range.

9.2.2.7.3. Calibration points in between the low and high ends may NOT be dropped.

9.2.3. Initial Calibration Verification (ICV)

9.2.3.1. Each new ICAL must be verified using a second-source standard. Since the regulatory agencies have not provided guidance on second-source verification, the following acceptance criteria are used: ± 30 percent difference (%D)

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for target analytes, with allowance for any four of the poor performers identified below to be at ± 55 %D. The %D calculation is provided in section 11.4:

9.2.3.1.1. 1,1-Dichloropropene

9.2.3.1.2. 1,2,3-Trichloropropane

9.2.3.1.3. 1,2,4-Trichlorobenzene

9.2.3.1.4. 1,4-Dioxane

9.2.3.1.5. trans-1,4-Dichloro-2-butene

9.2.3.1.6. 2-Butanone

9.2.3.1.7. 2-Hexanone

9.2.3.1.8. 2-Propanol

9.2.3.1.9. 4-Methyl-2-pentanone

9.2.3.1.10. Acetone

9.2.3.1.11. Acetonitrile

9.2.3.1.12. Acrolein

9.2.3.1.13. Acrylonitrile

9.2.3.1.14. Benzyl chloride

9.2.3.1.15. Ethanol

9.2.3.1.16. Hexachlorobutadiene

9.2.3.1.17. Iodomethane

9.2.3.1.18. Methyl-t-butyl ether

9.2.3.1.19. Naphthalene

9.2.3.1.20. Propene

9.2.3.1.21. Tetrahydrofuran

9.2.3.1.22. Vinyl acetate

9.2.3.2. The limits specified in section 9.2.3.1 are provided as guidance. If these criteria are not met, the following

corrective actions must be performed. Consult section 10.6 for troubleshooting guidelines:

9.2.3.2.1. Rerun the second source check standard.

9.2.3.2.2. Re-prepare or acquire a new standard.

9.2.3.2.3. Evaluate instrument conditions.

9.2.3.2.4. Regenerate a new ICAL.

9.2.3.3. Due to the limited availability of second-source manufacturers for the air standard mixes and some neat compounds, the following options may be considered as second-source:

9.2.3.3.1. Use of a certified different lot from the same manufacturer.

9.2.3.3.2. Preparation of an independent standard using the same source as the first standard but by another analyst. This procedure is particularly applied when the air standard was prepared from a neat liquid.

9.2.4. Continuing Calibration Verification

9.2.4.1. Unless the QC batch follows a new ICAL and an ICV, for every 24 hours of operation, a CCV standard is analyzed to verify the ICAL average RF. The %D of the CCV RF from the ICAL average RF is calculated for each target analyte. The %D calculation is provided in section 11.4.

9.2.4.2. The CCV is considered acceptable if at least 90% of the target analytes have a %D ± 30 and the average of the %D for all target analytes, including the surrogates, is ± 30. If the CCV fails acceptance criteria, corrective actions must be performed. Consult section 10.6 for troubleshooting guidelines.

9.2.4.3. The following NELAC requirements (NELAC Quality Systems, June 5, 2003, 5.5.5.10e, page 217 of 324) apply only when the acceptance criteria in section 9.2.4.2 are not met. If they are met and specific analytes are outside the ± 30 %D criteria, no further corrective action is required, but a hit reported in the analytes that are outside the ± 30 %D criteria must be flagged (see section 11.2.3).

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9.2.4.3.1. If routine corrective action procedures fail to produce a second consecutive (immediate) CCV within acceptance criteria, then either the laboratory has to demonstrate acceptable performance after corrective action with two consecutive CCVs, or a new ICAL must be generated.

9.2.4.3.2. When the acceptance criteria for an analyte in the CCV are exceeded high (i.e., high bias), and the analyte was ND in the associated samples, the ND analyte may be reported. Samples with analytes detected at positive hits must be re-analyzed after a passing CCV or after a new ICAL has been established, evaluated, and accepted. An NCM must be generated and the high bias discussed in the report narrative.

9.2.4.3.3. When the acceptance criteria for an analyte in the CCV are exceeded low (i.e., low bias), sample results may be reported if they exceed a maximum regulatory limit/decision level (if any). Otherwise, the samples affected must be re-analyzed after a passing CCV or after a new ICAL has been established, evaluated, and accepted. An NCM must be generated and the low bias discussed in the report narrative.

9.2.4.4. CCVs may be analyzed more frequently depending on documented client requirements.

9.3. Calibration standards and other QC samples (e.g., BFB, LCS/LCSD, MB, etc.) may not be analyzed more than twice without documented corrective action. If the initial run fails acceptance criteria, re-inject calibration standard or QC sample. If second run passes, analysis may proceed. Otherwise, conduct instrument maintenance or perform corrective action. Completely document failure, corrective action performed, and return to control in the instrument maintenance logbook. Section 10.6 lists troubleshooting guidelines.

10. PROCEDURE

10.1. Sample Preparation

10.1.1. The initial and final pressure must be recorded in the sample pressurization logbook and in the individual canister field data sheet.

10.1.1.1. The initial pressure of the sample canister is checked and recorded by attaching a vacuum/pressure gauge to the canister. The gauge should be rinsed before use with UHP

N_2 by physically holding against the gas outlet and flushing for 10 seconds.

10.1.1.2. If the initial pressure is less than 6 psia, pressurize the canister with UHP N_2 to 15 psia, or to approximately 2 times the initial pressure, whichever is higher. Record the final pressure.

10.1.2. When the canister vacuum/pressure is increased, a dilution factor (DF) is calculated and is applied to results. The calculation is provided in section 11.4.

10.1.2.1. The pressure DF must be compensated for by trapping more than the default volume. For example, a sample received at 12.0 psia and pressurized to 24.6 psia has a pressure DF of 2.05. If the default volume is 500 mL, then 1020 mL should be trapped (the recorded volume is rounded up to three significant figures).

10.1.3. Canisters received as trip blanks (without sample collected) are humidified with 50 µL of DI or nano-pure water and then pressurized to 40 psia. These samples are considered to have a DF =1.0.

10.1.4. Samples are screened to check for contamination before analysis or if suspected to contain significant contamination, using GC/Flame Ionization Detector (FID) analysis or other screening methods. Screening is performed to determine a proper dilution or the optimum volume of sample for the calibrated range, and to prevent overloading the analytical instrument. The screening instrument is generally calibrated at a single-point for common analytes of interest. Screening result printouts are called “screen reports”. The following screening procedure is followed:

10.1.4.1. Remove the sample from the Sample Control area by completing the internal chain of custody (ICOC) logbook.

10.1.4.2. Attach the sample to an active sample line on the screening instrument.

10.1.4.3. Start the screen sequence in the instrument data system.

10.1.4.4. Push START on the instrument.

10.1.4.5. Open sample container valve.

10.1.4.6. Collect data report and determine the dilution required for the analysis.

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10.1.5. A sample that requires only a small dilution can be analyzed by trapping a volume less than the standard volume. The minimum volume that can be trapped is 10 mL. The maximum volume that can be trapped is three times the default volume (see section 9.2.2.5).

10.1.5.1. Tedlar bag dilutions can be used for reporting analytes that exceeded calibration range in the original analysis, but not as a reportable analysis for all other analytes due to the low-level contamination in the Tedlar bag.

10.1.5.2. Serial dilutions, as above, are documented in the run log.

10.1.6. Tedlar bag samples are checked for damage and are analyzed as received.

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10.2. Water Addition

10.2.1. The analyst should be aware that humidity plays an important role in the recovery of certain target compounds, particularly polar compounds, and should be prepared to add humidity to canisters where appropriate. The addition of water helps to stabilize the behavior of these compounds, which might otherwise interact with the interior surface of the canister or with the stainless-steel lines of the sample manifold.

10.2.1.1. Low humidity is often indicated by low area counts (recovery) for internal standards Chlorobenzene-d5 and 4-Bromofluorobenzene (BFB).

10.2.2. Since it is not practical to know the relative humidity of all canisters received at the laboratory, the analyst should assume that canisters are received at approximately 80 percent relative humidity. When preparing canister dilutions, the analyst should attempt to preserve the relative humidity of canisters at a level that will minimize recovery loss due to low canister relative humidity.

10.3. Tuning

10.3.1. Refer to section 9.2.1 for details regarding instrument tuning.

10.4. Calibration

10.4.1. Before any instrument is used as a measurement device, the instrument response to known reference materials must be determined. The manner in which various instruments are calibrated depends on the particular type of instrument and its intended use. All sample measurements must be made within the calibration range of the instrument. Preparation of all reference materials used for calibration must be documented.

10.4.2. Refer to sections 9.2.2 through 9.2.4 for details regarding instrument calibration.

10.5. Sample Analysis

10.5.1. The calibration standards and the sample QC are analyzed in the same manner as client samples. After the calibration standards are analyzed and evaluated (section 9.2.2 through 9.2.4), the LCS/LCSD are analyzed and evaluated (section 9.1.1), and then the MB is analyzed and evaluated (see section 9.1.2), all prior to client sample analysis.

10.5.2. Analytical steps for the Tekmar AUTOCan with timing:

10.5.2.1. Special Bake (if necessary) – 5 min

10.5.2.2. Next Sample Pressure Check – 0.5 min

10.5.2.3. Trapping Volume – 10 mL to 1500 mL. For trapped volume over 100 mL, use flow rate of 100 mL/min. For trapped volume under 100 mL, use flow rate of 30mL/min. Use the TO14ASLO.mtc method on the AUTOCan for a 30 mL/min flow rate. Trap temperature is 10°C.

10.5.2.4. Dry Purge – 4 min. @ 35°C

Note: For a complete list of AUTOCan settings, see Attachment 5.

10.5.3. Instrument Operation (Tekmar AUTOcan)

10.5.3.1. A sample or standard canister is attached to the AUTOCan at one of the 16 autosampler positions. Before the canister is opened, a “Leak Check” is run from the Teklink software. This assures that the valves and lines are leak-free for unattended analysis. The leak check also cleans the fittings and lines of possible carryover from previous samples. The change in pressure for the leak checks (DeltaP) should be 1.0 psia or less.

10.5.3.2. Next, a schedule is constructed using the Teklink software. Schedules can be saved and recalled for routine analysis or custom built for sample runs where the trapping volumes may vary significantly. 100 mL of IS from position A is trapped on every analysis. After the IS is trapped, a sample or standard aliquot is trapped onto the trap with the IS. Trapping is followed by three minutes of dry purging. The cryo-focuser is then cooled to -165°C. The cryotrap is heated to 320°C and desorbs the analytes onto the cryo-focuser for three minutes. Finally, the cryo-focuser heats to

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120°C and injects the sample onto the GC column. Trapping volume should be kept between 10 mL and 1500 mL (see section 10.5.2.3).

10.5.4. Analysis of multi-component analytes – Multi-component analytes are reported from the total ion chromatogram as Total Non-Methane Organic Compounds (TNMOC) as Hexane or Total Petroleum Hydrocarbons (TPH) as Gasoline.

10.5.4.1. For TNMOC as Hexane, a multi-point external standard calibration of at least five points is analyzed. The hexane calibration is taken from the standard multi-component ICAL using the hexane peak in the total ion chromatogram. After calibration, the peak is changed to an "area sum peak" which will calculate the analyte concentration from the sum of all peaks in the total ion chromatogram. If the internal standard and surrogates are included in the method as target analytes, the analytical data processing software will automatically remove their areas from the area summation.

10.5.4.2. For TPH as Gasoline, the gasoline calibration is performed using gasoline in nitrogen standards. Using varying volumes, two or three different concentrations can be used to generate the curve. The current calibration levels are 0.50, 5.0, 10, 25 and 50 ppmv. The areas of all the peaks approximately between 2.1 and 25 minutes are summed, excluding the internal standards and surrogate peaks.

10.5.4.3. The response factor for each calibration point is calculated using the following formula:

RF=Area of compound in standard/Concentration of standard

10.5.4.4. The ICAL acceptance criteria in sections 9.2.2.3 and 9.2.2.4 are followed.

10.5.4.5. A CCV must be analyzed and compared to the criteria in sections 9.2.4.2 and 9.2.4.3.

10.5.4.6. A sample result is considered to exceed the calibration range when the peak height of the highest peak in the sample exceeds the peak height of the upper calibration level.

10.6. Troubleshooting

10.6.1. Many problems encountered during analysis are due to low standard pressures or carrier/detector gas supply issues. Always confirm that

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adequate pressure remains in the standards and that the instrument gas supplies are sufficient before working on the instrument hardware.

10.6.2. Low response – typically caused by leaking sample lines or valves or contaminated/dirty sources. Instrument software can perform automated leak checks of the system. Specific components can be checked by isolating the component in question from the system (disconnect and cap or plug the ends) and then performing a leak test using a pressure gauge and canister at positive pressure. Leaking components will not hold pressure when the canister is closed. Low internal standard areas may be caused by degradation of the MS performance and increasing the electron multiplier (EM) voltage may solve this concern.

10.6.3. Baseline noise – check for supply gas contamination and leaking fittings. Carrier gas filters may need to be changed, including the pencil filters inside the GC. Sample carry-over or contamination may also be an issue and baking the system while flushing sample lines will remove most carry-over. A dirty source or leaking MS may also cause issues. The use of automated leak check routines in the MS software can indicate if a leak is present. Source-cleaning should be performed according to the manufacturer's instructions.

10.6.4. Tune issues – if an instrument will not pass tune the first step is to perform a mass axis calibration and peak-width adjustment. If the failure is due to ratios of ions with large differences, the tune parameters should be adjusted to achieve the desired ratios. The final corrective action is to clean the source according to the manufacturer's instructions.

10.6.5. Instrument issues – if data loss or error messages are encountered, consult the instrument troubleshooting guidance found in the operator's manual. The manual is in the help section of the GC software.

10.7. Instrument Maintenance and/or Repair

10.7.1. All instrument maintenance and/or repair must be documented in the instrument maintenance logbook.

10.7.2. A new ICAL must be generated following major maintenance such as changing the column, cleaning or repairing the source, replacing filaments, changing electronics, replacing the multiplier or changing moisture or Tenax traps.

10.7.3. Minor maintenance includes cleaning the injector port, replacing filters, changing the pump oil, autotuning, switching filaments (instrument contains two filaments under vacuum), replacing the syringe or injector tower, changing/refilling the calibration vial, changing seals and o-

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rings, ballasting pump, replacing fuses, replacing roughing pumps or transfer lines.

11. CALCULATIONS / DATA REDUCTION

11.1. Qualitative Analyses

11.1.1. Two criteria must be satisfied to verify positive identification:

11.1.1.1. Elution of sample component at the same GC relative or absolute RT as those of the standard component.

11.1.1.1.1. The sample component relative retention time (RRT) must compare within ± 0.06 RRT units of the RRT of the standard component.

11.1.1.1.2. As an option, RT must compare within 0.33 minutes of the standard component absolute RT. For reference, the RT standard must be run within the same 24-hour shift as the sample.

11.1.1.2. Correspondence of the sample component and the standard component mass spectra.

11.1.1.2.1. All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) must be present in the sample spectrum.

11.1.1.2.2. The relative intensities of ions specified in section 11.1.1.2.1 must agree within ±30% between the standard reference and sample spectra. For example, for an ion with an abundance of 50% in the reference spectra, the corresponding sample abundance must be between 20 and 80%. Standard reference mass spectra must be obtained on each individual GC/MS system.

11.1.1.3. If an analyte cannot be verified by all of the criteria in the above sections but in the technical judgment of the analyst the identification is correct, then the analyte may be reported. A “JA” flag is used to identify the difference in the spectra and flags the analyte as estimated.

11.1.2. Tentatively Identified Compounds (TICs)

11.1.2.1. For samples containing components not associated with the calibration standards, a library search may be made for the

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purpose of tentative identification. The necessity to perform this type of identification will be determined by the type of analysis being conducted. The following sections identify the guidelines for making tentative identification:

11.1.2.1.1. Relative intensities of major ions in the reference spectrum (ions >10% of the most abundant ion) should be present in the sample spectrum.

11.1.2.1.2. Relative intensities of the major ions should agree within ±30%.

11.1.2.1.3. Molecular ions present in the reference spectrum should be present in the sample spectrum.

11.1.2.1.4. Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of co-eluting compounds.

11.1.2.1.5. Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or co-eluting peaks. Data system library reduction programs can sometimes create these discrepancies.

11.1.2.1.6. Only peaks having a total ion current greater than 10% of the nearest eluting IS total ion current will be evaluated for reporting.

11.1.2.2. TICs will be given general names consisting of major functional groups and number of carbon atoms unless an RT reference is available.

11.1.2.3. When TICs are requested to be reported using specific compound names, the following procedure must be followed:

11.1.2.3.1. Choose characterized ions of the specific compounds from the mass spectrum.

11.1.2.3.2. Search ions from expected RT range or entire RT range if the RT of the specific compound is unknown or uncertain.

11.1.2.3.3. Add the requested compounds as unknown in Target Review mode.

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11.1.3. Semi-quantitative results will be calculated for TICs using total ion current areas and assuming an RRF = 1.0.

11.1.4. Computer-generated library search routines should not use normalization routines that would misrepresent the library or unknown spectra when compared to each other. Only after visual comparison of sample with the nearest library searches will the analyst assign a tentative identification.

11.2. Quantitative Analysis

11.2.1. When an analyte has been identified, the quantification of that analyte will be based on the integrated abundance from the extracted ion current profile (EICP) of the primary characteristic ion. Quantitation will take place using the IS technique.

11.2.2. A sample must be analyzed and reported at a dilution if one or more target analytes have an on-column amount above the upper calibration level. Dilutions are acceptable if at least one of the following criteria are met:

11.2.2.1. Any target analyte in the diluted sample exceeds 80 ppbv on-column.

11.2.2.2. The peak height in the total ion chromatogram of any non-target analyte in the diluted sample exceeds the largest peak height of the highest calibration standard.

11.2.2.3. A heavy hydrocarbon matrix in the diluted sample raises the baseline two times that of the relative IS.

11.2.3. When an analyte that failed acceptance criteria in a reportable ICAL and/or in a CCV (i.e., at least 90% of analytes met acceptance criteria) is detected in any client sample, the analyte must be flagged.

11.2.4. Analyte quantitation must be performed off the ICAL and not from the CCV analysis. Test results must be qualified in reports when analyte quantitation is based on the CCV at the client's request. This request must also be documented in the report narrative.

11.3. All manual or re-integration of chromatograms must be documented in accordance with TestAmerica Corporate SOP CA-Q-S-002. Documentation includes, at a minimum, before and after copies of the chromatograms with a reference to the reason for re-integration, dated, and initialed. All manual integrations must undergo a secondary-level review. See section 11.8.

11.4. Calculations

11.4.1. Calculation for RPD

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$$RPD = \frac{Value\ A - Value\ B}{Average\ of\ Values} X\ 100$$

11.4.2. Calculation for RRF

$$RRF = \frac{Area\ cpd\ in\ Std.}{Area\ I.S.} X \frac{Conc.I.S.}{Conc.cpd\ in\ Std.}$$

The area of the primary quantitation ion is used in the calculation.
I.S. = Internal Standard

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11.4.3. Calculation for %RSD

$$\%RSD = \frac{Std.Dev.of\ RRFs}{Mean\ of\ RRFs} X\ 100$$

11.4.4. Calculation for %D

$$\%D = \frac{RF\ ICAL - RF\ CCV}{RF\ ICAL} X 100$$

11.4.5. Calculation for pressure DF

$$DF = \frac{Y_a}{X_a}$$

Where:

X_a = absolute canister pressure before dilution (initial pressure)
Y_a = absolute canister pressure after dilution (final pressure)

11.4.6. The data system automatically quantitates the sample results based on a standard sample size of 500 mL. If a sample size other than 500 mL was used and/or a canister sample was pressurized, the result must be adjusted as shown below:

$$\textit{Final result ppbv = raw } result ppbv X \frac{500mL}{sample\ volume\ injected} X \frac{final\ psia}{initial\ psia}$$

11.4.7. Calculation for Determining Concentration of Compounds

$$Conc.Cpd(ppbv) = \frac{Area\ cpd\ in\ sample}{Area\ I.S.in\ sample} X \frac{Conc.I.S.}{average\ RRF\ \ from\ \ ICAL} X\ Dil.Factor\ \ (see\ 12.5.1)$$

Note: The area of the primary quantitation ion is used in the calculation.
I.S. = Internal Standard

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11.4.8. Calculation for Percent Recovery (%Rec)

$$\%\,Rec = \frac{Amount\ cpd.\ recovered}{Amount\ cpd.\ spiked} X\ 100\%$$

11.4.9. Standard reporting unit is ppbv (also ppb v/v). If results are to be reported in ng/L or ug/m^3, use the following equation:

$$result\ ppbv\ X \frac{Molecular\ weight\ of\ compound}{24.45} = results\ ng/L\ or\ ug/m^3$$

Note: 24.45 is the molar volume of ideal gas in liters at 25°C and 1 atmosphere.

11.5. Estimates of uncertainty are based upon LCS historical control limits.

11.6. "J" values (results below the RL but above the MDL) are reported on request only.

11.7. No conversion of the analytical results to standard conditions is made.

11.8. Technical Data Review

11.8.1. Primary

11.8.1.1. Per the facility QAM, the primary review of analytical data is often referred to as a "bench-level" review. In most cases, the analyst who generates the data (prepares and/or analyzes the sample/reduces the data) is the primary reviewer. In some cases, an analyst may be reducing data for samples run by an autosampler that was set up by a different analyst. In this case, the identities of both analysts must be indicated, at a minimum, in the injection or run log.

11.8.2. Secondary

11.8.2.1. Per the facility QAM, the secondary review is a complete technical review of a data set. The secondary review is documented and the secondary reviewer is identified. If problems are found during the secondary review, the reviewer must work with the appropriate personnel to resolve them. If changes are made to the data, such as alternate qualitative identifications, identifications of additional target analytes, re-quantitation, or reintegration, the secondary reviewer must contact the analyst and/or primary reviewer of the data so that the primary analyst and/or reviewer may be aware of the changes made.

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11.9. Completeness/Project Management Review

11.9.1. Per the facility QAM, the completeness review includes the generation of a report narrative and/or cover letter that outlines anomalous data and nonconformances using notes and nonconformance reports generated during the primary and secondary review. The completeness review focuses on the accuracy of final client reporting forms.

11.9.2. The PM signs the final report package submitted to the client.

12. METHOD PERFORMANCE

12.1. Method Detection Limit Study – The MDL is the lowest concentration that can be detected for a given analytical method and sample matrix with 99% confidence that the analyte is present. The MDL is determined according to the laboratory's MDL procedure in section 20 of the facility QAM. MDLs reflect a calculated (statistical) value determined under ideal laboratory conditions in a clean matrix, and may not be achievable in all environmental matrices. At initial set-up and subsequently once per 12-month period, an MDL study must be performed and verified immediately thereafter for each target analyte in each test method.

12.1.1. For add-on or non-standard analytes, an MDL study is required by NELAC. Additionally, a calibration curve must be generated before analyzing any samples, unless lesser requirements (e.g., a single-point calibration, which should be at the RL) are previously agreed to with the client. Any such agreed deviation from the method must be clearly documented in the report narrative.

12.2. Demonstration of Capability (DOC) – Refer to section 20 of the facility QAM for the general procedures to follow in order to meet DOC (initial and on-going) requirements for a method.

12.2.1. For an analyst's DOC, four replicates of the LCS containing all of the target analytes approximately at the mid-range of the calibration curve must be analyzed and results compared to in-house QC acceptance limits. These data are used to establish method performance in terms

of accuracy and precision. Annual (on-going) DOCs must be generated to ensure an analyst's continued proficiency in the method.

13. POLLUTION CONTROL

13.1. It is TestAmerica's policy to evaluate each method and look for opportunities to minimize waste generated (i.e., examine recycling options, ordering chemicals based on quantity needed, preparation of reagents based on anticipated usage and reagent stability). Employees must abide by the policies in Section 13 of the Corporate Safety Manual for "Waste Management and Pollution Prevention."

14. WASTE MANAGEMENT

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14.1. Waste management practices are conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes are disposed of in an accepted manner. Waste description rules and land disposal restrictions are followed. Waste disposal procedures are incorporated by reference to SOP SANA-EHS-001. The following waste streams are produced when this method is carried out.

14.2. Waste Streams Produced

14.2.1. Expired standards in cylinders are returned to the manufacturer.

14.2.2. Tedlar bags are placed in sample bins in the warehouse and are disposed on a quarterly basis. Disposal involves the slashing of the bags in a hood and then placing the bag in the laboratory trash stream. Highly contaminated bags may need to be profiled according to the contaminant and "laboratory-packed".

15. REFERENCES / CROSS-REFERENCES

15.1. EPA/625/R-96/010b, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, 2nd edition, January 1999

15.1.1. Compendium Method TO-14A, Determination of Volatile Organic Compounds (VOCs) in Ambient Air using Specially Prepared Canisters With Subsequent Analysis Gas Chromatographic Analysis

15.1.2. Compendium Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)

15.2. EPA/600/R-04/003, 2003 NELAC Standard, June 5, 2003

15.3. Advisory – Active Soil Gas Investigations, January 28, 2003 (DTSC and LARWQCB)

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15.4. TestAmerica Corporate QA SOP CA-Q-S-005, Calibration Curves, current revision

15.5. TestAmerica Corporate Technical Policy CA-T-P-002, Selection of Calibration Points, current revision

15.6. TestAmerica Corporate QA SOP CA-Q-S-002, Acceptable Manual Integration Practices, current revision

15.7. TestAmerica Corporate QA SOP CW-Q-S-002, Writing an SOP, current revision

15.8. TestAmerica Los Angeles QAM, current revision

15.9. TestAmerica Los Angeles SOP LA-SRA-002, Releasing and Cleaning of Sample Canisters, and Cleaning, Calibration, and Setting of Flow Regulators and Vacuum Gauges, current revision

15.10. TestAmerica Los Angeles SOP LA-QAS-002, Standards Preparation, Traceability, and Verification, current revision

15.11. TestAmerica Los Angeles SOP LA-QAS-001, Statistical Evaluation of Quality Control Data and Development of Control Charts, current revision

15.12. TestAmerica Los Angeles SOP LA-MSA-015, Determination of Low-level Volatile Organics in Ambient Whole Air Samples using GC/MS-Scan Mode, Methods EPA TO-14A and EPA TO-15, current revision

15.13. TestAmerica Los Angeles Safety SOP SANA-EHS-001, Sample and Chemical Waste Characterization, Collection, Storage and Disposal, current revision

16. METHOD MODIFICATIONS

16.1. Nitrogen is used for dilution/pressurization purposes.

16.2. Method TO-14A recommends the use of a 0.32-mm column coupled directly to the mass selective detector (MSD). With the HP system, the MSD can only handle flow of 1 mL/min or less. The 0.32-mm column provides ~ 3 mL/min. TestAmerica Los Angeles uses a 0.53-mm column through a jet separator.

16.3. Method TO-14A describes an inlet system that uses a vacuum to pull the sample through the trap. TestAmerica Los Angeles optionally uses the pressure of the sample canister to drive the sample through the trap.

16.4. Method TO-14A describes the use of a Nafion dryer to remove excess moisture from air matrices. TestAmerica Los Angeles does not use a Nafion dryer since polar compounds may be lost during this removal step. The AUTOCan uses an adsorbent trap with a dry purge step to control moisture.

16.5. Method TO-14A describes the BFB tune check to be a gas sample introduced via a sample loop. TestAmerica Los Angeles traps and analyzes BFB using the same analytical technique used with samples.

16.6. Method TO-14A was written for ambient air samples, however, this SOP was designed for use on “non-ambient” air samples that generally have high level of contamination or do not require sub ppbv RLs.

16.7. Methods TO-14A and TO-15 describe the use of passivated steel canisters for sampling and analysis. No mention is made of the use of Tedlar bags. TestAmerica Los Angeles analyzes samples in Tedlar bags for VOCs using the same procedures described herein. A modification to the method is noted in the narrative of the final report.

16.8. Method TO-15 describes a shelf life of thirty days for primary working standards. TestAmerica Los Angeles maintains these standards for longer periods of time according to the manufacturer's recommendation and the results of stability monitoring.

16.9. The methods indicate that in order for the ICAL to be acceptable, all compounds must have a %RSD < 30 (with allowance for two that could be up to 40% in TO-15). For routine analysis, TestAmerica Los Angeles accepts the ICAL if 90% of the target compounds have a %RSD $\leq$ 30 and if the average of the %RSD for all target compounds is $\leq$ 30%. This modification accounts for analytical issues that arise for poor performing analytes.

16.10. For the continuing calibration criteria, Method TO-14A states that the RPD of each RF (in the CCV) from the mean RF of the ICAL curve should be < 30%; for Method TO-15, the %D for each target compound must compare to the ICAL at $\pm$ 30%. For routine analysis, TestAmerica Los Angeles accepts the CCV if 90% of the target compounds have a %D $\pm$ 30 and if the average of the %D for all target compounds is $\pm$ 30 . This modification accounts for analytical issues that arise for poor performing analytes.

16.11. Method TO-15 sets accuracy criteria of $\pm$ 30%D. TestAmerica Los Angeles uses project-specific QC criteria or control limits based on historical data that may be wider than the method limits.

16.12. Surrogates are not required by the methods. This SOP adds surrogates to every sample to help monitor for matrix effects and method performance. However, surrogates are not reported unless requested.

16.13. Method TO-15 states that the scan time must give 10 scans per peak, not to exceed 1 second per scan. The GC/MS software is set for a sampling rate of 3, which corresponds to approximately 2 to 3 scans per second, depending on the instrument. See the GC/MS operator’s manual or “help” on the software for more information about the sampling rate.

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17. ATTACHMENTS

17.1. Attachment 1: Standard Analytes and Reporting Limits

17.2. Attachment 2: Add-on Analytes and Reporting Limits

17.3. Attachment 3: BFB GC Operating Conditions

17.4. Attachment 4: GC Analytical Method

17.5. Attachment 5: Tekmar AUTOcan Operating Conditions

17.6. Attachment 6: BFB Acceptance Criteria, EPA TO-14A

17.7. Attachment 7: BFB Acceptance Criteria, EPA TO-15

17.8. Attachment 8: Internal Standards

17.9. Attachment 9: Surrogate Standards

Attachment 1. Standard Analytes and Reporting Limits

Compound	*RL, ppbv*
Acetone	10
Benzene	3.0
Benzyl chloride	25
Bromodichloromethane	2.0
Bromoform	2.0
Bromomethane	4.0
2-Butanone (MEK)	10
Carbon disulfide	10
Carbon tetrachloride	2.0
Chlorobenzene	2.0
Dibromochloromethane	2.0
Chloroethane	4.0
Chloroform	2.0
Chloromethane	4.0
1,2-Dibromoethane (EDB)	2.0
1,2-Dichlorobenzene	2.0
1,3-Dichlorobenzene	2.0

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Compound	*RL, ppbv*
1,4-Dichlorobenzene	6.0
Dichlorodifluoromethane	2.0
1,1-Dichloroethane	2.0
1,2-Dichloroethane	2.0
cis-1,2-Dichloroethene	2.0
trans-1,2-Dichloroethene	2.0
1,1-Dichloroethene	2.0
1,2-Dichloropropane	3.0
cis-1,3-Dichloropropene	3.0
trans-1,3-Dichloropropene	2.0
1,2-Dichloro-1,1,2,2-tetrafluoroethane	2.0
Ethylbenzene	2.0
4-Ethyltoluene	2.0
Hexachlorobutadiene	4.0
2-Hexanone	10
Methylene chloride	2.0
4-Methyl-2-pentanone (MIBK)	10
Styrene	2.0
1,1,2,2-Tetrachloroethane	2.0
Tetrachloroethene	2.0
Toluene*	2.0
1,2,4-Trichlorobenzene	5.0
1,1,1-Trichloroethane	2.0
1,1,2-Trichloroethane	2.0
Trichloroethene	2.0
Trichlorofluoromethane	2.0
1,1,2-Trichloro-1,2,2-trifluoroethane	2.0
1,2,4-Trimethylbenzene	3.0
1,3,5-Trimethylbenzene	3.0
Vinyl acetate	10
Vinyl chloride	3.0
m-Xylene & p-Xylene	4.0
o-Xylene	2.0
Xylenes (total)	2.0

* RL for Toluene in a Tedlar bag sample is 5.0 ppbv.

Attachment 2. Add-on Analytes and Reporting Limits

Compound	*RL, ppbv*
Acetaldehyde	10
Acetonitrile	20
Acrolein	10
Acrylonitrile	15
alpha-Methylstyrene	2.0
Bromobenzene	10
Vinyl bromide	2.0
1,3-Butadiene	4.0
n-Butane	3.0
t-Butanol (TBA)	15
n-Butylbenzene	2.0
sec-Butylbenzene	2.0
tert-Butylbenzene	2.0
Chlorodifluoromethane	10
Allyl chloride	4.0
2-Chlorotoluene	2.0
Cyclohexane	2.0
Cyclohexanone	10
1,2-Dibromo-3-chloropropane	10
Dibromomethane	3.0
trans-1,4-Dichloro-2-butene	40
1,3-Dichloropropane	10
2,2-Dichloropropane	2.0
1,1-Dichloropropene	5.0
Diisobutyl ketone	10
1,4-Dioxane	10
Ethanol	40
Tert-amyl methyl ether (TAME)	2.0
Ethyl-t-Butyl Ether (ETBE)	2.0
Ethyl acetate	5.0
Diethyl ether	2.0
n-Heptane	3.0
n-Hexane	2.0
Iodomethane	5.0

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Compound	*RL, ppbv*
Cumene	2.0
Diisopropyl ether (DIPE)	2.0
4-Isopropyltoluene (p-Cymene)	2.0
Methanol	25
Methyl methacrylate	7.0
Methyl tert-butyl ether (MTBE)	2.0
Naphthalene	6.0
n-Nonane	10
n-Octane	10
n-Pentane	2.0
Propane	5.0
2-Propanol	10
n-Propylbenzene	2.0
Propylene	5.0
1,1,1,2-Tetrachloroethane	2.0
Tetrahydrofuran	5.0
TPH (as Gasoline)	500
TNMOC as Hexane	10
1,2,3-Trichlorobenzene	6.0
1,2,3-Trichloropropane	2.0
2,2,4-Trimethylpentane	2.0
1,1-Dichloro-1-fluoroethane	2.0

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Attachment 3. BFB GC Operating Conditions

Method file: BFB.M (for HP5890 with AUTOCan autosampler)

METHOD FILE LIST

Method file:	**BFB.M**	GC Type: 5890	Run type: SCAN,GC,E1
		Column: Cap	Splitless: Yes

Temperature (°C):	**Inj.P**	**Intfc**	**Source**
	N/A	200	280

GC/DIP		**LEVEL A**	**LEVEL B**	**POST RUN**
Temp 1	180.0*	0.0	0.0	0.0
Time 1	4.40	0.0	0.0	0.0
Rate	0.0	0.0	0.0	
Temp 2	0.0	0.0	0.0	
Time	0.0	0.0	0.0	

Oven equilibration Time.	0.00 min			
Run time:	4.40			
Scan Start time	3.80			
Scan Parameters:	Mass Range:	28.5 to 270		
	Multiplier voltage:	Varies	Number of A/D samples:	8
	Threshold:	175 counts		

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* Isothermal at 180°C.

Attachment 4. GC Analytical Method

Method file: TO14A.M (for HP5890 with AUTOCan autosampler)

METHOD FILE LIST

Method file:	**TO14A.M**	GC Type: 5890	Run type: SCAN,GC,E1
		Column: Cap	Splitless: Yes

Temperature (°C):	**Inj.P**	**Intfc**	**Source**
	N/A	200	280

GC/DIP		**LEVEL A**	**LEVEL B**	**POST RUN**
Temp 1	40	170	0.0	0.0
Time 1	4.0	0.0	0.0	0.0
Rate	8	40	0.0	
Temp 2	170	230.0	0.0	
Time	0.0	0.0	0.0	

Oven equilibration Time.	0.00 min			
Run time:	Approx. 23.75			
Scan Start time	Approx. 0.10			
Scan Parameters:	Mass Range:	28.5 to 270		
	Multiplier voltage:	Varies	Number of A/D samples:	8
	Threshold:	175 counts		

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Attachment 5. Tekmar AUTOcan Operating Conditions

Method file: TO14A.mtc	**METHOD FILE LIST**
GC Start Option	End of Desorb
GC Cycle Time	3 Minutes
Cryo	On
Line Temp	120°C
Valve Temp	120°C
MCS Line Temp[1]	40°C
Trap Standby Temp	50°C
Cryo Standby Temp	70°C
MFC Standby Flow	60 mL/min
Trap Cool Temp	10°C
MFC Transfer Flow	100 mL/min[2]
Dry Purge Time	4 Minutes
Dry Purge Temp	35°C
Dry Purge Flow	100 mL/min
Desorb Preheat Temp	50°C
Trap Desorb Time	3 Minutes
Trap Desorb Temp	320°C
Cryo Cool Temp	-175°C
Cryo Inject Time	1 Minute
Cryo Inject Temp	120°C

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[1] MCS is not used for this application.
[2] For trapping volume < 100 mL, a separate method (TO14SLO.mtc) is used with a 30 mL/min transfer flow.

Trap Bake Time	10 Minutes
Trap Bake Temp	335°C
MCS Bake Temp[1]	40°C
MCS Cool[1]	40°C

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Attachment 6. BFB Acceptance Criteria, EPA TO-14A

Mass	*Ion Abundance Criteria*
50	15 to 40% of mass 95
75	30 to 60% of mass 95
95	Base Peak, 100% Relative Abundance
96	5.0 to 9.0% of mass 95
173	<2.0% of mass 174
174	>50% of mass 95
175	5.0 to 9.0% of mass 174
176	>95% but <101% of mass 174
177	5.0 to 9.0% of mass 176

Attachment 7. BFB Acceptance Criteria, EPA TO-15

Mass	*Ion Abundance Criteria*
50	8.0 to 40% of mass 95
75	30 to 66% of mass 95
95	Base Peak, 100% Relative Abundance
96	5.0 to 9.0% of mass 95
173	<2% of mass 174
174	50 to 120% of mass 95
175	4.0 to 9.0% of mass 174
176	93% to 101% of mass 174
177	5.0 to 9.0% of mass 176

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Attachment 8. Internal Standards

Bromochloromethane
1,4-Difluorobenzene
Chlorobenzene-d5

Attachment 9. Surrogate Standards

1,2-Dichloroethane-d4
Toluene-d8
4-Bromofluorobenzene

18. REVISION HISTORY

18.1. This section has been added beginning with revision 8. Prior revisions are documented in the QA files.

18.2. Changes to revision 7 implemented in revision 8:

18.2.1. The SOP title was corrected to indicate that the SOP is specifically used for the analysis of volatiles in non-ambient whole air samples by either method TO-14A or TO-15. This discussion was also added as a method deviation in section 15.10.6. Sole reference to TO-14A in some sections was also replaced with reference to both methods TO-14A and TO-15, as appropriate.

18.2.2. Specific references to "SUMMA canister" have been modified to either "passivated canister" or "canister". The latest revisions of Methods TO-14A and TO-15 have generalized the reference to "SUMMA canister" to other specially prepared canisters.

18.2.3. Sections 3 was expanded to include additional definition of terms used in this SOP.

18.2.4. The acceptance criterion for a "screen canister" discussed in section 4.2 was corrected, from having no target compounds above 0.20 ppbv to having no target compounds above the RL, in order to reflect the laboratory's current practice. Additionally, sections 4.2.1 and 4.2.2 were added to define additional canister certification requirements that may be requested from the laboratory.

18.2.5. The interference from high levels of carbon dioxide/moisture in the samples have been addressed by the laboratory and hence, no longer discussed in the SOP. This discussion used to be in section 4.3 of SOP revision 7.

18.2.6. Other sources of interferences that may possibly affect method performance were added in section 4.

18.2.7. Section 5 (Safety) was modified in order to comply with the requirements of the CSM.

18.2.8. Section 7 was expanded to identify reagents from standards. Additionally, a standards preparation section was added. Purge-and-trap grade water was added as a reagent (used for humidifying samples).

18.2.9. The NELAC requirements for LCS reporting were added as sections 9.5.1, 9.5.2, and 9.5.3 in the SOP's current revision.

18.2.10. Enhanced corrective action measures, when the LCS and/or LCSD fail, were also added as section 9.5.4 in the SOP's current revision.

18.2.11. The discussion in section 10.8 regarding IS evaluation in samples was moved to section 9.6 in the SOP's current revision.

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18.2.12. Section 9.7 was added to address the acceptance criteria for sample duplicate analysis, if requested by client.

18.2.13. Section 9.8 was added to address the contamination check on the N2 supply used to pressurize samples.

18.2.14. Section 9.9 was added to address the annual certification required for the master gauge that is used to calibrate the gauges used for samples and standards.

18.2.15. Section 9.10 was added to address the quarterly certification required for the process flow meter, which is used to set-up the flow rates of the flow regulators used by clients, for time-weighted sampling events.

18.2.16. The amount of standard mixtures used in preparing the low-level and the high-level dilution of the stock standard was corrected, in sections 10.2 and 10.3, respectively, in order to reflect the laboratory's current procedure.

18.2.17. The ICAL acceptance criteria in section 10.4.2 and subsection were corrected, in order to reflect the laboratory's current practice.

18.2.18. The method TO-15 ICAL acceptance criteria was added as section 10.4.2.1, to serve as reference when client-specific requirements dictate its use.

18.2.19. Use of linear or quadratic curve fits was addressed and added as section 10.4.3.

18.2.20. The discussion regarding IS evaluation in the ICAL was added as section 10.4.5 in the SOP's current revision.

18.2.21. Section 10.4.6 was added to address the criteria to be used when it becomes necessary to drop points from the ICAL.

18.2.22. Section 10.4.7 was added to address the use of the ICAL RF when calculating results and what to do if client-specific requirements dictate otherwise.

18.2.23. Section 10.5 was modified to address the new acceptance criteria for the ICV (second source) standard.

18.2.24. The CCV acceptance criteria in section 10.6 and subsections were corrected, in order to reflect the laboratory's current practice. Corrective actions to be performed when CCV fails were also addressed.

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18.2.25. The number of seconds required to flush the pressurization gas line prior to each sample preparation/pressurization was defined in section 11.2.1.

18.2.26. The dilution factor used in the analysis of trip blanks was defined in section 11.2.2.

18.2.27. The discussion in section 11.2.3 regarding sample screening was expanded.

18.2.28. Section 11.2.4 was added to address the minimum volume of sample that can be trapped in the GC/MS system and the possible resort to Tedlar bag dilution when original analysis exceeds calibration range.

18.2.29. The guidelines for sample humidification, when deemed necessary, was addressed and may be found as section 11.3 in the SOP's current revision.

18.2.30. Section 11.4 was added to address the requirement for a new calibration curve, after major changes to the GC/MS system occurred.

18.2.31. Section 11.5 was added to provide some examples of minor maintenance to the GC/MS system.

18.2.32. Corrective actions (and their proper documentation) when BFB tunes fail were addressed and added as section 11.6.4.1.

18.2.33. The trapping volume range (as indicated in section 12.1) used in the Tekmar AUTOcan system was corrected from 50-2000 mL to 10-1500 mL. This discussion may now be found in section 11.7.1.3 of the SOP's current revision.

18.2.34. The operation procedure for the Tekmar AUTOcan discussed in section 12.4 was rewritten to reflect the laboratory's current practice.

18.2.35. The RT acceptance criterion discussed in section 13.1.1.2 was corrected from 0.5 minutes to 0.33 minutes, in order to reflect the laboratory's current practice. This discussion may now be found in section 12.1.1.1.2 of the SOP's current revision.

18.2.36. The relative ion intensities acceptance criterion discussed in sections 13.1.1.3 and 13.1.2.1 was corrected from +20% to +30%, in order to reflect the laboratory's current practice. This discussion may now be found in sections 12.1.1.2.2 and 12.3.1.2 of the SOP's current revision.

18.2.37. The proper documentation procedure to be followed by the laboratory when manual peak integration is performed was added and may be found as section 12.4 of the SOP's current revision.

18.2.38. References to the use of the NELAC document for QA guidance and the use of certain corporate policies and SOPs was added in section 17. The reference section may now be found as section 15 in the SOP's current revision.

18.2.39. Table 1 was updated to reflect the laboratory's current RLs and LCS/LCSD and surrogate acceptance limits.

18.2.40. Table 2 was updated to reflect the laboratory's current add-on list and their corresponding RLs.

18.2.41. Tables 8, 9, and 10 were added in order to supply information regarding BFB acceptance criteria for methods TO-14A and TO-15, and the internal standards used in the analysis.

18.2.42. All other sections were modified only for clerical corrections.

18.3. Changes to revision 8 implemented in revision 9:

18.3.1. This SOP has been formatted using the TestAmerica Corporate QA SOP template specified in SOP CW-Q-S-002.

18.3.2. All references to "Severn Trent Laboratories, Inc." or "STL" have been changed to "TestAmerica".

18.3.3. Changes to section 1, Scope and Application:

18.3.3.1. A statement regarding the annual update of MDLs and RLs was added in section 1.2.1 of revision 8.

18.3.3.2. Applicable matrices were added in section 1.2.2 of revision 8.

18.3.3.3. Section 1.3 in revision 8 was added to define how modifications to the SOP, per client/project/contract, are handled.

18.3.4. Changes to section 3, Definitions:

18.3.4.1. The definition of the batch was clarified and expanded, based on the TestAmerica Corporate QAM guidelines.

18.3.4.2. The definitions for IS, SilcoCan, VFR, particulate filter, and pressure gauge were added.

18.3.4.3. The standard molar volume specified in section 3.10 (now section 3.7 in revision 9) was corrected from 24.5 L/mol to 24.45 L/mol. Corrections were also made to the formula found in section 13.1

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18.3.4.4. Reference to the use of the facility QAM, for the definition of other terms used in the SOP, was added

18.3.5. Changes to section 4, Interferences:

18.3.5.1. Section 4.2.2.1 was added to clarify that common laboratory contaminants may be present above the MDL in some screen cans.

18.3.5.2. The interference that would be caused by large amount of water, methane, and carbon dioxide in a sample was discussed in section 4.6 of revision 9.

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18.3.6. Section 5 (Safety) was revised in order to comply with the TestAmerica Corporate safety requirements.

18.3.7. Changes to section 7, Reagents and Standards:

18.3.7.1. DI or nano-pure water replaced purge and trap grade water as a reagent in section 7.1.4.

18.3.7.2. The requirement to humidify standards being prepared was added as section 7.3.1.1 in revision 9.

18.3.7.3. Section 7.3.1.2 was added to clarify that the IS mix is not humidified.

18.3.7.4. The preparation of the 50 ppbv and 200 ppbv working standards were summarized in sections 7.3.4 and 7.3.5, respectively, of revision 9. These sections replaced section 7.3.4 of revision 8.

18.3.7.5. Allowance for use of other standard preparation techniques was added as section 7.3.6 in revision 9.

18.3.8. Changes to section 8, Sample Collection, Preservation, and Storage:

18.3.8.1. The section was renamed “Sample Collection, Preservation, Shipment, and Storage”, as specified in the TestAmerica Corporate QA SOP template.

18.3.8.2. A table that includes holding time references and preservation requirements was added.

18.3.9. Changes to section 9, Quality Control:

18.3.9.1. The discussions regarding MDLs and DOCs were moved to section 12 (Method Performance) of revision 9, as specified in the TestAmerica Corporate QA SOP

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template. Reference to the facility QAM was added to the discussions.

18.3.9.2. Statements regarding the annual evaluation and implementation of surrogate control limits were added as section 9.1.3.3 in revision 9.

18.3.9.3. The requirement in section 9.8 to first test a UHP N_2 (or zero-grade N_2) tank for contamination, prior to use as a diluent gas in samples and standards, was moved to section 7 (Reagents and Standards) of revision 9.

18.3.9.4. Sections 9.9 (Annual Gauge Calibration) and 9.10 (Process Flow Meter Calibration) were deleted. These procedures were already specified in Sample Control SOP LA-SRA-002.

18.3.10. Changes to section 10, Calibration and Standardization:

18.3.10.1. Section 10 was deleted. The information in this section was incorporated into the QC section, as specified in the TestAmerica Corporate QA SOP template.

18.3.10.2. The standards preparation discussed in sections 10.2 and 10.3 were moved to section 7 (Reagents and Standards).

18.3.10.3. The requirement to generate a new ICAL annually, at a minimum, was added, as specified in the TestAmerica Corporate QAM template.

18.3.10.4. The ICAL acceptance criterion for averaging all RFs was added in section 9.2.2.3 of revision 9.

18.3.10.5. The requirement to perform corrective action for failed ICAL and the reference to consult the troubleshooting guidelines added as section 10.6 in revision 9, were also added in section 9.2.2.3 of revision 9.

18.3.10.6. Details regarding use of linear regression and second-order calibration curves in section 10.4.3 were deleted. The TestAmerica Corporate QA SOP CA-Q-S-005 was referenced in its place.

18.3.10.7. The acceptance criteria for evaluating IS in the ICAL in section 10.2.5 (now section 9.2.2.6 in revision 6) were corrected.

18.3.10.8. Section 9.2.3.3 in revision 9 was added to specify other alternatives that the laboratory may employ to qualify a

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particular standard (for which no other manufacturer exists) as a second-source standard.

18.3.10.9. Additional poor performers were identified and added to the list in section 10.5.2 (now section 9.2.3.1 in revision 9).

18.3.10.10. Section 10.4.7, regarding analyte quantitation based on ICAL RF, was moved to section 11.2 of revision 9.

18.3.10.11. The NELAC requirements for evaluating CCVs, as specified in CF1, were added to section 10.6.2 (now section 9.2.4 in revision 9).

18.3.10.12. The requirements for the analysis and evaluation of multi-component analytes, as defined in CF2, were added as section 10.5.4 in revision 9.

18.3.11. Changes to section 11, Procedures:

18.3.11.1. The section was renumbered in revision 9 as section 10.

18.3.11.2. Section 11.1 was deleted.

18.3.11.3. The requirement to humidify trip blanks (or other field QC) prior to analysis was added in section 11.2.2 (now section 10.1.3 in revision 9).

18.3.11.4. The maximum volume of sample that can be trapped in the GC/MS was defined in section 10.1.5 of revision 9.

18.3.11.5. The indication of low humidity in samples was described in section 10.2.1.1 of revision 9.

18.3.11.6. Section 11.3.3, regarding sample humidity, was deleted. The laboratory already ensures that all samples are humidified, as necessary, prior to analysis.

18.3.11.7. The requirement to record all major and minor instrument repair and maintenance in the instrument maintenance logbook was added as section 10.7.1 in revision 9.

18.3.11.8. The requirement to perform corrective action for failed BFB and the reference to consult the troubleshooting guidelines added as section 10.6 in revision 9, were added to section 11.6.2 (see section 9.2.1.2.2 in revision 9).

18.3.11.9. Common troubleshooting guidelines were added as section 10.6 in revision 9.

18.3.12. Changes to section 12, Data Interpretation:

18.3.12.1. The section was renamed “Calculations / Data Reduction”, as specified in the TestAmerica Corporate QA SOP template. The section was also renumbered in revision 6 as section 11.

18.3.12.2. The definition of the “JA” flag was added in section 12.1.1.3 (now section 11.1.1.3 in revision 9).

18.3.12.3. The requirement to flag positive results for an analyte that failed in a reportable ICAL or CCV was added as section 11.2.3 in revision 9.

18.3.12.4. Discussions regarding technical data review of analytical results and completeness/PM review of final reports were added as sections 11.8 and 11.9, respectively, in revision 9.

18.3.13. Changes to section 13, Reporting:

18.3.13.1. This section was deleted, as specified in the TestAmerica Corporate QA SOP template.

18.3.13.2. Sub-sections 13.1 through 13.4 were added to section 11 of revision 9.

18.3.14. Section 15 (Pollution Prevention and Waste Management) was divided into two sections (section 13 - Pollution Control and section 14 - Waste Management in revision 6), as specified in the TestAmerica Corporate QA SOP template. The specific discussions in each section were also revised according to the referenced template.

18.3.15. Changes to section 16, References:

18.3.15.1. The section was renamed “References / Cross-References”, as specified in the TestAmerica Corporate QA SOP template. The section was also renumbered in revision 6 as section 15.

18.3.15.2. Section 15.10 (Deviations from Method) was made a stand-alone section on its own and was renamed “Method Modifications”, as specified in the TestAmerica Corporate QA SOP template. The section was also renumbered in revision 9 as section 16.

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18.3.16. Changes to section 17, Miscellaneous (Tables, Appendices, etc.):

18.3.16.1. The section was renamed “Attachments”, as specified in the TestAmerica Corporate QA SOP template.

18.3.16.2. The %Rec and RPD limits specified in Table 1 were deleted. Revision 9 referenced that the LCS/LCSD QC limits may be found in the LIMS.

18.3.16.3. The surrogate standards were deleted from the target analyte list in Table 1. The surrogate standards were added into a separate attachment in revision 9 (see Attachment 9 in revision 9).

18.3.16.4. Tables 3 (Retention Time and Dynamic Range for Target Compounds) and 4 (VOC Key Ions) were deleted. If needed, this information may be obtained from the GC/MS methods stored in the instrument data system.

18.3.17. Other sections were modified for clerical corrections.

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APPENDIX F

FIELD EQUIPMENT SPECIFICATIONS

Ashtead TECHNOLOGY

Instruments: 1 800-242-3910
Offshore: 1 866-274-8323
www.ashtead-technology.com

RAE Systems MiniRAE 3000 PID

The MiniRAE 3000 PID is the most advanced handheld volatile organic compound (VOC) detector on the market. Its Photoionization Detector's (PID) extended range of 0 to 15,000 ppm makes it an ideal instrument for applications from industrial hygiene, to leak and hazmat detection.

The RF modem allows real-time data transmissions with a base controller located up to 500 feet (or two-miles with optional RAELink2 portable modem) away from the MiniRAE 3000 detector. A personal computer can be used as the base station for a Mini-RAE 3000 system. The standard ProRAE Remote software is capable of monitoring the input of up to 64 remotely-located monitors like MiniRAE 3000, or AreaRAE, etc.

Key Features

Real-time wireless data transmission with built-in RF modem or Bluetooth.

Easy access to lamp and sensor in seconds without tools.

Inbuilt full RAE Systems 350 compounds correction factors list measure more chemicals than any other PID

Technical Specifications

Title	Value
Sensors	Photoionization sensor with standard 10.6 eV or optional 9.8 eV or 11.7 eV lamps
Battery	Rechargeable, external field-replaceable Lithium-Ion battery pack Alkaline battery adapter
Display Graphic	4 lines, 28 x 43 mm, with LED backlight for enhanced display readability
Calibration	Two-point or three-point calibration for zero and span Calibration memory for 8 calibration gases, alarm limits, span values and calibration dates
Datalogging	Standard 6 months at one-minute intervals
Sampling Pump	Internal, integrated flow rate at 500 cc/mn Sample from 100' (30m) horizontally and vertically
Frequency	902 to 928 MHz (license-free), 2.400 to 2.4835 GHz (license-free), 433 MHz, 869 MHz
RF Range	Up to 500' (900 MHz, 433 Mhz, 869 Mhz) extendable with RAELink3 Repeater to 2 miles
Humidity	0% to 95% relative humidity (non-condensing)
Temperature	-4° to 113° F (-20° to 50° C)

Dimensions

Title	(mm)	(inch)	(kg)	(lbs)
	25.5 x 7.6 x 6.4 cm	10" x 3" x 2.5 "	738 g	26 oz

US: 1 800-242-3910
UK: +44 (0) 845 270 2707
Singapore: +65 6545-9350
www.ashtead-technology.com

Radiodetection MGD-2002 Multi-Gas Leak Locator

The MGD-2002 leak detector is designed for one-handed operation of all functions. Equipped with tacticle membrane keypad, all selections are easily confirmed with a distictive "click" and the backlit display can be viewed in all light conditions. The MGD-2002 is supplied with a built-in headphone jack for use with the audio indicator.

Key Features

Tactile Membrane Keypad

Backlit LCD Display

One Hand Operation

Headphone Jack for Audible Monitoring

Time-Lapse Bar Graph Display

Audible or Digital Output

Lightweight, telescoping ground probe with boot

Utilizes either Helium or Hydrogen* as a tracer gas

Operates in automatic (survey) mode or manual mode

Applications

Direct Buried Telephone Cables

Splice Cases

Underground Ducted Cables

Air Pipe Systems

Underground Storage Chambers/Tanks

Municipal Water Systems

Industrial Air/Gas/Liquid Piping Systems

Electronics Industry

Technical Specifications

Title	Value
Temperature Range	14 °F to 113 °F (-10 °C to 45 °C)
Humidity Range	10% rH to 50% rH
Sensitivity	Min = 25 ppm Max = 1,000,000 ppm (100%)
Tracer Gases	Hydrogen (H) Helium (He)
Resolution	Low range = +/- 25 ppm High range = +/- 0.2%
Response Time	5 seconds (approx.)
Power	Battery: Nickel Metal Hydride, 6 to 8 hours run time

Dimensions

Title	(mm)	(inch)	(kg)	(lbs)
Unit Weight	1.4 kg	3.1 lbs	33.7 x 12.3 x 8.3 cm	13.3 x 4.9 x 3.3 in
Shipping Weight (Complete Kit)			6.8 kg	15 lbs

APPENDIX G

ACTIVITY HAZARD ANALYSIS

ACTIVITY HAZARD ANALYSIS (AHA)

Activity/Work Task: Sub-Slab Vapor Well Installation and Sampling, Indoor Air Sampling	Overall Risk Assessment Code (RAC): 3
Project Location: Former TRW Microwave Facility	
Date Prepared: 3/15/13	
Prepared by (Name/Title): Holly Holbrook / Environmental Engineer	
Reviewed by (Name/Title): Devon Molitor / HSSE Manager	
Notes: (Field Notes, Review Comments, etc.) Level D Personal Protection Equipment (PPE): Hard Hat, Safety Glasses, Steel-Toe Boots and Safety Vest; Additional PPE: Sunscreen (SPF 30+)	

Risk Assessment Code (RAC) Matrix		Mishap Probability Subcategory			
		A. Likely to occur immediately or within a short period of time.	B. Probably will occur in time.	C. May occur in time.	D. Unlikely to occur.
Hazard Severity Category	I. May cause death, permanent total disability, or loss of a facility/asset.	1	1	2	3
	II. May cause permanent partial disability, temporary total disability in excess of 90 days, or major property damage.	1	2	3	4
	III. May cause minor injury, occupational illness, or property damage.	2	3	4	5
	IV. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.	3	4	5	5

Step 1: Review each "Hazard" with identified safety "Controls" and determine RAC (See above).

Step 2: Identify the RAC (Probability/Severity) as 1, 2, 3, 4, or 5 for each "Hazard" on AHA. Annotate the overall RAC at the top of AHA.

RAC Definitions
1- Critical
2-Serious
3-Moderate
4-Minor
5-Negligible

Job Steps	Hazards	Controls	RAC
1. Mobilize equipment and personnel to site.	• Driving hazards	• Inspect vehicles for defects and complete inspection form. • Implement safe driving practices to prevent transportation incidents.	3

Job Steps	Hazards	Controls	RAC
2. Hold Tailgate Safety Briefing, review applicable AHAs and SOPs; Inspect and don PPE; Inspect tools and equipment.	• Incorrect PPE usage • Equipment malfunction • Lack of knowledge of tasks being performed	• Site Safety and Health Officer (SSHO) should check that required PPE is being used, including sunscreen with minimum SPF of 30. • User (AECOM and/or Subcontract Personnel) should inspect equipment before use. • Discuss tasks to be performed by personnel, potential hazards and control measures. • Following daily safety briefing, have personnel sign attendance form which will be maintained onsite. • Inform workers of emergency contact information and hospital route. • Complete tailgate safety meeting form daily and maintain a record on file.	5
3. Evaluate area for hazards (this should be performed regularly throughout the duration of the task) and collect subsurface and survey data.	• Slips, trips and falls • Heat or cold stress • Biological Hazards • Traffic	• Personnel should identify and take measurable precautionary steps to observe areas for hazards: Ensure that pathways are clear and free of obstruction prior to initiating work; Adhere to proper housekeeping practices. • Begin heat or cold stress monitoring and continue while work is performed. • Implement appropriate heat stress prevention procedures (e.g. drink plenty of fluids and use appropriate work/rest schedule) or cold stress prevention procedures (e.g. dress appropriately), as necessary. • Avoid contact with poisonous plants, insects, and wildlife. • Use appropriate PPE. • Use delineators, cones, and/or caution tape to isolate the work area.	4

Job Steps	Hazards	Controls	RAC
4. Install sub-slab vapor monitoring wells	• Hand and power tools • Noise Hearing Loss	• Review and implement procedures provided in S3NA-305-PR, *Hand and Power Tools*. • Use appropriate tool for the job. Ensure that it is the right size and has sufficient power to do the job safely. • Ensure tool is well maintained and in good repair. • Select low vibrating tools, or chose vibration-absorbing handles. • Switch off tools before connecting to power supply. • Do not use electric tools in wet conditions or damp locations. • Do not operate the tool at a pressure above the manufacture rating. • Use only the attachments that the manufacturer recommends for the tools you are using. • Discard damaged or abused tools promptly. • Use appropriate personal protection equipment. • Position your body securely while working with the tool. • Follow instructions on the tool and / or package. • Review and implement procedures provided in S3NA-510-PR, *Hearing Conservation Program*. • Implement engineering controls to reduce noise levels. • Workers will be required to wear appropriate hearing protection during site activities when drilling tools/rigs or other heavy equipment is operated.	3
5. Collect indoor air and sub-slab vapor samples.	• Muscle strain • Manual tool usage • Injured by/striking hazard	• Practice proper lifting and manual handling of materials and equipment, lift with the knees, seek assistance or employ additional handling equipment as needed. • Inspect all tools prior to use. Ensure that tools are properly maintained and remove from use if damaged.	4

Equipment to be Used	Training Requirements for Equipment/Qualified Personnel name(s)	Inspection Requirements
PID Manual Tools	Review SOPs/NA Review SOPs/NA	Calibrate and maintain instruments daily and as instructed by manufacturer Inspect all tools prior to use

Pertinent SOPs:

S3NA-001-PR	*Safe Work Standards and Rules*	S3NA-307-PR	*Housekeeping, Worksite*
S3NA-002-PR	*Stop Work Authority for Unsafe Work*	S3NA-308-PR	*Manual Lifting, Field*
S3NA-005-PR	*Driver and Vehicle Safety Program*	S3NA-313-PR	*Wildlife, Plants and Insects*
S3NA-203-PR	*Emergency Response Planning, Field*	S3NA-505-PR	*Cold Stress Prevention*
S3NA-208-PR	*Personal Protective Equipment Program*	S3NA-509-PR	*Hazardous Waste Operations and Emergency Response*
S3NA-210-PR	*Project Safety Meetings*	S3NA-510-PR	*Hearing Conservation Program*
S3NA-305-PR	*Hand and Power Tools*	S3NA-511-PR	*Heat Stress Prevention*

Prepared by: Holly Holbrook / Environmental Engineer (Sign and Date): 3/15/13

Approved by: Devon Molitor / HSSE Manager (Sign and Date): 3/15/13

Abbreviations

AHA	activity hazard analysis	SSHO	site safety and health officer
HSSE	health, safety, security, environmental	SPF	sun protection factor
NA	not applicable	SOP	standard operating procedure
PPE	personal protective equipment	TBD	to be determined
RAC	risk assessment code		

Personnel Acknowledgement

Printed Name	Signed Name	Company	Date

APPENDIX H

RESPONSES TO COMMENTS

Responses to Comments on "Final Vapor Intrusion Evaluation Sampling and Analysis Work Plan, Former TRW Microwave Facility" dated July 2013

Prepared by Melanie Morash, EPA RPM on 08-23-13

Responses incorporate subsequent email from Melanie Morash on 09-17-13.

Page 1, Section 1.1

"Findings of previous VI investigations performed in 2003 and 2004 concluded that the VI pathway does not pose unacceptable risk..."

Please add language to the end of this section to indicate agency reconsideration of the vapor intrusion pathway. One option is to add the following sentence: "Subsequent changes in vapor intrusion evaluation methods and action levels have prompted a reconsideration of the vapor intrusion pathway and additional vapor intrusion-related sampling at properties on and downgradient of the source areas."

Response*: The sentence below will be added to the end of the first paragraph of Section 1.1 and will state:*

Subsequent changes in vapor intrusion evaluation methods and action levels have prompted a reconsideration of the vapor intrusion pathway and additional vapor intrusion-related sampling at the TRW Microwave Operable Unit.

Page 5, 5th paragraph

"Table 2 summarizes the results from previous indoor air sampling events...comparison to current USEPA RSLs and RWQCB ESLs..."

EPA Region 9 and the Regional Water Board will be clarifying shortly EPA Region 9's interim short-term action levels for TCE. Please add language to the effect that, in addition to comparison to current RSLs and ESLs, the indoor air sampling results will also be compared to Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs) and the EPA Region 9 interim short-term action levels for indoor air TCE exposures. Note that the May 2013 RSL tables may be found at http://www.epa.gov/region9/superfund/prg. The ATSDR MRL table may be found at http://www.atsdr.cdc.gov/mrls/mrllist.asp. The units are all in ppm (mg/m3) for inhalation, while the RSL table is in ug/m3, so a conversion will need to be performed. A conversion calculator may be found at http://www.skcinc.com/converter/converter.asp.

Response*: A review of the ATSDR Minimum Risk Level (MRL) for TCE which is the chronic level to protect under the residential exposure scenario, lists a January 2013*

value of 0.0004 ppm (2.176 µg/m^3). This value is essentially the same as the USEPA Region 9 chronic residential RSL for TCE (2.1 µg/m^3). As the TRW Microwave OU is currently zoned as industrial and expected to remain industrial in the future, this work plan will be evaluating the site for industrial exposure and proposes using the USEPA Region 9 industrial air RSL of 3 µg/m^3 as the PAL. However, the ATSDR MRL for TCE will be included in the indoor air results data table for comparison in the report.

The work plan includes the most current references for the RSL (May 2013) and ESL (May 2013) tables. Since these screening levels are currently recommended for use by USEPA, no change was made to the PALs in the work plan. A discussion of the rationale for the selection of project action levels is included in the last paragraph of Section A.1.4 of the QAPP and is shown below in blue font. A final sentence will be added to this paragraph (shown underlined below) and states that the most current RSLs and ESLs will be used during data evaluation and report preparation:

Since 2004, both toxicological research and the guidance for VI evaluations have continued to advance. Currently, USEPA Region 9 recommends use of "evergreen" USEPA Regional Screening Levels (RSLs) developed jointly by Regions 3, 6, and 9; the RSLs, most recently updated in May 2013, are the project action levels (PALs) selected for this project. In February 2013 the RWQCB updated its ESLs, which included revising the commercial/industrial ESLs to reflect an exposure frequency of 8 hours per day rather than 24 hours per day (used for residential screening levels). This change brought the indoor air industrial ESLs more in line with USEPA's indoor air industrial RSLs, with the exception that the ESLs for some chemicals are based on more restrictive toxicity criteria published by California's Office of Environmental Health Hazard Assessment (OEHHA) than criteria published in USEPA's Integrated Risk Information Service (IRIS) database. For this project, sampling results (where applicable) will be compared to ESLs as well as RSLs~~; however, the RSLs as stated above will be used as PALs~~, both of which were most recently updated in May 2013. Screening levels (both RSLs and ESLs) available at the time the data are evaluated will be used during preparation of the report.

Page 7, Section 3.2

"The USEPA RSLs for industrial exposure to indoor air will be used as PALs."

Please revise this section to state that PALs will include both the EPA RSLs and interim short-term TCE action levels (see above comment), as well as the State of California ESLs (which, for example, in the case of PCE and vinyl chloride, are lower than the EPA levels).

Response: *See response to previous comment above and Table A-2 that lists the PALs.*

Page 7, Section 3.2

Please revise to include a round of indoor air sampling during the wintertime (the coldest month in the Bay Area being January) when there is an increased potential for vapor intrusion.

Response: *It is understood that indoor air sampling results can be affected by operation of an HVAC system which can create positive pressure conditions in a building during the summer and reduce the potential for vapor intrusion. However, as the building is currently unfinished (please refer to site photographs in Appendix C) and is not equipped with an HVAC system, the wintertime may not present an increased potential for vapor intrusion. Please note that the work plan includes a provision for additional sampling as described in the fourth sentence of the last paragraph of Section 6.2 which states:*

Based on these discussions, additional sampling events and/or VI mitigation measures may be required.

Page 12, Section 6.2

"Indoor air sample results will be compared to the USEPA May 2013 indoor air RSLs..."

Please revise also to include comparison to EPA Region 9 interim short-term TCE indoor air action levels.

Response: *Please see response to previous comment above.*

Page 13, Section 6.2 last paragraph

"As a starting point for risk management decisions, Northrop Grumman proposes that no action is appropriate unless the screening-level risk evaluation indicates a cumulative risk exceeding a level of 10-5 for a commercial/industrial scenario..."

Please revise this section to reflect usage of the 10-6 risk level, as opposed to the 10-5 risk level. The following language may be used: Sampling results will be evaluated by comparing the concentrations of any chemicals detected to levels determined by EPA and the Regional Water Board to be protective of human health for long-term exposure. For cancer causing chemicals, EPA considers levels to be protective if they fall within the *range* of a 1 to 100 in a million increased lifetime cancer risk. The level that falls into the most protective end of the risk range—1 in a million or 10-6 increased lifetime risk—is what will be used as the *screening level* for any particular chemical.

Response: *The last paragraph of Section 6.2 (shown in blue below) will be revised as shown below (changes are underlined) to reflect 10-6 as the starting point for risk management decisions.*

As a starting point for risk management decisions, Northrop Grumman proposes that no

action is appropriate unless the screening-level risk evaluation indicates a cumulative risk exceeding a level of ~~10^{-5}~~ 10^{-6}~~.~~ for a commercial/industrial scenario. Based on this screening level risk evaluation, a conclusion will be provided regarding whether the cumulative cancer risk attributed to VI is below the risk level of ~~10^{-5}~~ 10^{-6} and a non-cancer HI of 1, in which case no further action will be recommended. If sampling results indicate a cumulative screening-level cancer risk attributed to VI between 10^{-4} and ~~10^{-5}~~ 10^{-6} and/or an HI greater than 1, Northrop Grumman will discuss and document appropriate risk management decisions with the regulatory agencies. Based on these discussions, additional sampling events and/or VI mitigation measures may be required.

Page 14, Section 7.0 last sentence

Please add a sentence regarding submittal of analytical results to the Agencies within 48 hours of receipt from the laboratory.

Response: *Section 7.0 of the work plan will be revised to include a statement indicating that final analytical results will be submitted to the Agencies within 48 hours of receipt from the analytical laboratory.*

Responses to **REVIEW COMMENTS**

Received on May 17, 2013

Note: These responses reflect the outcome of a June 4, 2013 conference call between Max Shahbazian (San Francisco Regional Water Quality Control Board), Klaus Rohwer (Northrop Grumman's Independent Project Manager) and Rebecca Mora (AECOM Project Manager).

The following are our review comments on Draft *Vapor Intrusion Sampling and Analysis Work Plan, Former TRW Microwave Facility, 825 Stewart Drive, Sunnyvale, California,* prepared for Northrop Grumman Systems Corporation by AECOM, dated March 15, 2013 (work plan). Our December 6, 2012, work plan requirement letter did not require sub-slab soil gas sampling. However, the work plan indicates that there are indoor air sources of trichloroethene (TCE) and tertachloroethene (PCE) inside the site building (see the last paragraph on page 3 of Appendix A). Therefore sub-slab soil gas sampling is needed to evaluate the source of TCE and PCE detected inside the site building.

Response: *AECOM will reword the last paragraph on page 3 of Appendix A to clarify that there are no indoor sources of TCE and PCE currently present within the building.*

General Comment

The work plan should describe plans to collect sufficient data to assess the vapor intrusion pathway at this building(s) and to evaluate the possible future need for a vapor intrusion (VI) remedy. The building has been vacant for over 10 years and there are no indoor sources of contaminants of concern (COCs). The property may be developed or redeveloped in the future, hence the need to evaluate the potential for vapor intrusion. Previous studies described in the Section 2.2 suggest a subsurface source of volatile organic compounds (VOCs) based on groundwater data and confirmed by past indoor air monitoring conducted without ventilation. Groundwater conditions at the Site are changing and NGC should collect sufficient lines of evidence to rule out any future response action related to VI. That is the investigation should not be limited to indoor air (IA) alone and should include sub-slab sampling. The source area remains above groundwater RSLs and historic indoor air sampling levels are above current RSLs indicate a potential risk from vapor intrusion that may suggest mitigation. If a remedy is needed, it will depend on the building use.

We recommend the work plan be revised to include sub-slab soil vapor sampling to assess the potential VI risk. If concentrations are found greater than RSLs, then a remedy may be required. Post mitigation IA sampling would also be required prior to occupancy to confirm mitigation is effective.

Response: *Sub-slab sampling will be incorporated into the sampling program in order to assess the potential for VI risk and the need for mitigation. Collection of indoor air and sub-slab soil gas samples will allow a multiple lines of evidence (MLE) evaluation of whether there are currently indoor air impacts and if so, identify the sources of those impacts. In addition, the results will provide the property owner with valuable information on the potential for VI risk.*

Specific Comments

1 **Comment: Overall Project Objectives.** The major objective to assess current conditions and evaluate the vapor intrusion pathway using the multiple lines of evidence approach as outlined in current EPA guidance to be able to make recommendations to select a VI remedy, if necessary. The building is and has been vacant since 2002 and determining the potential for vapor intrusion for this or

future building(s) is necessary.

Response: *Agree. The overall project objectives will be revised to include assessment of current conditions and the potential for VI risk using multiple lines of evidence.*

2 **[Section 2.2, Summary of Previous IA Sampling Activities]** This work plan should include a summary of previous soil vapor, source area, and groundwater data along with information on previous and on-going remedial actions (i.e., soil vapor data) in the vapor intrusion study area. This information should be summarized on maps where possible.

Response: *Agree. A summary of previous and on-going site remedial actions will be incorporated into Section 2.0 Site Background and Conceptual Site Model. Figure 4 of the draft work plan includes the most recent groundwater data on a site map; however, a summary of historic groundwater data for wells within the vapor intrusion study area will be added as an Appendix in the revised work plan.*

3 **[Section 2.3, CSM and Selection of Site Locations.** The approach should include following a multiple line of evidence (MLE) investigation for vapor intrusion. Primary lines of evidence that should be considered for commercial buildings are:

- Air Sampling Data
  - Breathing zone indoor air
  - Outdoor air background
  - Indoor air pathways
- Building Characteristics
  - Ventilation
  - Construction
  - Pathways
- Sub-slab Soil Vapor Data
- Shallow Groundwater Data
- Source Information
  - Location
  - Source removal actions

The goal of this investigation should be determining the potential for vapor intrusion for this or future building(s). Based on the evaluation of MLE for vapor intrusion the current or any potential future buildings will either need to be:

- Mitigated
  - high potential for vapor intrusion, e.g., above screening levels.
- Put into a long term monitoring program
  - vapor intrusion below screening levels and/or a moderate potential for vapor intrusion
- Ruled out for vapor intrusion unless site conditions change
  - No measured vapor intrusion and low potential for vapor intrusion

Response: *Agree. Section 2.3 will be revised to clearly identify potential VI pathways and incorporate multiple lines of evidence into the sampling strategy.*

4 **[Section 3.2, Air Sampling]** Indoor air samples should be collected to represent each ventilation

zone, if possible. Additionally, the duration of indoor air sample collection should not automatically be 8 hours. The duration of samples should be dependent on building occupancy hours and ventilation which are unknown. Sample durations of 8, 10, 12, or 24 hours are possible for indoor air sampling. Since the building is vacant EPA recommends 24 hours samples.

Response: *There is no ventilation system in the building and therefore, different ventilation zones do not currently exist. Based on the current and anticipated future land use and zoning for commercial/industrial purposes, we propose a sample duration of 8 or 12 hours. As a side point, (and as discussed on the conference call), as a result of past vandalism and the observed presence of transients residing near the property, collection of 24-hour samples would present logistical challenges regarding security of personnel and the outdoor sample containers.*

5 **[Section 3.0, SAP**] In addition to indoor air samples and outdoor air samples, pathway and sub-slab samples should be collected.

Response: *Agree. As discussed in the fourth paragraph of Section 2.3 of the draft work plan, pathway sampling locations have been selected (i.e., Eductor and elevator shaft) This paragraph will be reworded to clarify that these are potential vapor intrusion "pathways." Sub-slab sample locations will be incorporated into the revised work plan.*

6 **[Section 3.2., Air Sampling]** Summa canisters should be checked at least once during the day to ensure that they are operating properly. It is also recommended, to ensure that the 90 percent completeness requirement be met, that samples are checked early on in the sampling period to ensure that they are flowing at the proper rate. Low flow may indicate a sticking valve, this problem may be fixable or the can could be replaced. High flow indicates an improperly calibrated or leaking can that could be replaced. A can with flow is only slightly high can be picked up early (up to 1 hour) and still be representative of an integrated sample if pressure requirements are met.

Response: *Agree. Procedures for monitoring and ensuring proper operation of the Summa canisters during the sampling event will be added to Section 3.2 of the revised work plan.*

7 **[Section 3.2, Air Sampling,** Please include a table for surrogate or individual certification of canisters.

Response: *Agree. Copies of individual Summa canister certifications will be included in the report.*

8 **[Section 3.2 Outdoor Ambient Air Samples]** It is recommended that canisters placed outdoors be placed in containers (with the inlet extending out of the container) and be sampled for 24 hours. This will help to prevent the samples from being disturbed and protect them from direct sunlight. The duration of outdoor air samples should be at least as long as the longest indoor air collection duration. Note that the preservation for canister samples is to store at ambient pressure and temperature, avoiding temperature extremes and direct sunlight.

Response: *Agree. Outdoor samples will be placed in containers and appropriate language will be added to Section 3.2. Please see response to Comment 4 regarding collection of 24-hour samples.*

9 **[Section 3.3, Sample Handling, Sample ID, Sample Custody, and Shipping]** This plan needs to include

a. additional details on how each of the quality control samples listed will be collected in the

field and/or handled in the laboratory;

b. a requirement that pictures be taken of each sampling location during sampling;

c. canister identification numbers be added to the list of information recorded on the chain of custody.

Response: *Agree. Appropriate changes will be made to Section 3.3.*

10 **[Section 4, Appendix A, Quality Assurance Project Plan]**

a. **[Section A.1.6, Data Quality Objectives]** This section should discuss how building characteristics and sub-slab data will be used to support vapor intrusion decision making.

b. The QAPP should include an independent third party data validator in both this section and in the project organization.

Response: *Section A.1.6 will be revised as suggested. Regarding Comment 10b, the draft work plan identifies Conestoga-Rovers and Associates (CRA) as the third party data validator for the sampling event (see first paragraph of Section 6.1, Table A-1 in Appendix A, and Section A.5.1 of Appendix A).*

11 **[Section 6.2, Data Evaluation]** The contaminants of concern should be presented on a table along with their respective RSLs. It is also recommended that this section make an attempt to identify the contaminants that would most likely be the risk drivers if vapor intrusion is occurring (this may be source and/or building dependent).

Response: *Agree. Table 1 of the draft work plan includes the requested information. A reference to Table 1 will be added to Section 6.2. A footnote will be added to Table 1 to identify contaminants that are most likely to be the risk drivers if vapor intrusion is occurring.*

12 **[Section 6.2, Data Evaluation]** This section needs to be expanded to incorporate how other lines of evidence will be incorporated into the evaluation of data. Additionally, the plan needs to develop how many rounds and the type of indoor air sampling needed to represent seasonal and temporal variability and the potential for vapor intrusion.

Response: *Agree. Section 6.2 will be revised to include how sub-slab data will be evaluated. We propose that results from the indoor air and sub-slab sampling be evaluated for potential VI risk followed by a discussion with the regulatory agencies to assess the need and scope of an additional sampling event.*

13 **[Section 6.3, Reporting,]** A discussion should be added of screening levels for both cancer and non-cancer endpoints and the potential differences in the types of risk management decisions made when these different types of risk numbers are exceeded.

Response: *Agree. Both cancer and non-cancer endpoints will be evaluated and reported.*

14 **[Section 7.0, Schedule]** Please include a detailed schedule for all proposed activities through submission of VI Investigation Report.

Response: *As discussed during the conference call, Northrop Grumman is planning to perform additional investigation and remediation activities near the Eductor that could have an effect on indoor air results. These investigation and remediation activities can be expedited so that assuming*

the VI Work Plan is approved the indoor air and sub-slab sampling can be completed by September/October 2013. Therefore, Northrop Grumman requests that the schedule in the work plan remain flexible to allow the investigation and remediation activities to occur prior to indoor air and sub-slab sampling.

15 **[Table 2]** Please add soil gas and groundwater data, or include them in separate tables.

Response: *Agree. A summary of historic groundwater data for wells within the vapor intrusion study area will be included as an Appendix in the revised work plan.*

16 **[Figures]** Please add a figure of proposed sub-slab soil gas sampling probe locations.

Response: *Agree. A figure of the proposed sub-slab soil gas sampling locations will be included in the revised work plan.*

From: Shahbazian, Max@Waterboards [mailto:Max.Shahbazian@waterboards.ca.gov]
Sent: Thursday, June 20, 2013 9:48 AM
To: Mora, Rebecca
Cc: Klaus Rohwer; Cramer, Rick
Subject: RE: Regional Water Board REVIEW COMMENTS on Vapor Intrusion Sampling and Analysis Work Plan, former TRW Microwave facility

Rebecca,
The sampling duration should be 12 hours.
Thank you,
Max

From: Mora, Rebecca [mailto:Rebecca.Mora@aecom.com]
Sent: Wednesday, June 19, 2013 6:00 PM
To: Shahbazian, Max@Waterboards
Cc: Klaus Rohwer; Cramer, Rick; Wolfenden, John@Waterboards
Subject: RE: Regional Water Board REVIEW COMMENTS on Vapor Intrusion Sampling and Analysis Work Plan, former TRW Microwave facility

Thank you Max! Just a quick clarification… can the sampling duration be 12 hours (as opposed to less than 12 hours)? We are comfortable with the 12 hour sample. It is the 24-hr sampling requirement that would cause some logistical and potentially health and safety concerns. Can you please let us know and we will move forward with finalizing the work plan.

Thank you very much!

Rebecca

Rebecca Mora
Senior Technical Leader/Senior Engineer, Environment
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From: Shahbazian, Max@Waterboards [mailto:Max.Shahbazian@waterboards.ca.gov]
Sent: Wednesday, June 19, 2013 4:37 PM
To: Mora, Rebecca
Cc: Klaus Rohwer; Cramer, Rick; Wolfenden, John@Waterboards
Subject: Regional Water Board REVIEW COMMENTS on Vapor Intrusion Sampling and Analysis Work Plan, former TRW Microwave facility

Rebecca and Klaus,

I discussed your responses to the subject comments with my supervisor, John Wolfenden. We concur with all your responses except the response to specific comment #4. The indoor air sampling duration should not be less than 12 hours.

Please revise the work plan and resubmit it for final review and approval. Thank you,

Max Shahbazian, P.G.
California Environmental Protection Agency
Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, CA 94612
Tel. (510) 622-4824

From: Mora, Rebecca [mailto:Rebecca.Mora@aecom.com]
Sent: Tuesday, June 18, 2013 12:59 PM
To: Shahbazian, Max@Waterboards
Cc: Klaus Rohwer; Cramer, Rick
Subject: RE: REVIEW COMMENTS on Vapor Intrusion sampling and analysis work plan, former TRW Microwave facility

Hello Max,

Per our conference call on June 4th, we have revised the attached responses to comments on the vapor intrusion sampling and analysis plan for the former TRW Microwave facility in Sunnyvale. As you may recall, a couple of the comments still require a resolution. Please let us know when you would like to discuss.

Thank you very much,

Rebecca

Rebecca Mora
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From: Shahbazian, Max@Waterboards [mailto:Max.Shahbazian@waterboards.ca.gov]
Sent: Thursday, May 23, 2013 3:36 PM
To: Rohwer, Klaus; Kwan, Joseph
Cc: Cramer, Rick; Mora, Rebecca
Subject: REVIEW COMMENTS on Vapor Intrusion sampling and analysis work plan, former TRW Microwave facility

Hi Klaus and Joe,
Please let me know if you have any questions on the subject comments, and when would you submit a revised work plan.
Thank you,
Max

Joe and Klaus,

Attached please find our review comments on the subject work plan.

Please call me if you have any questions.

Sincerely,

Max Shahbazian, P.G.
California Environmental Protection Agency
Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, CA 94612
Tel. (510) 622-4824