APPENDIX C – SOIL VAPOR INVESTIGATION

FINAL REMEDIAL INVESTIGATION REPORT
CASMALIA RESOURCES SUPERFUND SITE
CASMALIA, CALIFORNIA

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ASTM	American Society for Testing and Materials
ATL	Air Toxics LTD
bgs	below ground surface
cm^3/minute	cubic centimeters per minute
COPC	chemical of potential concern
CSC	Casmalia Steering Committee
DQO	data quality objective
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
LARWQCB	Los Angeles Regional Water Quality Control Board
ml/min	milliliters per minute
MMP	Meteorological Monitoring Program
PCB	polycarbonate biphenyl
ppbv	part(s) per billion by volume
PSCT	Perimeter Source Control Trench
QA/QC	Quality Assurance/Quality Control
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RICH	RI Change Form
RPD	relative percent difference
SAP	Sampling Analysis Plan
SOP	Standard Operating Procedures
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

1.0 INTRODUCTION

The CSC completed the soil vapor investigation in accordance with the June 2004 *RI/FS Work Plan* which was prepared by the CSC and submitted to and approved by the EPA. This appendix presents the methodology used in the soil vapor investigation as well as the analytical results of the soil vapor samples.

1.1 Purpose of the Investigation

The purpose of the soil vapor portion of the Remedial Investigation was to evaluate (1) potential migration of landfill gas to areas outside the footprint of the landfills and (2) potential vapor migration from the Burial Trench area where wastes are known to be present. This information was to be used in both the Human Health Risk Assessment and Ecological Risk Assessment to evaluate potential exposures to chemicals in soil vapor. The soil vapor sampling program investigated the following areas of the Casmalia Resources Superfund Site (Site): areas around the Capped Landfills and PCB Landfill; Burial Trench Area; Liquid Treatment Area; and Central Drainage Area.

1.2 Scope of the Investigation

Soil vapor samples were collected from 43 locations at the Site as shown on Figure C-1. The soil vapor sampling was conducted in a phased approach during the RI activities to evaluate the sampling methodology and complete the soil vapor investigation.

- A one-day Soil Vapor Pilot Test was conducted on August 17, 2004 to test whether adequate flow through soils for vapor sample collection could be achieved and to test for potential leakage of ambient air through the top of the borehole and sample train. Three locations were sampled during the Soil Vapor Pilot Test;
- Following evaluation of the pilot test results, the Phase I investigation was conducted from September 20 to 23, 2004. Soil vapor samples were collected at twenty-one locations during the Phase I investigation;
- The Phase II investigation was conducted on November 11, 14, and 15, 2005, with follow-up sampling on July 31, 2006. Soil vapor samples were collected from nineteen locations during the Phase II investigation; and
- The Phase III investigation was conducted on October 12, 2007, and November 6 and 8, 2007. Soil vapor samples were collected at three locations previously sampled during the Phase II investigation, plus one sample of the leak test compound.

The following sections provide a summary of findings for the soil vapor sampling activities:

- Soil Vapor Sampling Methods and Procedures;
- Soil Vapor Pilot Testing;
- Soil Vapor Sampling Program;
- Results of Soil Vapor Sample Analyses; and
- Evaluation of Data Adequacy.

2.0 SOIL VAPOR SAMPLING METHODS AND PROCEDURES

The soil vapor sampling was conducted in accordance with the Casmalia Site Remediation RI/FS Work Plan [CSC, 2004]. The vapor probe installation and sampling activities followed regulatory guidance including the joint Department of Toxic Substance Control (DTSC) and California Regional Water Quality Control Board - Los Angeles Region (LARWQCB) Advisory on Active Soil Vapor Investigations [DTSC/RWQCB, 2003], and the applicable Standard Operating Procedures (SOP) contained in the Casmalia Site Remediation RI/FS Work Plan, Volume 2, Appendix A (Sampling and Analysis Plan (SAP)). The soil vapor sampling program included the Soil Vapor Pilot Test to evaluate sample collection methods and Phases I and II of the Soil Vapor Sampling Program for site assessment.

2.1 Detailed Approach

2.1.1 Planning and Preparation

Prior to sampling activities, soil vapor sample locations listed in the RI/FS Work Plan were staked at the site. A representative from the USEPA reviewed all locations prior to sampling. Any inaccessible locations were adjusted to facilitate sampling. The following locations were moved less than 15 feet from the original location to provide better access for the direct push drill rig or move samples out of a roadway:

Phase I samples: RISVBC-02, RISVBC-03, RISVCL-01, RISVCL-07, RISVCL-08, RISVCL-10, RISVCL-12, and RISVPB-01
Phase II samples: RISVCD-04.

Four samples were moved more than 15 feet from the original location:

- Sample location RISVCL-08 was moved approximately 20 feet to relocate the sample out of the roadway;
- Sample location RISVCD-01 was moved approximately 45 feet to provide access for the direct push drill rig;
- Sample location RISVPB-02 was moved approximately 100 feet to collect a more representative sample from the perimeter of the PCB landfill (the original location was on a hill above the landfill); and
- Sample location RISVCL-03D was moved uphill to the southwest approximately 110 feet from its original location to provide better access for the direct push drill rig.

The soil vapor sample locations are shown on Figure C-1 and the revised sample location coordinates are summarized in Table C-1.

Prior to initiating field activities, a health and safety plan was prepared pursuant to 29 CFR 1910.120. Geosyntec personnel and all subcontractors of Geosyntec performing field work for this project were briefed about job health and safety measures and the contents of the health and safety plan prior to commencing work each day.

2.1.2 Soil Vapor Sampling Methods and Procedures

The vapor probe installation and sampling activities were conducted in accordance with the Advisory on Active Soil Vapor Investigations, [DTSC/RWQCB, 2003], and Standard Operating Procedures (SOP) contained in the Casmalia Site Remediation RI/FS Work Plan, Volume 2, Appendix A (Sampling and Analysis Plan (SAP):

- SOP 1-9 on Soil Vapor Sampling;
- SOP 5-1 on Photo-Documentation;
- SOP 5-2 on Field Sample Location and Surveying;
- SOP 5-4 on Equipment Decontamination; and
- SOP 1-8 on Sample Handling, Preservation, and Shipping.

The Soil Vapor Sampling SOP 1-9 included in the SAP was revised to more clearly describe the planned soil vapor sampling activities. Concurrence from USEPA on the changes to SOP 1-9 was documented following the Casmalia Remedial Investigation management of change procedures.

2.1.2.1 Temporary Probe Installation

Soil vapor samples were collected at 7 ½ feet below ground surface (bgs) from all but three of the soil vapor locations. During the Phase II investigation, soil vapor samples were collected at 20 feet bgs at soil vapor locations RISVCL-03B, RISVCL-05B, and RISVCL-08B. A description of sampling activities included in field notes and photos taken during the field investigation are included in Attachment C-1. Temporary soil vapor probes were installed by pushing a 1-½-inch hollow steel rod into the subsurface using a direct push drill rig. Upon driving the rod to the desired depth, the probe at the end of the rod was then retracted by 4 to 6 inches to expose the sampling tip to the vadose zone soil vapor, and ¼ inch diameter polyethylene sampling line equipped with a screened sampling tip was inserted through the drill rod, with approximately 5 to 8 feet of sample tubing extending above the ground surface. Following the installation of the sample tubing, hydrated bentonite granules were packed at the annulus of the probe rod at the ground surface and at the top of the probe rod around the sampling line. The sub-surface conditions were then allowed to equilibrate for 20 minutes prior to purging and sampling.

2.1.2.2 Soil Vapor Probe Purging

To collect a representative soil vapor sample, the soil vapor probe was purged to remove stagnant and/or ambient air prior to sampling. Approximately three purge volumes of air were removed from each probe before sampling was initiated. Purge flow rate was manually controlled and the flow rate and vacuum pressure were monitored during purging. The purge flow rate was maintained at approximately 200 milliliters per minute (ml/min). The vacuum pressure during purging was typically below 15 inches of water and did not exceed 100 inches of water at any of the sites during this investigation.

2.1.2.3 Leak Test

A leak test was performed during each sample collected. Shaving cream containing isobutane was used for the leak test. The shaving cream was placed on the hydrated bentonite seal around the annulus of the probe rod at ground surface and, at some but not all locations, on the bentonite seal at the probe rod/sampling line interface. Shaving cream was also placed within a

trash bag placed over the flow controller valve and the sampling canister. Soil vapor analysis for each of these probe locations included analyses for isobutane.

To determine the source concentration for the leak test compound, shaving cream was placed into a trash bag, vapors were allowed to equilibrate, and a sample of the air in the trash bag was collected into a Tedlar bag on September 28, 2004. The procedures for this test were outlined in RI Change Form RICH-013. This sample was sent to Air Toxics, LTD and analyzed for isobutane by ASTM D-1945 and VOCs by USEPA Method TO-15. An additional source concentration sample was taken on November 8, 2007, in which shaving cream containing isobutane was placed in a trash bag and split summa canisters sampled the air within the trash bag. The split samples were sent to Air Toxics and Alpha Woods Hole Laboratory for comparison analysis.

2.1.2.4 Soil Vapor Sampling

Soil vapor samples were collected in Summa canisters provided by Air Toxics LTD, a State-certified fixed laboratory. During October and November, 2007, Alpha Woods Hole Laboratory was also utilized for split sampling to compare results to Air Toxics. Flow into the Summa canisters was regulated at approximately 150-cm^3/minute. Sampling was completed when the vacuum of the Summa canister had been reduced to less than approximately 5-inches of mercury.

Field duplicate and split samples were collected at several sample locations for quality control purposes. Field duplicate and split samples were collected by use of a sample T, which permitted simultaneous filling of the two canisters. For field duplicates, samples went to the same laboratory as blind samples, and comparison of results determine accuracy of the laboratory and field methods to duplicate sample results. For split samples collected prior to October and November, 2007, one sample was collected by Geosyntec, while the other was collected by the EPA, with each sample being analyzed by different laboratories. The October and November, 2007, split samples were collected by Geosyntec and sent to separate laboratories for analysis.

The temporary probe boreholes were then abandoned by backfilling with hydrated bentonite granules. Investigation derived wastes were not created during the investigation due to the nature of the sampling method. Soil vapor samples were sent to Air Toxics, LTD and Alpha Woods Hole Laboratory following the chain of custody protocol described in the SAP.

2.1.2.5 Analysis

Soil vapor samples were analyzed by Air Toxics LTD for VOCs using USEPA Method TO-15 and isobutane using method ASTM D-1945. Alpha Woods Hole Laboratory analyzed the soil vapor samples by USEPA Method TO-15, modified. Quality assurance and quality control (QA/QC) measures were implemented by the laboratory to evaluate the precision and accuracy of analytical procedures.

2.1.2.6 Meteorological Data Collection

The ambient air pressure and temperature were monitored during soil vapor sampling activities. These data were collected by the meteorological stations in operation for the Site Meteorological Monitoring Program (MMP). These stations are equipped with meteorological

sensing equipment that can measure average wind speed, peak wind speed, wind direction, barometric pressure, relative humidity, and ambient temperature. Ambient temperature and barometric pressure during sample collection are included in Attachment C-2.

2.1.3 Soil Vapor Pilot Test

The Soil Vapor Pilot Test was conducted to determine the effectiveness of soil vapor sampling techniques at this site and serve as a model for the subsequent Soil Vapor Investigation at the Site. Provided no sampling concerns were identified during the Pilot Test, the VOC results were to be included in the results of the overall Soil Vapor Investigation performed for the Casmalia Resources Superfund Site Remedial Investigation.

The Soil Vapor Pilot Test consisted of installation and sampling of three soil vapor probes at the edges of the Capped Landfills Area on August 17, 2004 (RISVCL-07, RISVCL-08, and RISVCL-10). The locations of these samples are shown on Figure C-1. The pilot test allowed for an evaluation of field conditions in terms of whether adequate flow was achievable to collect vapor samples. Additionally, samples were collected and sent to the laboratory to evaluate the potential for leakage through the top of the borehole and sample train. Field notes and photos from the Soil Vapor Pilot Test are provided in Attachment C-1.

Installation activities were performed by Gregg Drilling and Testing, Inc., and sampling activities were conducted by Geosyntec. Sampling activities were overseen by Christine Bucklin of the DTSC and Nathan Wall of CH2MHill, who served as a representative of the EPA. Air Toxics LTD, of Folsom, California provided analytical services.

Sampling procedures were performed according to the methods described in Section 2.1.2. Hydrated bentonite was initially placed only at the annulus of the probe rod and ground surface for locations RISVCL-07 and RISVCL-08. Upon recommendations from EPA representative Nathan Wall, bentonite was placed at the top of the probe rod around the sampling line as well for all remaining sample locations.

An EPA Split was performed on location RISVCL-08. Due to an apparent leak in one of the sample canisters, both canisters were removed and replaced with new canisters, and the location was re-sampled.

A duplicate sample was planned to be collected at RISVCL-10. However, a leak in the sample collection line was noted during sampling and both canisters were removed. Following this, an extra Summa canister was not available to collect a duplicate sample and only a single sample was collected.

2.1.4 Soil Vapor Sampling Program

Following completion of the Soil Vapor Pilot Test, the complete soil vapor sampling program for the site was conducted to evaluate potential vapor migration from the landfills and other previously identified waste areas.

The Soil Vapor Sampling Program consisting of installation and sampling of soil vapor probes was conducted in three phases. During Phase I sampling activities, twenty-one soil vapor probes were constructed and sampled at the edges of the Capped Landfills, PCB Landfill, Burial Trench Area, and Central Drainage Area on September 20 through 22, 2004. Based on results

of Phase I sampling, the Phase II investigation was performed which included sixteen soil vapor probes constructed and sampled at the northern and eastern edges of the Capped Landfills, Central Drainage Area, Burial Trench Area, and in the Liquid Treatment Area on November 11, 14, 15, 2005. The Phase II investigation also included three additional step-out soil vapor locations outside the northern and eastern edges of the Capped Landfills which were constructed and sampled on July 31, 2006. The Phase III investigation was conducted on October 12, 2007, and November 6 and 8, 2007, consisting of re-sampling the three step-out locations conducted during Phase II. Sampling locations are identified on Figure C-1. Additionally, the three samples collected during the Soil Vapor Pilot Test on August 17, 2004 are included in the site characterization results. Field notes and photos from the soil vapor sampling are provided in Attachment C-1.

Installation activities were performed by Gregg Drilling and Testing, Inc. and RSI Drilling, and sampling activities were conducted by Geosyntec. Sampling activities were overseen by Christine Bucklin of the DTSC, and Nathan Wall or Roy Soutee of CH2MHill, who served as representatives of the EPA. Air Toxics LTD, of Folsom, California and Alpha Woods Hole Laboratory of Mansfield, Massachusetts provided analytical services.

Sampling procedures were performed according to the methods described in Section 2.1.2. EPA splits were performed at locations RISVPB-01, RISVBC-01, RISVBC-02, RISVCD-03, and RISVCL-11 during the Phase I investigation. Additional split samples were collected during the Phase III investigation at RISVCL-03D, RISVCL-05D, and RISVCL-08D for confirmation of the presence of 1,3-butadiene. Field duplicate samples were collected from locations RISVBC-05 and RISVCL-12 during Phase I and at RISVCL-05C and RISVLT-03 during Phase II.

Due to either equipment malfunction or anomalous sample fill times for the Summa canisters, five instances occurred in which either new canisters or regulators needed to be replaced.

- At location RISVBC-04, a flow regulator was determined to be faulty. Consequently, a new canister and regulator were put in place for sampling;
- For duplicate sampling efforts at RISVBC-05, one flow regulator was determined to have a faulty gauge during sampling, thus sampling was restarted with two new canisters;
- At location RISVBC-02, which was an EPA split location, three samples were ultimately collected due to sampling complications. The first sample collected, Sample ID RISV-16, filled in 35 minutes, which was a shorter fill time compared to other split samples performed. Consequently, a second sample was collected, RISV-16B. This sample was completely filled (i.e., no vacuum remained in the canister following sample collection) due to a faulty vacuum gauge on the flow regulator. This canister was voided following discussions with the DTSC. A third sample was taken at a new location, located approximately five feet to the northeast. This sample was designated as RISV-16A, which filled in 28 minutes. Both Sample ID RISV-16 and RISV-16A were sent to the laboratory for analysis;
- At location RISVCL-08B, a flow regulator was determined to have a faulty gauge during sampling. Consequently, a new canister and regulator were applied for sampling; and
- At location RISVCL-03D, a flow regulator was determined to allow flow too quickly during split sampling on October 12, 2007. Consequently, two new canisters and a new regulator were applied for sampling.

2.1.5 Contractors and Subcontractors

The CSC contracted Geosyntec Consultants to complete the soil vapor investigation. Geosyntec Consultants subcontracted Gregg Drilling and Testing, Inc. and RSI Drilling to complete the soil vapor probe installation and Air Toxics LTD and Alpha Woods Hole Laboratory for the vapor sample analysis.

2.2 Deviations from the RI/FS Work Plan

Two RI Changes were completed for the soil vapor investigation:

- The Soil Vapor Sampling SOP 1-9 was revised to more clearly describe the planned soil vapor sampling activities (RICH-002); and
- Sampling and analysis of the leak test compound was conducted to quantify the source concentration of the leak check compound.

The CSC did not deviate from the modified RI/FS Work Plan in completing this soil vapor investigation.

3.0 INVESTIGATION RESULTS

3.1 Pilot Test Results

The primary objective of the Soil Vapor Pilot Test was to evaluate the field conditions to determine whether adequate flow is achievable to collect vapor samples and verify that sampling procedures would not result in leakage of ambient air into the sample. The key pilot test measurements considered for the effectiveness of the soil vapor sampling were the field measured volumetric flow rate, vacuum during purging, and leak tracer (isobutane) concentrations in the collected samples. The VOC analyses are summarized along with the Soil Vapor Sampling Program results in Section 3.2.

- During the field activities, all soil vapor probes were purged at flow rates of approximately 250 mL/min. The measured soil vapor probe vacuum during purging of each of the pilot test points is summarized in Table C-2 and the field notes included in Attachment C-1. Measured vacuums during purging varied between 0.7 and 4 inches of water. This confirmed that adequate purging flow rates were achievable at the site without excessive vacuum (below 100 inches of water);
- The source concentration of isobutane (the leak detection compound) was measured from an air sample collected from a trash bag holding shaving cream containing isobutane. This sample was analyzed by Air Toxics LTD, a State-certified laboratory, for VOCs by USEPA Method TO-15 and isobutane by ASTM D-1945. The analytical results for this sample are summarized in Table C-3 and the analytical laboratory report is provided in Attachment C-3. A concentration of 0.47% isobutane was reported for this sample. A threshold of 1% of the source concentration is used to determine if a potential leak is present during sampling (i.e., if the tracer concentration in a soil vapor sample is greater than 1% of the source concentration, then a potential leak may be possible). Note that since it is possible that isobutane is present in the subsurface, detection of this compound does not confirm that a leak occurred during sampling, it simply suggests that a leak is possible. The threshold concentration for a possible leak in a soil vapor sample is 1% x 0.47% = 0.0047%; and
- The analytical results for the leak test compound (isobutane) during the pilot test are listed in Table C-4 and the analytical laboratory reports are provided in Attachment C-3. Isobutane was not detected in any of the three soil vapor samples collected during the pilot test (detection limit = 0.0015% – 0.0019%). This confirms that atmospheric air was not leaking into the sampling train either through the annular region around the soil vapor probe or the fittings in the sampling train.

The results of the Soil Vapor Pilot Test indicated the methods used and results obtained are appropriate for the completion of the Soil Vapor Sampling Program.

3.2 Results of Soil Vapor Sample Analyses

Twenty-four soil vapor samples and two duplicate soil vapor samples were collected during the Soil Vapor Pilot Test and Phase I of the Soil Vapor Sampling Program. Nineteen soil vapor samples and two duplicate soil vapor samples were collected during Phase II of the Soil Vapor Sampling Program. Five soil vapor samples were collected during Phase III of the Soil Vapor Sampling Program. The samples were collected in 6-Liter Summa canisters and analyzed by

Air Toxics LTD, a State-certified laboratory, for VOCs by USEPA Method TO-15 and isobutane by ASTM D-1945. In addition, split samples were analyzed by Alpha Woods Hole Laboratory during the Phase III investigation. Standard chain of custody procedures along with standard laboratory Quality Assurance and Quality Control procedures were followed. Method detection limits were provided to the USEPA and DTSC prior to this investigation. The analytical results of constituents detected during the soil vapor investigation are summarized in Tables C-4 and C-5. A complete summary of the analytical results (including constituents not detected in any samples) and the chain of custody forms and laboratory analytical reports are attached as Attachment C-3.

3.2.1 Leak Detection Test Results

During each sample collection, shaving cream containing isobutane was placed at the ground surface and around all sample train connections to test for ambient air leaking into the sample. The isobutane analytical results are provided in Table C-4. The threshold concentration for isobutane in a soil vapor sample that would indicate a potential leak is 0.0047% (i.e., 1% of the source concentration). A couple of items to note regarding the leak test methods:

- At this threshold, the reported concentrations will theoretically be 99% of the actual concentration. This low bias is much less than typical variability observed in soil vapor samples; and
- There is the potential that isobutane exists in the subsurface. Isobutane has been detected in a small number of soil and pond sediment samples during the RI sampling. The leak test compound and threshold limit were selected to avoid impacts from site contamination, but the potential for subsurface sources must be recognized. The presence of isobutane in the sample may not be a result of a leak in the soil vapor sampling system.

Isobutane was detected in seven of the samples analyzed during the Soil Vapor Sampling Program. Three samples exceeded the 0.0047% threshold indicative of a potential leak:

Sample Location	Isobutane Conc (%)
RISVBC-06	0.0096
RISVCD-01	0.011
RISVCL-03D	0.0079

Four samples were slightly above the isobutane detection limit:

Sample Location	Isobutane Conc (%)
RISVBC-02 [a]	0.0019
RISVBC-03	0.0017
RISVPB-03	0.0025
RISVCD-06	0.0026

[a] The sample ID for this sample is RISV-16A

Note that the maximum isobutane detection was only approximately 2 times the threshold. This implies that the reported results for VOCs would be 98% of the actual concentrations that may be present in the subsurface. This difference is much less than typical variability observed in soil vapor samples. Consequently, the soil vapor data are of sufficient quality for their intended use in the human health and ecological risk assessments. Re-sampling of these locations is not necessary.

3.2.2 VOC Results

The VOC concentrations above sample quantitation limits were reported at all soil vapor sample locations, including both on-site and off-site step-out locations. A total of 43 individual VOCs were detected at the various sampling locations around the perimeter of the landfills, the Burial Trench Area, and the Central Drainage Area, including chlorinated and aromatic hydrocarbons, acetone, methyl ethyl ketone, and Freon gases. With only a few exceptions, those VOCs detected in off-site step-out locations were also reported to be present in on-site sampling locations. The presence of VOCs in areas adjacent to and outside major source areas indicate that soil vapor has migrated from the major source areas of the Site. Generally VOC concentrations are lower in step-out and offsite locations than the primary on-site samples.

Chemicals detected in soil vapor that show higher prevalence and reported concentrations, or that may contribute to human health or ecological risks, include acetone, methyl ethyl ketone, Freon 113, benzene, 1,3-butadiene, and tetrachloroethylene. Figure C-2 presents the chemical concentrations for those chemicals that are considered important from a human or ecological health perspective or are commonly detected. Maximum concentrations of total VOCs are observed at:

- two locations along the PSCT at the southern edge of the Central Drainage Area,
- one location at the base of the P/S Landfill along the western edge of the Central Drainage Area, and
- one location within the Burial Cells unit.

Elevated concentrations may also be present within the interior of the Central Drainage Area where LNAPL and DNAPL have been observed, however soil vapor samples were not collected in this area due to the planned remedy which includes a cap cover over the entire Central Drainage Area.

Maximum concentrations of individual constituents were encountered along the eastern and northeastern limits of the Capped Landfills Area (acetone and 1,3-butadiene), south of the PSCT below the Maintenance Shed Area (1,3-butadiene and benzene), the western limit of the Central Drainage Area and eastern margin of the Burial Trench Area (Freon 113), the southern and western Central Drainage Area (tetrachloroethylene), as well as west of the Burial Trench Area, the northwestern limit of the Capped Landfills Area, and two locations along the PSCT south of the Central Drainage Area and Burial Trench Area (methyl ethyl ketone). The locations of the samples with elevated concentrations are consistent with previously identified source areas at the site. Two of these samples (RISVBC-03 and RISVBC-06) were collected within the burial trenches, one sample (RISVCD-01) was located within the boundaries of former Pond R where waste was not removed, and two samples (RISVCD-02 and RISVCD-03) are located near the Perimeter Source Control Trench (PSCT) which has historically contained free product.

Off-site soil vapor samples generally contained similar chemicals as on-site samples but at lower concentrations. A few exceptions to this are the presence of acetone (Figure C-2) at similar concentrations as nearby onsite samples north of the capped landfill area and in the northern drainage and the detection of tetrachloroethylene at relatively low concentrations at offsite locations to the north of the capped landfills and in the northern drainage when nearby onsite samples were non-detect (Figure C-7).

The VOC analytical results for the soil vapor samples are provided in Table C-5. Tables C-6 though C-8 present the prevalence summary of the detected chemicals. Figure C-2 presents the soil vapor concentrations for select chemicals. The chemicals were selected to show the distribution of some of the most prevalent and highest concentration chemicals detected in soil vapor (acetone, methyl ethyl ketone and Freon 113) or that may contribute to human health or ecological risk. Notable findings from the soil vapor investigation include:

- Two samples were analyzed from location RISVBC-02. No VOCs were detected in the first sample collected (Sample ID RISV-16). Several VOCs were detected in the second sample analyzed (Sample ID RISV-16A). Based on these results, the concentrations reported from the second sample are considered to be representative of subsurface conditions at this location;
- Two samples were analyzed from location RISVLT-03. Low levels of VOC concentrations were detected in the primary sample. Significantly higher VOC concentrations were detected in the duplicate sample analyzed. Based on these results, the concentrations reported from the duplicate sample are considered to be representative of subsurface conditions at this location;
- Split samples were collected from step-out locations RISVCL-03D, RISVCL-05D, and RISVCL-08D for confirmation of the presence of 1,3-butadiene. Step-out location RISVCL-03D concentrations for 1,3-butadiene are non-detect as compared to detections at RISVCL-03. Step-out location RISVCL-05D has 1,3-butadiene detections at lower levels compared to the initial location while step-out location RISVCL-08D has similar 1,3-butadiene concentrations as those detected at the initial location prior to step-out. The split sample results confirm the presence of 1,3-butadiene;
- Samples were collected at three locations (RISVCL-03D, RISVCL-05D, and RISVCL-08D) at two or more different times. Chemical concentrations show some variability but no obvious temporal trends were observed based on the available data. This finding is uncertain in that a limited number of locations were sampled for only one or two additional rounds. Over the next 5 years, periodic soil vapor monitoring will be conducted at these locations to assess the temporal concentration trends;
- Samples were collected at two depths (7.5 ft and 20 ft bgs) at three locations in the Capped Landfills Area. No general concentration trend with respect to sample depth is seen. However, Freon 11 and Freon 113 have higher concentrations at depth at sample location clusters RISVCL-05/05B and RISVCL-08/08B. This finding is uncertain in that a limited number of locations were sampled for only one or two additional rounds;
- Elevated concentrations (greater than 10,000 ppbv) of chlorinated hydrocarbons (1,1,1-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, *cis* 1,2-dichloroethene, tetrachloroethene, trichloroethene, vinyl chloride, methylene chloride, chloroform, carbon tetrachloride) and Freon gases (Freon 11 and Freon 113) were detected in soil vapor samples collected along the southern boundary of the Central Drainage Area and the central portion of the Burial Trench Area. An elevated concentration for methyl ethyl ketone was also reported for one sample located south of the Burial Trench Area;
- The locations of the samples with elevated concentrations are consistent with previously identified source areas at the site. Two of these samples (RISVBC-03 and RISVBC-06) were collected within the burial trenches, one sample (RISVCD-01) was located within the boundaries of former Pond R where waste was not removed, and two samples (RISVCD-02 and RISVCD-03) are located near the Perimeter Source Control Trench (PSCT) which has historically contained free product;

- Moderately elevated (greater than 1,000 ppbv) of acetone and methyl ethyl ketone were detected in soil vapor samples collected around the PCB Landfill, Capped Landfills Area, Liquid Treatment Area, and within the Burial Trench Area. Moderately elevated concentrations of methyl ethyl ketone were also detected south of the Central Drainage Area;
- Low levels (less than 10 ppbv) of 1,3-butadiene were detected along the Capped Landfills Area northern boundary and step-out locations as well as the north western boundary of the PCB Landfill. Slightly higher 1,3-butadiene concentrations (up to 54 ppbv) were detected in samples collected south of the Central Drainage Area (RISVCD-05), at 20 ft bgs at the edge of the Capped Landfills Area (RISVCL-05B, RISVCL-03B), and in the Liquid Treatment Area (RISVLT-03); and
- VOCs have been detected in off-site samples including the North Drainage at relatively low concentrations.

3.3 Data Validation and QA/QC

Field quality assurance/quality control (QA/QC) samples were generated to evaluate the precision accuracy and integrity of field sampling and laboratory analytical procedures. Field QA/QC samples for the soil vapor investigation included one trip blank for the pilot test and four for the soil vapor sampling program. Additionally, four field duplicate samples (approximately 10% of the total samples) were collected. Six split samples were collected and provided to EPA representatives for analysis. An additional four split samples were collected and sent to Alpha Woods Hole Laboratories. The locations of the field duplicate and split samples are indicated in Table C-1.

Laboratory QA/QC requirements for the vapor analysis are listed in Appendix B of the June 2004 RI/FS Work Plan and were adhered to by the analytical laboratories. Level III and Level IV validations were performed on the data packages received by Geosyntec Consultants from Air Toxics, LTD of Folsom California and Alpha Woods Hole Laboratory of Mansfield Massachusetts. Data validation reports are included in Attachment C-4. The analytical data set generated as a part of the soil vapor investigation is considered to be usable for meeting the RI project objectives. No data were rejected. Some data was qualified as discussed in Attachment C-4.

No target analytes were detected in the trip blanks with the exception of one analyte in one trip blank. This indicates there is no evidence of significant cross-contamination occurring during sample storage and shipment. Toluene was detected in blank sample QCTB-1 at a concentration greater than the reporting limit. Toluene was detected in samples RISV-52 and RISV-52 Lab Duplicate at concentrations less than 5 times the blank concentration; therefore, the concentrations of Toluene in samples RISV-52 and RISV-52 Lab Duplicate are U qualified at elevated reporting limits.

The field duplicate samples were evaluated by calculating the relative percent difference (RPD) between the primary sample and its duplicate. The RPD was calculated only for those constituents that were detected in either sample at levels above or near the reporting limits. Precision acceptance criterion is a RPD of $\leq$100 percent. Results for all analytes satisfied the applicable evaluation criteria with the following exception. Six data records (Less than 0.4%) were listed as estimates (J) due to the RPD values outside of acceptable criteria. With the exceptions above, the field duplicate results indicate that the overall precision (sampling and analytical precision) is acceptable.

Split samples that were collected from step-out locations RISVCL-03D, RISVCL-05D, and RISVCL-08D for confirmation of the presence of 1,3-butadiene were evaluated with respect to the original samples. Table C-9 presents the relative percent differences between the two sets of samples. In general there was good agreement between the sample sets with the exception of Samples RISVCL-08D where the ATL results were all non-detect and the Alpha Woods Hole sample contained detections. Previous samples results from this location by ATL were similar to the Alpha Woods Hole results. Therefore, the ATL sample is considered anomalous and not representative of the concentrations at this location.

4.0 EVALUATION OF DATA ADEQUACY

The soil vapor data obtained during this RI investigation were evaluated with respect to the soil vapor Data Quality Objectives (DQOs) identified in the RI/FS Work Plan. Work Plan Sections 4.1 through 4.3 identify specific decisions and decision rules for issues related to this Task, including those related to human health and ecological risk assessment and contaminant fate extent and transport, groundwater modeling. Table 6.1 of the RI/FS Work Plan identifies all of the RI/FS DQO decisions and provides an evaluation of additional data needs associated with each. The decisions specific to soil vapor sampling are listed below.

The specific decisions and decision rules for issues related to soil vapor contaminant fate extent and transport are as follows:

- Is vapor migrating from the landfills, burial trenches, and residual contamination in the Central Drainage Area?
- If the 95% upper confidence limit (UCL) on the mean soil, sediment, soil vapor, surface water and groundwater concentration for chemicals of Potential Concern (COPCs) in the study area result in risk estimates within acceptable limits for the relevant exposure pathways, then no further sampling will be proposed for the chemical or media. If cumulative risks for the study area are within acceptable limits, no further action will be recommended.
- If the maximum and/or 95% UCL on the mean soil, soil vapor, sediment, and/or surface water concentrations for COPCs in each study area are greater than human health or ecological risk screening levels, then additional sampling and analysis may be proposed.

Concentrations above the sample quantitation limits were reported for the soil vapor data collected from the perimeter of the landfills, burial trenches, and Central Drainage Area and off-site locations. Consequently, these data may be used to evaluate the migration of vapors from these source areas. The collected soil vapor data (reported concentrations and detection limits) are sufficient to calculate risk estimates for relevant exposure pathways for human health and ecological receptors. The data have been used in the human health and ecological risk assessments (Appendices T and U, respectively).

The results of the soil vapor investigation found elevated concentrations of chlorinated hydrocarbons, acetone, methyl ethyl ketone and Freon gases along the southern boundary of the Central Drainage Area and the central portion of the Burial Trench Area. Based on Phase I sampling results, additional data needs were outlined and met during Phase II and III of the soil vapor investigation to delineate the soil vapor plumes in these areas as well as evaluate offsite step-out locations from sample locations RISVCL-03, RISVCL-05, and RISVCL-08. The results of the Phase II and III sampling indicated that chemicals have migrated in soil vapor to off-site locations along the Capped Landfill Area boundary and in the Northern Drainage. The Phase II and III data are also considered adequate for risk assessment and RI purposes.

While significantly elevated chemical concentrations were not detected at the boundary of the Capped Landfill Area or in off-site samples, periodic soil vapor sampling and analysis at off-site locations is planned to monitor the temporal trends of COPCs in soil vapor.

5.0 REFERENCES

CSC (Casmalia Steering Committee), 2004. Casmalia Site Remediation RI/FS Work Plan, June 3, 2004.

DTSC & LARWQCB (Department of Toxic Substance Control & California Regional Water Quality Control Board – Los Angeles Region), 2003. Advisory – Active Soil Vapor Investigations. http://www.grac.org/Soil_Gas_Advisory.pdf. January 13, 2003.