6. OTHER REPORTING REQUIREMENTS

6.1 Monitoring and Reporting in Accordance with Site Discharge Permits

From 1985 to May 2001, extracted ground water was treated by the air stripper and discharged to surface water under NPDES General Permit CAG912003, Order No. 99-051. Since May 2001, extracted ground water has discharged directly to the sanitary sewer, authorized by San Jose/Santa Clara Water Pollution Control Plant (WPCP) 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 RWQCB officially approved discontinuation of NPDES-specified sampling, monitoring, and quarterly reports (RWQCB, 2001b). Monitoring and reporting requirements related to Site Cleanup Orders remain in effect.

Treatment system effluent samples were collected monthly from January through June 2001, in accordance with the Site NPDES permit. Quarterly effluent samples, as specified by the Site Discharge Permit, were collected in September and December 2001. Effluent samples were collected directly into sampling containers from a sampling port on the air stripper discharge line. VOC analyses were conducted by STL and Entech Analytical Labs of Santa Clara, California. Other NPDES and Site Discharge permit parameters—which include pH, temperature, and turbidity—are measured in the field, during sample collection.

The Site Discharge Permit specifies that water discharged to the sanitary sewer may contain no more than 2.13 milligrams per liter (mg/L) of Total Toxic Organics. Additionally, the pH of water discharged from the Site must fall within the 6.0 to 12.5 range specified in the Site Discharge Permit. Total VOC concentrations in ground water from well AM1-10, presently the only operating ground water extraction well at the Site, are well within the Site Discharge Permit limits even without air-stripping.

No VOCs were detected above MDLs ranging from 0.2 ppb to 2.0 ppb in any treatment system effluent sample collected during this reporting period (Table A-1). All field measurements and sampling results remained within NPDES and WPCP permit limits during this reporting period. The 2001 and 2002 Site SMP schedules are presented in Tables 1-A and 1-B, respectively. Analytic results, extraction totals, and mass removal calculations for the February 2001 through January 2002 reporting period are presented in Table 3, Appendix A, and Appendix D.

6.2 VOC Mass Removal

VOC mass removed is calculated for each of the respective extraction wells using the well's total VOC concentration and total volume of extracted ground water. Between February 6, 2001 and February 20, 2002, only well AM1-10 was operational. An estimated 0.37 pounds of VOCs were

removed through the extraction and treatment system during this reporting period. Approximately 0.48 pounds were removed during the same period last year. The cumulative ground water extracted and mass removed from the Site is shown in Figure 13. VOC mass removal calculations are presented in Appendix D.

6.3 Projected Use of Applied Materials Building 1

Applied Materials Building 1 is currently used for manufacturing, demonstration laboratories, research and development, and engineering office space. There is no anticipated change in the Site building usage over the next calendar year, and no additional remedial action is planned within this time frame.

6.4 Hydrogeologic Setting

As required by the Site Cleanup Requirements Order, the first status report for each calendar year shall include a site hydrogeologic setting diagram. Figure 14 presents an interpretive geologic cross-section, showing subsurface materials and the water-bearing zones near the source area at the Site. The northeastern end of the section illustrates the interrelationship between the hydrostratigraphic units as they are defined at the Site and neighboring 3175 Bowers Avenue.

7. NATURAL ATTENUATION EVALUATION

This section evaluates whether passive remediation through monitored natural attenuation (MNA) of the Site ground water plume is feasible. The term MNA generally refers to the reliance on natural attenuation processes to achieve remedial objectives within a timeframe that is reasonable compared to that offered by other more active methods (USEPA, 1999a). The processes that are at work under MNA include a variety of natural physical, chemical, and biological processes that reduce the mass, toxicity, mobility, volume, and/or concentration of contaminants in soil or ground water. These in-situ processes include:

- Biodegradation;
- Chemical and biological processes that destroy, transform, or stabilize contaminants;
- Dispersion and dilution;
- Sorption; and,
- Volatilization.

7.1 MNA Program Requirements

An MNA remedy generally requires:

1. Removal of the source to the extent practicable;
2. Site characterization that demonstrates natural attenuation processes are adequate for controlling and reducing the ground water contaminant plume; and,
3. A monitoring and contingency plan to ensure that MNA is working and to provide an alternative if MNA is not working.

7.1.1 Source Area Removal

In 1985 the first phase of soil sampling commenced with removal of the three underground tanks at the Site. Up to 65 parts per million (ppm) total VOCs were detected in soil samples taken directly beneath the northwestern tank, in the deepest part of the excavation. Sample results indicated that most soil contamination was directly beneath the tanks.

A second phase of soil sampling and Site characterization was conducted in 1989. The results of this investigation indicated that only small, isolated areas of saturated soil had total VOC concentrations in excess of 1 ppm, with few exceptions ranging to a maximum concentration of 1.69 ppm. 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. As much saturated and unsaturated soil containing VOCs as reasonable (without endangering existing

structures) was removed from the Site. The volume of soil with VOCs in excess of 1 ppm left remaining at the Site after this removal action was small, with very limited horizontal and vertical extent.

A near-source, A2-zone investigation was conducted in March and April 1992. This investigation demonstrated that the A2-zone is not a moderate or high permeability zone as was previously believed, but is predominantly low to moderate permeability. The low yield in A2-zone well AM1-10 is a direct reflection of the formation permeability. Initial VOC concentrations and declining trends in well AM1-10 were similar to those in the near-source A-zone wells. The VOC concentration trends indicate that the source for well AM1-10 is limited and is effectively being removed (Figure 15).

7.1.2 Evidence of Natural Attenuation

There are three lines of evidence that can be used to demonstrate that natural attenuation is occurring at a site, or if conditions are favorable for an MNA program (USEPA; 1998, 1999b):

1. Historical ground water chemistry data demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time;
2. Hydrogeologic and/or geochemical data can be used to demonstrate indirectly the types and rates of natural attenuation processes active at the Site; and,
3. Data from field or microcosm studies that directly demonstrate the occurrence of a particular biodegradation process at the Site.

The first line of evidence is the most direct, although many sites do not have adequate data for this line of evidence alone to suffice. For most sites, the second line of evidence is sufficient to supplement information from the first and to determine that contaminant mass is being destroyed, and the third line of evidence (direct observation of biodegradation) is not necessary to demonstrate adequate natural attenuation.

7.1.2.1 Historical Ground Water Chemistry

Over 17 years of data exist for ground water beneath the Applied Materials Building 1 Site. A-zone ground water sampling and VOC analysis began in November 1983. A-zone ground water extraction for remediation purposes began in August 1985, and A2-zone ground water extraction began in 1990. By 1990, approximately 430 pounds of VOCs had been removed from the A-zone, and cumulative VOC mass removed from the A- and A2-zone totals 558 pounds to date (Figure 13).

Concentrations of 1,1,1-TCA, 1,1-DCA, and 1,1-DCE have decreased markedly over time. Concentrations of these analytes in source area well AM1-1 (initially as high as 44,000 ppb, 1,500 ppb, and 3,400 ppb, respectively) are 2.3 ppb, 1.6 ppb, and 1.4 ppb, respectively, as measured in January 2002. However, the breakdown products of 1,1,1-TCA (1,1-DCA and 1,1-DCE) have never shown increasing trends since ground water has been monitored at the Site. Since 1,1-DCA and 1,1-DCE were never used onsite, breakdown of 1,1,1-TCA must have occurred prior to initiating the ground water monitoring and remediation program at the Site. Figure 15 shows a complete history of 1,1,1-TCA, 1,1-DCA, and 1,1-DCE concentrations over time for six representative Site wells, including source area well AM1-1.

Site data from 1983 until about the mid-1990s provide potential indications of natural attenuation. First, there was a large reduction in VOC concentrations in ground water between source area well AM1-1 and further downgradient wells AM1-5E, AM1-6, and AM1-7. Additionally, the 1,1-DCA:1,1,1-TCA and 1,1-DCE:1,1,1-TCA ratios increased in wells AM1-1, AM1-5E, AM1-6, and AM1-7 during this period. During this period, however, pumping from A-zone wells AM1-1 and AM1-5E was occurring, and likely significantly contributed to reductions in VOC concentrations.

Unlike earlier data, concentrations of 1,1,1-TCA, 1,1-DCA, and 1,1-DCE in source area well AM1-1 have been relatively similar to concentrations of these analytes in downgradient wells since approximately the mid-1990s. The data continue to show declining trends, however, the 1,1-DCA:1,1,1-TCA and 1,1-DCE:1,1,1-TCA ratios have not changed significantly. Additionally, there have been very few detections of vinyl chloride, all of which have occurred in well AM1-10. This observation may indicate that anaerobic biodegradation of 1,1,1-TCA is not occurring or is occurring at slower rates than in previous years. Nonetheless, pumping from the A-zone was discontinued in mid-1999, and since that time the VOC plume has neither migrated, increased in size, nor increased in concentration. This observation indicates that natural physical, biological, and/or chemical processes are at a minimum maintaining the current plume concentrations and/or attenuating the plume.

7.1.2.2 Hydrogeologic Setting and Geochemical Data

The physical processes that contribute to natural attenuation—dispersion, diffusion, sorption, and volatilization—are difficult to measure directly, however, the hydrogeologic setting of the Site gives some indication of the likelihood that these attenuating processes may occur. The A-zone at the Site consists of higher permeability sediments of limited lateral extent within lower permeability sandy silts and silty or sandy clays. This high degree of grain-size heterogeneity, both on a small and larger scale, suggests that a fairly high degree of dispersion would occur. Chemical diffusion, although a less important attenuating process, would also be fairly significant. Typically, sorption is directly related to the amount of organic carbon present in the sediments. Based on soil data collected from A2-zone shallow sediments, the organic carbon content of ranges from 0.042 to 0.25 percent (a relatively small amount) implying that sorption would not be expected to be a significant attenuating process (Weiss, 1991). Because the A-zone VOC plume at the Site is quite shallow, advection-driven volatilization could be a fairly significant attenuating factor in the A water-bearing zone, although, the concrete/asphalt cover over most of the Site would severely limit this process. The low permeability sediments overlying the A2-zone limit volatilization of A2-zone contaminants.

Table 6 shows the results of natural attenuation parameter analyses for four Site wells, as well as natural attenuation screening values obtained from the United States Environmental Protection Agency (USEPA) protocol for MNA (USEPA, 1998). These screening values provide an indication of the likelihood that anaerobic biodegradation is occurring. In general, these results do not indicate that significant anaerobic biodegradation is occurring at the Site. However, in January 2002, well AM1-10 had a favorable oxidation/reduction potential (ORP) value (10.0 millivolts), and well AM1-1 had a favorable dissolved oxygen value (0.9 mg/L). ORP and dissolved oxygen will continue to be monitored in select Site wells in 2003 (Section 7.2).

Although the natural attenuation parameters shown in Table 6 are generally not indicative of anaerobic conditions that are favorable to reductive dechlorination, 1,1,1-TCA is known to commonly breakdown via other pathways. The abiotic dehydrohalogenation to 1,1-DCE is a common reaction of 1,1,1-TCA, while the breakdown to 1,1-DCA occurs through biologic reductive

dechlorination (Peters, 2001). The abiotic transformation of 1,1,1-TCA to 1,1-DCE can occur under both aerobic and anaerobic conditions. In downgradient plume wells, it appears that the 1,1-DCE pathway is favored over the 1,1-DCA pathway, although source area wells AM1-1 and AM1-10 show higher values for 1,1-DCA than 1,1-DCE. Therefore, there is evidence that both biotic and abiotic degradation or transformation has been or is functioning at the Site.

In summary, the Site data indicate that destructive natural attenuation processes have contributed significantly to the reduction of VOC plume concentrations at the Site, but may not be occurring presently or are occurring at slower rates than in previous years. Nonetheless, remedial measures to date have resulted in a steady decrease in plume concentrations and no significant downgradient or vertical migration of VOCs has occurred. Based on data for the two and a half years since A-zone ground water extraction was discontinued, the VOC plume is not migrating and shows steady to decreasing concentrations, indicating that natural physical, biological, and/or chemical processes are controlling and attenuating the plume.

7.2 Monitoring Plan

The proposed monitoring plan, based on the existing Site SMP, is presented in Table 1-B. The Site SMP includes sampling of all Site wells annually and analyzing samples for VOCs. Provided the contingency plan is not triggered (Section 7.3), the Site SMP will be reviewed and possibly revised in calendar year 2003. After evaluating MNA parameters in January 2002, it is recommended that the scope of MNA parameter measurement in the four MNA program wells (AM1-1, AM1-3, AM1-10, and AM1-11) be narrowed to include only ORP and dissolved oxygen measurements, and ongoing evaluation of 1,1-DCA:1,1,1-TCA and 1,1-DCE:1,1,1-TCA ratios.

7.2.1 Adequacy of Existing Monitoring Network

The current Site SMP encompasses a total of 15 wells to monitor a relatively small VOC plume, which is at most 450 ft long and 150 ft wide. The VOC plume is confined to the A- and A2-zones at depths of approximately 35 ft below ground surface (bgs) or less. Two wells are completed in the A2-zone and two additional wells are located in the B-zone.

7.2.1.1 A-Zone and A2-Zone Monitoring Wells

Given the plume's small size and the ongoing pumping from AM1-10, source area wells AM1-1 and AM1-EP provide adequate monitoring of the A-zone original source area, while downgradient well AM1-11 monitors the plume immediately downgradient of the source area. Well AM1-10 monitors the A2-zone source area. Well AM1-3 serves as the upgradient monitoring well at the Site.

Monitoring well AM1-9 is located cross-gradient of the source area, and serves as a cross-gradient guard well. The downgradient boundary of the A-zone plume is monitored by wells AM1-5E, AM1-6, and AM1-7, and wells AV-1A and AV-7A, located across Bowers Avenue, are an additional 200 ft downgradient of the plume boundary.

7.2.1.2 B-Zone Monitoring Wells

The B-zone is monitored by two wells: source area well AM1-2 and downgradient boundary well AM1-5B. Since about 1995, these wells have shown non-detectable or inconsistently detected trace levels of VOCs. AM1-2 and AM1-5B provide a monitoring network sufficient to detect any significant downward migration of VOCs into the B-zone.

7.3 Contingency Plan

As discussed in Section 4 and shown in Table 4, trigger concentrations for 1,1-DCA and 1,1-DCE have been established for four Site wells (AM1-5E, AM1-6, AM1-7, and AM1-11), and three offsite wells (AV-1A, AV-1B, and AV-7A). The trigger concentrations are set at the 99% upper confidence level for the mean of data collected during the two years prior to Phase I of the Site PMP, so that a trigger concentration exceedance represents a fairly significant increase in VOC concentrations in that well. For other wells, no trigger concentrations are established, however, concentration trends will be tracked and actions taken if MCLs are exceeded.

In general, three types of contingencies have been identified that warrant further evaluation or other actions:

1. VOC concentrations that exceed trigger concentrations;
2. VOC concentrations in Site wells are not decreasing as expected; and,
3. VOC concentrations in upgradient wells that show significant concentration increases.

The first contingency type requires immediate response, including re-sampling to confirm the result, increased monitoring frequency, and in some cases, restarting ground water extraction.

For the second contingency type (i.e. source area VOC concentrations are not decreasing as expected), possible enhancements to the SMP will be evaluated and, if appropriate, implemented. These may include, but are not limited to, *in-situ* destruction of 1,1,1-TCA through introduction of electron donors to enhance biodegradation.

For the third contingency type (i.e. VOCs in upgradient wells increase), monitoring frequency will be increased to confirm the encroachment of an offsite source and, if confirmed, the RWQCB will be notified.

8. PROPOSED REMEDIAL ACTIONS FOR 2002-2003

Site ground water cleanup activities are performed in accordance with RWQCB Site Cleanup Requirements No. 90-134. Additionally, ground water monitoring at Applied Materials Building 3 (consisting of sampling wells HP-2 and HP-5) is required by the RWQCB per a 1989 agreement.

According to the approved schedule, all onsite and 3175 Bowers Avenue wells are sampled annually each January (Table 1). Ground water elevation measurements occur bi-annually in January and July of each year. Applied Materials will continue to monitor the Site treatment system, however, as of May 19, 2001, effluent from the treatment system dicharges to the sanitary sewer and not San Tomas Aquino Creek. Consequently, the treatment system will henceforth be monitored under the terms of the Site Discharge Permit rather than NPDES General Permit CAG912003 (RWQCB, 2001b).

Due to the inconclusive nature of results received in analysis for natural attenuation parameters in January 2001 and January 2002, it is recommended that the scope of MNA measurements be narrowed to include only ORP and dissolved oxygen monitoring in wells AM1-1, AM1-3, AM1-10, and AM1-11, and continued evaluation of 1,1-DCA:1,1,1-TCA and 1,1-DCE:1,1,1-TCA ratios in Site wells. The current cleanup goals for the Site are DHS MCLs. If these goals change before MCLs are met at the Site, the Site SMP will be re-evaluated and may be modified.

9. CONCLUSIONS

VOC concentrations were within historical ranges during this reporting period, and 1,1,1-TCA concentrations in all Site wells remained below the cleanup standard. Concentrations of 1,1-DCA and 1,1-DCE remained stable or decreased in January 2002 as compared to historical levels. Only three wells contained 1,1-DCA or 1,1-DCE above MCLs (5 ppb and 6 ppb, respectively), and the highest concentrations of 1,1-DCA and 1,1-DCE detected during this reporting period was only slightly above the MCLs. No 1,4-dioxane was detected above the 1.0 ppb MDL. Concentrations of other VOCs detected in Site ground water are generally stable, and except for TCE, are below MCLs.

Until May 19, 2001, the air stripper properly treated extracted ground water in accordance with criteria specified in the Site NPDES permit. Since that date, the air stripper has treated extracted ground water in accordance with criteria specified in the Site Discharge Permit.

The Site SMP continues to effectively monitor the containment and treatment of VOCs in the subsurface. Given that this VOC plume is not near water supply wells nor any other exposure pathway, the threat to human health and the environment from VOCs is not, nor anticipated to become, a hazard to the environment or public health (Weiss, 1989).

10. REFERENCES

Applied Materials, 2001, Letter to Vince Christian, California Regional Water Quality Control Board, San Francisco Bay Region (RWQCB), regarding Ground Water Discharge to Sanitary Sewer, Applied Materials Building 1, 3050 Bowers Avenue, Santa Clara, California, July 30, 2001, 2 pp., 1 figure, 2 tables.

Peters, G., 2001, Personal Communication to Mary Stallard, Weiss Associates, regarding 1,1,1-TCA Breakdown, from Gene Peters, Manager, ENVIRON International Corporation, February 26, 2001.

RWQCB, 1996, Letter from Loretta K. Barsamian, Executive Officer, regarding Analytical Data in Self-Monitoring Reports, November 5, 1996, 7 pp.

RWQCB, 1999, Letter from Stephen I. Morse, Chief of Toxics Cleanup Division, regarding Proposal to Shutdown A-Zone Groundwater Extraction Wells and Modification of Groundwater Monitoring at 3050 Bowers Avenue, Santa Clara, California, June 15, 1999, 2 pp.

RWQCB, 2000, Letter from Stephen Hill, Chief of Toxics Cleanup Division, regarding Semi-Annual Monitoring Report for February-August 2000 for Applied Materials, 3050 Bowers Avenue, Santa Clara, California, November 21, 2000, 2 pp.

RWQCB, 2001a, Letter from Stephen Hill, Chief of Toxics Cleanup Division, regarding Request for Technical Report, Workplan for 1,4-Dioxane Screening at 3050 Bowers Avenue, Santa Clara, California, December 7, 2001, 1 p.

RWQCB, 2001b, Letter from Stephen Hill, Chief of Toxics Cleanup Division, regarding Groundwater Discharge to the Sanitary Sewer at Applied Materials Building 1, 3050 Bowers Avenue, Santa Clara, California, September 13, 2001, 1 p.

RWQCB, 2002, E-mail Communication from Vince Christian, RWQCB, to L. Maile Smith, Weiss, regarding 3050 Bowers, 1,4-Dioxane Screening Workplan, January 14, 2002.

United States Environmental Protection Agency (USEPA), 1986, Test Methods for Evaluating Solid Waste, Physical Chemical Methods, Volume 1A.

USEPA, 1998, Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, EPA/600/R-98/128, 78 pp., 6 figures, 6 tables, 3 appendices.

USEPA, 1999a, Monitored Natural Attenuation of Chlorinated Solvents, USEPA Remedial Technology Fact Sheet, EPA/600/F-98/022, 3 pp.

USEPA, 1999b, Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, OSWER Directive 9200.4-17P, 32 pp.

Weiss Associates (Weiss), 1989, Remedial Investigation and Feasibility Study for Applied Materials Building 1, Santa Clara, California, February 19, 1989, revised June 14, 1989, 118 pp., 42 figures, 38 tables, 13 appendices.

Weiss, 1991, A2 Water-Bearing Zone Investigation at Applied Materials Building 1, 3050 Bowers Avenue, Santa Clara, California, December 9, 1991, 14 pp., 6 figures, 6 tables, 2 appendices, 1 plate.

Weiss, 2000, Ground Water Monitoring and Remedial Action Self-Monitoring Semi-Annual Report, February 2000 - August 2000 at Applied Materials, Building 1, 3050 Bowers Avenue, Santa Clara, California, September 15, 2000, 11 pp., 12 figures, 4 tables, 4 appendices.

Weiss, 2002, Letter to Vince Christian, RWQCB, regarding Workplan for 1,4-Dioxane Screening, Applied Materials Building 1, January 7, 2002, 3 pp., 4 figures.