FOURTH FIVE-YEAR REVIEW REPORT

for

Applied Materials
Bowers Campus
Santa Clara, California

September 2010

U.S. Environmental Protection Agency, Region IX
San Francisco, California

Approved by:

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9/28/10

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ACRONYMS AND ABBREVIATIONS

1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
ALs	action levels
AM	Applied Materials
AM1	Applied Materials Building 1 Superfund Site
AWNS	acid waste neutralization system
bgs	below ground surface
COC	contaminant of concern
EPA	United States Environmental Protection Agency
ESL	environmental screening level
FFS	Focused Feasibility Study
ft	foot/feet
g	gram(s)
gpm	gallons per minute
HP	Hewlett-Packard
kg	kilograms
MCL	maximum contaminant level
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MAROS	Monitoring and Remediation Optimization System (software)
MSCA	multi-site cooperative agreement
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
PCE	perchloroethylene

PMP	pumping modification program
PRG	preliminary remediation goal
RAO	remedial action objective
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board – San Francisco Bay Region (Regional Board)
SBS	South Bay Sites
SCFD	Santa Clara Fire Department
SCR	site cleanup requirements from RWQCB orders
SMP	self monitoring program
SOW	scope of work
STLC	soluble threshold limit concentration
TBC	to be considered
TCE	trichloroethylene
TTLC	total threshold limit concentration
US EPA	United States Environmental Protection Agency, Region 9
UST	underground storage tank
VOC	volatile organic compound
WET	waste extraction test

EXECUTIVE SUMMARY

The United States Environmental Protection Agency (EPA) completed the fourth site-wide five-year review (FYR) of the remedial actions implemented at the Applied Materials Superfund Site (also known as the Applied Materials - Building 1 (AM1) Facility) in Santa Clara, California. The purpose of the five-year review is to evaluate whether the remedial measures implemented at AM1 continue to be protective of human health and the environment. This FYR is required because hazardous substances remain on-site above levels that allow for unlimited use and unrestricted exposure. The methods, findings, and conclusions of the review are documented in this report. In addition, this report summarizes issues identified during the review and includes recommendations and follow-up actions to address them. The triggering action for this review was the completion of the third FYR on September 29, 2005.

Volatile organic compounds (VOCs) were discovered in November 1983 in the shallowest water-bearing zone (A zone) downgradient of three underground storage tanks (USTs) adjacent to AM1. In 1985, the tank and about 60 cubic yards of soil were excavated, removing as much of the higher concentration VOCs as feasible at the AM1 source. The excavation was backfilled and converted into a ground water extraction pit, and two A-zone ground water extraction wells, well AM1-1 and well AM1-5E, were installed. In 1990, A2-zone extraction well AM1-10 was added to the extraction system. Extracted ground water was treated by air-stripping and initially discharged to surface water under a National Pollutant Discharge Elimination System (NPDES) permit. Later, beginning in May 2001, treated water was discharged to the site sanitary sewer under the site Sanitary Sewer Discharge Permit. The final ROD for the AM1 site determined that "no further remedial action other than that already implemented at the site is required to ensure protection of human health and the environment" (US EPA, 1993).

Although the AM1 site was listed on the National Priorities List (NPL) in 1987, the California Regional Water Quality Control Board – San Francisco Bay Region (Regional Board) continued to serve as lead agency until 2006. The Remedial Action Objectives (RAOs) presented in the Regional Board Orders (1989, 1990, and 1993) and the EPA RODs (1990, 1993) were developed to meet the following specific cleanup objectives for the AM1 site:

- restore the quality of a polluted water source to its potential suitability as a drinking water supply;
- prevent exposure to polluted water; and
- prevent pollution of the deeper aquifers (C zone) which presently supply water for domestic use (i.e., drinking water) and other beneficial uses.

During its operation from August 1985 through February 2002, the ground water extraction system adequately prevented plume migration, removed VOC mass, and reduced VOC plume concentrations. Since ground water pumping began, approximately 85 million gallons of ground water were treated and approximately 254 kilograms (kg) or 560 pounds of VOCs were

removed. During the first four years of ground water extraction, the AM1 system removed an estimated 187 kg of VOCs. During the first Five-Year Review period from mid-1989 to mid-1994, the system removed an additional 47 kg of VOCs. During the second Five-Year Review period from mid-1994 to mid-1999, the system removed an additional 19 kg of VOCs. During the third Five-Year Review period from mid-1999 to mid-2004, only A2-zone extraction well AM1-10 was operating, and this well removed an additional 1.39 kg of VOCs from the start of the period until it was shut down in February 2002. During this fourth five-year review period from mid-2004 to 2009, all extraction wells remained off.

Only four monitoring wells are currently being sampled annually: AM1-5E, AM1-6, AM1-7, and AM1-11. VOC concentrations have dropped over 99% in the A-zone source area; and from 1995 on, VOCs were consistently undetected above method detection limits in the B zone. From 1990 through February 2002, A2-zone ground water extraction from well AM1-10 reduced VOC concentrations in this localized hot spot by about 99%.

During the most recent sampling event in January 2010, the only VOC detected at the site above maximum contaminant levels (MCLs) is 1,1-dichloroethane (1,1-DCA) in wells AM1-5E and AM1-7.

This is the fourth site-wide five-year review for the AM1 Site. The activities conducted for this five-year review included a site inspection, technical interviews of operators and regulators of the site, community notice and technical review and analysis of data from the last six years of reports (2005-2010) submitted by Weiss Associates, for Applied Materials.

Currently, all monitoring data show that the contaminant concentrations continue to decrease, and with the institutional control in place to restrict the use of ground water as a drinking water source, the remedy is considered to be protective of human health and the environment. EPA is recommending continuation of annual monitoring in the four remaining wells.

Five-Year Review Summary Form
Site name : Applied Materials Building 1 Superfund Site
EPA ID: CAD042728840 **CERCLIS ID :** 0983
Region: 9 **State:** California **City/County:** Santa Clara/Santa Clara
SITE STATUS
NPL status: ☒ Final ☐ Deleted ☐ Other (specify) July 22, 1987
Remediation status (choose all that apply): ☐ Operating ☒ Complete
Multiple OUs? ☐ YES ☒ NO **Construction completion date:** September 1991
Has site been put into reuse? ☒ YES ☐ NO
REVIEW STATUS
Reviewing agency: ☒ EPA ☐ State ☐ Tribe ☐ Other Federal Agency
Author name: Kim Hoang, PhD, MPH
Author title: Remedial Project Manager **Author affiliation:** EPA Region 9
Review period: January 2010 – September 2010
Date(s) of Site inspection: April 2, 2010
Type of review: ☐ Statutory ☒ Policy ☐ Post-SARA ☐ Pre-SARA ☐ NPL-Removal only ☐ Non-NPL Remedial Action Site ☐ NPL State/Tribe-lead ☐ Regional Discretion)

Review number: ☐ 1 (first) ☐ 2 (second) ☐ 3 (third) ☒ Other (Fourth)

Triggering action:

☐ Actual RA Onsite Construction at OU No.__

☐ Actual RA at OU No.__

☒ Previous Five-Year Review Report

☐ Construction Completion

☐ Other (specify) _____

Triggering action date: September 29, 2005

Due date (five years after triggering action date): September 29, 2010

Issues and Recommendations

Issues

There are no issues that affect protectiveness.

Recommendations

There are no recommendations that affect protectiveness.

Protectiveness Statement

The conditions at AM1 are protective of human health and the environment because all exposure pathways that could result in unacceptable risk are being controlled. A deed restriction on the property prevents exposure to on-site soil contamination and restricts the use of shallow ground water for drinking water. Current monitoring data indicate that the ground water remediation was effective, and that the contaminant concentrations are in a decreasing trend towards achieving ground water remediation standards.

1. INTRODUCTION

This report documents the findings and recommendations of the Fourth Five-Year Review for the Applied Materials Building 1 (AM1) Superfund site, located at 3050 Bowers Avenue in Santa Clara, California (Figure 1). This review was conducted between January 2010 and September 2010. At the request of EPA, Weiss Associates submitted a "Five Year Review Report for Applied Materials Bowers Campus, Santa Clara, California" in March 2010 ("AM FYR 2010"), and the U.S. Army Corps of Engineers (USACE) provided site inspection and technical interviews in April 2010. EPA incorporated selected information from those efforts into its preparation of this report documenting the results of the five-year review

The purpose of this Five-Year Review is to determine whether the remedy at the site remains protective of public health and the environment and to address any issues remaining from the previous Five-Year Review. If the review finds that the site's remedy is not protecting human health and the environment, the Five-Rear Review report will recommend actions, identify milestones, and provide a schedule to accomplish the necessary tasks to achieve protectiveness.

The EPA is preparing this FYR report pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) § 121 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA §121(c) states:

> *If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.*

The EPA interpreted this requirement further in the NCP; 40 CFR § 300.430 (f) (4) (ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after initiation of the selected remedial action.*

Because contaminant levels will allow for unlimited use and unrestricted exposure upon achieving ROD cleanup goals, this Five-Year Review is not required by CERCLA (Section 121(c)) or by Section 300.430(f)(4)(ii) of the NCP. However, because cleanup will take five years or more to attain, this Five-Year Review must be conducted as a matter of Agency policy

(OSWER Directive 9355.7-02, "Structure and Components of Five-Year Reviews", 5/31/91. This review (Type 1) is applicable to sites at which construction is complete (OSWER Directive 9355.7-02A, "Supplemental Five-Year Review Guidance", 7/26/94. The purpose and focus of five-year reviews are further defined in EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9355.7-03B-P (EPA, 2001).

2. SITE CHRONOLOGY

A summary of the chronology of major events associated with both soil and ground water remedial actions at AM1 to date is presented below.

Date	**Event**
November 1983	Applied Materials (AM) voluntarily investigates its underground tank locations.
1983 -1985	Several extraction wells and monitoring wells are installed to treat contaminated ground water, together with granular activated carbon and air stripping treatment systems.
January 1985	Applied Materials implements initial response measures, including soil excavation, underground tank removal, and construction of an extraction pit and well AM1-EP.
August 1985	Applied Materials initiates a ground water monitoring program with extraction from wells AM1-1, AM1-5E, and AM1-EP.
October 1985	EPA and the Regional Board sign the South Bay Multi-Site Cooperative Agreement and the South Bay Ground Water Contamination Enforcement Agreement
July 1987	The AM1 site is added to the National Priorities List (NPL).
February 1988	Applied Materials submits the Remedial Investigation/Feasibility Study (RI/FS) report to regulatory agencies.
September 1989	Regional Board issues Site Cleanup Order No. 89-167. The Self-Monitoring Program (SMP) includes tri-annual VOC analysis for ground water from AM1 wells and off-site wells HP-1 and HP-6.
September 1990	Regional Board adopts revised Site Cleanup Order No. 90-134.
September 1990	EPA issues Record of Decision (ROD) for ground water remediation.
1990 -1991	Soil Assessment Phase 2 and Cleanup Proposal
December 1991	Applied Materials submits the A2 Water-Bearing Zone Investigation.
1985-1992	Several monitoring wells were abandoned and new ones constructed.
March 1992	Pump at extraction pit AM1-EP is shut off and disconnected due to drought-associated low ground water extraction rates.
June 1993	Regional Board adopts Site Cleanup Order No. 93-056.
August 1993	EPAissues ROD for soil and ground water remediation.

Date	Event
September 1994	First Five-Year Status Report and Effectiveness Evaluation submitted to Regional Board.
June - September 1996	Shutdown of well AM1-5E and a simultaneous increase of the AM1-1 extraction rate to about 10 gallons per minute (gpm).
1997 - 1999	Reduction of monitoring frequency in several monitoring wells.
July 1999	Extraction discontinued from well AM1-1, leaving A2-zone well AM1-10 the sole contributor of ground water to the AM1 treatment system.
September 1999	Second Five-Year Status Report and Effectiveness Evaluation submitted to the Regional Board.
1999-2001	Monitoring frequency changes in several wells. Several monitoring wells are destroyed and abandoned.
December 2002	Regional Board approves shutdown of the last active extraction well, AM1-10.
November - December 2003	All of the labs in Building 1 were closed, with most of the labs converted into office space. Destruction of several additional monitoring wells. The Regional Board approves destruction of three former extraction wells (AM1-EP, AM1-1 and AM1-10) and five monitoring wells (AM1-2, AM1-9, AM1-3, AM1-14 and AM1-5B), as well as removal of the air stripper and associated equipment pad.
September 2004	Applied Materials submits Third Five-Year Status Report and Effectiveness Evaluation to the Regional Board on September 28, 2004. Applied Materials proposes MCL attainment criteria.
December 2004	On December 17, the Regional Board approves further reductions in the SMP requirements for the site based on the very low and generally declining plume concentrations. The revised SMP requires monitoring in only four A-zone wells (AM1-5E, AM1 6, AM1-7 and AM1-11) and in off-site A2-zone well AV-1B. The SMP approved discontinuing monitoring of wells AV-1A and AV-7A, (RWQCB, 2004).
June 2006	On June 26, Applied Materials andEPA meet to discuss statistical evaluation results and Focused Feasibility Study (FFS) contents and how statistical results will be incorporated into that report.
August 2006	Regional Board transfers site back to EPA.
2006 - 2007	Applied Materials submits FFS to EPA.
2009 - 2010	Applied Materials meets with EPA to discuss Five-Year Review process and Close-out requirements.

3. BACKGROUND

3.1 Physical Characteristics

The AM1 site is located at 3050 Bowers Avenue in the City of Santa Clara, on a nine-acre parcel about 6.4 miles south of San Francisco Bay, within one mile of Calabazas, Saratoga, and San Tomas Aguino Creeks (see Figure 1). The population of the City of Santa Clara is about 90,000. The population density in the vicinity of the site is about 4,660 people per square mile. Land use near the site is primarily light industrial, commercial and residential.

Building 1, located at 3050 Bowers Avenue in Santa Clara, California (Figure 1) began operations in 1970 as a semi-conductor wafer manufacturing facility. Currently, AM1 is one of many sites in an area known as the South Bay Sites (SBS), where historical industrial activities have resulted in a broad area of solvent- contaminated ground water. AM1 was converted to offices and educational facilities in 2003, eliminating research and manufacturing activity on-site.

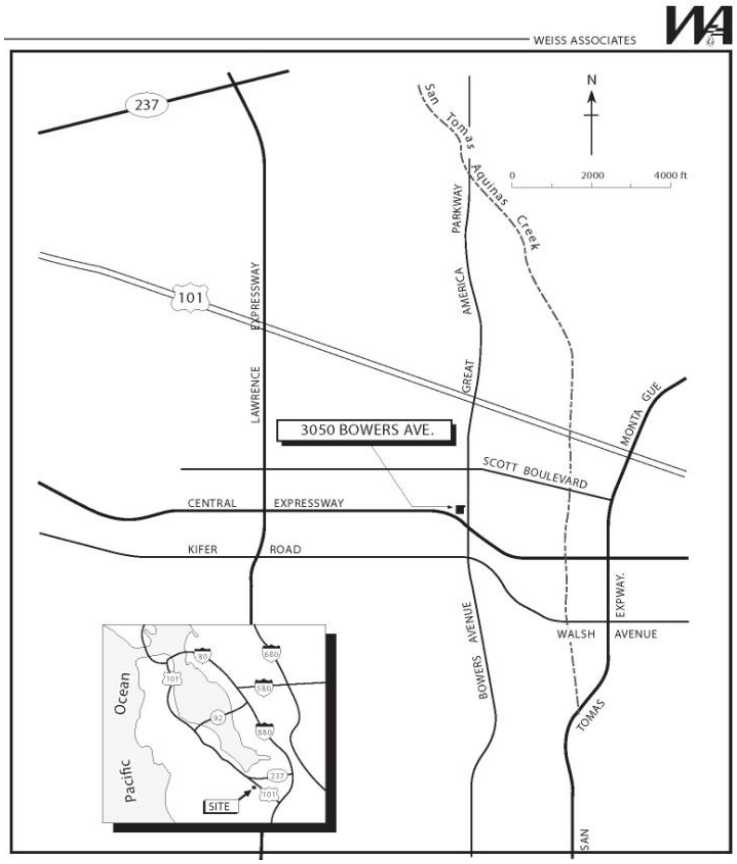

Figure 1: Location of 3050 Bowers Avenue, Applied Materials Building 1 and Vicinity, Santa Clara, California

Hydrogeology

The site is in the Santa Clara Valley, a sedimentary basin filled with unconsolidated heterogeneous alluvial material, sometimes interspersed with layers of marine clay. The alluvium is a mixture of permeable water-bearing sands and gravels inter-bedded with less permeable silts and clays. The soils are extremely variable over short distances, both horizontally and vertically.

Water-bearing deposits in the Santa Clara Valley and at the Building 1 site are generally divided into three laterally traceable units, beginning with the near-surface A zone and progressing with depth through the B zone and into the C zone. The top of the A zone is found at depths between 9 and 15 feet below the surface; the B zone at between 42 and 47 feet. The A and B zones are separated by a layer of silty clay at least 5 feet thick. The subsurface has been characterized by detailed logging of on-site boreholes drilled for well installation and soil sampling, and is described in detail in Appendix E, Data Review Memorandum. Figure 2 shows a geologic cross-section of the site and Figure 3 shows the location of all the wells on the site, respectively. Table 1 lists all the wells associated with the site and their characteristics.

Ground water is found at a depth of about eight feet in the A zone and is confined or semi-confined. Ground water flow is to the northeast, at a calculated velocity of about two feet per day. Water level measurements indicate an upward hydraulic gradient between the A and B zones. Water in the A and B zones at this site is not withdrawn for any current The C zone is located from 150 to more than 500 feet below the surface, and contains aquifers which produce water for domestic and other uses. The C zone aquifers are separated from the shallow A and B aquifers by clay layers ranging from 50 to 150 feet. These clay layers can provide an effective natural barrier to vertical ground water movement, but are not universally present. The integrity of clay barriers that are present may be compromised at specific locations by abandoned wells that are improperly sealed and act as conduits for the vertical migration of pollutants.

VOCs at this site are found in fine-grained silts and clays in the depth interval of 8 to 19 feet, and in the ground water and soils of the underlying gravelly sand of the A zone aquifer which is five or more feet thick. VOCs have also been found in the B zone, to a limited extent. By 1983, the AM1 plume had migrated a distance of 700 feet or more downgradient, 500 feet cross-gradient, and vertically downward to a depth of about 50 feet below the surface.

The primary migration pathway is through the aquifers. There are no surface migration pathways. No water supply wells, active or abandoned, are located within the plume. The nearest former water supply well, more than 500 feet deep in the C zone, was located east of Building 1 and just beyond the eastern margin of the plume. This well was closed in April 1986 under supervision of the Santa Clara Valley Water District. The nearest public water supply well is 3500 feet upgradient to the southwest. No contaminants have been detected in this well.

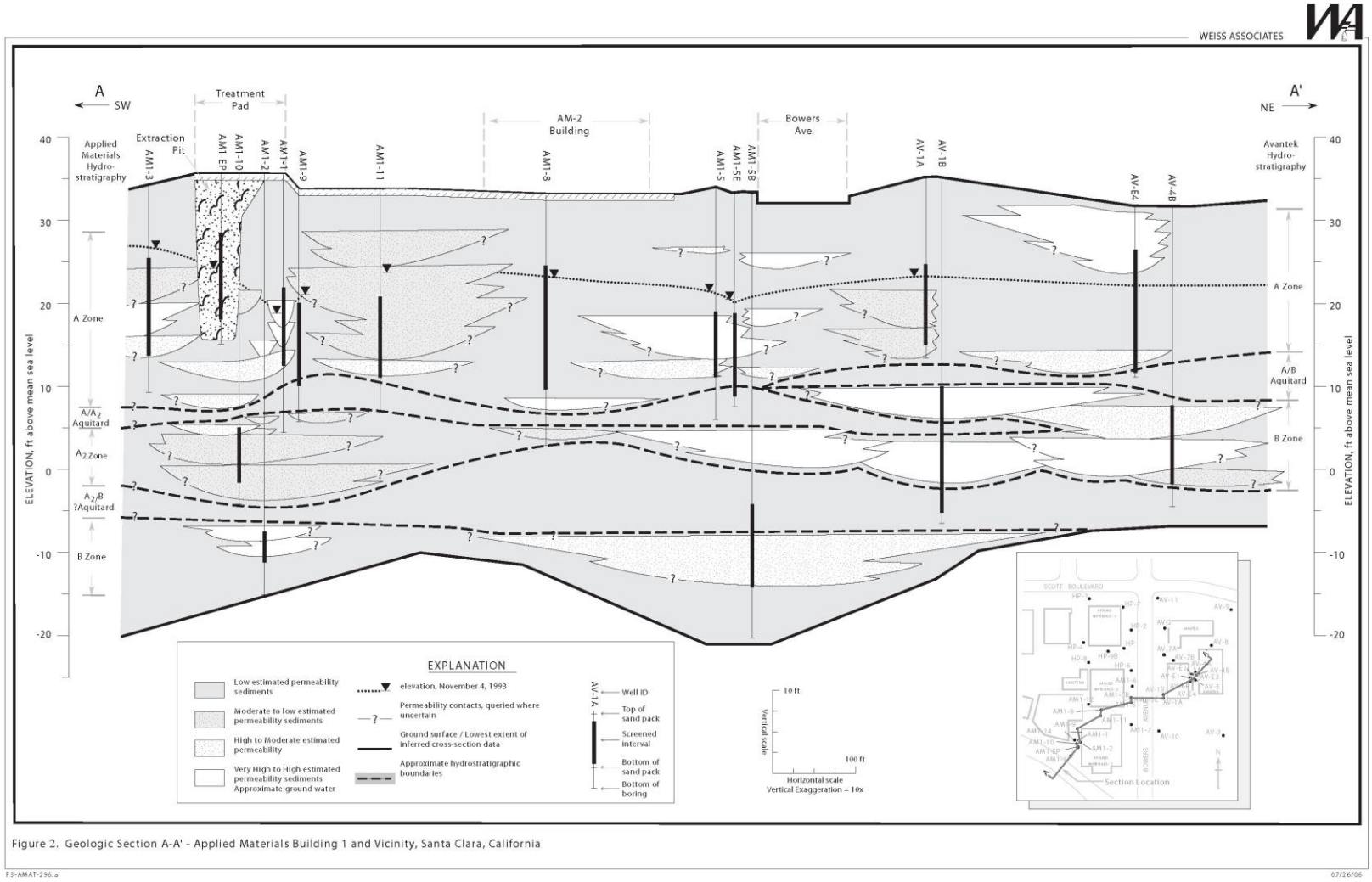

Figure 2. Geologic Section A-A' - Applied Materials Building 1 and Vicinity, Santa Clara, California

Figure 2: Geologic Section A-A' – Applied Materials Building 1 and Vicinity, Santa Clara, California

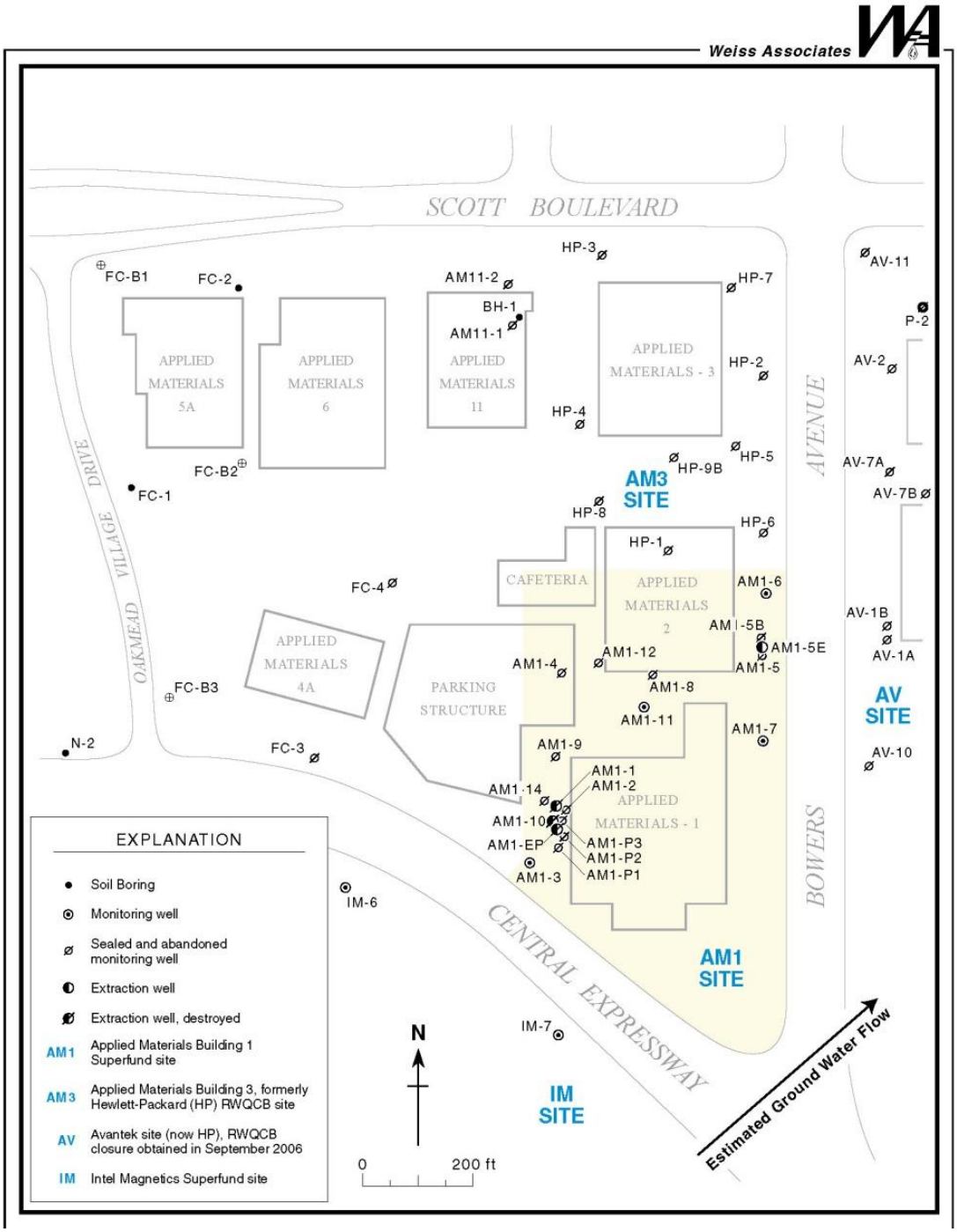

Figure 3: Well location, Applied Materials Building 1 and Vicinity, San Clara, California

Table 1: Well Details and Depths, Applied Materials Building 1 and Vicinity, Santa Clara, California.

Well ID	Well Type[1]	Date Installed	Top of Casing Elevation (ft above msl)	Screened interval (ft)	Sand Pack Interval (ft)	Casing diameter (in)	Original Well Depth [2] (ft)
A-Zone Wells							
AM1-1	EW	Nov-83	34.55	13.5-24.0	13.5-24.0	2	24.0
AM1-3	MW	Apr-84	34.55	8.7-21.0	8.0-21.0	2	21.0
AM1-4	MW	Apr-84	33.69	8.5-40.5	8-40.5	2	40.5
AM1-5	MW	Jun-84	32.42	15.0-23.0	14.0-23.0	2	23.0
AM1-5E	EW	Jan-85	31.90	14.0-24.0	13.0-24.0	4	24.0
AM1-6	MW	Apr-85	33.21	11.7-21.5	10.0-21.5	2	21.5
AM1-7	MW	Apr-85	33.78	17.5-27.0	15.5-27.5	2	27.5
AM1-8	MW	Apr-85	32.06	8.0-23.0	6.0-23.0	2	23.0
AM1-9	MW	Apr-85	34.36	14.0-24.0	9.54-24.0	2	24.0
AM1-11	MW	Feb-91	32.30	13.0-23.0	11.5-23.0	2	23.0
AM1-12	MW	Feb-91	33.17	13.0-23.0	10.5-23.0	2	23.0
AM1-EP	EW	Jan-85	36.13	8.0-16.0	1.0-16.0	6	16.0
AM1-P1	PZ	Nov-84	33.82	15.0-20	14.0-20.0	2	20.0
AM1-P2	PZ	Nov-84	35.02	14.5-19.5	13.5-19.5	1	19.5
AM1-P3	PZ	Nov-84	34.94	14.0-19.0	13.0-19.0	1	19.0
A2-Zone Wells							
AM1-10	EW	Mar-90	35.64	30.0-37.5	30.0-37.5	2	37.5
AM1-14	MW	Sep-91	34.44	29.8-35.0	28.0-35.0	2	35.0
B-Zone Wells							
AM1-2	MW	Jun-84	34.84	42.0-46.0	37.5-46.0	2	46.0
AM1-5B	MW	Jan-85	32.18	37.5-47.0	36.5-47.5	4	47.0

Notes and Abbreviations:

1: EW = Extraction well; MW = Monitoring Wells; PZ= Piezometer

2: Original well depth determined during well installation from ground level. Subsequent depth measurements are typically from a different datum after grading.

3.2 History of Contamination

AM1 site characterization and initial remedial activities began in 1983, with final listing on the NPL in 1987. In November 1983, Applied Materials discovered volatile organic compounds (VOCs) in shallow ground water, primarily 1,1,1-TCA at concentrations up to 12,000 parts per billion (ppb), with lower concentrations of 1,1-DCA and 1,1-DCE, and with trace amounts of perchloroethylene (PCE), 1,1,2-trichloroethane (1,1,2-TCA), trichloroethylene (TCE), 1,2-dichloroethane (1,2-DCA) and Freon 113 in the shallowest water-bearing zone, the A zone, downgradient of three USTs. The USTs were used for acid waste neutralization before discharge to the sanitary sewer. VOCs may have entered the tanks by inadvertent discharges into floor drains inside Building 1. The USTs were partially below the water table, overlying a concrete slab at about 12-ft depth (Weiss, 1989a). According to a hazardous materials inventory statement, 1,1,1-TCA was stored and used in several locations inside Building 1 in quantities not greater than 110 gallons at any time at any location. 1,1-DCE and 1,1-DCA were not listed on the inventory, and according to AM, not used at AM1 (Weiss, 1988).

3.3 Initial Response

3.3.1 Ground Water

In May 1985, following the discovery of VOCs in shallow ground water, Applied Materials implemented a full-scale ground water monitoring, extraction and treatment program at AM1. The initial remedial actionsimplemented in 1985 consisted of an extraction pit and an extraction well completed in the extraction pit (well AM1-EP), designed to remove ground water with high VOC concentrations near the source area, and ground water extraction from A-zone wells AM1-1 and AM1-5E. This program was designed to hydraulically control plume migration, reduce the areal extent of the plume, and reduce ground water concentrations of residual chemicals at the site to acceptable levels. Applied Materials extracted and treated ground water from the AM1 A zone from 1985–1999, and from the A2 zone from 1990–2002.

Subsequent installation of upgradient, downgradient, lateral and deeper monitoring wells on the AM1 site, along with monitoring well installation at neighboring sites related to other VOC plumes, identified a VOC plume on the AM1 site in the uppermost—or A—water-bearing zone, between 15- and 25-ft depth (Figure 2). In the next deeper, B water-bearing zone, between 41- and 48-ft depth, VOCs were either not detected or detected at trace concentrations below drinking water standards. The unique chemical signature of AM VOC plume—1,1,1-TCA, 1,1-DCA, and 1,1-DCE—distinguished it from other plumes originating at the HP (formerly Avantek) site to the northeast and the former HP building to the north, now Applied Materials Building 3.

AM installed and maintained nine onsite monitoring wells, including seven in the A zone and two in the underlying B zone, and three piezometers in the A zone in the vicinity of the extraction pit (See List of Wells in Table 1). The extraction system consisted of three wells and the extraction pit, and removed from 20,000 to 26,000 gallons of water per day.

The extracted ground water was processed through an air stripping unit which discharged to San Tomas Aquino Creek and ultimately to South San Francisco Bay. This discharge was regulated under a NPDES permit from the Regional Board.

3.3.2 Soil

Applied Materials conducted three phases of soil investigations and remedial actions. All three phases of implemented soil cleanup actions were pursuant to the Regional Board Orders, which required remediation for soils containing more than 1 part per million (ppm) total VOCs. Since there are no chemical-specific ARARs for soil, non-promulgated standards, criteria, guidance and advisories must be used to provide a protective remedy. In the Ground Water Basin Plan Amendments, adopted October 21, 1992, the RWQCB stated that "at this time the Regional Water Board finds that 1 mg/kg is an appropriate cleanup level for total VOCs in the unsaturated zone at sites where ground water is being monitored and where cleanup to background is unreasonable." Figure 4 shows the sample locations for each of these three phases.

Phase I

In response to the discovery of the VOCs in ground water, Applied Materials removed and properly disposed of the acid neutralization tanks and about 60 cubic yards of soil in January 1985. Soil sampling also commenced with this removal. Total VOCs concentrations up to 65 milligrams per kilogram (mg/kg) were detected in soil samples taken directly beneath the northwestern tank, in the deepest part of the excavation. Much lower concentrations were detected in the remaining samples collected only several feet away, indicating that most of the VOCs were directly beneath the USTs. The excavation was then backfilled with clean drain rock placed around a well screen to form an extraction pit. The tanks and soil excavation removed as much of the concentrated VOCs as possible at their source. Complete soil excavation at the source was not feasible due to severe sidewall stability problems, and the possibility of sand upwelling, settlement and structural damage to Building 1 and the adjoining equipment.

Additionally, thirty-seven vadose zone soil samples from 16 boreholes were collected at AM1 during removal of the tanks in 1985. Soil samples were collected at the source area from shallow depths down to about 17 ft. Either no or low concentrations of VOCs were detected in soil samples collected from the unsaturated zone, suggesting that the tanks leaked below the water table. The highest VOC concentrations were discovered directly beneath the tanks, in the vicinity of where wells AM1-1 and AM1-EP were completed. VOC concentrations greater than 1 mg/kg were not detected until about the 13-ft depth, well into the saturated zone.

Phase II

The second phase of sampling was conducted in 1989 and early 1990 to assess the extent of VOCs in soil at the source area and to address the issues outlined in Tasks 5 and 6, Section C, Provision 2.b, Regional Board Order No. 90-134 (Weiss, 1989b, 1990a, 1990b). For this phase, fourteen soil borings were completed at AM1 and 89 saturated and unsaturated soil samples collected at various depths were analyzed for VOCs (Figure 4). The purposes of this investigation were to:

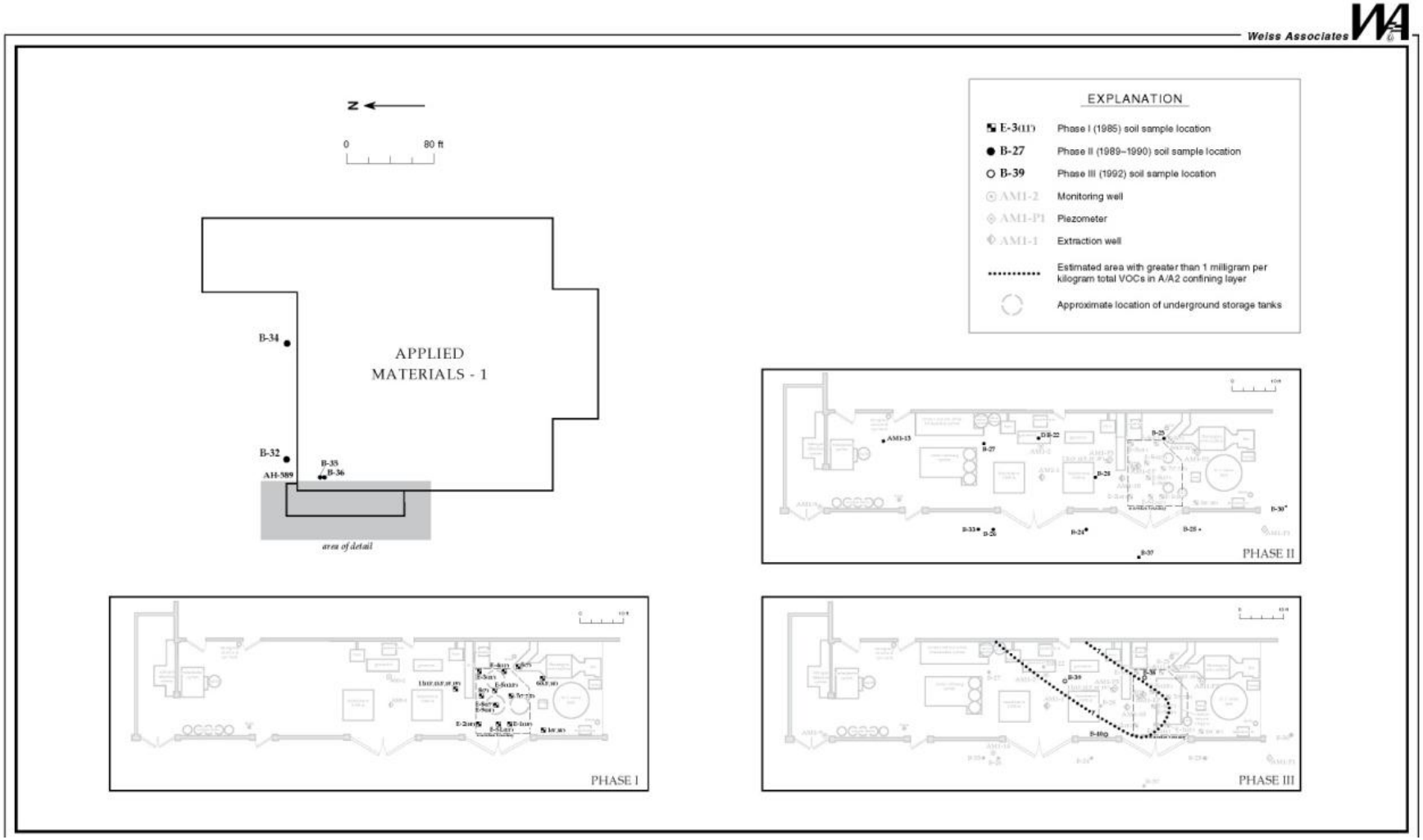

Figure 4: Phase I, II, and III Soil Sample Locations for Tank Excavation and Vicinity

- Evaluate the concentrations of VOCs in saturated soils around the former tanks;
- Determine whether or not a separate unidentified source may be contributing to the volume of VOCs being extracted from ground water; and,
- Determine whether or not VOCs were in the A2-zone.

The results of this investigation indicated that only small, isolated areas of saturated soil had total VOC concentrations in excess of 1 mg/kg, with few exceptions ranging to a maximum concentration of 1.69 mg/kg. The VOC detections exhibited no apparent distribution pattern based on known sources, which may be attributed to the heterogeneous lithology of the site. The horizontal and vertical distribution of analytic results indicated that the greatest concentration of VOCs was within the A-zone and between the A- and A2 water-bearing zones. Below the A water-bearing zone, VOC concentrations greater than 1 mg/kg in soil were almost exclusively encountered around boring DB-22 and well AM1-10 (Figure 9). Boring DB-22 and well AM1-10 were located downgradient from the source and thus, concentrations represent VOCs sorbed from ground water to the soil. No additional excavation was conducted, especially since results of this Phase II investigation indicated that the volume of soil with VOCs in excess of 1 mg/kg remaining at AM1 was small, with very limited horizontal and vertical extent (Weiss, 1994).

Phase III

The third phase was conducted in March and April 1992, to investigate the near-source A2-water bearing zone. The primary goal of this investigation was to provide the Regional Board staff the information required to determine if additional soil cleanup was needed and prepare the final Record of Decision (ROD) for the AM1 site.

The Phase III investigation (Weiss, 1992) revealed that the A2-zone stratigraphy is semi-continuous, irregular in shape, and its permeability varies from low to moderate depending on the location. Saturated soils containing VOCs in excess of 1 mg/kg were identified at around 25-ft depth in the A/A2 zone confining layer. Access problems, required excavation depth, local geology, and other AM1 site conditions made the removal of this small VOC mass prohibitively expensive compared to the cost of continued ground water extraction and treatment.

3.4 Summary of Basis for Taking Action

VOCs were first detected in ground water in November 1983, in the vicinity of three USTs at the west side of Building 1. The predominant pollutant in 1983 was trichloroethane (1,1,1-TCA) at concentrations up to 12,000 ppb; also detected were trichloroethylene (TCE), dichloroethylene (1,1-DCE), dichloroethane (DCA), Freon 113, and other VOCs.

In January 1985, soil sampling commenced with removal of the three USTs at AM1. Total VOCs concentrations up to 65 milligrams per kilogram (mg/kg) were detected in soil samples taken directly beneath the northwestern tank, in the deepest part of the excavation.

Analytical results of January-June 1989 showed the presence in ground water onsite of the VOCs shown in Table 2.

Table 2: VOC Concentrations in Ground Water in 1989

Contaminants	Concentrations (ppb)
1,1,1-TCA	1,100
1,1-DCA	120
1,1-DCE	50
TCE	20
PCE	9
1,2-DCA	2.3
1,2-DCE	0.6
1,1,2-TCA	1
Freon 113	170
Freon 11	48

The AM1 site overlies the Santa Clara Valley ground water basin. Ground water for human consumption is extracted from wells from about 150 to 500 ft deep in the Santa Clara Valley. The nearest drinking water supply well to the AM1 site is located 3,500 ft upgradient, to the southwest. The AM1 site became a Superfund site primarily because the past chemical release posed potential threat to the ground water resource.

4. REMEDIAL ACTIONS

The Regional Board was the Lead Agency overseeing the cleanup at AM1 until 2006, pursuant to the South Bay Multi-Site Cooperative Agreement and the South Bay Ground Water Contamination Enforcement Agreement (1985). On February 19, 1988,Applied Materials submitted a draft Remedial Investigation/Feasibility Study (RI/FS) for the AM1 site to the Regional Board (Weiss, 1988). The RI/FS Report presented five remedial alternatives, a comparative evaluation of these alternatives, a public health evaluation and a recommended remedial alternative. Based on the evaluations, Applied Materials recommended ground water extraction and air stripping treatment ("pump and treat"—Alternative 4) as a final remedial action.

In June 1989, EPA and the Regional Board accepted a revised RI/FS (Weiss, 1989a) and approved of the pump and treat remedial approach for the AM1 site. In September 1989, as the lead agency, the Regional Board issued Site Cleanup Requirements (SCR) Order No. 89-167 for the AM1 site, which was later amended by Orders No. 90-134 and No. 93-056, on September 6, 1990, and June 16, 1993, respectively. EPA Records of Decision (RODs) for ground water and soil were signed in 1990 and 1993, respectively.

4.1 Ground Water Remedy Selection

The Remedial Action Objective for the remedy as stated in the 1990 EPA Record of Decision was to restore ground water to beneficial use. The 1990 ROD selected the final remedial action for the ground water operable unit. Several initial response measures were previously implemented at the site by Applied Materials to remove contaminants from ground water. The major components of the selected remedy in the 1990 ROD are:

a. *Continue pumping from existing ground water extraction wells until drinking water standards for TCE (5 ppb); 1,2-DCA (0.5 ppb); 1,1-DCE (6 ppb); 1,1-DCA (5 ppb); cis-1,2-DCE (6 ppb); trans-l,2-DCE (10 ppb); 1,1,1-TCA (200 ppb); 1,1,2-TCA (32 ppb); Freon 113 (1200 ppb); Freon 11 (150 ppb); chloroform (6 ppb); and vinyl chloride (0.5 ppb) are achieved;*

b. *Treat extracted ground water using an existing air stripping system;*

c. *Continue ground water monitoring at the site during the cleanup period;*

d. *Implement institutional controls, such as deed restrictions, which will control and restrict the withdrawal and use of contaminated ground water and control and limit activities that could result in exposure to volatile organic compound (VOC) contamination. Controls and restrictions within the plume will be necessary until drinking water levels have been achieved for all VOCs.*

e. Reclamation and/or reuse of 100% of the ground water that is extracted and treated is a goal of this remedial action.

f. Discharge treated water off-site to a storm sewer system tributary of San Tomas Aquino Creek pursuant to an NPDES permit.

The ground water cleanup standards are set at California proposed or adopted MCLs, EPA MCLs, California Action Levels, or levels based on a risk assessment. The ground water cleanup levels are shown in Table 3, and applied to all the AM1 wells shown in Table 1.

Table 3: Cleanup Standards for Ground Water

Chemical	Cleanup Standard (µg/L or ppb)
1,1-Dichloroethane (1,1-DCA)	5
1,2-Dichloroethane (1,2-DCA)	0.5
1,1 -Dichloroethene (1,1 -DCE)	6
cis-1,2 -Dichloroethene (cis-1,2 -DCE)	6
trans-1,2 -Dichloroethene (trans-1,2 -DCE)	10
Tetrachloroethylene (PCE)	5
1,1,1 -Trichloroethane (1,1,1 -TCA)	200
1,1,2 -Trichloroethane (1,1,2 -TCA)	3.2
Trichloroethene (TCE)	5
Freon 113	1,200
Freon 11	150
Chloroform	6
Vinyl chloride	0.5

4.2 Soil Remedy Selection

The 1993 ROD adopted the RWQCB soil cleanup level of 1 mg/kg for total VOCs used in the RWQCB orders, and found that:

- Phases II and III of the soil studies have shown that the unsaturated portion of the soil located at the surface and near surface were not contaminated and that the contaminated soils, under investigation at the time of the first ROD (1990), were in the saturated portion of the soils beneath the structures. Since these saturated zone soils, which begin at about 25 feet below the surface in the A/A2 zone confining layer, are part of the aquifer that contains the ground water, the ground water remedy selected in the 1990 ROD provides for remediation of this contamination.

The 1993 ROD therefore determined that "no further remedial action [for soils] other than that already implemented at the site is required to ensure protection of human health and the environment" (US EPA, 1993).

4.3 Remedy Implementation

As described above, several initial response actions occurred at the site prior to issuance of the RODs.The remedy implementation following the ROD for ground water (1990) included continued operation of the pump and treat system,a monitoring and reporting program to evaluate the effectiveness of the selected remedy, and implementation of institutional controls to prevent potential future exposures. At the time of the EPA final ROD (1993) for the soil, the response actions for contaminated soil were already completed.

4.3.1 Ground Water Extraction and Treatment

The ground water extraction and treatment system and the ground water monitoring program were fully implemented at the time the first SCR was adopted in 1989. The initial response actions implemented in 1985 consisted of an extraction pit and an extraction well completed in the extraction pit (well AM1-EP), designed to remove ground water with high VOC concentrations near the source area, and ground water extraction from A-zone wells AM1-1 and AM1-5E. In March 1990, as an additional remedial action, extraction well AM1-10 was installed in the A2 zone, between the high permeability A and B zones.

4.3.2 Soil

The 1993 ROD concluded that the only contaminated soils were those in the saturated zone and that the ground water remedy selected in the 1990 ROD would provide for remediation of that contamination. The 1 ppm total VOCs cleanup level for soil is lower than the residential screening levels of many of the main VOCs found on the site. This level has been achieved for

VOCs in vadose zone soil down to the water table. Consequently,1993 ROD determined that no further remedial action for soil was implemented.

4.4 Institutional Controls

A restrictive covenant (deed restriction) was prepared for the property and recorded with the Santa Clara County Records Office on June 9, 1992. The deed restriction prohibits the use of ground water from the shallow aquifer as a source of drinking water. A copy of the deed restriction is provided in Appendix I.

4.5 System Operations/Operation and Maintenance

4.5.1 Ground Water

Treatment System Operation and Modifications

The extracted ground water was initially treated by activated carbon until a double-tower air stripper system was installed. On March 14, 1994, the double-tower air stripper was replaced with a shallow-tray, skid-mounted air stripper. In January 1998, the JP-7 chemical system used to control scaling of the air stripper was changed to FLOGARD PT805. The shallow-tray air stripper was replaced with a Carbonair, stainless steel, low-profile air stripper in February 1998 (Figure 5).

Treated ground water was discharged to a storm drain tributary of San Tomas Aquino Creek and to South San Francisco Bay under a general NPDES permit issued for this purpose in July 1994, and subsequently reissued in July 1999. Beginning in May 2001, extracted ground water was discharged directly to the sanitary sewer, authorized by San Jose/Santa Clara Water Pollution Control Plant Industrial Wastewater Discharge Permit No. SC-043A (Site Discharge Permit). In July 2001, Applied Materials requested discontinuation of sampling and reporting specified by the site NPDES permit (Applied Materials, 2001). On September 13, 2001, the Regional Board officially approved discontinuation of NPDES-specified sampling, monitoring, and quarterly reports (RWQCB, 2001).

Figure 6 presents cumulative totals for VOC mass removed at AM1 from August 1985 through February 2002. Tabulated data are provided in Table E-3, Appendix E. Since ground water pumping began, approximately 85 million gallons of ground water have been treated (Appendix E) and approximately 254 kg of VOCs have been removed through the extraction system (Table E-3). Figures 7, 8, and 9 show the VOC mass removed and ground water extracted to date for the AM1 extraction wells AM1-1, AM1-5E, and AM1-10, respectively.

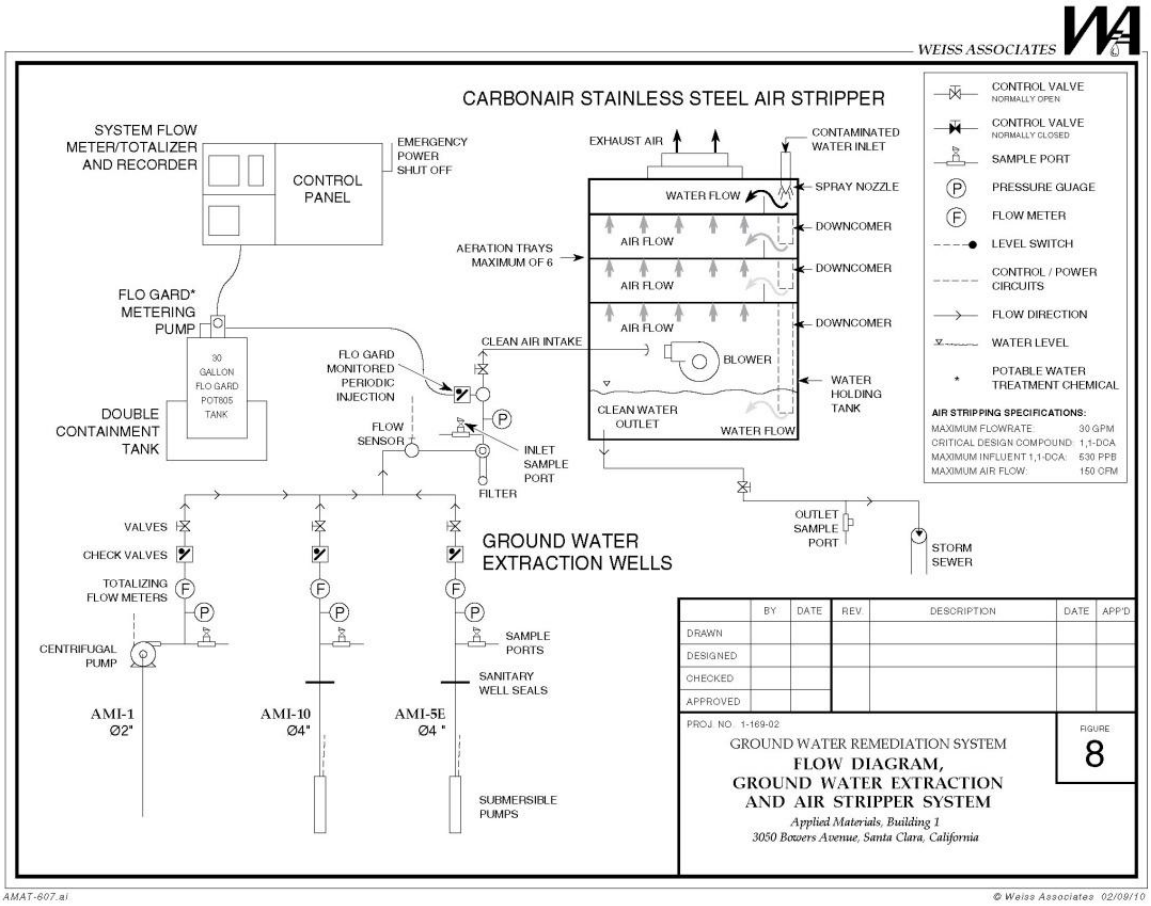

Figure 5: Flow Diagram, Ground Water Extraction and Air Stripper System

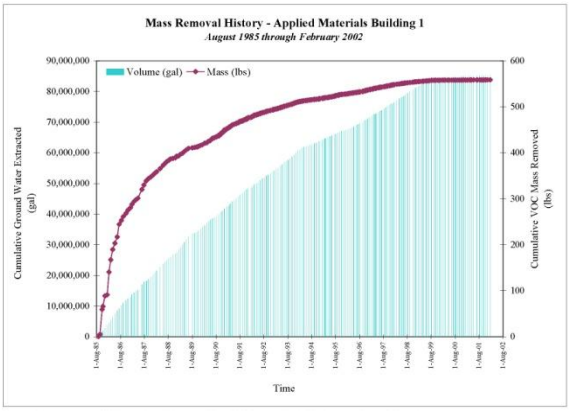

Figure 6: Total Mass Removal

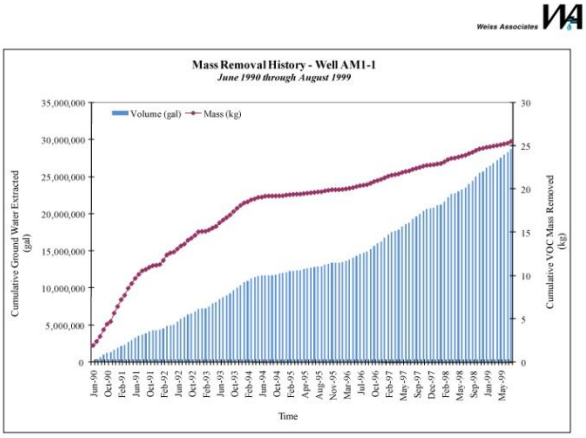

Figure 7: Mass Removal History in AM1-1

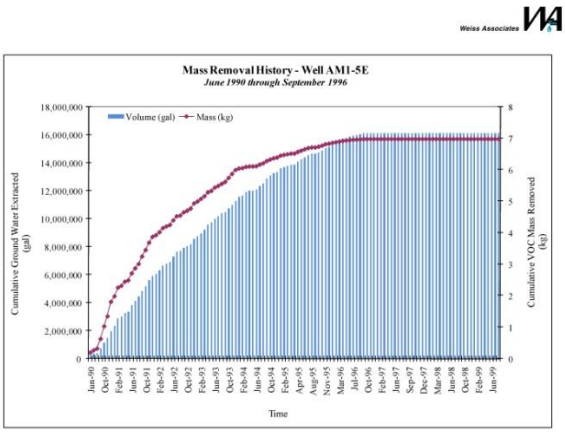

Figure 8: Mass Removal History in AM1-5E

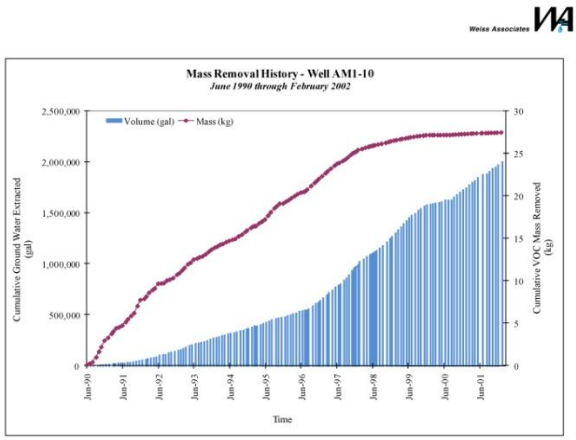

Figure 9: Mass Removal History in AM1-10

Extraction Well Operation and Modifications

Since 1985, the number of wells extracting ground water on-site, as well as their pumping rates, has been modified. Below is a summary of the major changes.

On March 18, 1992, the wellhead for extraction well AM1-EP was cut and set below grade to allow drill rig access for an A2-zone soil investigation at the AM1 source area. At that time, AM1-EP was disconnected from the treatment system because the gravel-filled extraction pit in which it was completed had nearly gone dry due to drought-related conditions.

From June 21 through July 2, 1996, well AM1-10 was reconstructed. Reconstruction was necessary after the pump became permanently lodged at the bottom of the well. Efforts to remove the pump were unsuccessful. A 2-inch diameter well was subsequently constructed

within the existing 4-inch diameter casing. Repairs to piping between the well and the treatment system were also made during this time.

On March 22, 1996, as the Lead Agency, the Regional Board approved a proposed pumping modification program (PMP) at AM1. The PMP implemented a phased increase of ground water extraction near the source area while simultaneously decreasing—and ultimately ceasing—pumping from downgradient well AM1-5E. The intention of the PMP was to reduce the potential of VOCs being drawn across the AM1 site towards the 3175 Bowers Avenue property. Phase I of the PMP was initiated on April 3, 1996, increasing the extraction rate of AM1-1 to 4.5 gpm while simultaneously reducing the extraction rate of AM1-5E to 1.5 gpm.

Phase II of the PMP was initiated on September 11, 1996. Phase II included a complete shutdown of well AM1-5E and an increase in the extraction rate of well AM1-1 to approximately 10 gpm. Phase II required monitoring of specific VOC concentration in four on-site boundary wells and three neighboring off-site wells. The success and continued operation of Phase II was contingent upon VOC concentrations remaining below established trigger levels within the seven boundary wells. Given that 1,1-DCA and 1,1-DCE remained below the trigger concentration limits established in Phase II, on June 15, 1999, the Regional Board approved the discontinuation of ground water extraction from the A water-bearing zone. On July 30, 1999, extraction was discontinued from well AM1-1, leaving well AM1-10 the sole extraction well serving the AM1 treatment system. A contingency plan, involving restarting one or more of the extraction wells, was to be implemented if concentrations at or exceeding the trigger concentrations are detected. After one full year of implementation, the PMP was deemed successful (i.e., the VOC plume remained contained on-site and trigger concentrations were not exceeded), and a reduction in sampling frequency took effect.

The only remaining active extraction well, A2-zone well AM1-10, ceased operation in late February 2002, due to equipment problems that were exacerbated by low permeability and yield of the A2 zone. On December 19, 2002, Applied Materials received formal approval from the Regional Board for the present phase of the PMP: suspending all ground water extraction at the site (RWQCB, 2002). The Regional Board supported its decision by noting that VOC concentrations in both the A and A2 zones are low and gradually decreasing towards meeting cleanup goals, even in the absence of pumping. Apparently, naturally occurring physical, chemical and/or biological attenuating processes are continuing to contain and reduce concentrations in the residual VOC plume.

Piping associated with the ground water extraction and treatment system was removed in November 2003. Several wells were destroyed in December 2003 due to the remodel of AM1 equipment pad. The current operation and maintenance requirements of the site include water level and water quality monitoring. Purge water from the annual monitoring events is managed and discharged to a sanitary sewer on-site.

Between the years 1990-2005, the Regional Board approved the discontinuation of monitoring at several wells. Table 4 provides the abandonment dates of the extraction and monitoring wells. The monitoring program for the remaining wells for the period 2004-2009 is on an annual basis, usually done in January.

Table 4: Extraction and Monitoring Wells Abandonment Schedule

Well ID	Well type	Installation Date	Abandonment Date
A-Zone Wells			
AM1-1	EW	Nov-83	8-Dec-03
AM1-3	MW	Apr-84	---
AM1-4	MW	Apr-84	1-Jun-90
AM1-5	MW	Jun-84	23-Jan-01
AM1-5E	EW	Jan-85	---
AM1-6	MW	Apr-85	---
AM1-7	MW	Apr-85	---
AM1-8	MW	Apr-85	1-Jun-90
AM1-9	MW	Apr-85	8-Dec-03
AM1-11	MW	Feb-91	---
AM1-12	MW	Feb-91	23-Jan-01
AM1-EP	EW	Jan-85	8-Dec-03
AM1-P1	PZ	Nov-84	23-Jan-01
AM1-P2	PZ	Nov-84	23-Jan-01
AM1-P3	PZ	Nov-84	23-Jan-01
A2-Zone Wells			
AM1-10	EW	Mar-90	8-Dec-03
AM1-14	MW	Sep-91	8-Dec-03
B-Zone Wells			
AM1-2	MW	Jun-84	8-Dec-03
AM1-5B	MW	Jan-85	24-Jun-05

Notes and Abbreviations:
EW = Extraction Well; MW = Monitoring Well; PZ = Piezometer

4.5.2 Soil Actions Since 1993

In 1998, the Acid Waste Neutralization System (AWNS) overlying the former AM1 VOC source area was shut down. During closure of this system, soil samples were collected in the upper two feet of soil beneath the equipment pad and analyzed only for lead, since based on the Phase III soil study, VOCs above the cleanup standard were only found in thedeeper saturated soils. Total lead and soluble leadconcentrations in shallow soils were as high as490 mg/kg and 8.9 milligrams per liter (mg/L), respectively. A total of 17 cubic yards of impacted soil was removed from an area measuring 10 feet by 15 feet. Confirmation sampling indicated that the cleanup goal of 5.0 mg/L soluble lead had been met. Impacted soil was segregated for disposal at Class I or Class II disposal facilities. Upon completion, the area was backfilled with clean fill, and a new concrete pad installed (MJO Earthscience, 2004).

In 2003, Applied Materials began remodeling activities at Building 1, turning the building from a research and development facility into offices and educational facilities. An initial soil investigation showed that lead, other metals, motor oil, VOCs, and pesticides were detected at various concentrations. Except for lead, which was detected at concentrations as high as 380 mg/kg total lead and 5.7 mg/L soluble lead, all other contaminant concentration were below regulatory levels. In April 2004, approximately 220 cubic yards of impacted soil were removed (Figure 10). Confirmation samples showed that the cleanup goal of 50 mg/kg lead had been met. After the excavation was complete, the area was backfilled with clean fill, paved and/or landscaped (MJO Earthscience, 2004).

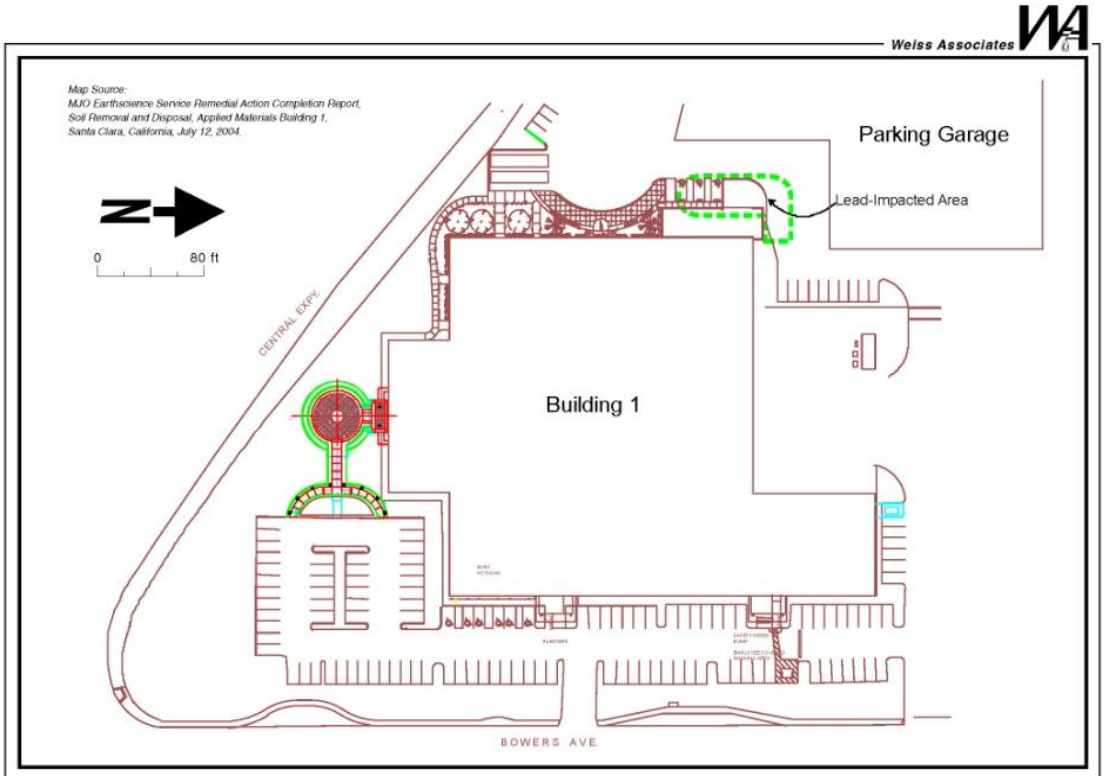

Figure 10: Location of Lead-Impacted Soil, April 2004

4.6 Annual O&M Costs

During this Five-Year Review period, Applied Materials spent about $151,898 on ground water monitoring and regulatory interface while determining the path forward for the site. This total, which does not including internal personnel costs, is equivalent to about $30,000 per annual sampling event of the four remaining wells. During the period from September 2004 to December 2009, the ground water extraction and treatment system was off and monitoring wells were sampled on an annual basis. Table 5 presents the annual costs over the last five years (amounts shown do not include Applied Materials' internal costs).

Table 5. Cost Summary, September 2004 through December 2009, Applied Materials Building 1 and Vicinity, Santa Clara, California

Description	09/2004 - 12/2004	01/2005 - 12/2005	01/2006 - 12/2006	01/2007 - 12/2007	01/2008 - 12/2008	01/2009 - 12/2009	2004-2009
MONITORING AND REPORTING (sampling, monitoring, well maintenance, self-monitoring reports, interface with EPA on path forward, etc.)	$13,950	$31,613	$43,803	$23,043	$20,988	$18,502	$151,898

Note:
Actual costs are presented as they were incurred. Costs are rounded to the nearest dollar.
Costs presented do not include Applied Materials internal costs.

Applied Materials spent approximately $2.6 million between September 1989 and September 2004 for response actions at the AM1 site. Prior to September 1989, Applied Materials' costs on the AM1 site investigation and initial response actions amounted to approximately $1,000,000.

5. PROGRESS SINCE LAST FIVE-YEAR REVIEW

5.1 Protectiveness Statement from Last Review

The following protectiveness statement is from the third Five-Year Review report (RWQCB, 2005):

Because the remedial actions are protective, the site is protective of human health and the environment in the short- and long-term.

5.2 Status of Recommendations and Follow-Up Actions from Last Review

Table 6 summarizes the recommendations from the last Five-Year Review report (RWQBC, 2005), and the actions taken to address them.

Table 6: Status of Recommendations from Third Five-Year Review

Recommendations/ Follow-up Action	Responsible Party	Implementation Status
Continue ground water monitoring	AM	AM continues annual sampling of remaining monitoring wells.
Consider other alternative remedies such as in-situ bioremediation	AM	AM prepared a draft Focused Feasibility Study (FFS) and submitted it to EPA in August 2006 (Weiss, 2006) with the goal of obtaining a Technical Impracticability (TI) waiver for all four existing wells from meeting ground water cleanup levels specified in the 1990 ROD. EPA commented on the draft FFS on January 16, 2007, and on the draft final FFS on December 21, 2007.
Develop a proposal and timeline for State and EPA review that outlines how the site will achieve the clean-up goals.	AM	Since the results from the 2008 annual sampling event were lower than anticipated, AM decided to continue monitoring the site and move forward with proposal for an exit strategy without a TI waiver. AM submitted a proposal that outlined how clean-up goals can be met. EPA will be addressing this issue separately from the current FYR.

5.3 Status of Any Other Prior Issues

No prior issues are outstanding.

6. FIVE-YEAR REVIEW PROCESS

6.1 Administrative Components, Community Notification, Document Review

This section presents the activities performed during the five-year review process and a summary of the findings. This fourth five-year review consisted of: public notification by EPA Region 9 that a FYR was underway in the Santa Clara Valley Weekly on 04/14/2010; a review of relevant documents (Appendix B); a regulatory review (Appendix C); a review of ecological and human health risk evaluations (Appendix D); a data review (Appendix E); a site inspection (Appendix F & G); technical interviews of Weiss Associates employees and AM staff, and the Regional Board Project Manager (Appendix H); and a review of the deed restriction in Appendix I. The AM fourth five-year review was led by Kim Hoang, the EPA Remedial Project Manager for the Site. EPA received technical support from Weiss Associates on behalf of AM, and the US Army Corps of Engineers. No community interviews were conducted since there was no request in response to the public notification.

A copy of this report will be made available through the EPA Region 9 Superfund Records Center located in San Francisco, on-line via the EPA's web page for the AM site (www.epa.gov/region09/appliedmaterials) and from the information repository at the Regional Water Quality Control Board - San Francisco Bay Region, 2101 Webster Road, Suite 500, Oakland, CA 94612. Notice of the completion of this report will be announced in the above local newspaper.

6.2 Data Review

The site is currently under a long-term monitoring program. No active remediation has been performed at the site since 2002. Appendix E, Data Review Memorandum provides a comprehensive data analysis for the ground water monitoring data (including water levels and contaminant concentrations) covering the six-year period from 2005 to January 2010. Appendix E includes a trend analysis of all the data from 1983 - January 2010 and a statistical analysis to evaluate MCL attainment in the AM1 wells. The last six years of data for the remaining four monitoring wells (AM1-5E, AM1-6, AM1-7, and AM1-11) are presented in Table E-1, and discussed below.

6.2.1 Monitoring Program Changes

Ground water monitoring at the site since the 2005 Third Five-Year Review consisted of:

- Sampling and analyzing ground water for VOCs annually; and,
- Measuring water levels and well depths in site monitoring wells annually.

In December 2004 and February 2005, the Regional Board approved further reductions in the Self-Monitoring Program (SMP) requirements for the site based on the very low and declining plume concentrations. Monitoring was required in only four on-site A-zone wells

(AM1-5E, AM1-6, AM1-7 and AM1-11) and in off-site A2-zone well AV-1B. Therefore, and with the approval of the Regional Board, off-site monitoring wells HP-5, HP-6, HP-8 and site well AM1-5B were destroyed on June 23 and 24, 2005. Additionally, off-site monitoring wells HP-2 and HP-3 were destroyed on October 25, 2005. The Regional Board approval for destruction of well AM1-3 was also granted in December 2003, but this well has not been destroyed yet. The off-site A2-zone well AV-1B was destroyed in late 2006.

6.2.2 Ground Water Elevations

As discussed in Appendix E, historical water level measurements indicate shallow ground water flow beneath AM1 is generally to the northeast at a natural hydraulic gradient estimated to range from 0.002 to 0.007 ft/ft. This flow gradient is consistent with northerly regional flow towards San Francisco Bay.

A review of water level elevations in the key remaining AM1 wells, i.e., AM1-5E, AM1-6, AM1-7 and AM1-11, shows that there is no discernible seasonal pattern to water level elevations at AM1. In addition, the ground water elevation versus time plots of the four individual wells AM1-5E, AM1-6, AM1-7 and AM1-11 (Figure 11) indicate that a hydraulic steady state was reached over ten years ago.

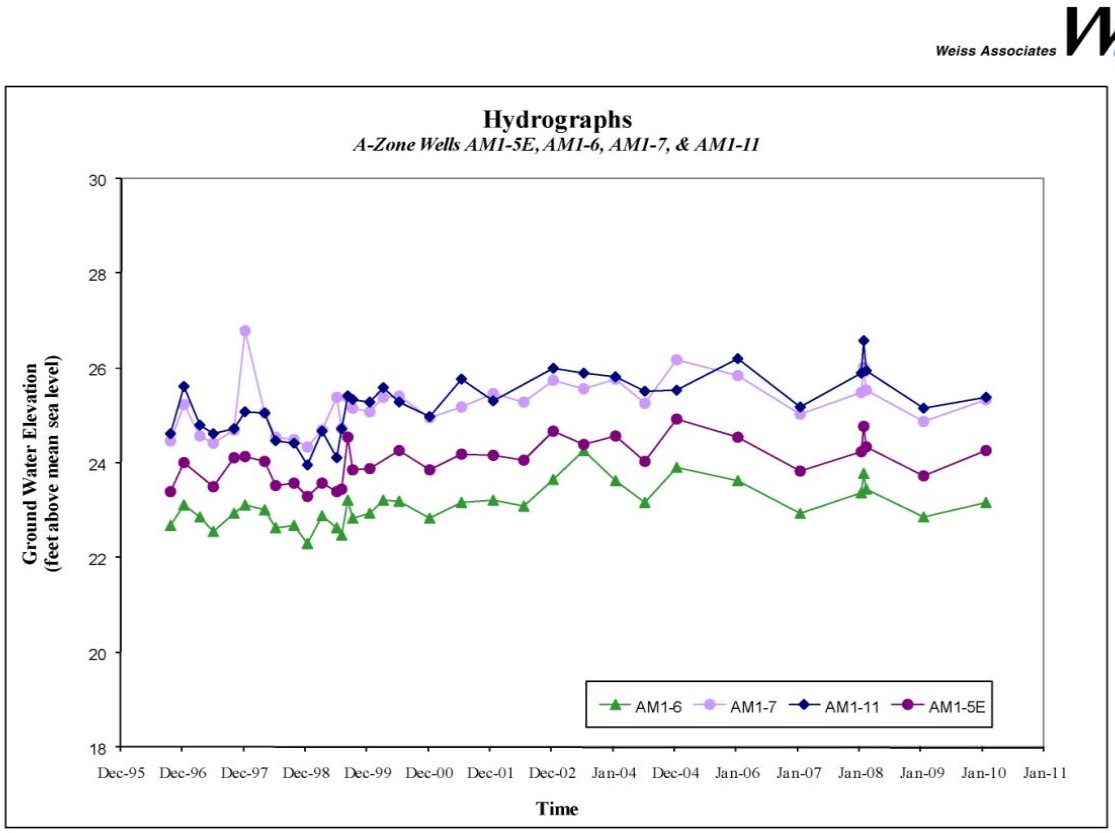

Figure 11. Ground Water Elevation vs. Time, Representative A-Zone Monitoring Wells

6.2.3 Volatile Organic Compounds Analysis

Since ground water extraction was initiated, VOC concentrations in ground water have dramatically decreased as shown in the composite A-zone iso-concentration maps for 1,1,1-TCA, 1,1-DCA and 1,1-DCE, the three signature compounds found at AM1 (Appendix E).

Additionally, concentration data versus time for the three signature compounds 1,1,1-TCA, 1,1-DCE and 1,1-DCA are presented in Appendix E for all historical data. Figure 12 shows the concentration-time plots of these three chemicals in the last four remaining wells. Based on the most recent sampling event in January 2010, all three key contaminants are below MCLs in wells AM1-6 and AM1-11, and around MCLs for AM1-5E and AM1-7.

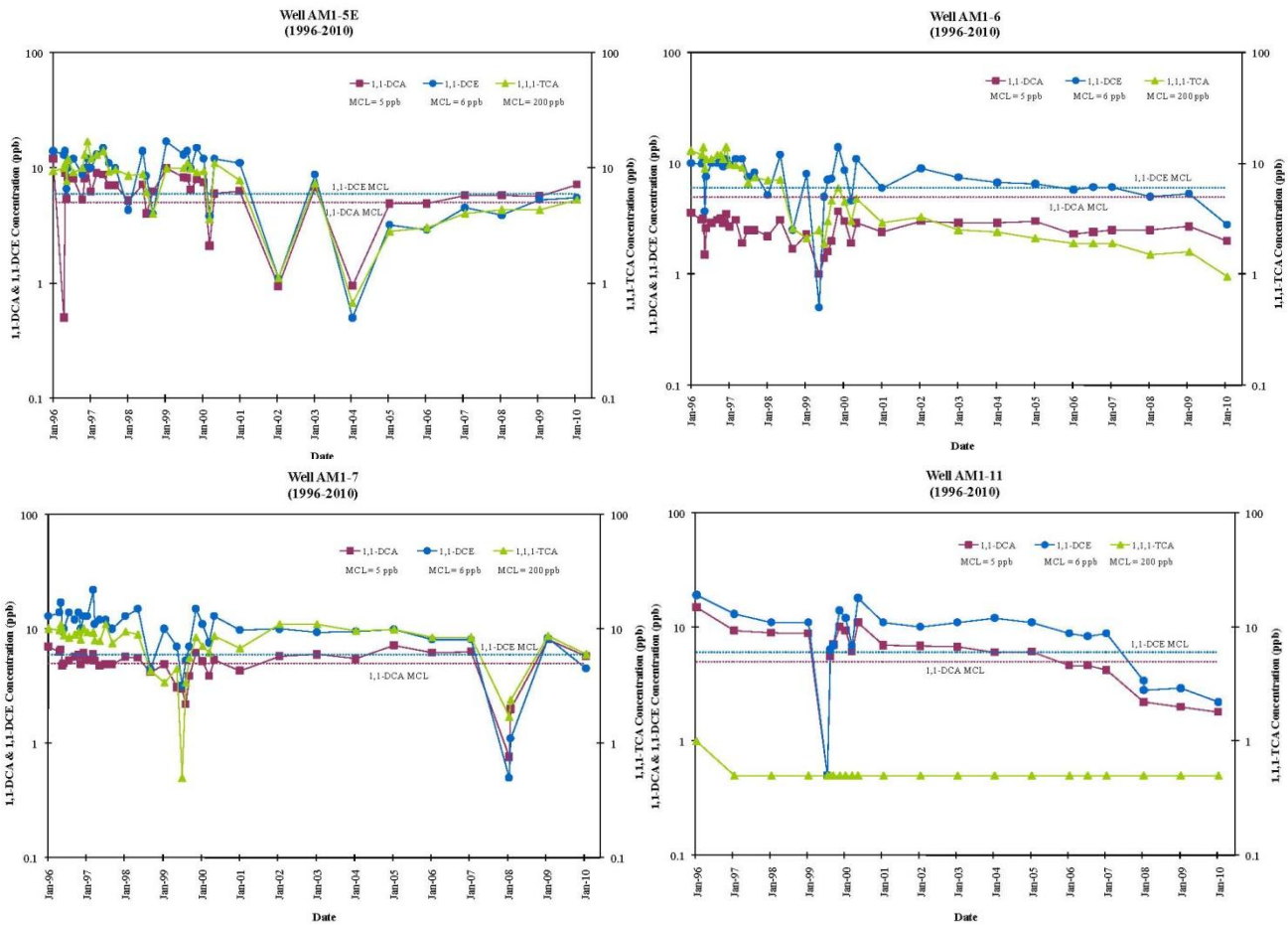

Figure 12: Contaminant concentration in the four remaining monitoring wells

6.2.4 1,1-DCA and 1,1-DCE Plume Mass

Dissolved plume mass concentrations were calculated for the A zone for 1,1-DCA and 1,1-DCE based on ground water monitoring data collected in January 2010. Using this approach described in Appendix E, the calculated mass currently remaining at AM1 for 1,1-DCA and 1,1-DCE is 28.9 grams (g) and 32.4 g, respectively, or approximately one ounce each.

6.2.5 Trend analysis and MCL attainment

Table 6 summarizes the trend analysis using the Monitoring and Remediation Optimization System (MAROS) software and MCL attainment for the key chemicals in the remaining four monitoring wells. Analysis for all the wells is presented in Appendix E.

Table 7: Trend analysis and MCL attainment (Data from 2003-2010)

Well Name	Number of Samples	Number of Detects	Percent Detection	Mann-Kendall Trend	Below MCLs on Most Recent Sample Date? (2010)	Sequential t-test Statistically Below Standard?	Recommended Sampling Frequency
1,1-Dichloroethane (MCL = 5 μg/l)							
AM1-5E	9	9	100%	D	No	No	Annual
AM1-6	8	8	100%	NT	Yes	No	Annual
AM1-7	9	9	100%	S	No	Yes	Annual
AM1-11	8	8	100%	NT	Yes	No	Annual
1,1-Dichloroethene (MCL = 6 μg/l)							
AM1-5E	33	32	100%	D	Y	No	Annual
AM1-6	35	34	88%	NT	Y	Yes	Annual
AM1-7	34	34	100%	D	Y	No	Annual
AM1-11	21	20	100%	PD	Y	No	Annual

Note: D = decreasing; PD = possibly decreasing; NT = no trend; S = stable

Extensive remediation efforts over the past 30 years have achieved ground water concentrations very close to cleanup goals at the AM1 site. Trend analysis indicates that contamination concentration in the remaining wells is not increasing. The sampling frequency algorithm in MAROS confirms the annual sampling frequency for the remaining wells. As shown in Table 7, direct comparison of the last sampling data in 2010 to MCLsshows that 1,1-DCA is below the MCL in wells AM1-6 and AM1-11. While several statistical measures can be used for MCL attainment, results of the sequential t-test are shown in Table 6 for comparison.

6.3 Site Inspection

EPA and the USACE did a site inspection of the AM1 site on April 2, 2010. All the existing monitoring wells are checked for security and access. The Site Inspection Checklist is including in Appendix F, and the Site photographs are included in Appendix G.

6.4 Technical Interviews

The EPA and USACE met with AM and Weiss Associates representatives to discuss remedial activities at the site. The EPA and USACE also interviewed the Regional Board Project Officer. Interview records are included in Appendix F, and the list of interviewees is as follows:

- Adriana Constantinescu, Engineering Geologist/Case Officer, Regional Water Quality Control Board – San Francisco Bay Region
- Joyce Adams, Sr. Project Geologist/Project Manager, Weiss Associates
- Bruce Klafter, Sr. Director of Environmental Health and Safety, Applied Materials
- Daven Mistry, Environmental Engineer, Applied Materials

Overall, the interviewees were pleased with the monitoring program, and overall performance of the remediation systems. No adverse comments were received, though all interviewees expressed an interest to see an exit strategy being implemented for the site. The Regional Board Case Officer explicitly requested to have EPA either close out the AM1 site, or issue an equivalent enforcement document so that the Board can end its involvement with the site. AM made the same request in its AM FYR 2010 report submitted to EPA, as well as through previous meetings and communications. Communication among the various stakeholders appears to be quite good at the present time.

7. TECHNICAL ASSESSMENT

7.1 Question A: Is the remedy functioning as intended by the decision documents?

The ground water pump and treatremedy which was selected in the ROD is no longer in operation at the site. The system was completely shutdown in 2002. The current ground water monitoring program is sufficient to detect any contaminant migration. The remedy selected in the Final Remedial Action Plan and 1990 ROD was implemented as planned and was successful in removing 254 kg (560 pounds) of VOC mass from the ground water from August 1985 through February 2002 and reducing VOC concentrations in ground water to near the MCL cleanup levels.

The restrictive covenant recorded in 1992 includes prohibition on the use of ground water until cleanup levels are achieved.

7.1.1 Remedial Action Performance and Monitoring Results

There is no active ground water extraction at this site, which is not currently reflected in any of the decision documents for this site.

The current ground water monitoring program consists of sampling four on-site wells (AM1-5E, AM1-6, AM1-7 and AM1-11) annually to evaluate contaminant migration. No other remedial actions have been performed at the site during 2005-2010. Monitoring results show that the plume is stable, there is no increasing concentration trend in any of the four remaining monitoring wells, and two out of four wells have concentrations below MCLs for the key constituents in the last sampling event of January 2010.

7.1.2 Early Indicators of Potential Remedy Problems

There are no early indicators of potential remedy problems.

7.1.3 Implementation of Institutional Controls and Other Measures

A deed restriction was prepared for the property and recorded with the Santa Clara County Recorder's Office in 1992. The deed restriction prohibits the use of ground water from the site for drinking water and restricts excavation below a depth of 20 ft (the approximate depth to the water table). The deed restriction is included in Appendix I.

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

Yes, the exposure assumptions, toxicity data, cleanup levels, and RAOs are still valid.

7.2.1 Changes in Standards, Newly Promulgated Standards, and To Be Considered Criteria (TBCs)

No significant changes in standards and TBCs, or site clean-up levels have been identified during the Five-Year Review process. Site clean-up standards that were established in the ROD have not been revised and do not require revision at this time.

7.2.2 Expected Progress towards Meeting the RAOs

MCLs have been met for over ten years for 1,1,1-TCA. Direct comparison of the last sampling data in 2010 to MCLs in Table 6 shows that 1,1-DCA is below the MCL in wells AM1-6 and AM1-11. While several statistical measures can be used for MCL attainment, results of the sequential t-test are shown in Table 6 for comparison.

7.2.3 Changes in Exposure Pathways

In August 2005, EPA conducted an Evaluation of Ecological Risk for the Third Five-Year Review of Applied Materials. Based on a careful review of the information available for this site, EPA concluded that no complete exposure pathways to ecological receptors exist at this site, and therefore there is no ecological risk.

No changes in the exposure pathway have occurred over the last five years.

7.2.4 Changes in Land Use

During the review period, there have been no changes to the physical conditions and land use of the site that would affect the protectiveness of the remedy. Institutional controls prohibit the use of ground water, and ground water is not currently used at the site.

7.2.5 New Contaminants and/or Contaminant Sources

No new chemicals, sources, or routes of exposure were identified as part of this review.

7.2.6 Remedy Byproducts

According to a hazardous materials inventory statement, 1,1,1-TCA was stored and used in several location inside AM1, however, 1,1-DCE and 1,1-DCA have never been used at the site (Weiss, 1988). Therefore, the presence of 1,1-DCE and 1,1-DCA suggests that 1,1,1-TCA is degraded through both abiotic and biotic processes. Abiotically, 1,1,1-TCA is transformed by hydrolysis to 1,1-DCE, and biotically, 1,1,1-TCA is reductively dechlorinated under anaerobic conditions to 1,1-DCA, chloroethane, and ethane. The degradation product 1,1-DCE can further undergo reductive dechlorination to vinyl chloride and ethene.

7.2.7 Changes in Toxicity and Other Contaminant Characteristics

Toxicity values have changed with time, but did not affect the RAOs based on MCLs. The summary from Appendix D for the Risk Assessment shows that there is no change for ecological risk, and for human health risk, both the aggregate cancer and non-cancer risks for all contaminants of concern are below those of the aggregate risks at MCL for these contaminants of concerns.

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

None identified.

7.4 Summary of Technical Assessment

Applied Materials removed much of the AM1 source soon after its discovery, and the residual source and ground water plume were effectively remediated by the ground water extraction system until its shutdown in February 2002. Since the extraction system shutdown, VOC concentrations have continued to be stable or decreasing in all AM1 wells. The Regional Board approved of this suspension and supported its decision by noting that the low VOC concentrations at the site are gradually decreasing to meeting cleanup goals for the site without ground water extraction. Ground water monitoring continues at the site to monitor the stability of the downgradient edge of the plume and to determine when MCLs are met.

- All site wells except two are below MCLs for the chemicals of concern in the last couple of annual sampling events. Wells AM1-5E and AM1-7 exceeded the MCL for 1,1-DCA slightly in the last couple of annual sampling events (Table E-1)
- The remedy is considered to be protective of human health and the environment because there are no unacceptable risks from potential vapor intrusion, and ground water at the site is not currently used for drinking water and institutional controls are in place restricting future ground water use.

8. ISSUES

No issues were identified during the technical assessment.

9. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

The current cleanup goals for the site are California MCLs. VOC concentrations in all site wells are currently less than the MCL cleanup goals except for 1,1-DCA in well AM1-5E and well AM1-7. Concentrations of 1,1-DCA in these wells are less than two times the MCL. A conservative statistical analysis using the sequential-t-test showed that both of these chemicals are not below MCLs for most of the wells. Based on the trend analysis, they are expected to reach MCLs within a few years.

Follow-up Actions

Since EPA expects that this attainment may be achieved in a few years, annual sampling should continue.

10. PROTECTIVENESS STATEMENT

The remedy at the Applied Materials (Bowers Campus Facility) Superfund Site in Santa Clara, California is currently fully protective of human health and the environment. Contaminant concentrations in the ground water plume have been reduced to levels close to or below the MCL cleanup standards. Institutional controls are in place to prevent the use of ground water. There is no current or potential exposure to contaminants in ground water.

11. NEXT REVIEW

The next Five-Year review is due within five years, i.e., no later than September 2015.