VAPOR INTRUSION ASSESSMENT REPORT

Port of Longview
Maintenance Facility Area

Prepared for

INTERNATIONAL PAPER

International Paper
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1.0 INTRODUCTION

This Vapor Intrusion Assessment (VIA) report presents the results URS Corporation's (URS's) indoor air quality assessment conducted within the Mechanics Shop located in the Port of Longview's Maintenance Facility Area (MFA). During an additional investigation URS completed within the MFA in September 2008, elevated concentrations of polynuclear aromatic hydrocarbons (PAHs) associated with creosote contamination were identified adjacent to the northeastern portion of the Mechanics Shop. During a May 12, 2009 conference call between URS, International Paper, and the Washington State Department of Ecology (Ecology), it was determined that an indoor air quality assessment would be conducted within the Mechanics Shop employee lunch room (Figure 1). A draft VIA Sampling and Analysis Plan (SAP) was submitted to Ecology on June 2, 2009. The scope of work for this VIA was further developed after receiving comments from Ecology on June 24, 2009 and subsequent correspondence with Ecology and the Port of Longview. A revised SAP was submitted to Ecology on November 3, 2009, and Ecology granted conditional approval of the revised SAP on November 10, 2009 (Petersen, 2009b) pending resolution of a few minor issues that were then resolved on a conference call between URS, International Paper, and Ecology on November 18, 2009. This VIA was developed to address specific questions identified regarding the vapor intrusion (VI) pathway during development of a Remedial Investigation/Feasibility Study (RI/FS) for this site, and is not intended to be a comprehensive evaluation, but rather a screening level assessment intended to answer specific questions. This report presents the background, scope of work, results, and conclusions and recommendations regarding the indoor air quality within the Mechanics Shop building.

2.0 BACKGROUND

Between 1937 and 1982, International Paper conducted wood treatment operations at the International Paper Longview facility in the Treated Wood Products (TWP) Area, which is located adjacent to and southeast of the MFA (Figure 2). These operations included discharges of liquid wastes to on-site ponds that may have overflowed via a ditch that ran from the TWP Area through the MFA to the northwest between 1947 and 1953.

During installation of a subsurface barrier wall in 1997, URS observed impacted soils outside the barrier wall alignment. Subsequent investigations identified impacted soil and groundwater in the MFA. In 2002, URS commenced cleanup actions in the MFA that included installing a biosparging/bioventing treatment system. During the 2008 MFA Additional Investigation, diesel-range organics (DRO), naphthalene, and carcinogenic PAHs (cPAHs) were detected in the soil adjacent to the Mechanics Shop building at concentrations exceeding Model Toxics Control Act (MTCA) cleanup levels (e.g., naphthalene was detected at 1,700 milligrams per kilogram [mg/kg] in soil boring PB–59). Evidence of sheen and stained soils were noted in the northeastern corner of the building in borings PB–59, PB–60, and PB–61 (Figure 2).

2.1. Nature and Extent of Contamination Overview

Indications of dense non-aqueous phase liquid (DNAPL) occurrence within the MFA in the proximity of the Mechanics Shop building have included observations of residual DNAPL (sheen/staining) in soil samples collected within the Upper Sand and pooled DNAPL noted in perched groundwater measured at bioventing well BV-13 and former well 97-6A located east of the Mechanics Shop near the eastern boundary of the MFA (Figure 2).

The locations of soils exhibiting evidence of residual and/or pooled DNAPL is illustrated on Figure 2. The area depicted with observed sheen on soils generally runs parallel with the former wastewater overflow conveyance ditch (Figure 2). The source of the DNAPL occurrence in the MFA appears to be the TWP area, approximately 250 feet to the southeast. Based on the analytical results for soil samples collected within the zones of pooled DNAPL, the chemical composition of this DNAPL appears to consist of DRO (ranging from 1,800 mg/kg to 26,000 mg/kg) and part per million (ppm) concentrations of a number of PAHs, such as naphthalene (ranging from 140 mg/kg to 4,580 mg/kg) and 2-methylnaphthalene. These findings are consistent with the typical composition of diesel/creosote wood treating mixtures, which may contain up to 50% of a carrier fluid (diesel fuel) and many other hydrocarbons, primarily PAHs and phenolic compounds (U.S. Environmental Protection Agency, 2003).

The highest concentrations of petroleum hydrocarbons and PAHs generally coincide with the occurrence of DNAPL in soil and are concentrated in the eastern portion of the MFA. Other impacted soils are primarily situated along a linear trend parallel to the wastewater overflow conveyance ditch situated north of the Mechanics Shop building. The vertical distribution of DRO, cPAHs and naphthalene within the MFA are depicted on Figures 3 and 4. It is evident from these figures that the DNAPL and residual soil contamination is inferred to extend beneath the northeastern corner of the Mechanics Shop building based on the observations and soil data from borings PB-59 and PB-61 that outline the northeast perimeter of the Mechanics Shop (Figure 2), and the general vertical distribution in the subsurface in that area (Figures 3 and 4).

Groundwater is present within the Upper Sand and the Lower Sand units. Within the Upper Sand, groundwater occurs as a shallow perched zone identified above the contact between the Upper Sand (fill) and the Upper Silt unit. The perched groundwater zone appears to be intermittent and is primarily evident in the southeastern portion of the MFA. The direction of perched groundwater flow is inferred to be northeasterly based on shallow wells (Bioventing Wells, BV-12, 13 and 15) screened across the perched groundwater and observed potentiometric gradients. Perched groundwater in these wells has been noted at depths ranging from approximately 3.3 to 6 feet below ground surface (bgs). The primary saturated zone lies within the Lower Sand which is divided into two units (Aquifer A and Aquifer B) that are separated by a silt layer referred to as the Intermediate Silt. The base of Aquifer B is bounded by the Lower Silt. The Upper and Intermediate Silt units underlie the MFA and are considered confining layers based on the fine grained nature of these units. Groundwater encountered in Aquifer A is semi-confined to confined and in Aquifer B groundwater is confined. Groundwater elevations in the Lower Sand range from approximately 10 feet bgs to 15 feet bgs.

Historic groundwater monitoring conducted in Aquifer A beneath the MFA identified groundwater containing DRO, naphthalene and cPAHs concentrations exceeding applicable MTCA cleanup levels. However, the concentrations of these constituents have declined since the initiation of the remedial system operation in 2002, and based on groundwater sampling of new and existing wells conducted in 2008, the highest concentrations of DRO, naphthalene and cPAHs exist in the central portion of the MFA, oriented northwest-southeast along the alignment of the former conveyance ditch/lineament (Figures 5, 6 and 7). The highest concentrations of DRO, naphthalene and cPAHs noted in site groundwater are situated in areas overlying DNAPL occurrence and are parallel to the former wastewater overflow conveyance ditch.

The source of the DNAPL and the associated sorbed and dissolved phase constituents of concern within the MFA appears to be the former unlined ditch that once conveyed wastewater discharges northwesterly from the TWP wastewater ponds through the MFA. The primary factors contributing to the distribution of DNAPL and associated chemical constituents identified in the Upper Sand in the MFA appear to include:

1) The alignment of the historic wastewater overflow conveyance ditch and historic topography along this feature;
2) The distance from the source area (TWP area);
3) The topography of the Upper Silt unit (e.g., troughs or depressions in the Upper Silt surface); and
4) The direction of perched groundwater flow.

It is apparent that residual DNAPL is concentrated in the eastern portion of the MFA, with the alignment of the historic wastewater overflow conveyance ditch and distance from the source area (TWP area) having the greatest effect on its distribution. At the interface with the Upper Silt DNAPL pools apparently occurred within topographic depressions or lower lying areas. Perched groundwater in contact with the residual DNAPL also likely contributed to the transport and distribution of contaminants.

3.0 SCOPE OF WORK AND METHODOLOGY

The purpose of the VIA was to evaluate whether the presence of DNAPL and impacted soils observed adjacent to the Mechanics Shop have adversely affected indoor air quality within the Mechanics Shop building and whether the concentrations of volatile PAHs in the indoor air are a potential health risk that could require vapor intrusion mitigation measures. The scope of work for this assessment was developed based on review of vapor intrusion guidance documents developed and specified by Ecology and other relevant guidance, including the New Jersey Department of Environmental Protection's *Vapor Intrusion Guidance* (NJDEP 2005), Ecology's *Sampling and Analysis Plan Outline for VI Investigations* (Petersen, 2009a), The Interstate Technology & Regulatory Counsel's technical and regulatory guidance *Vapor Intrusion Pathway: A Practical Guideline* (ITRC 2007), and Ecology's *Draft Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Ecology 2009). A description of the Mechanics Shop building and the methods implemented to complete the scope of work are discussed below.

3.1. Building Description and Pre-Sampling Building Survey

Prior to surveying the Port of Longview's Mechanics Shop design drawings provided by the Port of Longview were reviewed for pertinent information regarding building features such as the building slab, subsurface utilities (and slab penetrations), and the configuration of the heating, ventilating, and air conditioning (HVAC) system. This information was subsequently reviewed with the Port of Longview on an October 8, 2009 conference call. The following paragraphs provide a summary description of building construction.

The Mechanics Shop was constructed in 1992 and is an approximately 15,000-square-foot single-story L-shaped building. The Mechanics Shop was constructed with a concrete slab-on-grade foundation. The building consists of the main work room, lubrication room, tire room, compressor room, welding room, electrical room, battery room, parts storage room, fuel and work truck storage room, wash bay, filtration equipment room, restrooms, two offices, and the employee lunch room (Figure 1). There are large roll-up bay/garage doors on the east and southwest sides of the building. The restrooms, two offices, and employee lunch room are understood to be heated/cooled by a single heat pump system. The outdoor air intake for the employee lunch room is located on the eastern exterior wall of the building (Figure 1). The remaining portions of the building (e.g., work bays, work rooms) are heated through radiant floor heating or are unheated.

The employee lunch room contains a lunch table and chairs, two couches, a refrigerator, two televisions, a kitchen counter and sink, and employee lockers. According to Port of Longview personnel, cigarette smoking occasionally occurs within the employee lunch room.

Prior to conducting the indoor air sampling event, a survey of the building was conducted on October 20, 2009. The purpose of the pre-sampling building survey was to identify potential background sources of indoor air contaminants that could influence the results of indoor air sampling. The survey included interviewing facility personnel and completing a questionnaire modeled after the NJDEP *Indoor Air Building Survey and Sampling Form*. The completed questionnaire is included as Appendix A. The walkthrough of the building was conducted to identify potential sources of any chemicals of concern (e.g., creosote treated wood). No cigarettes or ashtrays were observed within the employee lunch room during the pre-sampling building survey or during the sampling event. Other features noted during the walkthrough included potential preferential pathways for vapor intrusion including floor drains and cracks noted in the floor slab within the employee lunch room and Office #2 (Figure 1). Based on the survey findings, the indoor air samples were proposed to be collected above the two observed cracks within the employee lunch room and above the crack observed within Office #2. These locations were selected based on their proximity to the observed DNAPL occurrence near the building at location PB-59 (Figure 2) and because they were assumed to be less ventilated compared to other areas of the building (e.g., absence of open roll-up bay/garage doors). Therefore, these areas were determined to have the highest potential for vapor intrusion impacts. The proposed sample locations, rationale, collection methods, and analysis were presented in URS' November 3, 2009 revised SAP, which was conditionally approved by Ecology on November 10, 2009 (Petersen, 2009b) pending resolution of a few minor issues that were then resolved on a conference call between URS, International Paper, and Ecology on November 18, 2009. Prior to conducting the VIA sampling event, sampling equipment was installed and checked at the locations identified in the revised SAP during a November 20, 2009 site visit.

3.2. Sampling Locations and Sample Collection

The indoor air sampling event was conducted on Saturday, December 5, 2009. On the morning of the sampling event, prior to sampling, URS performed another cursory walkthrough of the building interior to confirm that potential sources of chemicals of concern were not present in the proposed sampling locations. Chemical containers were identified beneath the employee lunch room sink and within a locker located in Office #2, however. These containers were subsequently placed in a cardboard box and removed from the sampling areas prior to sampling. A list of the chemical containers removed from the sampling areas is provided in Section 12 of the completed Indoor Air Quality Building Questionnaire in Appendix A.

The indoor air sampling locations are shown on Figure 1. One sample was collected from Office #2 (MFA-IA-1), and three samples were collected from the employee lunch room (MFA-IA-2, MFA-IA-3, and MFA-IA-4 [a field duplicate of MFA-IA-3]). Ambient/background air samples were collected from two locations:

- Approximately 50 feet east and upwind of the employee lunch room portion of the building (MFA-AA-1), and
- Outside of the building, adjacent to the air intake along the building exterior outside the lunch room (MFA-AA-2).

A field blank (MFA-AA-3) was also collected outside and upwind of the building (near the location at which MFA-AA-1 was collected) by opening and then immediately resealing the sampling tube.

Air sampling was conducted on Saturday, December 5, 2009 and performed as described in URS' November 3, 2009 SAP, and in conformance with the procedures outlined in Air Toxics Ltd. *Guide to Air Sampling & Analysis, Sorbents and Solutions* (Appendix B) and the U.S. Environmental Protection Agency's (EPA) *Compendium Method TO-17, Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes* (Appendix C). Air samples were collected using stainless steel Tenax GR-SVOC desorption tubes attached via ¼-in Tygon tubing to URS' SKC Airchek Sampler (Model 224-PCXR4) portable low-flow industrial hygiene pumps. The sorbent tubes were provided by the analytical laboratory (Air Toxics Ltd. of Folsom, CA). Based on discussions with Air Toxics Ltd., it was determined that equipping each sampling train with an ozone scrubber or particulate filter was not necessary. The sampling tubes and pumps were set up at three locations within the building (Figure 1) at approximately three to five feet above the floor to represent a typical worker/patron seating height and breathing zone. To achieve these sampling heights, the sampling tubes were attached to copper wires that were hung from the suspended ceiling tiles. The ambient air samples were collected upwind of the building and adjacent to the air intake located on the east exterior wall of the building (Figure 1) to assess potential ambient/background air sources. Photographs of the sample locations and sampling devices are presented in Appendix D. Prior to sample collection, URS confirmed that the HVAC system was operated identically each day of the week and that conditions during sampling would represent typical weekday work shift conditions. The building doors in the sampling area were also ensured to be positioned (open/closed) in the same configuration as a typical work shift (i.e., exterior doors to maintenance bays/outside were closed, restroom doors were closed, and office doors were open). More conservatively, the roll-up maintenance bay doors were closed in the adjacent areas, although these doors are typically open during a standard work shift.

URS also confirmed that no precipitation had fallen in the vicinity of the MFA within 24 hours prior to the sampling event. Meteorological history data (e.g., wind direction, barometric pressure and temperature) from a local weather station (MLOPW1, Port of Longview) for the sampling period is provided in Appendix E. This weather station located approximately 1,200 feet to the west of the Mechanics Shop building. The weather during sampling was overcast with temperatures ranging between 33 and 45 degrees Fahrenheit and barometric pressure declining from approximately 1027 millibars (mB) to 1022 mB over the duration of the sampling period. Winds were out of the east at an average speed of 3 miles per hour. No precipitation was recorded during the sampling event.

Prior to field mobilization, the pumps were calibrated to the desired flow rate using a "set-up" tube and a BIOS International Drycal DC-1 Flow Calibrator (calibrator). Flow rates were then measured again in the field using the calibrator prior to sampling. Samples were collected over an 8-hour period with sampling pumps operating at flow rates ranging between 22 to 24 milliliters per minute (mL/min). These rates produced a sample volume of approximately 11 liters (L), which met the laboratory-recommended safe sampling volume (SSV) for EPA Method TO-17 necessary to achieve a method reporting limit of 1 microgram per cubic meter ($\mu g/m^3$) for naphthalene and 2-methylnaphthalene. The post-sampling flow rates were checked and found to be within 10% of the pre-sampling flow rates for each sample, with the exception of ambient air sample MFA-AA-1 (Table 1).

The sample identification, sampling tube and/or pump model/serial number, date and time(s) of collection, and flow rates were all recorded on the sampling tube, the chain-of-custody record, and the Field Test Data Sheets (Appendix F). At the end of the sampling period, end plugs were placed on both ends of the sampling tubes and the post-sampling flow rate was measured using the "set-up" tube and recorded on the Field Test Data Sheets along with stop times. The samples were shipped on ice in coolers within two days of sample collection to Air Toxics Ltd. for analysis.

3.3. Johnson and Ettinger Modeling, Sample Analysis and Data Evaluation

As previously discussed, elevated concentrations of PAHs were previously detected in prior soil and groundwater samples obtained in the vicinity of the MFA Mechanics Shop building. The PAHs that exceeded MTCA Method C soil cleanup levels in soil and groundwater in the vicinity of the MFA Mechanics Shop building, were first examined with regard to whether they met EPA's definition of a volatile chemical (i.e., having a Henry's Law constant (atm–m3/mol) greater than 10^{-5} and a molecular weight less than 200 g/mol [USEPA 2002]). Those that did were evaluated using the NAPL version of the Johnson and Ettinger Model (JEM) for Subsurface Vapor Intrusion (USEPA 2002 and 2004a), which simulates the transport of soil vapors in the subsurface by both diffusion and advection into indoor air. The model uses conservative assumptions, and tends to overestimate indoor air concentrations. Following discussion with the Port of Longview, default model assumptions for building slab thickness (6-in) and air exchange rate (2/hour) were replaced with site specific slab thickness (12-in) and air exchange rate (5/hour) information. The results of the modeling indicate that naphthalene and 2-methylnaphthalene could potentially be exceeding MTCA Method C air cleanup levels in the vicinity of the lunch room of the MFA Mechanics Shop building. The JEM evaluation of indoor air concentrations within the Mechanics Shop is summarized in Appendix G.

To refine the estimates provided by the indoor air modeling, Air Toxics, Ltd. analyzed the indoor air and ambient air samples for naphthalene and 2-methylnaphthalene using EPA Method TO–17. In order to ensure that data was of a known and acceptable quality, all analytical data generated for this project underwent a data quality review. This review is an assessment of data precision and accuracy using quality control summary sheet results provided by the laboratory for each data package. Data was evaluated based on the method requirements, the project Quality Assurance Project Plan (QAPP) requirements (QAPP Air Sampling Addendum, Appendix H), and laboratory criteria at the time samples were submitted to the laboratory. Based on upon URS' data review, the data reported by Air Toxics, Ltd. was determined to be acceptable for meeting the objectives of this project. The data quality review memorandum is included as Appendix I.

4.0 RESULTS

The indoor air sampling results are summarized in Table 2 for all sampling locations shown on Figure 1. Naphthalene and 2-methylnaphthalene were not detected above the laboratory method reporting limit, which ranged between 0.43 $\mu g/m^3$ and 0.49 $\mu g/m^3$, in any of the samples with the exception of indoor air sample MFA-IA-3, where naphthalene was detected at a concentration equal to the laboratory method reporting limit of 0.49 $\mu g/m^3$. A duplicate sample (MFA-IA-4) collected from the same approximate location as MFA-IA-3 did not contain naphthalene concentrations at or above the laboratory method reporting limit. The concentration of naphthalene detected in indoor air sample MFA-IA-3 was below the MTCA Method C air cleanup level of 3.0 $\mu g/m^3$. The laboratory analytical report is included as Appendix J.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This VIA identified naphthalene in one of the four indoor air samples (MFA-IA-3) at a concentration of 0.49 $\mu g/m^3$, which is below the MTCA Method C air cleanup level of 3.0 $\mu g/m^3$. Naphthalene and 2-methylnaphthalene were not detected above laboratory method reporting limits in the three other indoor samples or the three ambient/blank samples. The sampling locations for samples MFA-IA-3 and duplicate MFA-IA-4 were nearest to (approximately 25 feet from) the observed DNAPL occurrence near the building at soil boring location PB-59. Since naphthalene was detected in one of the four indoor air samples and not detected in any of the three ambient/blank air samples, the vapor intrusion pathway into the building may be considered to be potentially complete. However, other indoor sources (e.g., cigarette smoke, diesel fuel-stained clothing within the employee lockers, etc.) and/or outdoor sources (e.g. treated wood, fuels/exhausts) may have also contributed to the naphthalene detected at location MFA-IA-3. Since results of all four indoor samples were below cleanup levels, the vapor intrusion pathway is considered to be potentially complete but insignificant at the Mechanics Shop.

6.0 REFERENCES

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TABLES

TABLE 1

VAPOR INTRUSION ASSESSMENT - SAMPLING VOLUME CALCULATIONS

MAINTENANCE FACILITY AREA - MECHANICS SHOP

Sample ID	Field Data Collected - Start					Field Data Collected - End					Sample Duration (min)	Average Flow (mL/min)	Volume (mL)	Initial Volume (L)	Average Pressure (in Hg)	Average Temperature (ºF)	STP Corrected Volume[a] (L)	Start	End	Variance
	Time	Flow (mL/min)	Pressure (in Hg)	Temp (ºF)	Relative Humidity (%)	Time	Flow (mL/min)	Pressure (in Hg)	Temp (ºF)	Relative Humidity (%)								Corrected Flow (mL/min)	Corrected Flow (mL/min)	STP Corrected Flows
MFA-IA-1	9:38	22.35	30.40	59.4	32.4%	17:38	24.80	30.29	62.4	31.1%	480	23.58	1.13E+04	11.3	30.35	60.9	10.8	21.5	23.6	9.93%
MFA-IA-2	9:38	22.13	30.42	60.0	32.4%	17:37	24.08	30.29	62.3	31.1%	479	23.11	1.11E+04	11.1	30.36	61.2	10.6	21.3	23.0	7.87%
MFA-IA-3	9:37	21.41	30.42	60.6	32.1%	17:37	23.05	30.29	62.4	31.2%	480	22.23	1.07E+04	10.7	30.36	61.5	10.2	20.6	22.0	6.83%
MFA-IA-4[b]	9:37	23.76	30.43	61.8	32.0%	17:37	24.01	30.29	62.3	31.2%	480	23.89	1.15E+04	11.5	30.36	62.1	11.0	22.8	22.9	0.49%
MFA-AA-1	9:36	22.02	30.43	39.2	43.2%	17:36	25.41	30.28	38.2	54.2%	480	23.72	1.14E+04	11.4	30.36	38.7	11.4	22.1	25.4	15.06%
MFA-AA-2	9:35	23.60	30.43	39.2	43.2%	17:36	24.20	30.28	38.2	54.0%	481	23.90	1.15E+04	11.5	30.36	38.7	11.5	23.7	24.2	2.24%
MFA-AA-3[c]	17:36	0.00	30.28	38.2	54.2%	17:36	0.00	30.28	38.2	54.2%	0	0.00	1.12E+04	11.2	30.28	38.2	11.2	---	---	---

NOTES:

[a] Volumes corrected to standard temperature (273.15 K) and pressure (1 atm / 29.92 in Hg)

[b] MFA-IA-4 was a field duplicate collected near MFA-IA-3 using completely separate/duplicate sampling apparatu

[c] MFA-AA-3 was a field blank collected by opening and immediately resealing sampling tube at the location of MFA-AA-1 (upwind ambient sample). Volume shown is based upon average of six project pumps and corrected using MFA-AA-1 site data.

mL/min = milliliters per minute
in Hg = inches of mercury
ºF = degrees Fahrenheit
mL = milliliters
L = liters

TABLE 2

VAPOR INTRUSION ASSESSMENT - SUMMARY OF INDOOR AIR ANALYTICAL RESULTS

MAINTENANCE FACILITY AREA - MECHANICS SHOP

Sample ID:	**MTCA Method C Air Cleanup Level**		**Johnson-Ettinger Modeled Indoor Air Concentration**	**MFA-IA-1**	**MFA-IA-2**	**MFA-IA-3**	**MFA-IA-4**	**MFA-AA-1**	**MFA-AA-2**	**MFA-AA-3**
Sample Date:				12/5/2009	12/5/2009	12/5/2009	12/5/2009	12/5/2009	12/5/2009	12/5/2009
Sample Volume (L):				10.8	10.6	10.2	11.0	11.4	11.5	11.2
	(Cancer)	**(Non-cancer)**								
PAHs (ug/m^3)										
Naphthalene	0.7	3	11.3	0.46 U	0.47 U	0.49	0.45 U	0.44 U	0.43 U	0.45 U
2-Methylnaphthalene	--	3	2.87	0.46 U	0.47 U	0.49 U	0.45 U	0.44 U	0.43 U	0.45 U

Notes:

All units in micrograms per cubic meter (ug/m^3)

Samples were collected on Tenax-TA adsorbent tubes

Samples were analyzed using EPA Method TO-17 (Modified - naphthalene and 2-methylnaphthalene)

Model Toxics Control Act Cleanup Regulation, WAC 173-340. MTCA Method C and Johnson-Ettinger Modeled Indoor Air Concentration values are from *Vapor Intrusion Assessment Sampling and Analysis Plan, Port of Longview Maintenance Facility Area, Appendix D,* Table D-4, URS, November 3, 2009.

Ecology's CLARC database does not currently list an inhalation SF for naphthalene; however, EPA is currently reviewing the carcinogenic potency of naphthalene through the inhalation pathway, and the IRIS database is expected to be updated with an inhalation SF. California EPA has derived an inhalation SF for naphthalene of 0.12 (mg/kg-day)-1. This SF was used to calculate a cancer-based MTCA Method C air cleanup level for naphthalene.

MTCA C cleanup level exceedances are **bolded**.

U - Not detected above the reporting limit shown.

UJ - Not detected above the reporting limit shown. Reporting limit is an estimated value.

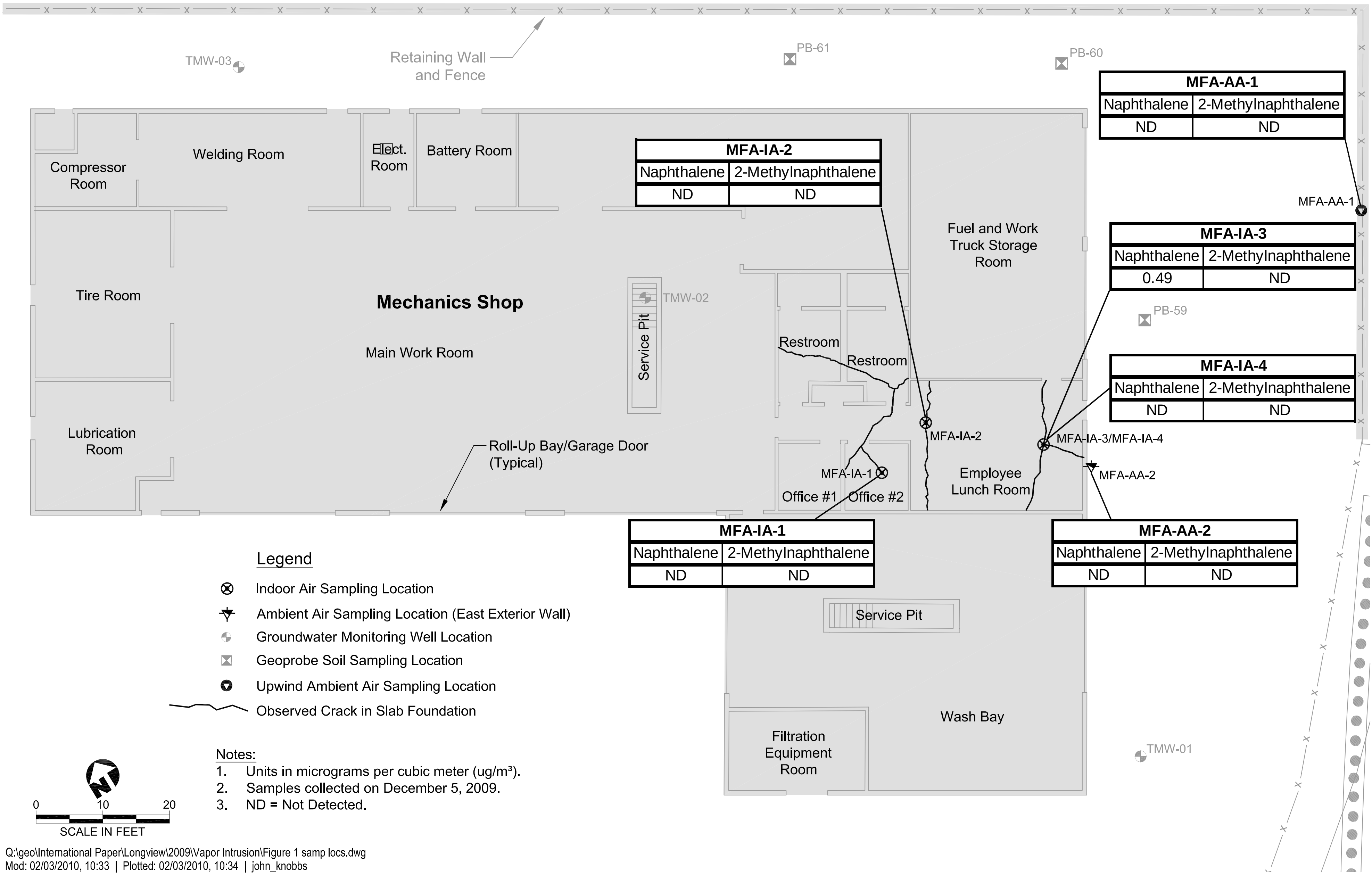
J - Estimated value.

ND - Not Determined.

NA - Not Analyzed

PAHs - Polycyclic aromatic hydrocarbons

FIGURES



MFA-AA-1

Naphthalene	2-Methylnaphthalene
ND	ND

MFA-IA-2

Naphthalene	2-Methylnaphthalene
ND	ND

MFA-IA-3

Naphthalene	2-Methylnaphthalene
0.49	ND

MFA-IA-4

Naphthalene	2-Methylnaphthalene
ND	ND

MFA-IA-1

Naphthalene	2-Methylnaphthalene
ND	ND

MFA-AA-2

Naphthalene	2-Methylnaphthalene
ND	ND

Legend

⊗	Indoor Air Sampling Location
▼	Ambient Air Sampling Location (East Exterior Wall)
◐	Groundwater Monitoring Well Location
☒	Geoprobe Soil Sampling Location
▼	Upwind Ambient Air Sampling Location
〰	Observed Crack in Slab Foundation

Notes:
1. Units in micrograms per cubic meter (ug/m³).
2. Samples collected on December 5, 2009.
3. ND = Not Detected.

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International Paper
Longview, WA

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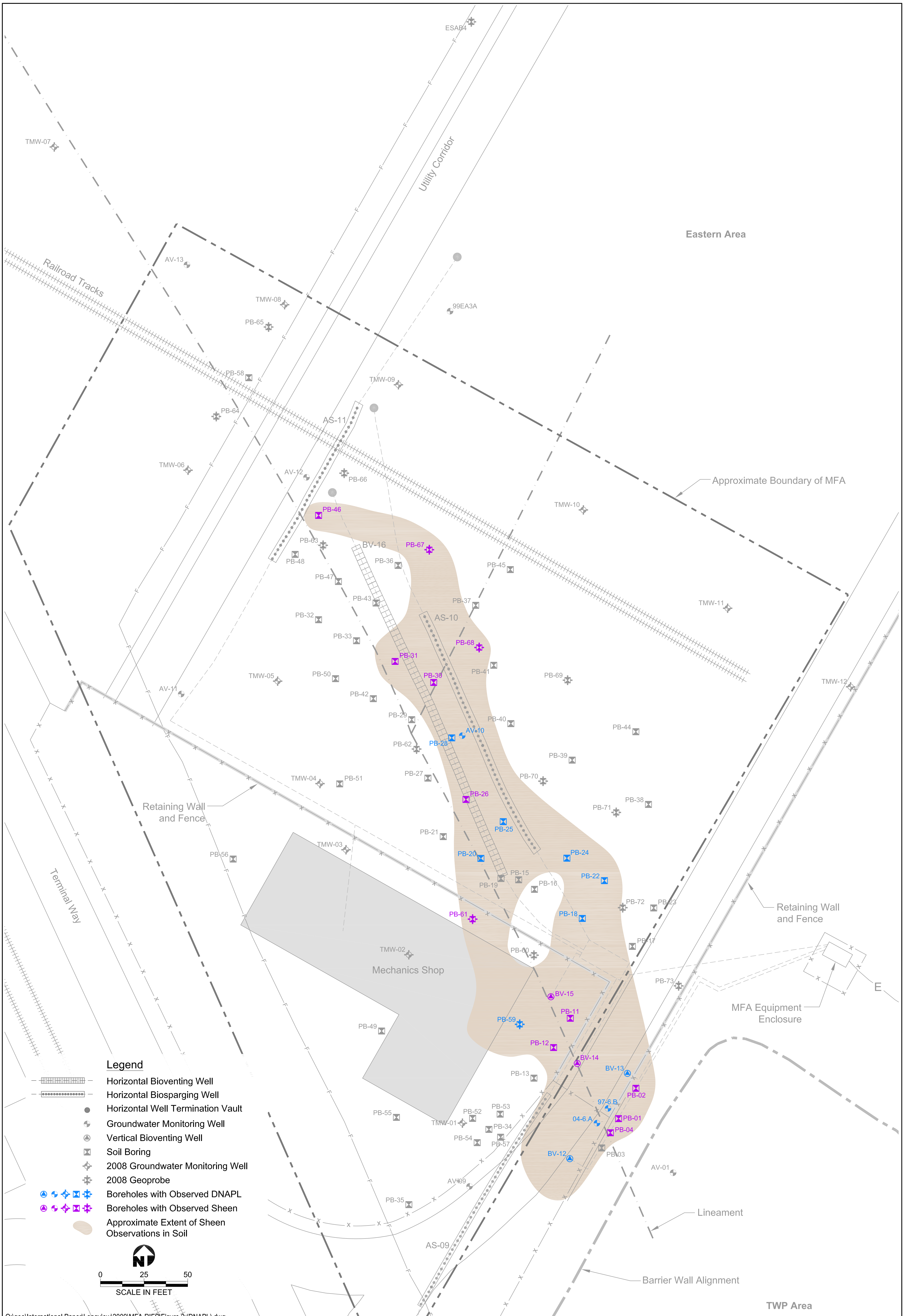
Site Plan and Air Sampling Locations/Results
MFA Mechanics Shop

Figure
1



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International Paper Longview, WA	Project No. 33759250	Extent of Sheen and DNAPL Occurrence in Soil	Figure 2
URS			

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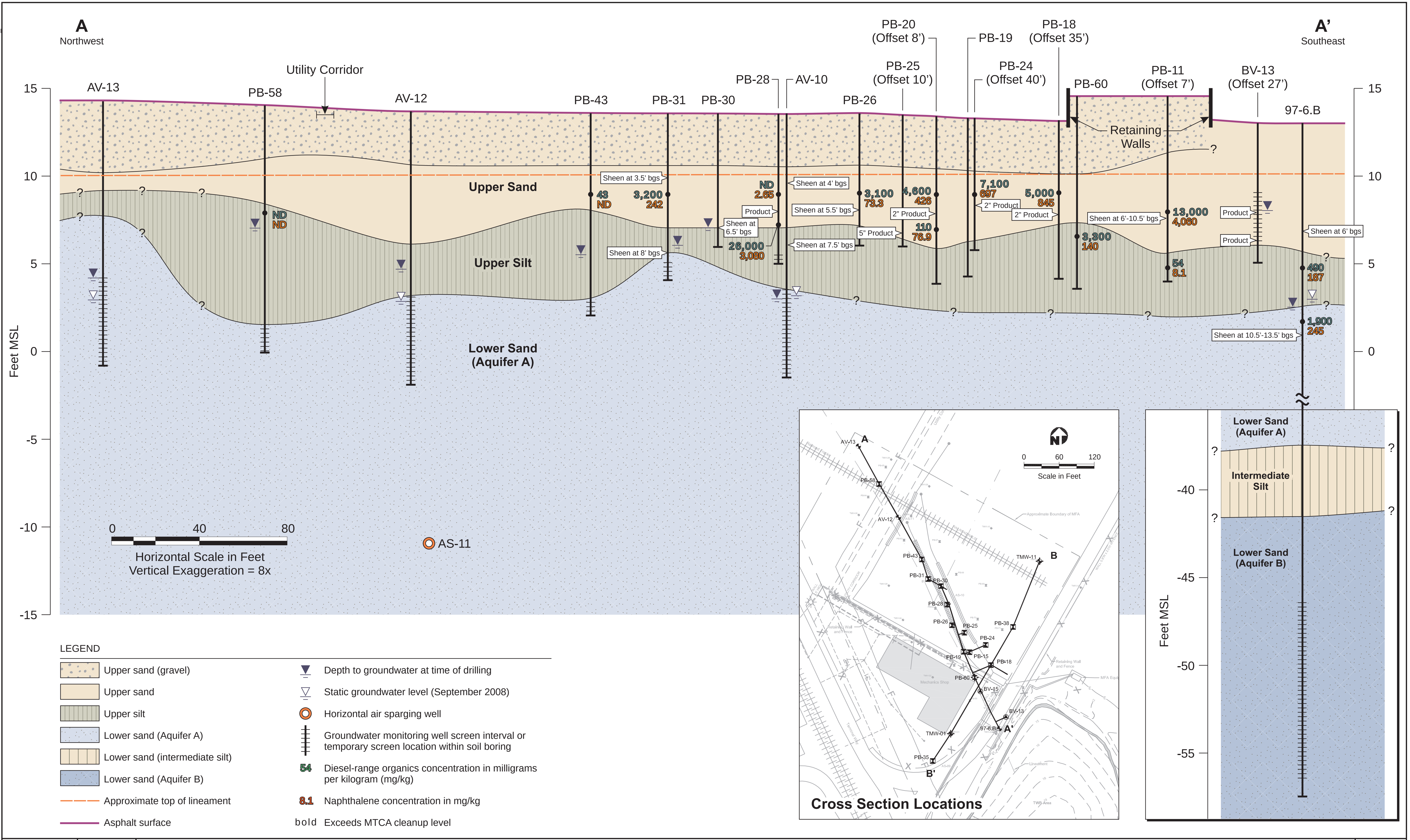

International Paper
Longview, WA

Project No.
33759250

URS

Geologic Cross Section A-A'

Figure
3

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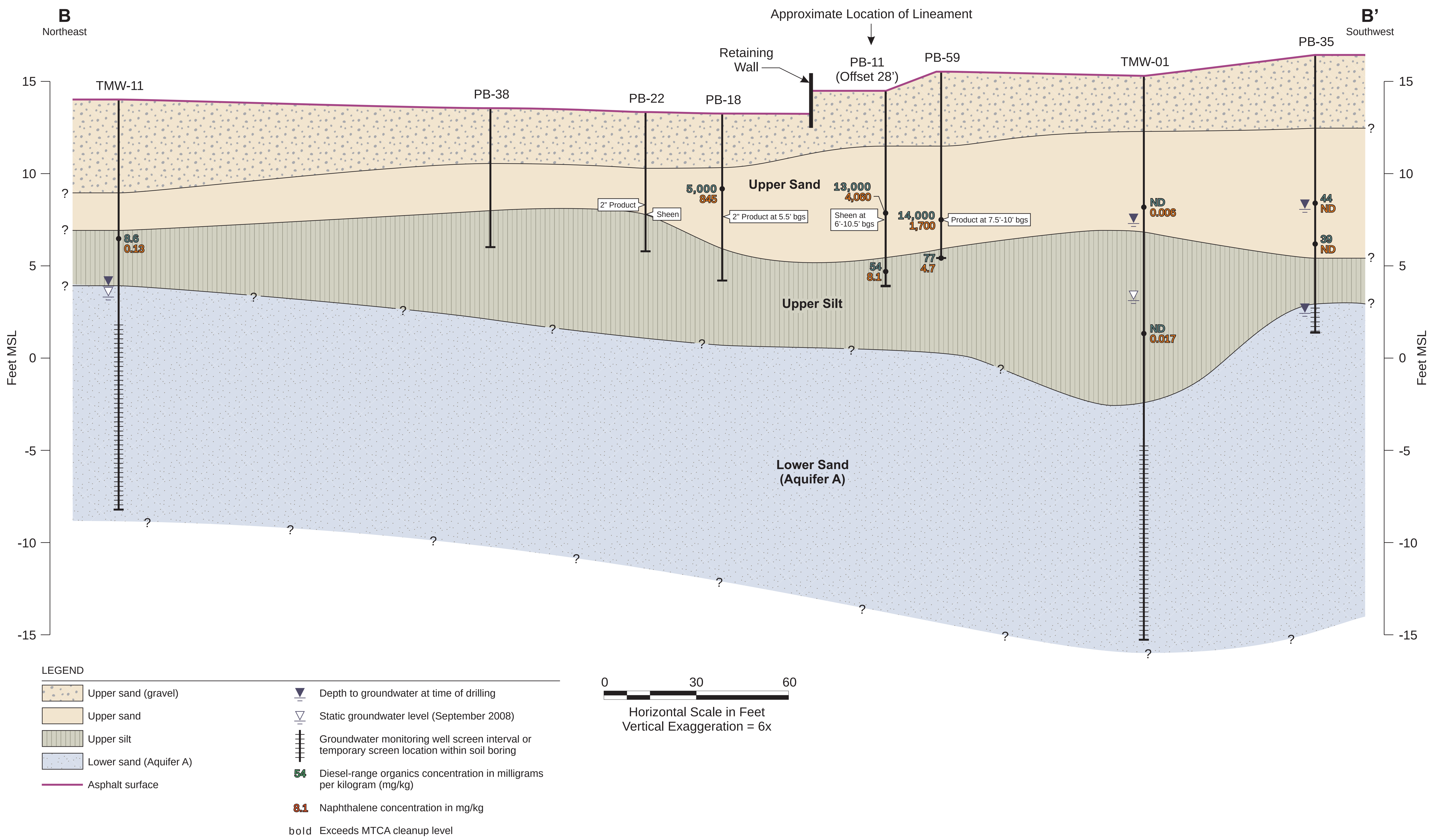

International Paper Longview, WA	Project No. 33759250

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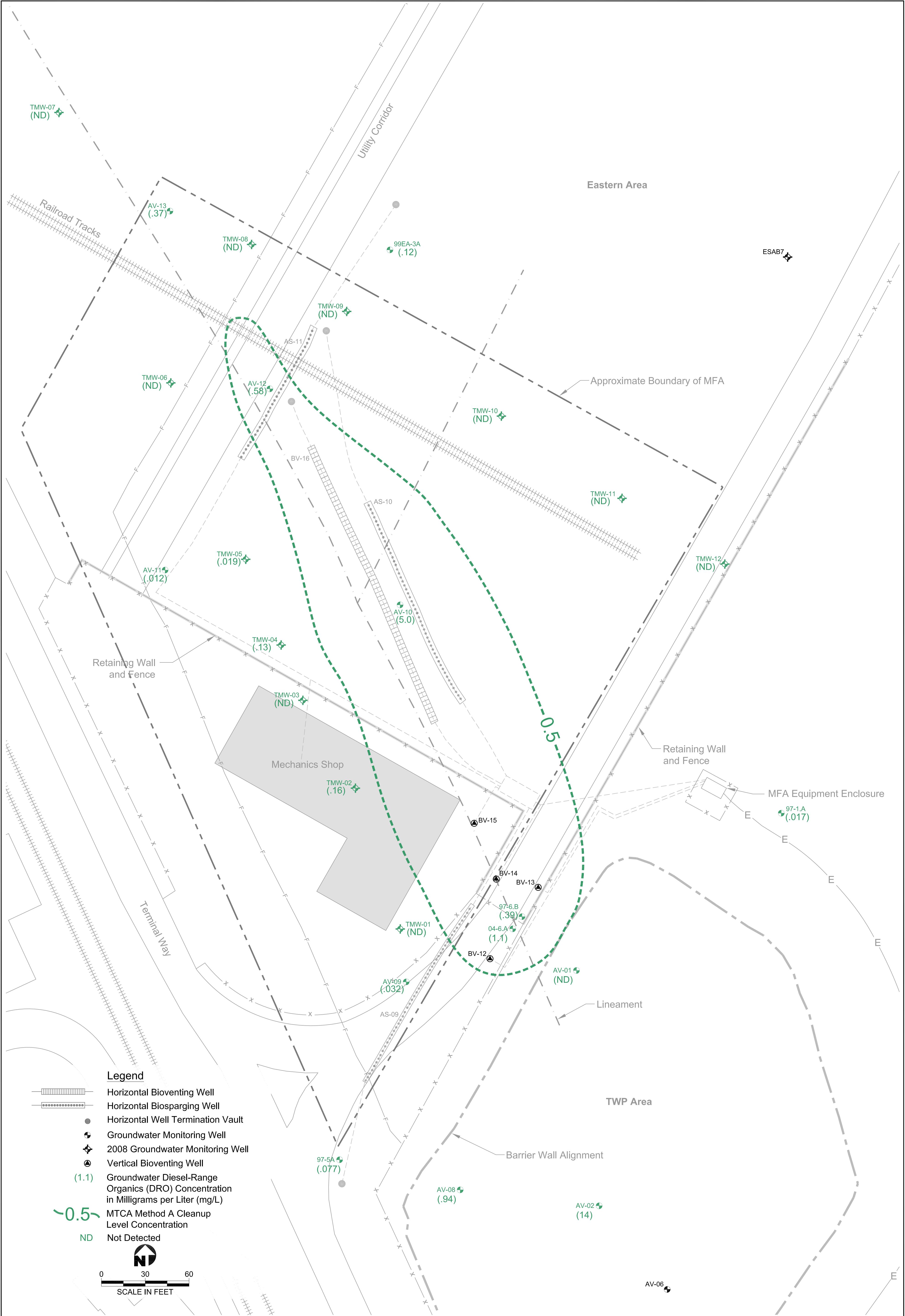
Geologic Cross Section B-B'

Figure
4



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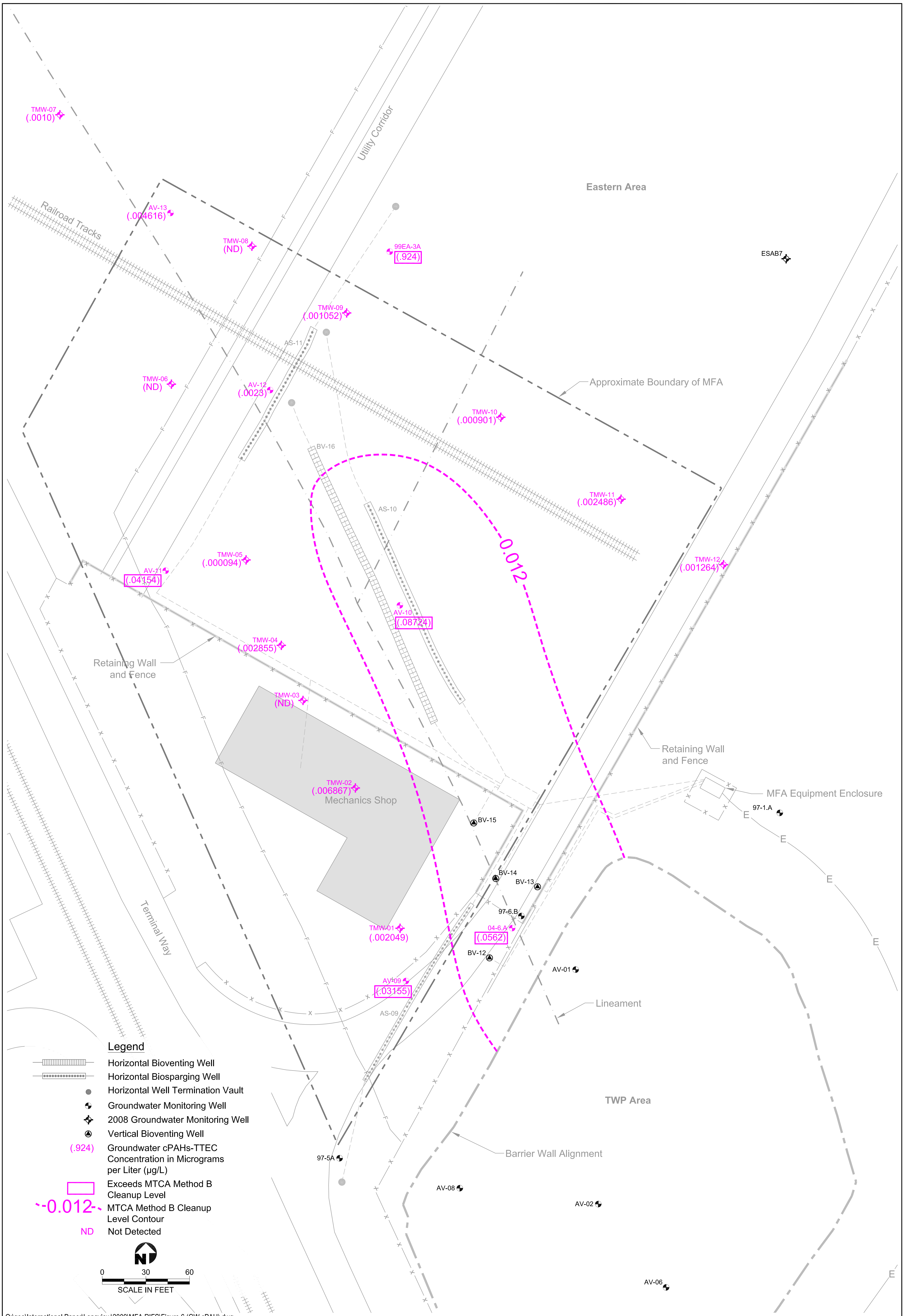
International Paper Longview, WA	Project No. 33759250	Groundwater Diesel-Range Organics Concentrations September 2008 Maintenance Facility Area	Figure 5
URS			



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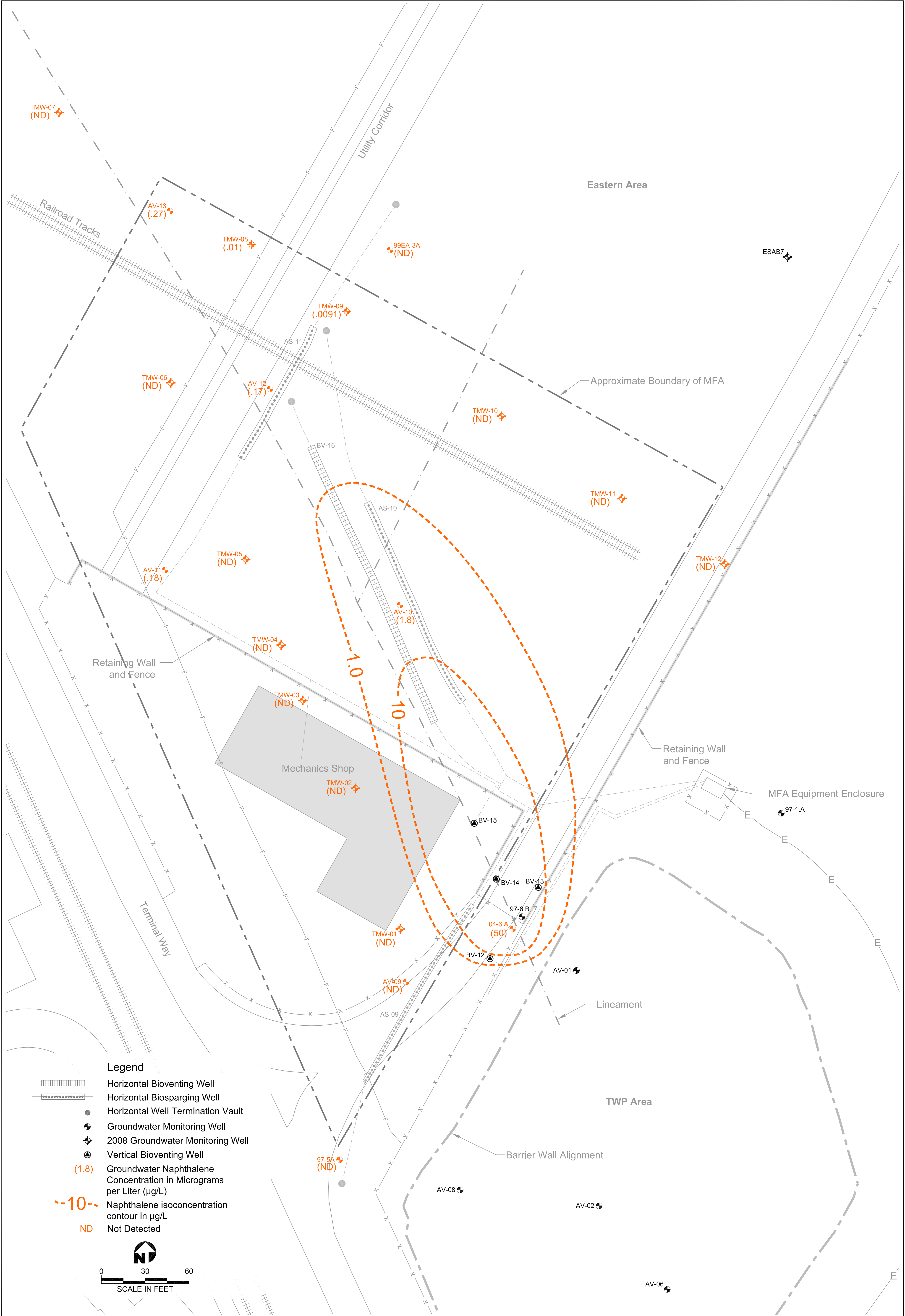
International Paper Longview, WA	Project No. 33759250	Groundwater cPAH-TTEC Concentrations March 2009 Maintenance Facility Area	Figure 6
URS			



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International Paper Longview, WA	Project No. 33759250	Groundwater Naphthalene Concentrations March 2009 Maintenance Facility Area	Figure 7
URS			

APPENDIX A
COMPLETED INDOOR AIR QUALITY BUILDING QUESTIONNAIRE

INDOOR AIR QUALITY BUILDING QUESTIONNAIRE

FACILITY NAME: MECHANICS SHOP – PORT OF LONGVIEW

Purpose of Investigation Evaluate indoor air concentrations of naphthalene / 2-methylnaphthalene

Preparer's Name IAN VERMEEREN Date/Time Prepared 10/20/09

Preparer's Affiliation URS Phone No. 2087

1. FACILITY PERSONNEL INTERVIEWED [✓ Y] N

Last Name: MARKO First Name: LARRY

Title: FACILITIES

Job Duties:

Phone: Cell Phone:

Number of On-site Workers at this Location ~6

2. PROPERTY OWNER: (Check if same as Occupant ___)

Interviewed: Y / [✓ N]

Last Name: PORT First Name: OF LONGVIEW

Address:

County:

Home Phone: Office Phone:

3. BUILDING CHARACTERISTICS

Type of building: (Circle appropriate response)

[✓ Industrial] Commercial/Multi-use Other: ______

Description of building type:

Business Use(s) MECHANIC SHOP

Other characteristics:

Number of floors 1 Building age ______

Is the building insulated? [✓ Y] / N How air tight? Tight / [✓ Average] / Not Tight

Description/Comments: LUNCHROOM / RESTROOMS / OFFICE MORE AIR TIGHT THAN WORKBAYS

4. AIRFLOW

Outdoor air intake type/location

INTAKE LOCATED WHERE INDICATED ON PLANS (E SIDE OF LUNCHROOM)

Airflow between floors and/or within building

AIRFLOW W/IN LUNCHROOM/OFFICES + RESTROOMS SEEMS RELATIVELY HIGH - DOORS TO BAYS ARE WEATHER SEALED. BAY AIRFLOW UNRESTRICTED.

Outdoor air infiltration

SINGLE DOOR TO OUTSIDE (EAST WALL) APPEARS AIR TIGHT. GAPS PRESENT ABOVE CEILING PANELS ON N. WALL OF LUNCHROOM AROUND ROOF SUPPORT BEAMS

Intermediate infiltration locations into air ducts?

AIR DUCTS APPEAR TO BE TIGHT.

5. BASEMENT/SLAB AND CONSTRUCTION CHARACTERISTICS (Circle all that apply)

a. Above grade construction:	wood frame	[✓ metal frame]	concrete	masonry
b. Basement/slab type:	full	crawlspace	[✓ slab]	other ________
c. Basement/slab floor: ?	concrete	dirt	stone	other ________
c1. Unpaved floor: ?	uncovered	covered	covered with ______________	
c2. Paved floor: ?	unsealed	sealed	sealed with ______________	
d. Foundation walls: ?	poured	block	stone	other ________
e. Foundation walls: ?	unsealed	sealed	sealed with ______________	
f. The basement/slab is:	wet	damp	[✓ dry]	moldy
g. The basement/slab is:	finished	unfinished	[✓ partially finished]	
h. Sump present?	Y / N			
i. Water in sump?	Y / N / [✓ not applicable]			

Basement/Lowest level depth below grade: ________ (feet)

Identify potential soil vapor entry points and approximate size (e.g., cracks, utility floor penetrations, drains)

2 DRAINS IN EACH RESTROOM, 1 DRAIN IN CLOSET, TOILET PLUMING IN EACH RESTROOM, WATER PIPE IN LUNCHROOM TO WATER FOUNTAIN. CRACK FROM ~~EA~~ EAST RESTROOM TO EAST OFFICE THROUGH HALL, CRACK N-W ON WEST SIDE OF LUNCHROOM, CRACK N-W ON EAST SIDE OF LUNCHROOM

6. HEATING, VENTILATION, AND AIR CONDITIONING (Circle all that apply)

Type of heating system(s) used in this building: (Circle all the apply – note primary)

Hot air circulation
Space Heaters
Electric baseboard
[✓ Heat pump]
Steam radiation
Wood stove
Hot water baseboard
[✓ Radiant floor]
Other ______________

The primary type of fuel used is:

Natural Gas
[✓ Electric]
Wood
Fuel Oil
Propane
Kerosene
Solar

Hot water tank fueled by: NATURAL GAS

Building location (more specific): JANITOR CLOSET OFF LUNCHROOM

Boiler/furnace located in: Basement Outdoors [✓ Main Floor] Other ______

Building location (more specific): EAST OF BATTERY ROOM

Air conditioning: [✓ Central air] Window units Open Windows None

Building location (more specific): ROOF?

Are there air distribution ducts present? [✓ Y] / N

Describe the supply and cold air return ductwork and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.

JOINTS AND DUCTS APPEAR TO BE IN GOOD SHAPE. LOCATIONS MATCH UP W/ PLANS W/ EXCEPTION OF ONE AIR RETURN VENT NEAR SINK IN LUNCHROOM (IN LINE W/ HALL) ATTACHED TO MAIN AIR UNIT, 2 SUPPLY VENTS IN RESTROOMS HOOKED INTO MAIN AIR SUPPLY LINE, 2 VENTS SUCKING AIR OUT OR RESTROOMS DIRECTLY TO OUTSIDE OF BUILDING.

7. OCCUPANCY

Is basement/lowest level occupied? [✓ Full-time] Occasionally Seldom Almost Never

Level	General Use of Each Floor
Basement	SHOP / OFFICES / LUNCH ROOM / RESTROOMS
1st Floor	LOFT W/ WASTE OIL HEATER?
~~2nd Floor~~	
~~3rd Floor~~	
~~4th Floor~~	

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

a. Do the garage service bay door(s) remain open while servicing vehicles? [✓ Y] / N

Where/When/How Long? ALL DOORS

b. Does the garage have a separate heating unit? [✓ Y] / N / NA

Where/Type? WASTE OIL HEATER?

c. Are diesel or gasoline powered machines or vehicles stored in the garage? [✓ Y] / N / NA

Please specify ______

Where/When/Type? VEHICLES

d. Is diesel or gasoline fuel stored within the building? [✓ Y] / N

Where/When? 1000 GAL DIESEL TANK IN SE CORNER WASH BAY

e. Is a kerosene or unvented gas space heater present? Y / [✓ N]

Where/When?

f. Is there a workshop area? [✓ Y] / N

Where/Type? ENTIRE GARAGE MINUS LUNCHROOM AREA

g. Is there smoking in the building? [✓ Y] / N

Where/How Frequently? ?

h. Cleaning product use? [✓ Y] / N

Where/Type? IN WORK AREAS

i. Have cosmetic products been used recently? Y / [✓ N]

When/Type?

j. Has painting/staining been done in the last 6 months? Y / N

Where/When? ?

k. Is there new carpet, drapes or other textiles? Y / [✓ N]

Where/When?

l. Have air fresheners been used recently? Y / [✓ N]

When/Type?

m. Is there a kitchen exhaust fan? [✓ Y] / N

If yes, where is it vented? VENTED INTO MAIN HVAC UNIT

n. Is there a bathroom exhaust fan? [✓ Y] / N

If yes, where is it vented? VENTED TO OUTSIDE BUILDING (N WALL)

o. Is there a clothes dryer? Y / [✓ N]

If yes, where is it vented?

p. Has there been a pesticide application? Y / N

When/Type? ?

Are there odors in the building? [✓ Y] / N

If yes, please describe: SOLVENT / OIL ODORS IN WORK AREA

Are solvents used during work? Y / N [✓ LIKELY]

(e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler)

If yes, what types of solvents are used?

If yes, are their clothes washed at work? Y [✓ N]

Is treated wood used or stored at the facility? (Circle appropriate response)

Yes, treated wood is present within the building [✓ No] Unknown
[✓ Yes], treated wood is present outside of the building No Unknown
Yes, treated wood is handled by employees [✓ No] Unknown

9. WATER AND SEWAGE

Water Supply: [✓ Public Water] Drilled Well Driven Well Dug Well Other: ______
Sewage Disposal: [✓ Public Sewer] Septic Tank Leach Field Dry Well Other: ______

10. FLOOR PLANS

Draw a plan view sketch of the building floor layout. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings where/when possible. If the building does not have a basement, please note.

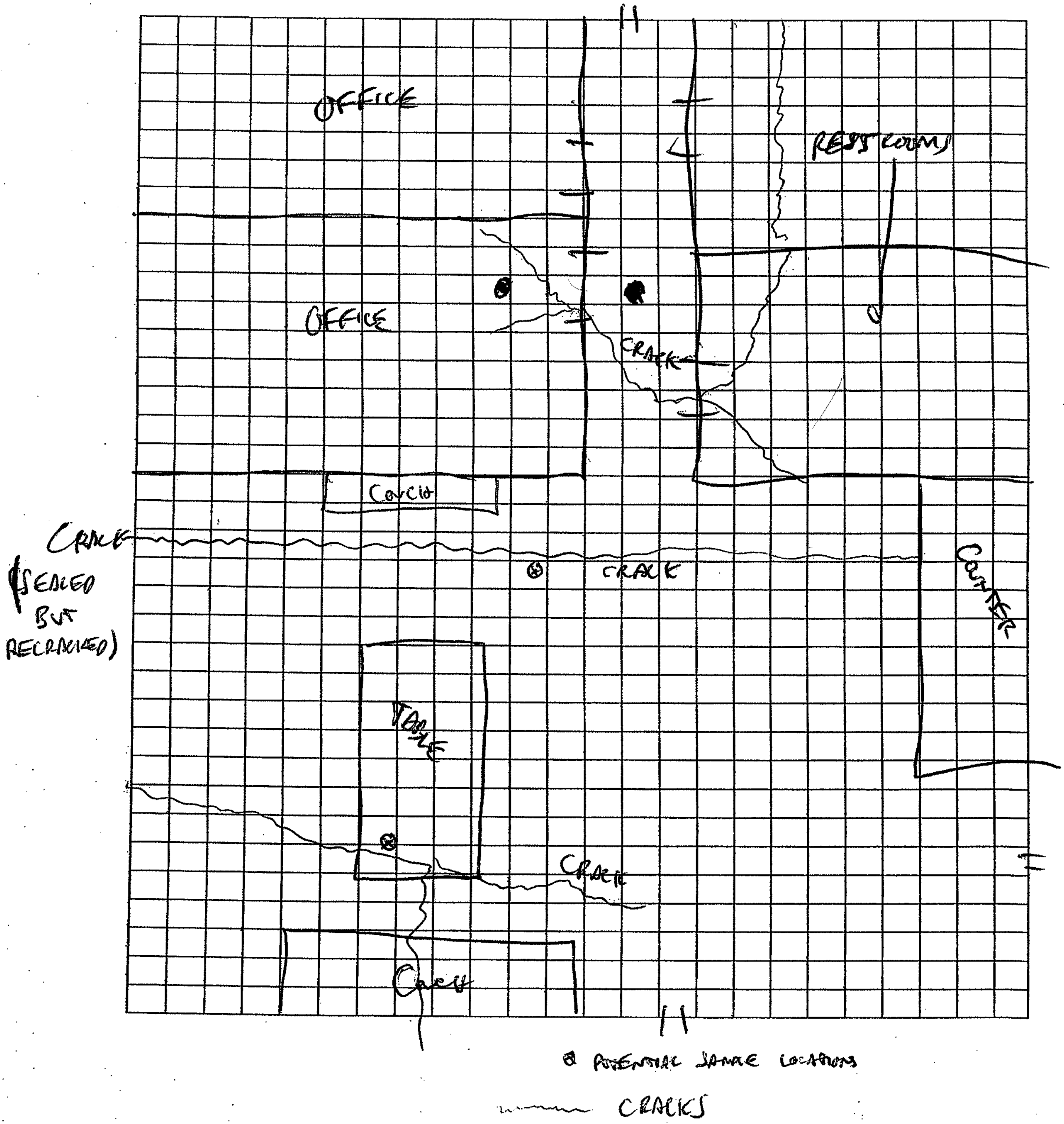
Basement: SEE NEXT PAGE

First Floor:

11. OUTDOOR PLOT

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources, (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s) and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.



12. PRODUCT INVENTORY FORM

Make & Model of field instruments used: ______________________________

List specific products found in the facility that have the potential to affect indoor air quality.

Location	Product Description	Size (units)	Condition*	Chemical Ingredients	Field Instrument Reading (units)	Photo** Y / N
UNDER	BROWGEEN	14OZ	MOSTLY			
SINK	DISINFECTANT	↓	FULL		↓	
	BUG SPRAY		↓			
↓	ARMORALL	16 OZ				
OFFICE	WOOD CLEANER	14OZ				
LOCKER	ZEP RESTORE	↓				
	METAL PROTECTOR					
	ID FLUSH					
	MYSTERY OIL					
	ICE CUTTER					
	INSULATING FOAM					
	COMPRESSOR OIL					
	SPRAY PAINT					
	RUST CUTTER					
	DEGREASER					
	SILICON SPRAY					

*Describe the condition of the product containers as **Unopened (UO), Used (U), or Deteriorated (D)**

Photographs of the **front and back of product containers can replace the handwritten list of chemical ingredients. However, the photographs must be of good quality and ingredient labels must be legible.

13. SAMPLING INFORMATION (Fill in During the Sampling Event)

a. Sample Technician: IAN VERMEEREN **Sample Date:** 12/5/09

b. Sample Source: [✓ Indoor Air] / Sub-Slab / Soil Gas + OUTDOOR AIR

c. Air Sampling Methods (e.g., Summa Canister, Sorbent Tubes, etc.)
Used: SORBENT TUBES - LOW FLOW

d. Testing Locations and Sample Designations:

1) Indoor Locations: MFA-IA-1,2,3,4 ; ~~MFA-AA-1,2~~

2) Outdoor/Background Locations: MFA-AA-1,2 ; MFA-AA-3 FIELD BLANK

e. Air Testing Method (e.g., TO-14, TO-17, etc): TO-17

f. Air Sampling Info Completed on Laboratory Chain-of Custody Record: Y/N**
**** (Please Attach a Copy of the COC to this Questionnaire)**

g. Meteorological Conditions: (Describe weather conditions, wind speed/direction, barometric pressure, rainfall within last 24 hrs)

CLEAR + COLD, NO RAINFALL, WIND CALM FROM EAST, ~30 BAROMETRIC

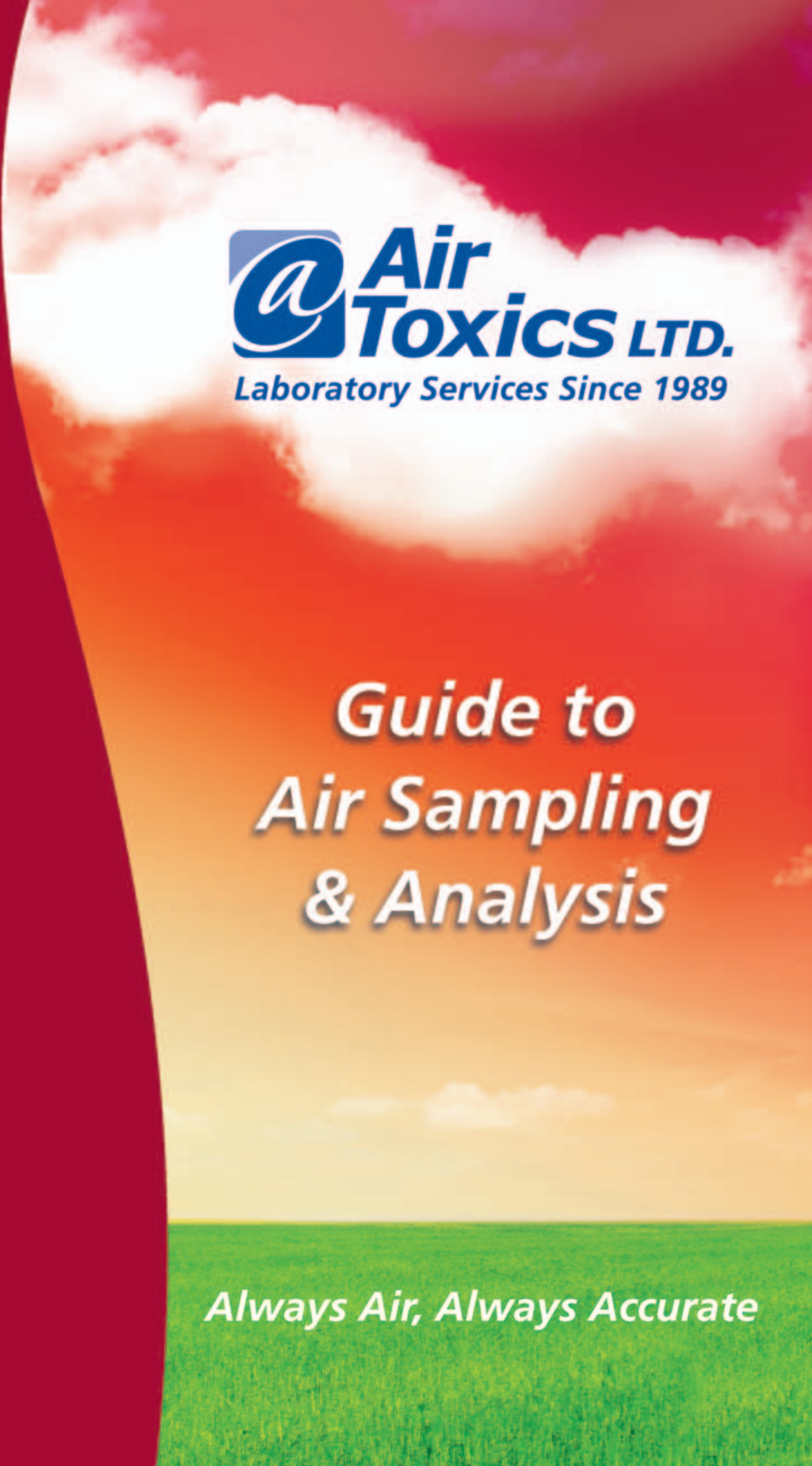
h. General Observations: (Provide any info that may be pertinent to the sampling event and may assist in interpretation of the data)

VERIFIED HVAC SYSTEM RUNNING AS NORMAL -
ALL DOORS CLOSED EXCEPT OFFICES

IA-1 OFFICE AA-1 - UPWIND
IA-2 NEAR HALL AA-2 - INTAKE
IA-3+4 EAST LUNCHROOM

APPENDIX B
AIR TOXICS GUIDE TO AIR SAMPLING & ANALYSIS

Sorbents and Solutions



Air Toxics LTD.
Laboratory Services Since 1989

Guide to Air Sampling & Analysis

Always Air, Always Accurate

Sorbent & Solution Sampling Guide

Table Of Contents

1.0 Introduction

2.0 Sorbent Sampling

2.2 Method Specific Sampling Instructions

3.0 Solution Sampling

3.1 Method Specific Sampling Instructions

4.0 Filter Sampling

4.1 Method Specific Sampling Instructions

1.0 Introduction

Air Toxics Ltd. presents this guide as a resource for air sampling. Air sampling can be more involved than water or soil sampling due to the reactivity of chemical compounds in the gas matrix and sample interaction with the sampling equipment and media. Ensuring that air samples are collected properly is an important step in acquiring meaningful analytical results. This guide is not a substitute for experience and cannot address the multitude of actual field conditions. Note that this guide is intended for typical projects involving sampling of volatile and semi-volatile organic compounds (VOCs and SVOCs) with sorbent tubes and impingers, and airborne particulates with filters. Air Toxics Ltd. also provides a "Guide to Air Sampling and Analysis – Canisters and Tedlar Bags" for whole air sampling of VOCs.

2.0 Introduction To Sorbent Sampling

Using a sorbent to collect an air sample normally involves "active" sampling, unlike an evacuated canister that can be filled "passively" by simply opening the valve. The most common method to draw an air sample through a sorbent device is to use a small pump with low flow rates between 10 to 200 milliliters per minute (mL/min) and tubing for connecting the components. For high volume applications, a high volume air sampler can be used with a larger sorbent cartridge.

Determining the Safe Sampling Volume

Determining the appropriate volume of air sample to draw through a sorbent tube is critical to achieving the data quality objectives. The tendency is to increase the sampling volume in order to lower the final reporting limit.

Note that over-sampling may saturate the sorbent tube and allow the target compound to breakthrough. *See method for volume guidelines.*

2.0 Introduction To Sorbent Sampling

It is imperative to know the flow rate through the sorbent tube and the sampling interval. A “set up” sorbent tube is often used to set the pump flow rate. It must be very similar to the actual sorbent tube being used for sample collection. The pressure drop through the sorbent tube determines the flow rate for a given pump setting. The flow rate through the sorbent tube should be monitored continuously (or at least periodically) using a rotometer or electronic flow sensor. If the sampling flow rate is greater than 200 mL/min, simple rotometers and electronic flow sensors cannot be used. It is necessary to use a device capable of measuring high flow rates. Refer to the method for information on the proper method of measuring the flow.

Common Sorbent Sampling Trains
The sampling train generally includes a sorbent tube, pump, and optional components such as a needle valve, particulate filter, and rotometer or electronic flow sensor. The sorbent tube is generally the first component in a sampling train, with the tubing and pump located downstream to minimize contamination of the sample.

The sorbent tube should be upstream of the pump.

For thermal desorption methods, it is critical that the air be drawn through the inlet side of the tube. The inlet side may be marked with a ring or the sampling direction may be indicated with an arrow. Proper orientation is especially important when using the multi-bed sorbent tubes described in EPA Method TO-17. If the low vapor pressure compounds are adsorbed on the high surface area sorbent (i.e., the one designed for gaseous compounds like vinyl chloride), they cannot be removed at the desorption temperatures routinely used.

For thermal desorption methods, the sorbent tube must be sampled in the appropriate direction.

2.0 Sorbent Sampling

Possible Components of a Sorbent Sampling Train

Tubing and Fittings: The components in the sampling train are connected with tubing and fittings as needed. Because tubing used to connect the sorbent tube to the pump does not come in contact with the air sample, the tubing material can be selected on its ability to seal. Tygon is an excellent material for this purpose, although Nylon and Teflon can be used. The length of tubing connecting the pump to the sorbent tube is not critical. Many sorbent tubes accept 1/4 in. Swagelok fittings and 1/4 in O.D. tubing.

Note that if the tubing is in the sample stream then it is necessary to select the appropriate grade material.

Needle Valve: If a variable speed/adjustable rate air sampling pump is not available, a needle valve can be used to adjust the flow rate. A rotometer (see the following section) with a built-in needle valve can provide an economical solution to adjust and measure sampling flow rate.

Rotometer or Electronic Flow Sensor: Although the flow rate for an air sampling pump can be calibrated before use, it is often desirable to include a flow measuring device in the sampling train. Note that the flow rate produced by a pump can decrease as more components are added to the sampling train. A rotometer is a relatively inexpensive meter that indicates flow with a small weight in a tapered column. As flow increases, air resistance of the weight increases and raises the weight until it is equilibrium with gravity. For best results, the rotometer must be kept vertical and free of particulates or moisture. An electronic flow sensor can provide more precise flow measurement than a rotometer, but is considerably more expensive. Both devices have optimum working ranges of flow rate (e.g., a typical rotometer may provide measurement from 100 to 500 mL/min).

Particulate Filter: If the air sample is known to have high levels of particulate matter, it may be necessary to place a filter at the sorbent tube inlet. In this case, the connecting tubing between the filter and the sorbent tube will be in the sampling stream and it should be new Teflon and as short as possible.

2.1 Considerations For Sorbent Sampling

Sorbent sampling requires the determination of the optimal sampling parameters: sample volume, flow rate and duration.

Appropriate sample volume should be determined by the media capacity and the required RLs. Matrix constituents such as water vapor and other non-target compounds should also be considered. See method specific sections for media capacity information and use the calculation provided to determine sample volume needed to meet specific RLs.

Determine the Final Reporting Limit for the Target Compound: the concentration may be a risk-based action level or EPA preliminary remediation goal (PRG).

Determine the Method Reporting Limit: the mass value is provided by the laboratory and is based on the analytical method selected and the sensitivity of the instrumentation. The method reporting limit may vary for each target compound.

Calculate the Sampling Volume: use the equation on the next page to determine the volume of air sample that must be drawn through the sorbent in order to achieve the final reporting limit.

Compare the Sampling Volume to the SSV: Refer to tables of safe sampling volume (SSV) for the sorbent being used – (e.g., Table 1 and Appendix 1 in Method TO-17). If the SSV for the compound of interest is not available, use the SSV of a compound in the same class (e.g., toluene for xylene, chloroform for carbon tetrachloride, etc.) and ensure that the compound will not breakthrough when sampling the volume calculated using the equation above. If breakthrough is a possibility, select a sorbent with greater sorbent strength (i.e., surface area).

2.1 Considerations For Sorbent Sampling

1) Calculate Minimum Sample Volume

$$\text{Minimum Volume (L)} = \frac{\text{Reporting Limit (ug)}}{\text{Action Level (ug/m}^3\text{)}} * \frac{1000\ \text{L}}{\text{m}^3}$$

Example: Screening Level = 0.08 ug/m^3

$$\text{Minimum Volume (L)} = \frac{0.05\ \text{ug}}{0.08\ \text{ug/m}^3} * \frac{1000\ \text{L}}{\text{m}^3} = 625\ \text{Liters}$$

2) Calculate Minimum Flow Rate if time duration is set.

$$\text{Minimum Flow Rate (L/min)} = \frac{\text{Minimum Volume (L)}}{\text{Duration (min)}}$$

Example: TWA of 24 hours

$$\text{Minimum Flow Rate (L/min)} = \frac{625\ \text{L}}{24\ \text{hour}} * \frac{\text{hour}}{60\ \text{min}} = 0.44\ \text{L/min}$$

3) Calculate if Overloading of tube is possible.

For a source-impacted environment, estimate total concentration to estimate maximum volume. A safe sampling volume is considered to be 75% or less of the cartridge capacity.

Example: the standard TO-11A cartridge supplied by Air Toxics has a capacity of approximately 75 ug total carbonyls.

$$\text{Estimated maximum volume (L)} = \frac{(0.75 * 75\ \text{ug})}{\text{Est. Form. Conc (ug/m}^3\text{)}} * \frac{1000\ \text{L}}{\text{m}^3}$$

Example: Source-impacted site 3 ppmv (3700 ug/m^3*) Formaldehyde*

$$\text{Estimated maximum volume (L)} = \frac{0.75 * 75\ \text{ug}}{3700\ \text{ug/m}^3} * \frac{1000\ \text{L}}{\text{m}^3} = 15\ \text{L}$$

2.1 Considerations For Sorbent Sampling

Avoid Over Sampling: The adage, “more is better”, often finds its way into sorbent sampling practice. In attempting to ensure low reporting limits, you may over sample a sorbent tube – especially if concentrations of target compounds are higher than expected.

Use a Backup Sorbent Tube: The use of a second, or “backup”, sorbent tube in series can help prevent compound breakthrough. Even if a safe sampling volume was calculated and not exceeded during sampling, a backup sorbent tube can provide insurance. The backup sorbent tube is only analyzed if a predetermined level of a given compound or total mass is found on the first tube. While the use of a backup sorbent tube will increase media costs, it usually has little effect on sampling costs. It will, however, provide definitive support for data integrity.

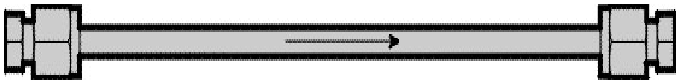
2.2 Method Specific Sampling Instructions

EPA Method TO-17

Determination of Volatile Organic Compounds in Ambient Air using Active Sampling Onto Sorbent Tubes.

http://www.epa.gov/ttn/amtic/files/ambient/airtox/to-17r.pdf

This method replaces earlier sorbent-based EPA Methods TO-1 and TO-2 and provides an alternative to canister-based EPA Method TO-15. The target compound list is the same as TO-15 (i.e., subsets of the 97 VOCs listed as hazardous air pollutants in the Clean Air Act Amendments of 1990). However, TO-17 can collect VOCs over a wider volatility range than TO-15, by using a tube with multiple sorbents packed in increasing sorbent strength. Both single and multi-bed sorbent tubes are described in TO-17. Tube Style 3 (i.e., Carbotrap 300 by Supelco) can be used for compounds ranging in volatility from n-C_3 to n-C_{16} for air volumes of 2 L at relative humidity below 65% and temperatures below 30°C. Volumes greater than 5 L can be collected, but C_3 compounds are not quantitatively retained. Single bed tubes, such as Tenax TA, can be used to effectively collect Naphthalene and middle distillate fuels in indoor air.



Media	Sorbent tube (e.g., Carbotrap 300) with optional particulate filter and ozone scrubber
Type of Pump	Low flow rate pump (10 to 200 mL/min) or high flow pump with low flow adapter
Sampling Rate and Interval	17 and 67 mL/min for 1 hour (example flow rates)
Sampling Volume	1 and 4 L (example volumes not mandated)
Sample Handling	Cap ends, place in culture tube, keep chilled at 4ºC
Media Hold Time	Not specified - recommend 30 days at 4ºC
Sample Hold Time	30 days from collection at 4ºC
Field QC	Field Blanks - two per sampling event
Distributed Pair	One location sampled at two volumes

2.2 Method Specific Sampling Instructions

Although the method suggests sampling volumes of 1 and 4 L, there is considerable mention of calculating a safe sampling volume. The sampling volume you select should include consideration of both the desired final reporting limit and the safe sampling volume of the sorbent being used (see Section 2.1) . The thought process is outlined below.

Determine the Final Reporting Limit for the Target Compound: the concentration may be a risk-based action level or EPA preliminary remediation goal (PRG).

Determine the Method Reporting Limit: the mass value is provided by the laboratory and is based on the analytical method selected and the sensitivity of the instrumentation. The method reporting limit may vary for each target compound.

Calculate the Sampling Volume: use the equation on page 6 of this guide to determine the volume of air sample that must be drawn through the sorbent in order to achieve the final reporting limit.

Compare the Sampling Volume to the SSV: Refer to tables of safe sampling volume (SSV) for the sorbent being used – (e.g., Table 1 and Appendix 1 in Method TO-17). If the SSV for the compound of interest is not available, use the SSV of a compound in the same class (e.g., toluene for xylene, chloroform for carbon tetrachloride, etc.) and ensure that the compound will not breakthrough when sampling the volume calculated using the equation above. If breakthrough is a possibility, select a sorbent with greater sorbent strength (i.e., surface area).

To illustrate the thought process, an example is provided below:

1. Assume Benzene is the target compound and must be reported at a final reporting limit of 0.0005 ug/L.
2. The laboratory provides a method reporting limit of 10 ng (0.010 ug).
3. Using Equation 3, the sampling volume = 0.010/0.0005 = 20 L.
4. TO-17 Appendix 1 shows that for Benzene, a SSV of up to 26 L can be collected using a Type 3 (CarboTrap 300) multi-sorbent tube.

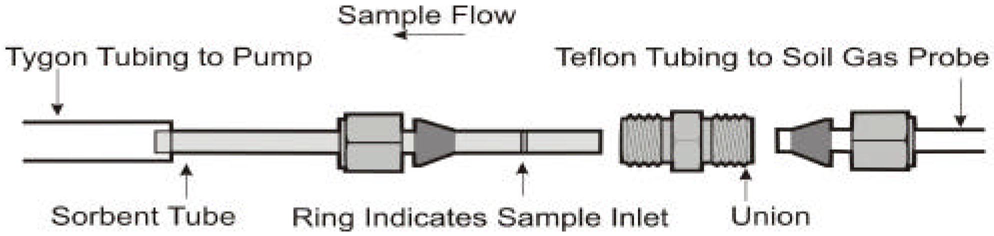
In this example, Benzene can theoretically be reported at a final reporting limit of 0.0005 ug/L with a sampling volume of 20 L.

TO-17 Sampling Instructions

Application: Soil Gas

Media: TO-17 tube, 1/4"Teflon tubing, 1/4"Tygon tubing, 1/4" to 1/4"Union, 1/4"fittings with ferrules, a sample pump and a low flow holder maybe required if using a higher flow pump

Typical Sampling Parameters: Sample Flow Rate = 50mL/min **Total Vol.** = 200 mL **Duration** = 4 min. These parameters may change depending on project objectives.



Instructions:

1) In order to calibrate the pump use a "set-up" tube. Using the Tygon tubing connect the sampling pump to the outlet of the sorbent tube, if using a higher flow pump a low flow holder may be necessary to lower the flow rate, then connect the inlet (the ringed side) to the calibrator. Adjust setting to desired flow rate and record.
2) Replace the "set-up" tube with a sample tube. Again using the Tygon tubing connect the sampling pump to the outlet of the sample tube. Attach the inlet to the union fitting using a Swagelok nut. Using a 9/16" wrench on the nut and a 7/16" wrench on the union, tighten the nut. In the same manner, attach the union to the Swagelok nut on the soil gas probe tubing. DO NOT OVERTIGHTEN.
3) Start the sample pump and record the start time. After the desired duration, stop the pump and record the end time.
4) Replace the end plugs on both ends of the sample tube. Record the sample ID, tube ID and the collection date/time on the COC.
5) When completed with a set of samples, re-attach the "set-up" tube to the calibrator and measure the post-sampling flow. Record post-sampling flow rate. This should match within 10% of the pre-sample flow rate.
6) Record sample volume on the COC using the average of the pre- and post- flow rates.
7) Send tubes to the lab in the cooler with ice.

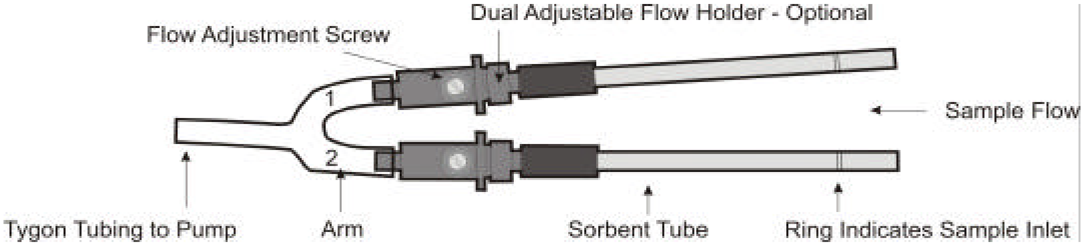
2.2 Method Specific Sampling Instructions

TO-17 Sampling Instructions

Application: Indoor Air

Media: TO-17 tube, 1/4”Tygon tubing, sample pump & optional dual adjustable flow holder

Parameters: Typical flows should be between 10 to 200 ml/min. Consult with the laboratory to insure appropriate volumes are collected to meet desired reporting limits.



Instructions:

1) Connect the sampling pump to the outlet of a “set-up” tube using Tygon tubing, connect the inlet (the ringed side) to the calibrator. Adjust setting to desired flow rate and record. A low flow holder may be required for a higher flow pump.
2) Replace the “set-up” tube with a sample tube. Using the Tygon tubing connect the sampling pump to the outlet of the sample tube.
3) The picture above shows a distributed pair using an adjustable 2-tube flow holder. This allows you to take replicate or distributed samples. The flow is adjusted by tightening the screw on the holder. Two different flows can be used to collect two volumes for a distributed pair. A 2-tube holder is not necessary for single sample collection. If using a dual holder it is important to notate which arm corresponds to each recorded flow measurement.
4) Start the sample pump and record the start time. After the desired duration, stop the pump and record the end time.
5) Replace the end plugs on both ends of the sample tube. Record the sample ID, tube ID and the collection date/time on the COC.
6) When completed with a set of samples, re-attach the “set-up” tube to the calibrator and measure the post-sampling flow. Record post-sampling flow rate. This should match within 10% of the pre-sample flow rate.
7) Record sample volume on the COC using the average of the pre- and post- flow rates.
8) Send tubes to the lab in the cooler with ice.

APPENDIX C
U.S. EPA'S COMPENDIUM METHOD TO-17

EPA/625/R-96/010b

Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

Compendium Method TO-17

Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes

Center for Environmental Research Information
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268

January 1999

Method TO-17
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DISCLAIMER

METHOD TO-17

Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes

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METHOD TO-17

Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes

1. Scope

1.1 This document describes a sorbent tube/thermal desorption/gas chromatographic-based monitoring method for volatile organic compounds (VOCs) in ambient air at 0.5 to 25 parts per billion (ppbv) concentration levels. Performance criteria are provided as part of the method in Section 14. EPA has previously published Compendium Method TO-1 describing the use of the porous polymer Tenax® GC for sampling nonpolar VOCs and Compendium Method TO-2 describing the use of carbon molecular sieve for highly volatile, nonpolar organics (1). Since these methods were developed, a new generation of thermal desorption systems as well as new types of solid adsorbents have become available commercially. These sorbents are used singly or in multisorbent packings. Tubes with more than one sorbent, packed in order of increasing sorbent strength are used to facilitate quantitative retention and desorption of VOCs over a wide volatility range. The higher molecular weight compounds are retained on the front, least retentive sorbent; the more volatile compounds are retained farther into the packing on a stronger adsorbent. The higher molecular weight compounds never encounter the stronger adsorbents, thereby improving the efficiency of the thermal desorption process.

1.2 A large amount of data on solid adsorbents is available through the efforts of the Health and Safety Laboratory, Health and Safety Executive (HSE), Sheffield, United Kingdon (UK). This group has provided written methods for use of solid adsorbent packings in monitoring workplace air. Some of their documents on the subject are referenced in Section 2.2. Also, a table of information on safe sampling volumes from their research is provided in Appendix 1.

1.3 EPA has developed data on the use of solid sorbents in multisorbent tubes for concentration of VOCs from the ambient air as part of its program for methods development of automated gas chromatographs. The experiments required to validate the use of these sorbent traps include capture and release efficiency studies for given sampling volumes. These studies establish the validity of using solid adsorbents for target sets of VOCs with minimal (at most one hour) storage time. Although questions related to handling, transport and storage of samples between the times of sampling and analysis are not addressed, these studies provide information on safe sampling volumes. Appendix 2 delineates the results of sampling a mixture of humidified zero air and the target VOCs specified in the Compendium Method TO-14 (2) using a specific multisorbent.

1.4 An EPA workshop was convened in November of 1995 to determine if a consensus could be reached on the use of solid sorbent tubes for ambient air analysis. The draft method available at the workshop has evolved through several reviews and modifications into the current document. The method is supported by data reported in the scientific literature as cited in the text, and by recent experimental tests performed as a consequence of the workshop (see Table 1).

1.5 The analytical approach using gas chromatography/mass spectroscopy (GC/MS) is identical to that mentioned in Compendium Method TO-15 and, as noted later, is adapted for this method once the sample has been thermally desorbed from the adsorption tube onto the focusing trap of the analytical system.

1.6 Performance criteria are given in Section 14 to allow acceptance of data obtained with any of the many variations of sampling and analytical approaches.

2. Summary of Method

2.1 The monitoring procedure involves pulling a volume of air through a sorbent packing to collect VOCs followed by a thermal desorption-capillary GC/MS analytical procedure.

2.2 Conventional detectors are considered alternatives for analysis subject to the performance criteria listed in Section 14 but are not covered specifically in this method text.

2.3 Key steps of this method are listed below.

2.3.1 Selection of a sorbent or sorbent mix tailored for a target compound list, data quality objectives and sampling environment.

2.3.2 Screening the sampling location for VOCs by taking single tube samples to allow estimates of the nature and amount of sample gases.

2.3.3 Initial sampling sequences with two tubes at nominally 1 and 4 liter total sample volumes (or appropriate proportional scaling of these volumes to fit the target list and monitoring objectives).

2.3.4 Analysis of the samples and comparison to performance criteria.

2.3.5 Acceptance or rejection of the data.

2.3.6 If rejection, then review of the experimental arrangement including repeat analysis or repeat analysis with backup tubes and/or other QC features.

[Note: EPA requires the use of distributed volume pairs (see Section14.4) for monitoring to insure high quality data. However, in situations where acceptable data have been routinely obtained through use of distributed volume pairs and the ambient air is considered well characterized, cost considerations may warrant single tube sampling. Any attendant risk to data quality objectives is the responsibility of the project's decision maker.]

2.4 Key steps in sample analysis are listed below.

2.4.1 Dry purge of the sorbent tube with dry, inert gas before analysis to remove water vapor and air. The sorbent tube can be held at temperatures above ambient for the dry purge.

2.4.2 Thermal desorption of the sorbent tube (primary desorption).

2.4.3 Analyte refocusing on a secondary trap.

2.4.4 Rapid desorption of the trap and injection/transfer of target analytes into the gas chromatograph (secondary desorption).

2.4.5 Separation of compounds by high resolution capillary gas chromatography (GC).

2.4.6 Measurement by mass spectrometry (MS) or conventional GC detectors (only the MS approach is explicitly referred to in Compendium Method TO-17; an FID/ECD detector combination or other GC detector can be used if Section 14 criteria are met. However, no explicit QA guidelines are given here for those alternatives).

2.5 The target compound list (TCL) is the same as listed in Compendium Method TO-15 (i.e., subsets of the 97 VOCs listed as hazardous pollutants in Title III of the Clean Air Act Amendments of 1990). Only a portion of these compounds has been monitored by the use of solid adsorbents. This method provides performance criteria to demonstrate acceptable performance of the method (or modifications of the method) for monitoring a given compound or set of compounds.

3. Significance

3.1 This method is an alternative to the canister-based sampling and analysis methods that are presented in Compendium Methods TO-14 and TO-15 and to the previous sorbent-based methods that were formalized as Compendium Methods TO-1 and TO-2. All of these methods are of the type that include sampling at one location, storage and transport of the sample, and analysis at another, typically more favorable site.

3.2 The collection of VOCs in ambient air samples by passage through solid sorbent packings is generally recognized to have a number of advantages for monitoring. These include the following:

- The small size and light weight of the sorbent packing and attendant equipment.
- The placement of the sorbent packing as the first element (with the possible exception of a filter or chemical scrubber for ozone) in the sampling train so as to reduce the possibility of contamination from upstream elements.
- The availability of a large selection of sorbents to match the target set of compounds including polar VOC.
- The commercial availability of thermal desorption systems to release the sample from the sorbent and into the analytical system.
- The possibility of water management using a combination of hydrophobic sorbents (to cause water breakthrough while sampling); dry gas purge of water from the sorbent after sampling; and splitting of the sample during analysis.
- The large amount of literature on the use of sorbent sampling and thermal desorption for monitoring of workplace air, particularly the literature from the Health and Safety Executive in the United Kingdom.

3.3 Accurate risk assessment of human and ecological exposure to toxic VOCs is an important goal of the U. S. Environmental Protection Agency (EPA) with increased emphasis on their role as endocrine disrupters. Accurate data is fundamental to reaching this goal. The portability and small size of typical sampling packages for sorbent-based sampling and the wide range of sorbent choices make this monitoring approach appealing for special monitoring studies of human exposure to toxic gases and to use in network monitoring to establish prevalence and trends of toxic gases. Microenvironmental and human subject studies are typical of applications for Compendium Method TO-17.

3.4 Sorbent-based monitoring can be combined with canister-based monitoring methods, on-site autoGC systems, open path instrumentation, and other specialized point monitoring instruments to address most monitoring needs for volatile organic gases. More than one of these approaches can be used simultaneously as a means to check and insure the quality of the data being produced.

3.5 In the form specified in Compendium Method TO-17, sorbent sampling incorporates the distributed volume pair approach that provides inherently defensible data to counter questions of sample integrity, operator performance, equipment malfunction during sampling, and any other characteristic of sample collection that is not linear with sampling volume.

3.6 In keeping with the consensus of EPA scientists and science advisors, the method is performance-based such that performance criteria are provided. Any modification of the sorbent approach to monitoring for VOCs can be used provided these criteria are met.

4. Applicable Documents

4.1 ASTM Standards

- Method D1356 *Definition of Terms Relating to Atmospheric Sampling and Analysis*
- Method E260 *Recommended Practice for General Gas Chromatography*
- Method E355 *Practice for Gas Chromatography Terms and Relationships*

4.2 EPA Documents

- *Technical Assistance Document for Sampling and Analysis Toxic Organic Compounds in Ambient Air*, U. S. Environmental Protection Agency, EPA-600/4-83-027, June 1983.
- *Quality Assurance Handbook for Air Pollution Measurement Systems*, U. S. Environmental Protection Agency, EPA-600/R-94-038b, May 1994.
- *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Methods TO-1 and TO-2*, U. S. Environmental Protection Agency, EPA 600/4-84-041, April 1984.
- *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Method TO-14, Second Supplement*, U. S. Environmental Protection Agency, EPA 600/4-89-018, March 1989.
- *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Method TO-15*, U. S. Environmental Protection Agency, EPA 625/R-96-010b, January 1997.

4.3 Other Documents

- MDHS 3 - Generation of Test Atmospheres of Organic Vapors by the Syringe Injection Technique, *Methods for the Determination of Hazardous Substances (MDHS)*, Health and Safety Laboratory, Health and Safety Executive, Sheffield, UK.
- MDHS 4 - Generation of Test Atmospheres of Organic Vapors by the Permeation Tube Method, *Methods for the Determination of Hazardous Substances (MDHS)*, Health and Safety Laboratory, Health and Safety Executive, Sheffield, UK.
- MDHS 72 - Volatile Organic Compounds in Air, *Methods for the Determination of Hazardous Substances (MDHS)*, Health and Safety Laboratory, Health and Safety Executive, Sheffield, UK.
- TAD - *Technical Assistance Document (TAD) on the Use of Solid Sorbent-based Systems for Ambient Air Monitoring*, Perkin Elmer Corp., 50 Danbury Rd., Wilton, CT 06897, USA.

5. Definitions

[Note: Definitions used in this document and any user-prepared Standard Operating Procedures (SOPs) should be consistent with those used in ASTM D1356. All abbreviations and symbols are defined within this document at the point of first use.]

5.1 Thermal Desorption-the use of heat and a flow of inert (carrier) gas to extract volatiles from a solid or liquid matrix directly into the carrier gas and transfer them to downstream system elements such as the analytical column of a GC. No solvent is required.

5.2 Two-stage Thermal Desorption-the process of thermally desorbing analytes from a solid or liquid matrix, reconcentrating them on a focusing tube and then rapidly heating the tube to ?inject” the concentrated compounds into the GC system in a narrow band of vapor compatible with high resolution capillary gas chromatography.

5.3 Sorbent Tube (Also referred to as ‘tube’ and ‘sample tube’)-stainless steel, glass or glass lined (or fused silica lined) stainless steel tube, typically 1/4 inch (6 mm) O.D. and of various lengths, with the central portion packed with greater than 200 mg of solid adsorbent material, depending on density and packing bed length. Used to concentrate VOCs from air.

5.4 Focusing Tube-narrow (typically <3mm I.D.) tube containing a small bed of sorbent, which is maintained near or below ambient temperature and used to refocus analytes thermally desorbed from the sorbent tube. Once all the VOCs have been transferred from the sorbent tube to the focusing tube, the focusing tube is heated very rapidly to transfer the analytes into the capillary GC analytical column in a narrow band of vapor.

5.5 Cryogen (Also referred to as ‘cryogenic fluid’)-typically liquid nitrogen, liquid argon, or liquid carbon dioxide. In the present context, cryogens are used in some thermal desorption systems to cool the focusing tube.

5.6 High Resolution Capillary Column Chromatography-conventionally describes fused silica capillary columns with an internal diameter of 320 µm or below and with a stationary phase film thickness of 5 µm or less.

5.7 Breakthrough Volume (BV)-volume of air containing a constant concentration of analyte which may be passed through a sorbent tube before a detectable level (typically 5%) of the analyte concentration elutes from the nonsampling end. Alternatively, the volume sampled when the amount of analyte collected in a back-up sorbent tube reaches a certain percentage (typically 5%) of the total amount collected by both sorbent tubes. These methods do not give identical results. For purposes in the document the former definition will be used.

5.8 Retention Volume (RV)-the volume of carrier gas required to move an analyte vapor plug through the short packed column which is the sorbent tube. The volume is determined by measuring the carrier gas volume necessary to elute the vapor plug through the tube, normally measured at the peak response as the plug exits the tube. The retention volume of methane is subtracted to account for dead volume in the tube.

5.9 Safe Sampling Volume (SSV)-usually calculated by halving the retention volume (indirect method) or taking two-thirds of the breakthrough volume (direct method), although these two approaches do not necessarily give identical results. The latter definition is used in this document.

5.10 Sorbent Strength—term used to describe the affinity of sorbents for VOC analytes. A stronger sorbent is one which offers greater safe sampling volumes for most/all VOC analytes relative to another, weaker sorbent. Generally speaking, sorbent strength is related to surface area, though there are exceptions to this. The SSVs of most, if not all, VOCs will be greater on a sorbent with surface area **?**10n" than on one with a surface area of **?**n". As a general rule, sorbents are described as **?**weak" if their surface area is less than 50 m^2g^{-1} (includes Tenax®, Carbopack™/trap C, and Anasorb® GCB2), **?**medium strength" if the surface area is in the range 100-500 m^2g^{-1} (includes Carbopack™/trap B, Anasorb® GCBI and all the Porapaks and Chromosorbs listed in Tables 1 and 2) and **?**strong" if the surface area is around 1000 m^2g^{-1} (includes Spherocarb®, Carbosieve™ S-III, Carboxen™ 1000, and Anasorb® CMS series sorbents.)

5.11 Total Ion Chromatogram (TIC)-chromatogram produced from a mass spectrometer detector operating in full scan mode.

5.12 MS-SCAN-mode of operation of a GC mass spectrometer detector such that all mass ions over a given mass range are swept over a given period of time.

5.13 MS -SIM-mode of operation of a GC mass spectrometer detector such that only a single mass ion or a selected number of discrete mass ions are monitored.

5.14 Standard Sorbent (Sample) Tube-stainless steel, glass or glass lined (or fused silica lined) stainless steel tube, 1/4 inch (6 mm) O.D. and of various lengths, with the central portion packed with $\geq$200 mg of solid adsorbent material depending on sorbent density. Tubes should be individually numbered and show the direction of flow.

5.15 Time Weighted Average (TWA) Monitoring-if air is sampled over a fixed time period **-** typically 1,3, 8 or 24 hours, the time weighted average atmospheric concentration over the monitoring period may be calculated from the total mass of analyte retained and the specific air volume sampled. Constraints on breakthrough volumes make certain combinations of sampling time and flow rates mutually exclusive.

6. Overview of Methodology

[*Note: The following is intended to provide a simple and straightforward method description including the example of a specific sampling problem. Although specific equipment is listed, the document is intended only as an example and equipment mentioned in the text is usually only one of a number of equally suitable components that can be used. Hence trade names are not meant to imply exclusive endorsement for sampling and analysis using solid sorbents. Later sections in the text give guidance as to what considerations should be made for a number of VOC monitoring applications.*]

6.1 Selection of Tube and Sorbent

6.1.1 Select a tube and sorbent packing for the sampling application using guidance from Tables 1 and 2 on sorbent characteristics as well as guidance from Appendix 1 and Table 3 on safe sampling volumes and breakthrough characteristics of sorbents.

6.1.2 As an example, assume the TCL includes a subset of the compounds shown in Table 3. In this case, the multisorbent tube chosen consists of two sorbents packed in a 1/4 inch O.D., 3.5" long glass tube in the following order and amounts: 160 mg of Carbopack™ graphitized carbon black (60/80 mesh) and 70 mg of Carboxen™-1000 type carbon molecular sieve (60/80 mesh). This is an example of Tube Style 2 discussed Section 9.1.3.2.

6.1.3 Pack the tube with the adsorbent by using the guidance provided in Section 10.1 or buy a prepacked tube from a supplier. In the example, tubes were purchased from Supelco Inc., Supelco Park, Bellefonte, PA 16823-0048.

6.2 Conditioning the Tube

6.2.1 Condition newly packed tubes for at least 2 hours (30 mins for preconditioned, purchased tubes) at 350°C while passing at least 50 mL/min of pure helium carrier gas through them.

[Note: Other sorbents may require different conditioning temperatures - see Table 2 for guidance.]

Once conditioned, seal the tube with brass, 1/4 inch Swagelok® -type fittings and PTFE ferrules. Wrap the sealed tubes in uncoated aluminum foil and place the tubes in a clean, airtight, opaque container.

6.2.2 A package of clean sorbent material, e.g. activated charcoal or activated charcoal/silica gel mixture, may be added to the container to ensure clean storage conditions.

6.2.3 Store in a refrigerator (organic solvent-free) at 4°C if not to be used within a day. On second and subsequent uses, the tubes will generally not require further conditioning as above. However, tubes with an immediate prior use indicating high levels of pollutant trace gases should be reconditioned prior to continued usage.

6.3 Sampling Apparatus

6.3.1 Select a sampling apparatus with accommodations for two sampling tubes capable of independent control of sampling rate at a settable value in the range 10 to 200 mL/min. Laboratory and field blanks must also be included in the monitoring exercise.

6.3.2 Backup tubes may be required to determine the cause of any problem if performance criteria, outlined in Section 14, are not met.

6.4 Sampling Rates

6.4.1 Select sampling rates compatible with the collection of 1 and 4 liter total sample volume (or of proportionally lower/higher sampling volumes).

6.4.2 Air samples are collected over 1 hour with a sampling rate of 16.7 mL/min and 66.7 mL/min, respectively.

6.5 Preparing for Sample Collection

6.5.1 At the monitoring location, keep the tubes in their storage and transportation container to equilibrate with ambient temperature.

6.5.2 Using clean gloves, remove the sample tubes from the container, take off their caps and attach them to the sampling lines with non-outgassing flexible tubing. Uncap and immediately reseal the required number of field blank tubes.

6.5.3 Place the field blank tubes back in the storage container. If back-up tubes are being used, attach them to the sampling tubes using clean, metal Swagelok® type unions and combined PTFE ferrules.

6.6 Set the Flow Rates

6.6.1 Set the flow rates of the pump using a mass flow monitor.

6.6.2 The sampling train includes, from front to back, an in-line particulate filter (optional), an ozone scrubber (optional), a sampling tube, a back-up tube if any is being used, and a flow controller/pump combination.

6.6.3 Place the mass flow monitor in line after the tube. Turn the pump on and wait for one minute. Establish the approximate sampling flow rate using a dummy tube of identical construction and packing as the sampling tube to be used. Record on Field Test Data Sheet (FTDS), as illustrated in Figure 1.

6.6.4 Place the sampling tubes to be used on the sampling train and make final adjustments to the flow controller as quickly as possible to avoid significant errors in the sample volume.

6.6.5 Adjust the flow rate of one tube to sample at 16.7 mL/min. Repeat the procedure for the second tube and set the flow rate to 66.7 mL/min. Record on FTDS.

6.7 Sample and Recheck Flow Rates

6.7.1 Sample over the selected sampling period (i.e., 1-hour). Recheck all the sampling flow rates at the end of the monitoring exercise just before switching off each pump and record on FTDS.

6.7.2 Make notes of all relevant monitoring parameters including locations, tube identification numbers, pump flow rates, dates, times, sampled volumes, ambient conditions etc. on FTDS.

6.8 Reseal the Tubes

6.8.1 Immediately remove the sampling tubes with clean gloves, recap the tubes with Swagelok® fittings using PTFE ferrules, rewrap the tubes with uncoated Al foil, and place the tubes in a clean, opaque, airtight container.

6.8.2 If not to be analyzed during the same day, place the container in a clean, cool (<4°C), organic solvent-free environment and leave there until time for analysis.

6.9 Selection of Thermal Desorption System

6.9.1 Select a thermal desorption system using the guidance provided in Section 8.

6.9.2 Place the thermal unit in a ready operational status.

6.10 Dry Purge the Tubes and Prepare for Thermal Desorption

6.10.1 Remove the sampling tubes, any backup tubes being used, and blanks from the storage area and allow the tubes to come to room temperature. Using clean gloves, remove the Swagelok®-type fittings and dry purge the tubes with a forward (sampling direction) flow of, for example, 50 mL/min of dry helium for 4 minutes (see Section 7.2 concerning dry purging).

[Note: Do not dry purge the laboratory blanks.]

6.10.2 Reseal the tubes with Teflon® (or other) caps compatible with the thermal desorber operation. Place the sealed tubes on the thermal desorber (e.g., Perkin Elmer Model ATD 400 Automated System or equivalent). Other thermal desorbers may have different arrangements for automation. Alternatively, use equivalent manual desorption.

6.11 Check for System Integrity

6.11.1 Check the air tightness of the seals and the integrity of the flow path.
6.11.2 Guidance is provided in Section 11.2 of this document.

6.12 Repurge of Tube on the Thermal Desorber/Addition of Internal Standard

6.12.1 Because of tube handling after dry purge, it may be necessary to repurge each of the tubes with pure, dry helium (He) before analysis in order to eliminate any oxygen.

6.12.2 If the initial dry purge can be performed on the thermal desorber so as to prevent any further exposure of the sorbent to air, then this step is not necessary. Proceed with the addition of an internal standard to the sorbent tube or the focusing tube.

6.13 Thermally Desorb the Packing

6.13.1 Reverse the flow direction of He gas, set the flow rate to at least 30 mL/min, and heat the tube to 325°C (in this case) to achieve a transfer of VOCs onto a focusing tube at a temperature of 27°C. Thermal desorption continues until all target species are transferred to the focusing trap. The focusing trap is typically packed with 20 mg of Carbopack™ B (60/80 mesh) and 50 mg of a Carboxen™ 1000-type sorbent (60/80 mesh).

6.14 Trap Desorption and GC/MS Analysis

6.14.1 After each tube is desorbed, rapidly heat the focusing trap (to 325°C in this example) and apply a reverse flow of at least 3 mL/min of pure helium carrier gas. Sample splitting is necessary to accommodate the capillary column. Analytes are transferred to the column in a narrow band of vapor.

6.14.2 The GC run is initiated based on a time delay after the start of thermal desorption. The remaining part of the analytical cycle is described in Section 3 of Compendium Method TO-15.

6.15 Restoring the Tubes and Determine Compliance with Performance Standards

6.15.1 When tube analysis is completed, remove the tubes from the thermal desorber and, using clean gloves, replace the Teflon® caps with Swagelok fittings and PTFE ferrules, rewrap with aluminum foil, replace in the clean, airtight container, and re-store the tubes in a cool environment (<4°C) until the next use.

6.15.2 Using previously prepared identification and quantification subroutines, identify the target compounds and document the amount of each measured compound (refer to the Section 3 of Compendium Method TO-15). Compare the results of analysis for the distributed volume pair taken during each sampling run and use the comparison to determine whether or not the performance criteria for individual sampling events have been met. Also examine the results of any laboratory blanks, field blanks, and any backup tube being used. Accept or reject the data based on the performance criteria (see Section 14).

6.16 Record and Store Data

6.16.1 Accurately retrieve field data (including the tube identification number) from the FTDS. The data should include a sampling site identifier, time of sample initiation, duration of sampling, air pump identification, flow rate, and other information as appropriate.

6.16.2 Store GC/MS data in a permanent form both in hard copy in a notebook and in digital form on a disk. Also store the data sheet with the hard copy.

[Note: Sections 7 through 14 below elaborate on the method by providing important information and guidance appropriate to explain the method as outlined in Section 6 and also to generalize the method for many applications. Section 14 gives the performance criteria for the method.]

7. Interferences and Limitations

7.1 Interference from Sorbent Artifacts

7.1.1 Minimizing Artifact Interference.

7.1.1.1 Stringent tube conditioning (see Section 10.2.1) and careful tube capping and storage procedures (see Section 10.2.2) are essential for minimizing artifacts. System and sorbent tube conditioning must be carried out using more stringent conditions of temperature, gas flow and time than those required for sample analysis.

7.1.1.2 A reasonable objective is to **reduce artifacts to 10% or less of individual analyte masses** retained during sampling. A summary of VOC levels present in a range of different atmospheric environments and the masses of individual components collected from 1, 2 or 10 L samples of air in each case is presented in Table 4.

7.1.1.3 Given that most ambient air monitoring is carried out in areas of poor air quality, for example in urban, indoor and factory fenceline environments where VOC concentrations are typically above 1 ppb, Table 4 demonstrates that the mass of each analyte retained will, therefore, range from ~5 ng to ~10 μg in most monitoring situations. Even when monitoring 'ultraclean' environments, analyte masses retained will usually exceed 0.1 ng (3).

7.1.1.4 Typical artifact levels for 1/4 inch O.D. tubes of 3.5" length range from 0.01 ng and 0.1 ng for carbonaceous sorbents and Tenax® respectively. These levels compare well with the masses of analytes collected - even from sub-ppb atmospheric concentrations (see Table 4). Artifact levels are around 10 ng for Chromosorb® Century series and other porous polymer sorbents. However, these types of sorbents can still be used for air monitoring at low ppb levels if selective or mass spectrometer detectors are used or if the blank profile of the tube demonstrates that none of the sorbent artifacts interfere analytically with the compounds of interest.

7.1.1.5 Some varieties of charcoal contain metals which will catalyze the degradation of some organic analytes during thermal desorption at elevated temperatures thus producing artifacts and resulting in low analyte recoveries.

7.1.2 Artifacts from Long-term Storage of Blank Tubes.

7.1.2.1 Literature reports of the levels of artifacts on (a) Carbotrap/pack™ C, Carbotrap/pack™ B and Carbosieve™ SIII multi-bed tubes and (b) Tenax® GR tubes, by workers sealing the tubes using metal Swagelok®-type caps and PTFE ferrules with multi-tube, glass storage jars are reported to be between 0.01 ng [after 1-2 months (4)] and 0.1 ng [after 6 months (5)] for (a) and (b) respectively.

7.1.2.2 Artifact levels reported for other porous polymers are higher - for example 5 ng for Chromosorb 106 after 1 week (5). More information is given in the Technical Assistance Document (TAD) referred to in Section 4.3.

7.1.3 Artifacts Generated During Sampling and Sample Storage.

7.1.3.1 Benzaldehyde, phenol and acetophenone artifacts are reported to be formed via oxidation of the polymer Tenax® when sampling high concentration (100-500 ppb) ozone atmospheres (6).

7.1.3.2 Tenax® should thus be used with an ozone scrubber when sampling low levels (<10 ppb) of these analytes in areas with appreciable ozone concentrations. Carbotrap™/pack type sorbents have not been reported to produce this level of artifact formation. Once retained on a sorbent tube, chemically stable VOCs, loaded in laboratory conditions, have been shown to give good recoveries, even under high ozone concentrations for storage of a year or more (7-9).

7.2 Minimizing Interference from Water

7.2.1 Selection of Hydrophobic Sorbents

7.2.1.1 There are three preferred approaches to reducing water interference during air monitoring using sorbent tubes. The first is to minimize water collection by selecting, where possible, a hydrophobic sorbent for the sample tube.

7.2.1.2 This is possible for compounds ranging in volatility from n-C5 (see SSVs listed in Appendix 1). Tenax®, Carbotrap™ or one of the other hydrophobic sorbents listed in Table 2 should be used.

[<u>Note</u>: It is essential to ensure that the temperature of the sorbent tube is the same and certainly not lower than ambient temperature at the start of sampling or moisture will be retained via condensation, however hydrophobic the sorbent.]

7.2.2 Sample Splitting

7.2.2.1 If the sample loading is high, it is usually possible to eliminate sufficient water to prevent analytical interference by using sample splitting (10).

7.2.2.2 Sample may be split either (1) between the focusing trap and the capillary column (single splitting) during trap (secondary) desorption or (2) between both the tube and the focusing trap during primary (tube) desorption and between the focusing trap and the column during secondary (trap) desorption (see Section 8.2.3) (double splitting). It may, in fact, be necessary to split the sample in some cases to prevent overloading the analytical column or detector.

7.2.3 Dry Purge

7.2.3.1 The third water management method is to ?dry purge” either the sorbent tube itself or the focusing trap or both (11-13). Dry purging the sample tube or focusing trap simply involves passing a volume of pure, dry, inert gas through the tube from the sampling end, prior to analysis.

7.2.3.2 The tube can be heated while dry purging at slightly elevated temperatures (11). A trap packing combination and a near ambient trapping temperature must be chosen such that target analytes are quantitatively retained while water is purged to vent from either the tube or trap.

7.3 Atmospheric Pollutants not Suitable for Analysis by this Method

7.3.1 Inorganic gases not suitable for analysis by this method are oxides of carbon, nitrogen and sulfur, O_3 and other permanent gases. Exceptions include CS_2 and N_2O.

7.3.2 Other pollutants not suitable are particulate pollutants, (i.e., fumes, aerosols and dusts) and compounds too labile (reactive) for conventional GC analysis.

7.4 Detection Limits and Maximum Quantifiable Concentrations of Air Pollutants

7.4.1 Detection limits for atmospheric monitoring vary depending on several key factors. They are:

- Minimum artifact levels.
- GC detector selection.
- Volume of air sampled. The volume of air sampled is in turn dependent upon a series of variables including SSVs (see Section 10.8, Table 1 and Appendix 1), pump flow rate limitations and time-weighted-average monitoring time constraints.

7.4.2 Generally speaking, detection limits range from sub-part-per-trillion (sub-ppt) for halogenated species such as CCl_4 and the freons using an electron capture detector (ECD) to sub-ppb for volatile hydrocarbons in 1 L air samples using the GC/MS operated in the full SCAN mode.

7.4.3 Detection limits are greatly dependent upon the proper management of water for GC capillary analysis of volatile organics in air using sorbent technology (14).

7.5 Suitable Atmospheric Conditions

7.5.1 Temperature range.

7.5.1.1 The normal working range for sorbent packing is 0-40°C (8).

7.5.1.2 In general, an increase in temperature of 10ºC will reduce the breakthrough volume for sorbent packings by a factor of 2.

7.5.2 Humidity.

7.5.2.1 The capacity of the analytical instrumentation to accommodate the amount of water vapor collected on tubes is usually the limitation in obtaining successful results, particularly for GC/MS applications. This limitation can be extreme, requiring the use of a combination of water management procedures (see Section 7.2).

7.5.2.2 The safe sampling volumes of VOCs on hydrophobic adsorbents such as Tenax®, other porous polymers, Carbotrap™ and Carbopack™ are relatively unaffected by atmospheric humidity. Spherocarb® or carbonized molecular sieve type sorbents such as Carbosieve™ SIII and the Carboxens® are affected by high humidity, however, and SSVs should typically be reduced by a factor of 10 at 90-95% RH (8). Hydrophilic zeolite molecular sieves cannot be used at all at high humidity.

7.5.3 Wind speeds.

7.5.3.1 Air movement is not a factor indoors or outdoors at wind speeds below 10 miles per hour (<20 km per hour).

7.5.3.2 Above this speed, tubes should be orientated perpendicular to the prevailing wind direction and should be sheltered from the direct draft if wind speeds exceed 20 miles per hour (30-40 km per hour) (see Section 10.5).

7.5.4 High concentrations of particulates.

7.5.4.1 It may be necessary to connect a particulate filter (e.g., a 2 micron Teflon® filter or short clean tube containing a loose plug of clean glass wool) to the sampling end of the tube in areas of extremely high particulate concentrations.

7.5.4.2 Some compounds of interest may, however, be trapped on the Teflon® or on the glass wool. Particulates trapped on the sorbent tube have the potential to act as a source or sink for volatiles, and may remain on the tube through several cycles of sampling and desorption. Frequent replacement of the particulate filter is therefore recommended.

8. Apparatus Selection and Preparation

8.1 Sample Collection

8.1.1 Selection of Tube Dimensions and Materials.

8.1.1.1 The most extensively used sorbent tubes are 1/4 inch O.D. stainless steel or 6 mm O.D. stainless steel or glass. Different suppliers provide different size tubes and packing lengths; however, 3.5 inch long tubes with a 6 cm sorbent bed and 1/4 inch O.D. stainless steel (see Figure 2) were used to generate the SSV information presented in Appendix 1.

8.1.1.2 As an approximate measure, for sorbents contained in equal diameter tubes the breakthrough volume is proportional to the bed-length (weight) of sorbent. Therefore, doubling the bed-length would approximately double the SSV (15).

8.1.1.3 Stainless steel (304 or “GC” grade) is the most robust of the commonly available tube materials which include, in addition, glass, glass-lined, and fused silica lined tubing. Tube material must be chosen to be compatible with the specifics of storage and transport of the samples. For example, careful attention to packaging is required for glass tubes.

8.1.2 Tube Labeling.

8.1.2.1 Label sample tubes with a unique identification number and the direction of sampling flow. Stainless steel tubes are most conveniently labeled by engraving. Glass tubes are best labeled using a temperature resistant paint. If empty sample tubes are obtained without labels, it is important to label and condition them before they are packed with adsorbent.

8.1.2.2 Recondition prepacked, unlabeled tubes after the tube labeling process and record the blank chromatogram from each tube. Record in writing the details of the masses and/or bed lengths of sorbent(s) contained in each tube, the maximum allowable temperature for that tube and the date each tube was packed or repacked.

8.1.3 Blank and Sampled Tube Storage Apparatus.

8.1.3.1 Seal clean, blank sorbent tubes and sampled tubes using inert, Swagelok®-type fittings and PTFE ferrules. Wrap capped tubes individually in uncoated aluminum foil. Use clean, sealable glass jars or metal cans containing a small packet of activated charcoal or activated charcoal/silica gel for storage and transportation of multiple tubes. Store the multi-tube storage container in a clean environment at 4°C.

8.1.3.2 Keep the sample tubes inside the storage container during transportation and only remove them at the monitoring location after the tubes have reached ambient temperature. Store sampled tubes in a refrigerator at 4°C inside the multi-tube container until ready for analysis.

[Note: The atmosphere inside the refrigerator must be clean and free of organic solvents.]

8.1.4 Selection of Sampling Pumps.

8.1.4.1 The selected monitoring pump(s) should be capable of operating in the range 10 to 200 mL/min. Label the pumps with a unique identification number and operate them according to manufacturer's guidelines.

8.1.4.2 Constant mass flow type pumps are ideal for air monitoring as they deliver a constant flow rate for a wide range of tube impedances. They thus compensate for moderate impedance variations between the sorbent tubes in use. The pump should meet US criteria for intrinsic safety where applicable. Connect the pump to the non-sampling end of the sample tube by means of flexible, nonoutgassing tubing.

8.1.5 Parallel Sampling onto Multiple Tubes with a Single Pump.

8.1.5.1 Select a sample collection system for collecting samples onto 2 tubes in parallel.

8.1.5.2 If a single pump is used for both tubes, ensure that the flow rates will be controlled at a constant flow rate during sampling and that the two flow rates can be independently controlled and stabilized.

8.1.6 Apparatus for Calibrating the Pumped Air Flow.

8.1.6.1 Calibrate the pump with the type of sorbent tube to which it will be connected during the monitoring exercise. Use the actual sampling tube to fine tune the sampling flow rate at the start of sample collection.

8.1.6.2 Use a flow meter certified traceable to NIST standards.

8.1.7 Sorbent Tube Protection During Air Sample Collection.

8.1.7.1 Protect sorbent tubes from extreme weather conditions using shelters constructed of inert materials. The shelter must not impede the ingress of ambient air.

8.1.7.2 If the atmosphere under test contains significant levels of particulates - fume, dust or aerosol, connect a Teflon® 2-micron filter or a (metal, glass, glass-lined or fused silica lined stainless) tube containing a short plug of clean glass wool prior to the sampling end of the tube and using inert, Swagelok®-type fittings and PTFE ferrules for fitting connections.

8.2 Apparatus

8.2.1 Essential Sample Protection Features of the Thermal Desorption Apparatus.

8.2.1.1 As thermal desorption is generally a one shot process, (i.e., once the sample is desorbed it cannot readily be reinjected or retrieved), stringent sample protection measures and thorough preanalysis system checks must form an integral part of the thermal desorption-GC procedure and should be systematically carried out.

8.2.1.2 The sample integrity protection measures and preanalysis checks required include:

- **Sealed tubes**. Sample tubes awaiting analysis on an automated desorption system must be completely sealed before thermal desorption to prevent ingress of VOC contaminants from the laboratory air and to prevent losses of weakly retained analytes from the tube.
- **Inert and heated sample flow path**. To eliminate condensation, adsorption and degradation of analytes within the analytical system, the sample flow path of manual and automated thermal desorbers should be uniformly heated (minimum temperature range 50° - 150°C) between the sample tube and the GC analytical column. The components of the sample flow path should also, as far as possible, be constructed of inert materials, i.e., deactivated fused silica, glass lined tubing, glass, quartz and PTFE.
- **Tube leak testing**. This activity must not jeopardize sample integrity.
- **Leak testing of the sample flow path**. This activity must not jeopardize sample integrity.
- **System purge**. Stringent, near-ambient temperature carrier gas purge to remove oxygen.
- **Analytical system**. ?Ready" status checks.

8.2.2 Thermal Desorption Apparatus.

8.2.2.1 Two-stage thermal desorption is used for the best high resolution capillary chromatography (i.e., analytes desorbed from the sorbent tube must be refocused before being rapidly transferred to the GC analytical column). One type of analyte refocusing device which has been successfully used is a small sorbent trap (17). One cryogen-free trap cooling option is to use a multistage Peltier electrical cooler (18,19).

8.2.2.2 Closed cycle coolers are also available for use. At its low temperature, the trap must provide quantitative analyte retention for target compounds as well as quantitative and rapid desorption of target analytes as high boiling as n-C_{12}. The peak widths produced must be compatible with high resolution capillary gas chromatography.

8.2.2.3 Typical key components and operational stages of a two-stage desorption system are presented in Figure 3(a) - (f) and a stepwise description of the thermal desorber operation is presented in Section 11.3.

8.2.3 Sample Splitting Apparatus.

8.2.3.1 Sample splitting is often required to reduce water vapor interference, for the analysis of relatively high concentration (>10 ppb level) air samples, when large volume air samples are collected, or when sensitive selective detectors are in use.

8.2.3.2 Sample splitting is one of the three key approaches to water management detailed in this method (see Section 7.2). Moisture management by sample splitting is applicable to relatively high concentrations ($\geq$10 ppb) or large volume air samples or to analyses employing extremely sensitive detectors - for example, using the ECD for low levels of tetrachloroethylene. In these cases the masses of analytes retained by the sorbent tube when monitoring such atmospheres is large enough to allow, or even require, the selection of a high split ratio (>10:1) during analysis to avoid overloading the analytical column or detector. The mass of water retained by the sorbent tube during sample collection may be sufficiently reduced by the split alone to eliminate the need for further water management steps.

8.2.4 The Thermal Desorber - GC Interface.

8.2.4.1 Heat the interface between the thermal desorber and the GC uniformly. Ensure that the interface line is leak tight and lined with an inert material such as deactivated fused silica.

8.2.4.2 Alternatively, thread the capillary column itself through the heated transfer line/interface and connected directly into the thermal desorber.

[Note: Use of a metal syringe-type needle or unheated length of fused silica pushed through the septum of a conventional GC injector is not recommended as a means of interfacing the thermal desorber to the chromatograph. Such connections result in cold spots, cause band broadening and are prone to leaks.]

8.2.5 GC/MS Analytical Components. This method uses the GC/MS description as given in Compendium Method TO-15, Section 7.

8.3 Tube Conditioning Apparatus

8.3.1 Tube Conditioning Mode

8.3.1.1 Condition freshly packed tubes using the analytical thermal desorption apparatus if it supports a dedicated 'tube conditioning mode' (i.e., a mode in which effluent from highly contaminated tubes is directed to vent without passing through key parts of the sample flow path such as the focusing trap).

8.3.2 Stand Alone System

8.3.2.1 If such a tube conditioning mode is not available, use separate stand-alone tube conditioning hardware.

8.3.2.2 The tube conditioning hardware must be leak-tight to prevent air ingress, allow precise and reproducible temperature selection (±5°C), offer a temperature range at least as great as that of the thermal desorber and support inert gas flows in the range of 50 to 100 mL/min.

[Note: Whether conditioning is carried out using a special mode on the thermal desorber or using separate hardware, pass effluent gases from freshly packed or highly contaminated tubes through a charcoal filter during the process to prevent desorbed VOCs polluting the laboratory atmosphere.]

9. Reagents and Materials

9.1 Sorbent Selection Guidelines

9.1.1 Selection of Sorbent Mesh Size.

9.1.1.1 Sieved sorbents of particle size in the range 20 to 80 mesh should be used for tube packing.

9.1.1.2 Specific surface area of different sorbents is provided in Table 2.

9.1.2 Sorbent Strength and Safe Sampling Volumes.

9.1.2.1 Many well-validated pumped and diffusive sorbent tube sampling/thermal desorption methods have been published at the relatively high atmospheric concentrations (i.e., mid-ppb to ppm) typical of workplace air and industrial/mobile source emissions (8, 20-30).

9.1.2.2 These methods show that SSVs are unaffected by analyte concentrations far in excess of the 25 ppb upper limit of this method. The effect of humidity on SSVs is discussed in Section 7.5 and Table 2.

9.1.2.3 Select a sorbent or series of sorbents of suitable strength for the analytes in question from the information given in Tables 1 and 2 and Appendices 1 and 2. Where a number of different sorbents fulfill the basic safe sampling volume criteria for the analytes in question, choose that (or those) which are hydrophobic and least susceptible to artifact formation. Keep the field sampling volumes to 80% or less of the SSV of the least well-retained analyte. Using one of the two procedures given in Section 10.8, check the safe sampling volumes for the most volatile analytes of interest on an annual basis or once every twenty uses of the sorbent tubes whichever occurs first.

9.1.3 Three General-Purpose 1/4 Inch or 6 mm O.D. Multi-Bed Tube Types.

[Note: The three general-purpose tubes presented in this section are packed with sorbents in the mesh size range of 20-80 mesh. The difference in internal diameter between standard glass and stainless steel tubes will result in different bed volumes (weights) for the same bed length.]

9.1.3.1 Tube Style 1 consists of 30 mm Tenax®GR plus 25 mm of Carbopack™ B separated by 3 mm of unsilanized, preconditioned glass or quartz wool. Suitable for compounds ranging in volatility from n-C_6 to n-C_{20} for air volumes of 2 L at any humidity. Air volumes may be extended to 5 L or more for compounds ranging in volatility from n-C_7.

9.1.3.2 Tube Style 2 consists of 35 mm Carbopack™ B plus 10 mm of Carbosieve™ SIII or Carboxen™ 1000 separated by glass/quartz wool as above. Suitable for compounds ranging in volatility from n-C_3 to n-C_{12} (such as ?Compendium Method TO-14 air toxics") for air volumes of 2 L at relative humidities below 65% and temperatures below 30°C. At humidities above 65% and ambient temperatures above 30°C, air volumes should be reduced to 0.5 L. Air volumes may be extended to 5 L or more for species ranging in volatility from n-C_4. A dry purge procedure or a large split ratio must be used during analysis when humid air has been sampled on these tubes.

9.1.3.3 Tube Style 3 consists of 13 mm Carbopack™ C, 25 mm Carbopack™ B plus 13 mm of Carbosieve™ SIII or Carboxen™ 1000 all separated by 3 mm plugs of glass/quartz wool as above. Suitable for compounds ranging in volatility from n-C_3 to n-C_{16} for air volumes of 2 L at relative humidities below 65 percent and temperatures below 30°C. At humidities above 65 percent and ambient temperatures above 30°C, air volumes should be reduced to 0.5 L. Air volumes may be extended to 5 L or more for compounds ranging in volatility from n-C_4. A dry purge procedure or a large split ratio must be used during analysis when humid air has been sampled on these tubes.

[Note: These multi-bed tubes are commercially available prepacked and preconditioned if required.]

[Note: These general purpose multi-bed tubes are only recommended for monitoring unknown atmospheres or wide volatility range sets of target analytes. Most routine monitoring of industrial air (for example at factory fencelines) only involves monitoring a few specific target analytes such as benzene, toluene, ethylbenzene, and xylenes (BTEX), carbon disulfide (CS_2) or 1,1,1-trichloroethane. Single-bed sorbent tubes selected from the options listed in Appendix 1 are typically used in these cases.]

[Note: In the interests of minimizing water retention it is advisable to stick to hydrophobic (i.e., weak and medium strength) sorbents whenever possible; this generally is the case when components more volatile than n-C_6 are not of interest.]

9.2 Gas Phase Standards

9.2.1 Standard Atmospheres.

9.2.1.1 Standard atmospheres must be stable at ambient pressure and accurate (±10%). Analyte concentrations and humidities should be similar to those in the typical test atmosphere. Standard atmospheres must be sampled onto conditioned sorbent tubes using the same pump flow rates as used for field sample collection.

9.2.1.2 If a suitable standard atmosphere is obtained commercially, manufacturer's recommendations concerning storage conditions and product lifetime should be rigidly observed.

9.2.2 Concentrated, Pressurized Gas Phase Standards.

9.2.2.1 Use accurate (± 5%), concentrated gas phase standards in pressurized cylinders such that a 0.5 - 5.0 mL gas sampling volume (GSV) loop contains approximately the same masses of analytes as will be collected from a typical air sample. Introduce the standard onto the sampling end of conditioned sorbent tubes using at least ten times the loop volume of pure helium carrier gas to completely sweep the standard from the GSV.

9.2.2.2 Manufacturer's guidelines concerning storage conditions and expected lifetime of the concentrated gas phase standard should be rigidly observed.

9.3 Liquid Standards

9.3.1 Solvent Selection.

9.3.1.1 If liquid standards are to be loaded onto sorbent tubes for calibration purposes, select a solvent for the standard that is pure (contaminants <10% of minimum analyte levels) and that, if possible, is considerably more volatile than the target analytes. This then allows the solvent to be purged and eliminated from the tube during the standard preparation process.

9.3.1.2 Methanol most commonly fills these criteria. If the target analyte range includes very volatile components, it will not be possible to do this. In these cases, select a pure solvent which is readily chromatographically resolved from the peaks/components of interest (ethyl acetate is commonly used) or use a gas phase standard. Test the purity of the solvent by comparing an analysis of the prepared standard with an analysis of pure solvent under identical chromatographic conditions.

9.3.2 Liquid Standard Concentrations.

9.3.2.1 Liquid standards should be prepared so that the range of analyte masses introduced onto the tubes is in the same order as the range of masses expected to be collected during sampling.

9.3.2.2 Concentrations of benzene in urban air may be expected to range from 0.5-25 ppb. Thus if 5 L air samples were to be collected at approximately 25°C, the masses of benzene collected would range from around 8 ng (0.5 ppb level) to around 400 ng (25 ppb level).

[Note: The above calculation was derived from Boyle's law (i.e., 1 mole of gas occupies around 25 L at 25°C and 760 mm Hg).

- *25 L of pure benzene vapor contains 78 g benzene*
- *5 L of pure benzene vapor contains 15.6 g benzene*
- *5 L of a 1 ppm benzene atmosphere contains 15.6 µg benzene*
- *5 L of a 100 ppb benzene atmosphere contains 1560 ng benzene*
- *5 L of a 1 ppb benzene atmosphere contains 15.6 ng benzene.]*

9.3.3 Loading Liquid Standards onto Sorbent Tubes.

9.3.3.1 Introduce 0.1 - 10 µL aliquots of the liquid standards onto the sampling end of conditioned sorbent tubes using a conventional 1/4 inch GC packed column injector and a 1, 5 or 10 µL syringe. The injector is typically unheated with a 100 mL/min flow of pure carrier gas. The solvent and analytes should completely vaporize and pass onto the sorbent bed in the vapor phase. It may be necessary to heat the injector slightly (typically to 50°C) for analytes less volatile than n-C_{12} to ensure that all the liquid vaporizes.

9.3.3.2 The sample tube should remain attached to the injector until the entire standard has been swept from the injector and onto the sorbent bed. If it has been possible to prepare the liquid standard in a solvent which will pass through the sorbent while analytes are quantitatively retained (for example, methanol on Tenax® or Carbopack™ B), the tube should not be disconnected from the injector until the solvent has been eliminated from the sorbent bed - this takes approximately 5 minutes under the conditions specified. Once the tube has been disconnected from the injector, it should be capped and placed in an appropriate storage container immediately.

[Note: In cases where it is possible to purge the solvent from the tube while quantitatively retaining the analytes, a 5-10 µL injection should be made as this can usually be introduced more accurately than smaller volumes. However, if the solvent is to be retained in the tube, the injection volume should be as small as possible (0.5 - 1.0 µL) to minimize solvent interference in the subsequent chromatogram.]

9.3.3.3 This method of introducing liquid standards onto sorbent tubes via a GC injector is considered the optimum approach to liquid standard introduction as components reach the sorbent bed in the vapor phase (i.e., in a way which most closely parallels the normal air sample collection process). Alternatively, liquid standards may be introduced directly onto the sorbent bed via the non-sampling end of the tube using a conventional GC syringe.

[Note: This approach is convenient and works well in most cases, but it may not be used for multi-bed tubes or for wide boiling range sets of analytes and does not allow solvent to be purged to vent.]

9.4 Gas Phase Internal Standards

9.4.1 The ideal internal standard components are:

- chemically similar to the target analytes
- extremely unlikely to occur naturally in the atmosphere under test
- readily resolved and distinguished analytically from the compounds of interest
- stable in the vapor phase at ambient temperature
- compatible with metal and glass surfaces under dry and humid conditions
- certified stable in a pressurized form for a long time period (i.e., up to 1 year).

9.4.2 Deuterated or fluorinated hydrocarbons usually meet all these criteria and make perfect internal standards for MS based systems. Typical compounds include deuterated toluene, perfluorobenzene and perfluorotoluene. Multiple internal standards should be used if the target analytes cover a very wide volatility range or several different classes of compound.

9.4.3 Obtain a pressurized cylinder containing accurate (±5%) concentrations of the internal standard components selected. Typically a 0.5 to 5.0 mL volume of this standard is automatically introduced onto the back of the sorbent tube or focusing trap after the tube has passed preliminary leak tests and before it is thermally desorbed. The concentration of the gas should be such that the mass of internal standard introduced from the GSV loop is approximately equivalent to the mass of analytes which will be sampled onto the tube during sample collection. For example, a 1 L air sample with average analyte concentrations in the order of 5 ppb, would require a 10 ppm internal standard, if only 0.5 mL of the standard is introduced in each case.

9.5 Commercial, Preloaded Standard Tubes

9.5.1 Certified, preloaded commercial standard tubes are available and should be used for auditing purposes wherever possible to establish analytical quality control (see Section 14). They may also be used for routine calibration. Suitable preloaded standards should be accurate within ±5% for each analyte at the microgram level and ±10% at the nanogram level.

9.5.2 The following information should be supplied with each preloaded standard tube:

- A chromatogram of the blank tube before the standard was loaded with associated analytical conditions and date.
- Date of standard loading
- List of standard components, approximate masses and associated confidence levels
- Example analysis of an identical standard with associated analytical conditions (these should be the same as for the blank tube)
- A brief description of the method used for standard preparation
- Expiration date

9.6 Carrier Gases

Inert, 99.999% or higher purity helium should be used as carrier gas. Oxygen and organic filters should be installed on the carrier gas lines supplying the analytical system. These filters should be replaced regularly according to the manufacturer's instructions.

10. Guidance on Sampling and Related Procedures

10.1 Packing Sorbent Tubes

10.1.1 Commercial Tubes

10.1.1.1 Sorbent tubes are commercially available either prepacked and preconditioned or empty.

10.1.1.2 When electing to purchase empty tubes and pack/condition them as required, careful attention must be paid to the appropriate manufacturer's instructions.

10.1.2 Tube Parameters

10.1.2.1 Key parameters to consider include:

- **Sorbent bed positioning within the tube**. The sampling surface of the sorbent bed is usually positioned at least 15 mm from the sampling end of the tube to minimize sampling errors due to diffusive ingress. The position of the sorbent bed must also be entirely within that section of the tube which is surrounded by the thermal desorption oven during tube desorption.
- **Sorbent bed length**. The sorbent bed must not extend outside that portion of the tube which is directly heated by the thermal desorption oven.
- **Sorbent mesh size**. 20 to 80 mesh size sorbent is recommended to prevent excessive pressure drop across the tube which may cause pump failure. It is always recommended that sorbents be sieved to remove **?**fines" (undersized particles) before use.
- **Use of appropriate sorbent bed retaining hardware inside the tube**. Usually 100 mesh stainless steel gauzes and retaining springs are used in stainless steel tubes and unsilanized, preconditioned glass or quartz wool in glass tubes.
- **Correct conditioning procedures**. See Table 2 and Section 10.2.
- **Bed separation**. If a single tube is to be packed with two or three different sorbents, these must be kept in discreet beds separated by ~3 mm length plugs of unsilanized, preconditioned glass or quartz wool or glass fiber disks and arranged in order of increasing sorbent strength from the sampling end of the tube. Do not use sorbents of widely different maximum temperatures in one tube or it will be difficult to condition the more stable sorbents without exceeding the maximum recommended temperature of the less stable sorbents.

[Note: Silanized glass or quartz wool may be used for labile species such as sulfur or nitrogen containing compounds but should not be taken to temperatures above 250°C.]

- **Compression of bed**. The sorbent bed must not be compressed while packing the tube. Compression of the sorbent can lead to excessive tube impedance and may produce **?**fines".

10.1.2.2 Tubes packed with porous polymer sorbents (Chromosorbs®, Porapaks® and Tenax®) should be repacked after 100 thermal cycles or if the performance criteria cannot be met. Tubes packed with carbonaceous sorbents such as Spherocarb®, Carbotrap™, Carbopack™, Carbosieve™ SIII and Carboxens® should be repacked every 200 thermal cycles or if the safe sampling volume validation procedure fails.

10.2 Conditioning and Storage of Blank Sorbent Tubes

10.2.1 Sorbent Tube Conditioning.

10.2.1.1 The success of sorbent tube sampling for ppb and sub-ppb level air monitoring is largely dependent on artifact levels being at significantly lower levels (<10%) than the masses of analytes collected during air monitoring. A summary of recommended conditioning parameters for various individual sorbents and multibed tubes is given in Table 2. 1/4 inch O.D. sorbent tubes may be adequately conditioned using elevated temperatures and a flow of ultra-pure inert gas. Washing or any other preconditioning of the bulk sorbent is not usually necessary. Appropriate, dedicated tube conditioning hardware should be used for tube conditioning unless the thermal desorption system offers a separate tube conditioning mode.

10.2.1.2 The tube conditioning temperatures and gas flows recommended in Table 2 should be applied for at least 2 hours when a tube is packed with fresh adsorbent or when its history is unknown.

Sorbent tubes which are:

- desorbed to completion during routine analysis (as is normally the case)
- stored correctly (see Section 10.2.2)
- re-issued for air sampling within 1 month (1 week for Chromosorb®, Tenax® and Porapak® porous polymers)
- and are to be used for atmospheres with analytes at the 10 ppb level or above

do not usually require any reconditioning at all before use. However, tubes to be used for monitoring at lower levels should be both reconditioned for 10-15 minutes using the appropriate recommended conditioning parameters and put through a **?**dummy” analysis using the appropriate analytical conditions to obtain blank profiles of each tube before they are issued for sampling.

10.2.1.3 Analytical system conditioning procedures are supplied by system manufacturers. Generally speaking, both system and sorbent tube conditioning processes must be carried out using more stringent conditions of temperature, gas flow and time than those required for sample analysis - within the maximum temperature constraints of all the materials and equipment involved.

10.2.2 Capping and Storage of Blank Tubes.

10.2.2.1 Blank tubes should be capped with ungreased, Swagelok®-type, metal screw-caps and combined PTFE ferrules. The screw caps should be tightened by hand and then an extra 1/4 turn with a wrench. If uncoated aluminum foil is required, tubes should be wrapped individually.

10.2.2.2 Batches of blank, sealed tubes should be stored and transported inside a suitable multi-tube container.

10.3 Record Keeping Procedures for Sorbent Tubes

Sample tubes should be indelibly labeled with a unique identification number as described in Section 8.1.2. Details of the masses and/or bed lengths of sorbent(s) contained in each tube, the maximum allowable temperature for that tube and the date each tube was packed should be permanently recorded. A record should also be made each time a tube is used and each time the safe sampling volume of that tube is retested so that its history can be monitored. If a tube is repacked at any stage, the records should be amended accordingly.

10.4 Pump Calibration and Tube Connection

10.4.1 Tube Deployment

10.4.1.1 Once at ambient temperature, remove the tubes from the storage container, uncap and connect them to the monitoring pumps as quickly as possible using clean, non-outgassing flexible tubing. Multi-bed sorbent tubes must be orientated so that the air sample passes through the series of sorbents in order of increasing sorbent strength (i.e., weaker sorbent first). This prevents contamination of the stronger adsorbent with less volatile components.

10.4.1.2 In all cases the sampling end of the tube must be clearly identified and recorded.

10.4.1.3 A typical sampling configuration for a distributed volume pair of sampling tubes is shown in Figure 4.

10.4.2 Pump Calibration

10.4.2.1 Pumps should be calibrated according to the manufacturer's instructions, preferably at the monitoring location immediately before sampling begins or, alternatively, in a clean environment before the tubes and pumps are transported to the monitoring site. The apparatus required is described in Section 8.1.6. Details of the pump flow rate delivered with a given identified tube and the flow rate, stroke rate or pressure selected on the pump itself should be recorded together with the date.

10.4.2.2 The pump flow rate should be retested at the end of each sampling period to make sure that a constant pump rate was maintained throughout the sample collection period. The flow rate measured at the end of sampling should agree within 10% with that measured at the start of the sampling period for the sample to be considered valid and the average value should be used.

10.5 Locating and Protecting the Sample Tube

The sampling points of individual sorbent tubes or sequential tube samplers should not be unduly influenced by nearby emission sources unless the emission source itself is specifically being monitored. Common sense generally determines the appropriate placement. Field notes on the relative location of known emission sources should be part of the permanent record and identified on the FTDS. Some shelter or protection from high winds (see Section 8.1.7) other extreme weather conditions and high levels of particulates is required for the sample tube if it is to be left unattended during the monitoring period.

10.6 Selection of Pump Flow Rates and Air Sample Volumes

10.6.1 Flow Rate Selection

10.6.1.1 For 1/4 inch O.D. tubes, 50 mL/min is the theoretical optimum flow rate (31). However, negligible variation in retention volume will in fact be observed for pump flow rates varying from 5 to 200 mL/min. Pump flow rates above 10 mL/min are generally used in order to minimize errors due to ingress of VOCs via diffusion. Flow rates in excess of 200 mL/min are not recommended for standard 1/4-inch sample tubes unless for short term (e.g. 10 minute) monitoring (21).

[Note: High sampling flow rates can be used longer term for high boiling materials such as low level, vapor phase polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in air.]

10.6.1.2 One and four liter air sample volumes are recommended for this method if consistent with anticipated safe sampling volumes. Adjustments of the flow rates to accommodate low safe sampling volumes should be made by proportionally reducing both rates with the qualification that the lower flow rate result is no less than 300 mL total volume. The 300 mL sample gives adequate detection limits (<0.5 ppb per analyte) with full scan mass spectrometry detection for ambient air applications (see Table 4). Sensitivity is generally enhanced at least ten-fold if conventional GC detectors or selected ion monitoring are applied. However; the pump flow rate, sampling time and consequently air volume selected may be varied to suit the requirements of each individual air monitoring exercise.

10.6.1.3 Typical example pump flow rates include:

- 16 mL/min to collect 1 L air samples in 1 hour
- 67 mL/min to collect 4 L air samples in 1 hour
- 10 mL/min to collect 1800 mL air samples over 3 hours
- 40 mL/min to collect 7200 mL air samples over 3 hours

10.6.2 Pump Flow Rate Selection

10.6.2.1 The pump flow rate used is dependent upon:

- **Safe sampling volume constraints**. The flow rate must be adjusted (within the allowed range) to ensure that, for the chosen sample collection time, SSVs are not exceeded for any target analyte
- **Time weighted average monitoring requirements**. If long-term - 3, 8 or even 24 hour - time weighted average data are required, the pump flow rate must be adjusted to ensure SSVs are not exceeded during the sample collection period.
- **GC detection limits**. Within the constraints of safe sampling volumes and pump flow rate limits, air volumes selected for trace level (ambient) air monitoring, should be maximized such that the largest possible analyte masses are collected.

10.6.2.2 Typical VOC concentrations and the associated analyte masses retained from a range of different air sample volumes in various atmospheres are presented in Table 4.

10.7 Sampling Procedure Verification - Use of Blanks, Distributed Volume Pairs, Back-Up Tubes, and Distributed Volume Sets

10.7.1 Field and Laboratory Blanks

10.7.1.1 Laboratory blanks must be identically packed tubes, from the same batch, with similar history and conditioned at the same time as the tubes used for sample collection. At least two are required per monitoring exercise. They must be stored in the laboratory in clean controlled conditions (<4°C) throughout the monitoring program and analyzed at the same time as the samples-- one at the beginning and one at the end of the sequence of runs.

10.7.1.2 Field blanks are the same as laboratory blanks except that they are transported to and from the monitoring site, are uncapped and immediately resealed at the monitoring site, but do not actually have air pumped through them. One field blank tube is taken for every ten sampled tubes on a monitoring exercise and no less than two field blanks should be collected, however small the monitoring study. The field blanks should be distributed evenly throughout the set of sampled tubes to be analyzed. Guidance on acceptable performance criteria for blanks is given in Section 13.

10.7.2 Distributed Volume Pairs

10.7.2.1 When monitoring for specific analytes using a validated sorbent tube but in an uncharacterized atmosphere, it is advisable to collect distributed volume tube pairs - e.g. 1 and 4 L samples - in parallel at every monitoring location as described in Section 6. If single tube sampling is used to reduce analysis costs, a reduction in the quality assurance associated with this method has to be assumed.

10.7.2.2 Back-up tubes (identical to those used for sample collection) should be used to investigate situations in which distributed volume pairs do not agree within acceptable tolerance. To use back-up tubes, a second identical sampling tube is placed in series with a primary (front) tube. The purpose of the backup tube is to capture compounds that pass through the primary tube because of breakthrough. Analysis of the backup tube may indicate unexpected breakthrough or give evidence of channeling of sample through the tube because of loose packing.

10.7.2.3 A significant volume of literature exists on the use of distributed volume sets to determine the occurrence of nonlinearities when different sample volumes are taken from the same sample air mix. Ideally, the quantity of material collected scales linearly with sample volume. If this is not the case, then one of a number of problems has occurred. The 4-tube distributed volume developed by Walling, Bumgardner, and co-workers (32,33) is a method by which sample collection problems can be investigated.

10.8 Determining and Validating Safe Sampling Volumes (SSV)

10.8.1 Field Test Method for Tube Breakthrough.

10.8.1.1 If SSV information is not readily available for the analytes under test on the sorbent tube selected, or if the safe sampling volumes need validating - the following field experiment may be used. Link at least 12 of the sorbent tubes under test together in series to give 6 pairs of tubes. Use inert, preferably Swagelok®-type 1/4-inch metal unions with PTFE fittings. The sampling end of the back up tube should be connected to the exit end of the front tube in each of the pairs. The tube pairs are then connected to calibrated monitoring pumps and used to simultaneously sample at least 3 different air volumes at pump flow rates between 10 and 200 mL/min with 2 replicates at each air sample volume.

10.8.1.2 The experiment should be carried out in the atmosphere to be monitored and, if possible, under worst-case conditions (i.e., highest natural humidity and highest typical VOC concentrations). The sampling points of all the tube pairs should be placed close together to ensure that, as far as possible, tubes are all sampling the same atmosphere. The sampling location selected should be well ventilated. Both the front and back-up tubes of each tube pair should subsequently be analyzed using thermal desorption - capillary GC.

10.8.1.3 If more than 5% of one or more of the target analytes is observed on any of the back-up tubes, breakthrough is shown to have occurred at that sample volume. For practical purposes, the BV for a given sorbent/analyte combination is usually considered to be the sample volume at which there is 5% breakthrough of that analyte onto the back-up tube. The SSV for that analyte/sorbent combination is then taken as two thirds (~66%) of the BV.

10.8.2 Chromatographic Test of Tube Retention Volume for Individual Analytes

10.8.2.1 Inject 0.5 mg of each analyte into a stoppered ~1L volume glass flask fitted with a septum. Check that all the analyte has evaporated.

10.8.2.2 Connect the sample tube under test to a 1/4 inch injection port inside a GC oven. Use 530 μm, uncoated fused silica capillary tubing, or other appropriate narrow bore tubing, to connect the other end of the sample tube to a FID detector. Use 1/4 inch fittings with graphite ferrules to connect to the sample tube itself.

10.8.2.3 Set a nitrogen carrier gas flow of 50 mL/min through the tube.

10.8.2.4 Inject a 0.1 mL sample of the vapor phase standard onto the tube using a gas syringe. Adjust the GC oven temperature so that the analyte peak elutes on the FID between 1 and 20 minutes.

10.8.2.5 Repeat the experiment 4 or 5 times using different GC oven temperatures. Try to ensure that at each of the GC temperatures selected, the peak elutes within 1-20 minutes.

[Note: Use the time from injection to peak crest as the retention time. This may have to be measured manually, depending on the type of integrator available.]

10.8.2.6 Inject a sample of methane to measure the delay time of the system and subtract this from the analyte retention times determined.

10.8.2.7 Use the flow of nitrogen carrier gas and corrected retention times to calculate the analyte retention volumes at different sorbent temperatures.

10.8.2.8 A graph of $\log_{10}$ retention volume vs. 1/temp(K) should produce a straight line plot which can be readily extrapolated to ambient temperatures. Use this plot to obtain the retention volume.

A SSV for the analyte on that sorbent tube is then derived by halving the calculated retention volume at ambient temperature. When required, this experiment should be carried out for the least well retained compound(s) of interest.

10.9 Resealing Sorbent Tubes After Sample Collection

Sampled tubes should be recapped with the metal, Swagelok®-type caps and combined PTFE ferrules, rewrapped in the aluminum foil (if appropriate) and replaced in the storage container immediately after sampling. They should not be removed from the sampling container until they are in the laboratory and about to be analyzed.

10.10 Sample Storage

Samples should be refrigerated at <4°C in a clean environment during storage and analyzed within 30 days of sample collection (within one week for limonene, carene, *bis*-chloromethyl ether and labile sulfur or nitrogen-containing volatiles). Samples taken on tubes containing multiple sorbent beds should be analyzed as soon as possible after sampling unless it is know in advance that storage will not cause significant sample recovery errors (see also Section 7.1.3 concerning artifacts).

11. Analytical Procedure

11.1 Preparation for Sample Analysis

Follow the description given in Compendium Method TO-15 for set up of the GC/MS analytical system including column selection, MS tune requirements, calibration protocols, etc.

11.2 Predesorption System Checks and Procedures

The following sample and system integrity checks and procedures must be carried out manually or automatically before thermal desorption:

- **Dry purge**. Dry purge the batch of sampled, back-up and field blank tubes (do not purge lab blanks).
- **Cap**. Cap tubes with PTFE ‘analytical’ caps and place on instrument carousel.
- **Leak test the tubes**. Each tube must be stringently leak tested at the GC carrier gas pressure, without heat or gas flow applied, before analysis. Tubes which fail the leak test should not be analyzed, but should be resealed and stored intact. On automated systems, the instrument should continue to leak test and analyze subsequent tubes after a given tube has failed. Automated systems should also store a record of which tubes in a sequence have failed the leak test in battery-protected system memory until the error is acknowledged by an operator. These measures prevent sample losses and help ensure data quality.

- **Leak test the sample flow path**. All parts of the sample flow path should be stringently leak tested before each analysis without heat or gas flow applied to the sample tube. An automatic sequence of tube desorptions and GC analyses should be halted if any leak is detected in the main sample flow path.
- **Purge air**. Purge air from the tube and sample flow path at ambient temperature using carrier gas immediately before tube desorption. It helps to dry the sample and prevents analyte and sorbent oxidation thus minimizing artifact formation, ensuring data quality and extending tube lifetimes. The focusing trap should be in-line throughout the carrier gas purge to retain any ultra-volatile analytes "desorbed" from the tube prematurely.
- **Check GC/MS analytical system ready status**. The "ready" status of the GC, detector(s), data processor and all parts of the analytical system should be automatically checked by the thermal desorption device before each tube desorption. It should not be possible to desorb a tube into the analytical system if it is not ready to accept and analyze samples.
- **Internal standard**. Introduce a gas phase internal standard onto the sorbent tube or focusing trap before primary (tube) desorption, as an additional check of system integrity (optional).

A series of schematics illustrating these steps is presented in Figure 3, Steps (a) through (f).

11.3 Analytical Procedure

11.3.1 Steps Required for Reliable Thermal Desorption.

11.3.1.1 A stepwise summary of the complete thermal desorption procedure is as follows:

- Predesorption system checks (see Section 11.2).
- Introduction of a fixed volume gas phase internal standard (optional) [see Figure 3, Step (d)].
- Desorption of the sorbent tube (typically 200-300°C for 5-15 minutes with a carrier gas flow of 30-100 mL/min - see Table 2) and refocusing of the target analytes on a focusing trap held at near- ambient or subambient temperatures [see Figure 3, Step (e)].

[Note: Analytes should be desorbed from the tube in ?backflush" mode, i.e., with the gas flow in the reverse direction to that of the air flow during sampling].

- Splitting the sample as it is transferred from the tube to the focusing trap (Optional). This is only required to prevent column or detector overload due to excess water accumulation or during the analysis of high concentration/large volume air samples or when using ultra-sensitive detectors such as the ECD [see Figure 3, Step (e)].
- Rapid desorption of the focusing trap (typically 40 deg/sec. to a top temperature of 250-350°C, with a ?hold" time of 1-15 mins at the top temperature and an inert/carrier gas flow of 3-100 mL/min) and transfer of the analytes into the analytical column [see Figure 3, Step (f)].

[Note: Components should normally be desorbed from the focusing trap in ?backflush" mode, i.e., with the gas flow through the 'cold' trap in the reverse direction to that used during analyte focusing.]

- Splitting the sample as VOCs are transferred from the focusing trap to the analytical column. (Optional). This is only required to prevent column or detector overload due to excess water accumulation or during the analysis of high concentration/large volume air samples or when using ultra-sensitive detectors such as the ECD [See Figure 3, Step (f)].
- Desorbing the focusing trap initiates the GC run. [See Figure 3, Step (f)].

- All volatiles should be stripped from the sorbent tubes during the thermal desorption process leaving them clean and ready for reuse. The tubes should be resealed to ensure they are kept clean and ready for immediate reuse while the sequence of tube desorptions and analyses is completed.

11.3.2 GC/MS Analytical Procedure

11.3.2.1 Once the GC run has been initiated by desorption of the focusing trap, the chromatographic procedure continues as described in Compendium Method TO-15.

11.3.2.2 The precision of the analytical system should be tested using six standard tubes all loaded with a mid-concentration-range standard. This procedure should be carried out whenever the thermal desorption - GC/MS analytical method is changed and should be repeated once every tenth series of samples run with an analytical method or once every three months, whichever happens first. The report produced from the most recent precision test should be included with the final batch report generated for each series of samples.

12. Calibration of Response

Descriptions of how to load tubes from standard atmospheres, concentrated gas phase standards or liquid standards are given in Sections 9.2 and 9.3. Once the tubes are desorbed to the focusing trap and into the analytical GC/MS system the calibration procedure becomes identical to that presented in Section 3 of Compendium Method TO-15. The guidance given in Section 3 of Compendium Method TO-15 concerning multi-level calibration procedures and calibration frequencies should be followed for this Compendium method. It is also advisable to analyze a single level calibrant (i.e. tubes loaded with analyte masses in the mid-range of those expected to be collected during sampling) approximately every tenth sample during an analytical sequence, as a check on system performance. All samples processed that exceed the calibration range will require data qualifiers to be attached to the analytical results.

13. Quality Assurance

13.1 Validating the Sample Collection Procedure

13.1.1 Blanks.

13.1.1.1 Artifact levels on laboratory and field blanks should be at the low or sub-nanogram level for carbonaceous sorbents and Tenax® and at the double digit ng level for Porapaks®, Chromosorb® Century series sorbents and other porous polymers as described in Section 7.1. If artifact levels are considerably above this, careful attention must be paid to the tube conditioning and storage procedures described in Sections 10.2.1 and 10.2.2. Artifact peaks which are 10% or more of the area of average component peaks should be marked as artifacts in the final data reports. When monitoring unknown atmospheres, special care must be taken to distinguish between sorbent artifacts and analytes, using the MS to identify components which are significant in both blank and sampled tubes.

13.1.1.2 If the same profile/pattern of VOCs is observed on the field blanks as on the sampled tubes and if the level of these components is 5% or more of the sampled volatiles, careful attention must be paid to the method of sealing the tubes and other storage procedures in future studies. If the profile of volatiles on the field blanks matches that of the sampled tubes and if the areas of the peaks on the field blank are 10% or more of sampled tube levels, the sampled tube data are invalidated.

13.1.2 Routine Checking of Sorbent Tube Safe Sampling Volumes.

13.1.2.1 The SSVs of sorbent tubes should be retested annually or once every 20 uses (whichever happens first) using one of the procedures described in Section 10.8.

13.1.2.2 If the SSV of a tube (i.e., half the RV or two thirds of the BV) falls below the normal air sample collection volume for the analytes in question, the tube should be repacked with fresh adsorbent and reconditioned.

13.2 Performance Criteria for the Monitoring Pump

Records of the pump flow rate delivered against the pump flow rate, stroke rate or pressure selected on a pump should be reviewed at least once per three months. If the performance of any pump has been found to have changed significantly over that time; for example if completely different pump settings are required to deliver the same pump flow rate, the pump should be serviced by the manufacturer or their approved agent.

Sampling pump errors can normally be presumed to be in the order of 5% (8). If the pump sampling flow rate measured at the end of sample collection varies more than 10% from that measured at the beginning of sample collection, then that sample is invalidated.

14. Performance Criteria for the Solid Adsorbent Sampling of Ambient Air

14.1 Introduction

There are four performance criteria which must be met for a system to qualify under Compendium Method TO-17. These criteria closely parallel those of Compendium Method TO-15, *"The Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)"*. These criteria are:

- A method detection limit $\leq$0.5 ppb.
- Duplicate (analytical) precision within 20% on synthetic samples of a given target gas or vapor in a typical target gas or vapor mix in humidified zero air.
- Agreement within 25% for distributed volume pairs of tubes taken in each sampling set.
- Audit accuracy within 30 percent for concentrations normally expected in contaminated ambient air (0.5 to 25 ppb). Either mass spectrometry as emphasized here, or specific detectors can be used for analysis. Details for the determination of each of the criteria follow.

14.2 Method Detection Limit

The procedure chosen to define the method detection limit is that given in the Code of Federal Regulations (40CFR136 Appendix B). The method detection limit is defined for each system by making seven replicate measurements of a concentration of the compound of interest near the expected detection limit (within a factor of five), computing the standard deviation for the seven replicate concentrations, and multiplying this value by 3.14 (the Student's t value for 99 percent confidence for seven values).

14.3 Analytical Precision of Duplicate Pairs

The measure of analytical precision used for this method is the absolute value of the relative difference between two identical samples (same flow rate over the same time period from with a common inlet to the sample volume). The analytical precision is expressed as a percentage as follows:

$$\text{Analytical Precision} = \left(\frac{[|X1 - X2|]}{X}\right) 100$$

where:

X1 = A measurement value taken from one of the two tubes using in sampling.
X2 = A measurement value taken from the second of two tubes using in sampling.
X = Average of X1 and X2.

The analytical precision is a measure of the precision achievable for the entire sampling and analysis procedure including the sampling and thermal desorption process mentioned above and the analytical procedure that is same as the TO-15 analytical finish, although specific detector systems can also be used.

14.4 Precision for the Distributed Volume Pair

The measure of precision used for this method is the absolute value of the relative difference between the distributed volume pair expressed as a percentage as follows:

$$\text{percent difference} = \left(\frac{[|X1 - X2|]}{X}\right) 100$$

where:

X1 = One measurement value (e.g., for a defined sample volume of 1 L).
X2 = Duplicate measurement value (e.g., for a defined sample volume of 4 L taken over the same time period as the first sample).
X = Average of the two values.

There are several factors that may affect the precision of the measurement as defined above. In fact any factor that is nonlinear with sample volume may be significant enough to violate the constraint placed on distributed volume pair precision. These factors include artifact formation, compound reactions on the sorbent, breakthrough of target compounds, etc.

14.5 Audit Accuracy

A measure of audit accuracy is the degree of agreement with audit standards. Audit accuracy is defined as the relative difference between the measurement result and the nominal concentration of the audit compound:

$$\text{Audit Accuracy, \%} = \left[\frac{(\text{Spiked Value} - \text{Observed Value})}{(\text{Spiked Value})}\right] \text{x } 100$$

The choice of audit standard is left to the analyst.

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TABLE 1. GUIDELINES FOR SORBENT SELECTION

Sample Tube Sorbent	Approx. Analyte Volatility Range	Max. Temp., (°C)	Specific Surface Area, (m^2/g)	Example Analytes
CarbotrapC® CarbopackC® Anasorb® GCB2	n-C_8 to n-C_{20}	>400	12	Alkyl benzenes and aliphatics ranging in volatility from n-C to n-C .
Tenax® TA	bp 100°C to 400°C n-C_7 to n-C_{26}	350	35	Aromatics except benzene, Apolar components (bp>100°C) and less volatile polar components (bp>150°C).
Tenax GR	bp 100°C to 450°C n-C_7 to n-C_{30}	350	35	Alkyl benzenes, vapor phase PAHs and PCBs and as above for Tenax TA.
Carbotrap® CarbopackB® Anasorb® GCB1	(n-C_4) n-C_5 to n-C_{14}	>400	100	Wide range of VOCs inc., ketones, alcohols, and aldehydes (bp>75°C) and all apolar compounds within the volatility range specified. Plus perfluorocarbon tracer gases.
Chromosorb® 102	bp 50°C - 200°C	250	350	Suits a wide range of VOCs incl. oxygenated compounds and haloforms less volatile than methylene chloride.
Chromosorb 106	bp 50°C - 200°C	250	750	Suits a wide range of VOCs incl. hydrocarbons from n-C to n-C . Also good for volatile oxygenated compounds
Porapak Q	bp 50°C - 200°C n-C_5 to n-C_{12}	250	550	Suits a wide range of VOCs including oxygenated compounds.
Porapak N	bp 50°C - 150°C n-C_5 to n-C_8	180	300	Specifically selected for volatile nitriles; acrylonitrile, acetonitrile and propionitrile. Also good for pyridine, volatile alcohols from EtOH, MEK, etc.
Spherocarb*	-30°C - 150°C C_3 to n-C_8	>400	1,200	Good for very volatile compounds such as VCM, ethylene oxide, CS and CH Cl . Also good for volatile polars e.g. MeOH, EtOH and acetone.
Carbosieve SIII*® Carboxen 1000*® Anasorb® CMS*	-60°C to 80°C	400	800	Good for ultra volatile compounds such as C C hydrocarbons, volatile haloforms and freons.
Zeolite Molecular Sieve 13X**	-60°C to 80°C	350		Used specifically for 1,3- butadiene and nitrous oxide.
Coconut Charcoal* (Coconut charcoal is rarely used)	-80°C to 50°C	>400	>1,000	Rarely used for thermal desorption because metal content may catalyze analyte degradation. Petroleum charcoal and Anasorb® 747 are used with thermal desportion in the EPA's volatile organic sampling train (VOST), Methods 0030 and 0031.

* These sorbents exhibit some water retention. Safe sampling volumes should be reduced by a factor of 10 if sampling a high (>90%) relative humidity.

** Significantly hydrophilic. Do not use in high humidity atmospheres unless silicone membrane caps can be fitted for diffusive monitoring purposes.

CarbotrapC™, CarbopackC™, CarbopackB™, Carboxen™ and Carbosieve SIII™ are all trademarks of Supelco, Inc., USA; Tenax® is a trademark of Enka Research Institute; Chromosorb® is a trademark of Manville Corp.; Anasorb® is a trademark of SKC, Inc.; Porapak® is a trademark of Waters Corporation.

TABLE 2. GUIDELINES FOR SORBENT USE

Sample Tube Sorbent	Maximum Temp., (°C)	Hydro-phobic (?)	Temp. and Gas Flow for Conditioning	Temp. and Min. Gas Flow for Desorption	Recommended Focusing Trap Packing
CarbotrapC® CarbopackC® Anasorb® GCB2	>400	Yes	350°C and 100 mL/min	325°C and 30 mL/min	Tenax® or Carbopack C®
Tenax® TA	350	Yes	330°C and 100 mL/min	300°C and 30 mL/min	Tenax®
Tenax GR	350	Yes	330°C and 100 mL/min	300°C and 30 mL/min	Tenax®
Carbotrap® CarbopackB® Anasorb® GCB1	>400	Yes	350°C and 100 mL/min	325°C and 30 mL/min	Tenax or Carbopack B®
Chromosorb® 102	250	Yes	250°C and 100 mL/min	225°C and 30 mL/min	Dual-bed CB plus CMS trap or Chrom. 102
Chromosorb 106	250	Yes	250°C and 100 mL/min	250°C and 30 mL/min	Dual-bed CB plus CMS trap or Chrom. 106
Porapak Q	250	Yes	250°C and 100 mL/min	225°C and 30 mL/min	Dual-bed CB plus CMS trap or Porapak Q
Porapak N	180	Yes	180°C and 100 mL/min	180°C and 30 mL/min	Dual-bed CB plus CMS trap or Porapak N
Spherocarb*	>400	No	400°C and 100 mL/min	390°C and 30 mL/min	Dual-bed CB plus CMS trap or Spherocarb
CMS such as CSIII*® Carboxen 1000*® Anasorb® CMS*	400	No	350°C and 100 mL/min	325°C and 30 mL/min	Dual-bed CB plus CMS trap or CMS alone
Zeolite Molecular Sieve 13X**	350	No	330°C and 100 mL/min	300°C and 30 mL/min	Dual-bed CB plus CMS trap or CMS alone
Tenax / CB : comb. Tube Type 1 (see Sect. 9.1.3)	350	Yes	330°C and 100 mL/min	300°C and 30 mL/min	Tenax
Carb B / CMS* comb. Tube Type 2 (see Sect. 9.1.3)	400	No	350°C and 100 mL/min	325°C and 30 mL/min	Dual-bed CB plus CMS trap
Carb. 300 type*, comb. Tube Type 3 (see Sect. 9.1.3)	400	No	350°C and 100 mL/min	325°C and 30 mL/min	Dual-bed CB plus CMS trap

* These sorbents exhibit some water retention. Safe sampling volumes should be reduced by a factor of 10 if sampling a high (>90%) relative humidity.

** Significantly hydrophilic. Do not use in high humidity atmospheres unless silicone membrane caps can be fitted for diffusive monitoring purposes.

CB is short for Carbopack B and CMS is short for carbonized molecular sieve.

CarbotrapC™, CarbopackC™, CarbopackB™, Carboxen™ and Carbosieve SIII™ are all trademarks of Supelco, Inc., USA; Tenax® is a trademark of Enka Research Institute; Chromosorb® is a trademark of Manville Corp.; Anasorb® is a trademark of SKC, Inc.; Porapak® is a trademark of Waters Corporation.

TABLE 3 - LIST OF COMPOUNDS WITH BREAKTHROUGH VOLUMES >5L USING THE AIR TOXICS TUBE STYLE 2 LISTED IN SECTIONS 6.1.2 AND 9.1.3 OF COMPENDIUM METHOD TO-17

*[Note: The following list of compounds was determined to have breakthrough volumes of greater than 5 liters of trace levels in humidified zero air for humidities of 20%, 65% and 90% RH at 25°C. The tests were performed immediately prior to the publication of this document at the Research Triangle Institute, Research Triangle Park, NC as a result of activities leading up to the publication of this document. Compounds with an * were not tested at 90% RH.]*

Halocarbon 114
1,3,5-Trimethylbenzene
Halocarbon 11
1,2,4-Trimethylbenzene
Halocarbon 113
Dichlorobenzenes
1,1-Dichloroethene
1,2,4-Trichlorobenzene
Methylene Chloride
Hexachloro-1,3,-butadiene
1,1 Dichloroethane
*1,3 Butadiene
cis-1,2-Dichloroethene
*Acetonitrile
Chloroform
*Acetone
1,1,1-Trichloroethane
*2-Propanol
Carbon tetrachloride
*Acrylonitrile
Benzene
*Isoprene
1,2-Dichloroethane
*Methyl Acetate
Trichloroethene
*Methyl tert-Butyl Ether
1,2-Dichloropropane
*Methyl Ethyl Ketone
cis-1,3-Dichloropropene
*Ethyl Acrylate
Toluene
*Methyl Acrylate
Trans-1,3-Dichloropropene
*Methyl Isobutyl Ketone
*Furfural
Tetrachloroethene
1,2-Dibromoethane
Chlorobenzene
Ethylbenzene
m-Xylene
p-Xylene
o-Xylene
1,1,2,2-Tetrachloroethane

TABLE 4. MASS OF AN ANALYTE 'X' COLLECTED FROM 1, 2 OR 10 L AIR SAMPLES AT DIFFERENT ATMOSPHERIC CONCENTRATIONS
(ASSUMING 'X' HAS A MOLAR WEIGHT OF 100 g)

Sample type	Typical concentration	Mass collected in 1 L sample volume	Mass collected in 2 L sample volume	Mass collected in 10 L sample volume
Fenceline/severe urban area	10-250 ppb	40-1,000 ng	80 ng-2 μg	0.4-10μg
Indoor air sampling	1-100 ppb	4-400 ng	8-800 ng	40 ng-4μg
Avg. exposure to benzene	~3 ppb	11 ng	22 ng	110 ng
Normal urban area	1-10 ppb	4-40 ng	8-80 ng	40-400 ng
Normal rural area	0.1-1 ppb	0.4-4 ng	0.8-8 ng	4-40 ng
Forested area	0.25-2.5 ppb	1-10 ng	2-20 ng	10-100 ng
Mt. Everest/K2 site	0.025-7.5 ppb	0.1-30 ng	0.2-60 ng	1-300 ng
Arctic on an ultraclean day	15-50 ppt	60-200 pg	0.12-0.4 ng	0.6-2 ng

COMPENDIUM METHOD TO-17
FIELD TEST DATA SHEET (FTDS)

I. GENERAL INFORMATION

PROJECT:________________________
SITE:____________________________
LOCATION:______________________
INSTRUMENT MODEL NO.:_________
PUMP SERIAL NO.:________________

DATE(S) SAMPLED:______________________
TIME PERIOD SAMPLED:_________________
OPERATOR:_____________________________
CALIBRATED BY:________________________
RAIN: ____YES _____NO

ADSORBENT CARTRIDGE INFORMATION:

	Tube 1	Tube 2
Type:	__________	__________
Adsorbent:	__________	__________
Serial No.:	__________	__________
Sample No.:	__________	__________

II. SAMPLING DATA

Tube Identification	Sampling Location	Ambient Temp., °F	Ambient Pressure, in Hg	Flow Rate (Q), mL/min		Sampling Period		Total Sampling Time, min.	Total Sample Volume, L
				Tube 1	Tube 2	Start	Stop		

III. FIELD AUDIT

	Tube 1	Tube 2
Audit Flow Check Within 10% of Set Point (Y/N)?	_ pre- __________ post-	_ pre- __________ post-

CHECKED BY:____
DATE:____

Figure 1. Compendium Method TO-17 Field Test Data Sheet.

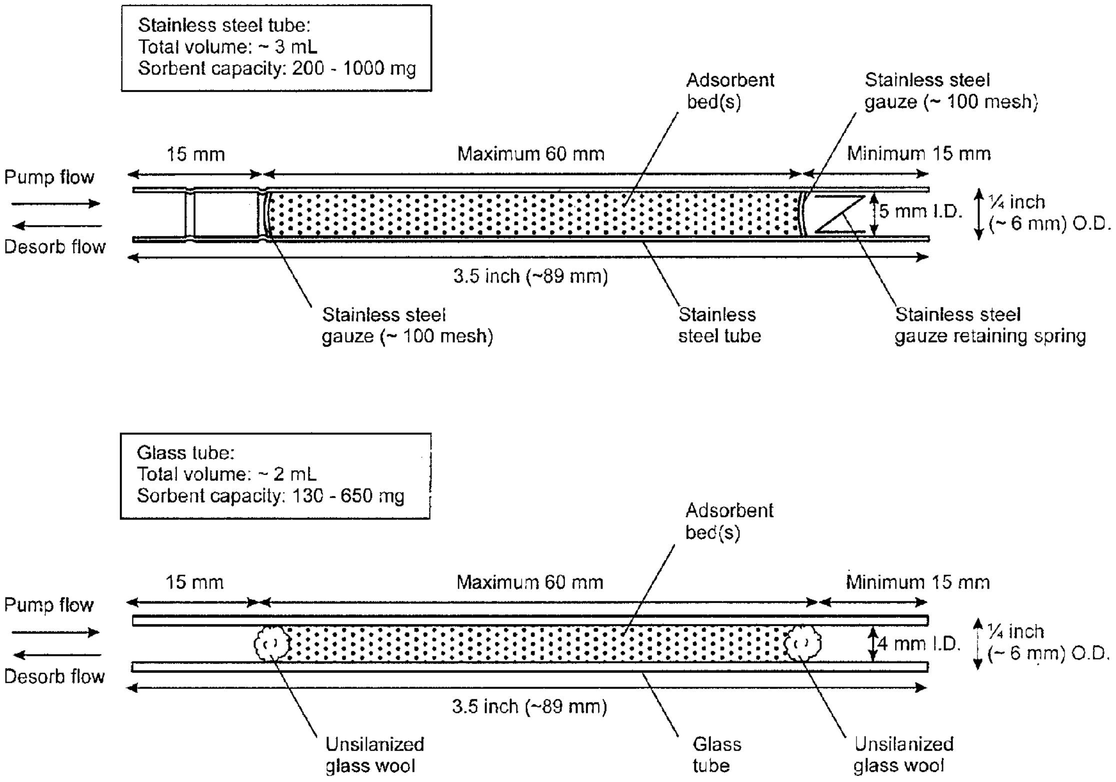
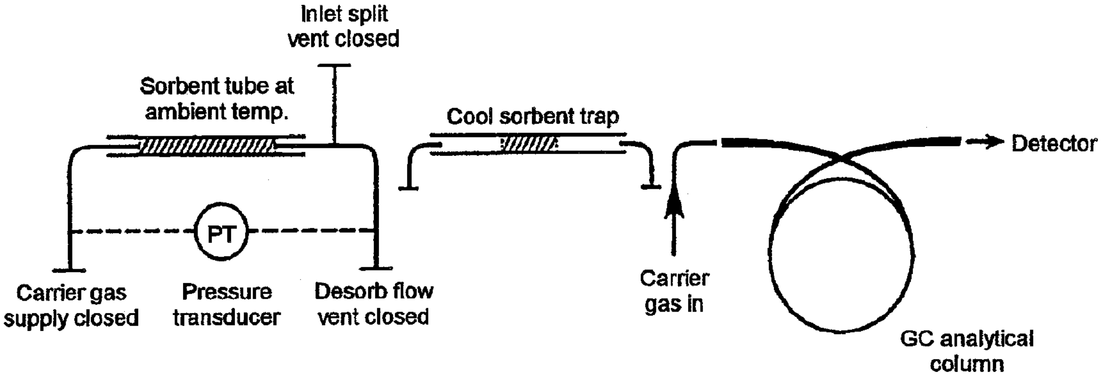
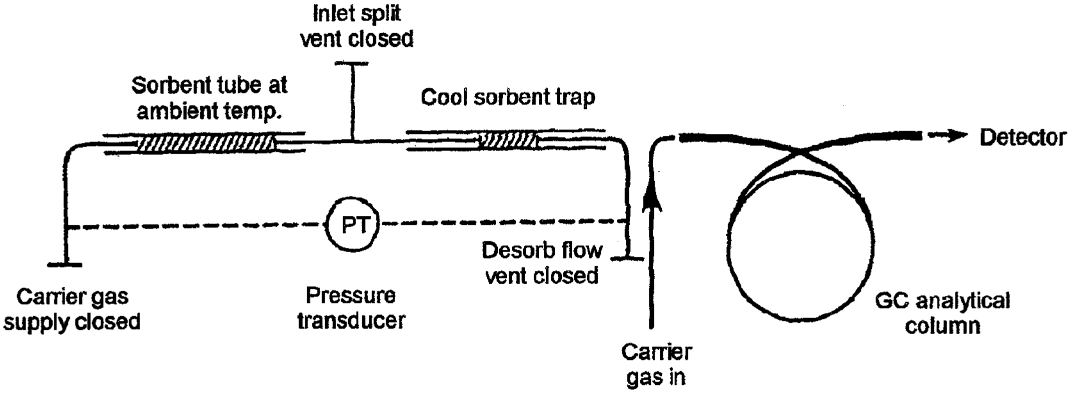


Figure 2. Example of construction of commercially available adsorbent tubes.

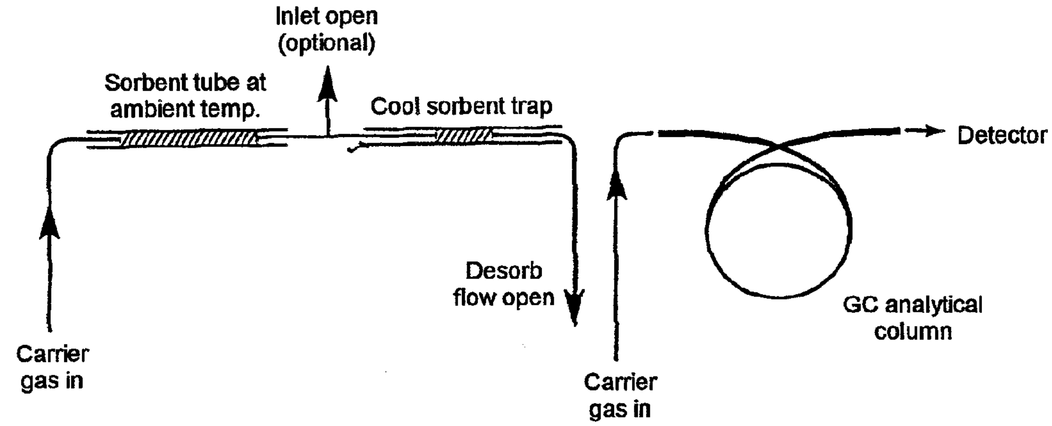


(a) **Tube leak check.**

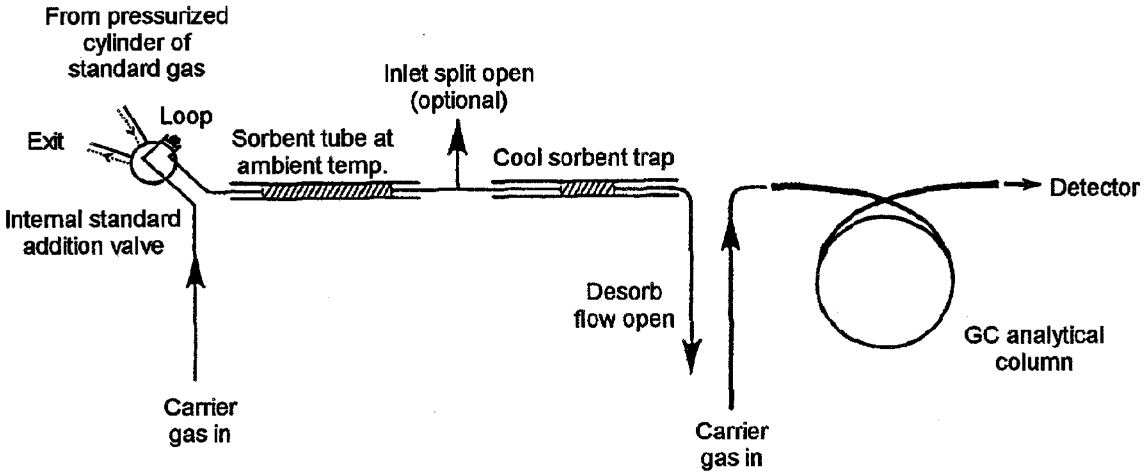


(b) **Leak check sample flow path.**

Figure 3. Sequence of operations to thermally desorb the sample from the sorbent tube and transfer to the gas chromatograph: (a) tube leak test and (b) leak check flow path.

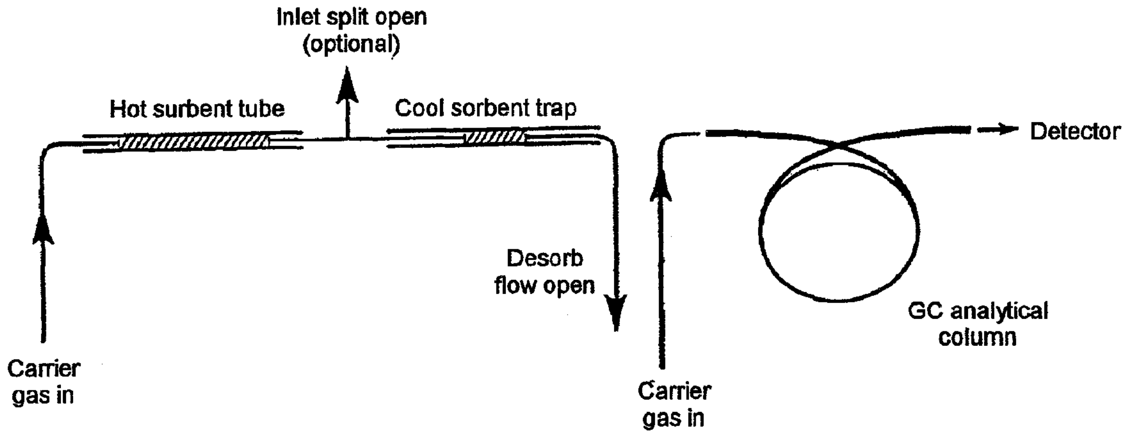


(c) Purge to remove air.

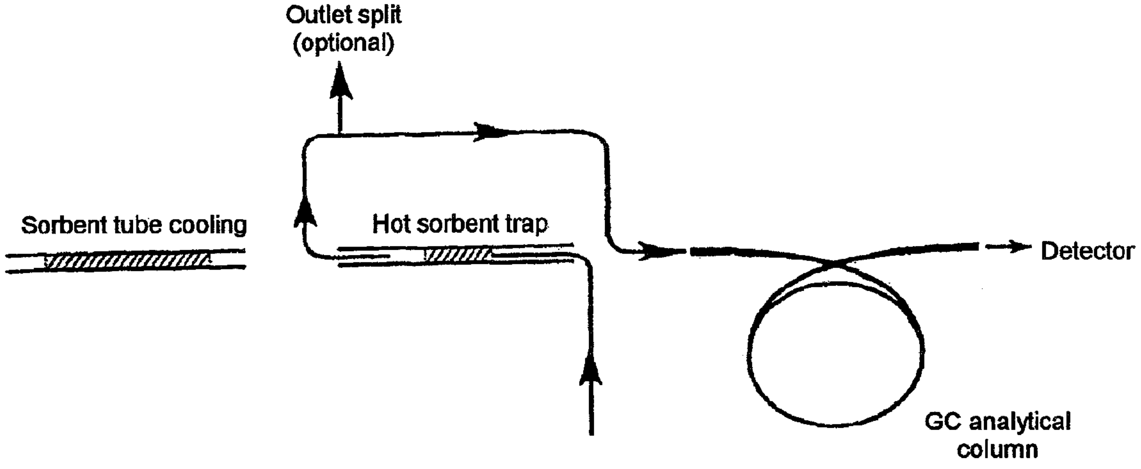


(d) Gas phase internal standard addition to sample tube.

Figure 3 (cont). Sequence of operations to thermally desorb the sample from the sorbent tube and transfer to the gas chromatograph: (c) purge to remove air and (d) gas phase internal standard addition to sample tube.



(e) Primary (tube) desorption.



(f) Secondary (trap) desorption.

Figure 3 (cont). Sequence of operations to thermally desorb the sample from the sorbent tube and transfer to the gas chromatograph: (e) primary (tube) desorption and (f) secondary (trap) desorption.

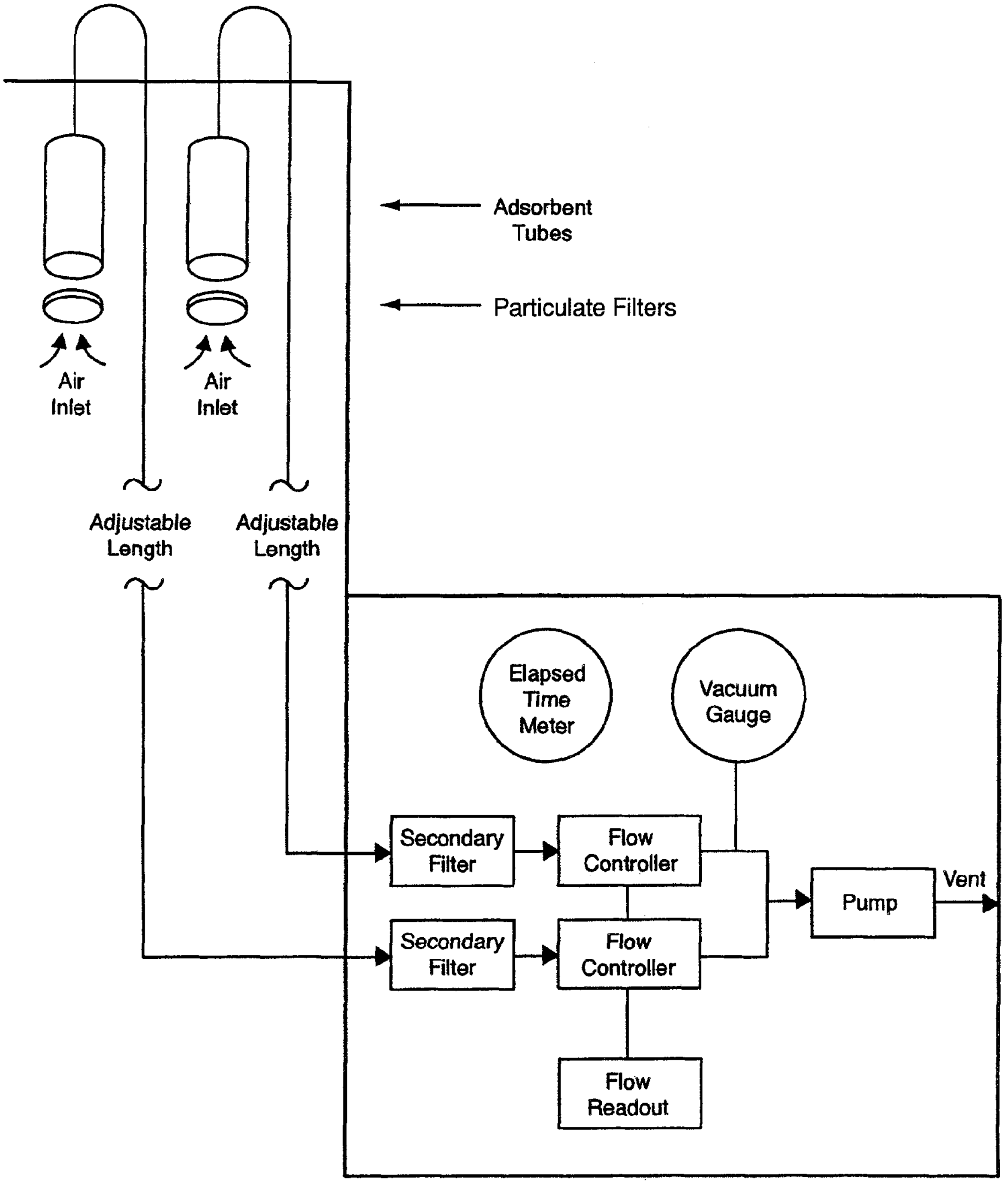


Figure 4. Example of distributive air volume using adsorbent tube technology.

APPENDIX 1.

The following list includes safe sampling volume data generated by the UK Health and Safety Executive (4) on single sorbent bed 1/4 inch O.D. stainless steel tubes and compatible with a thermal desorption - capillary GC analytical procedure. It is provided as a resource to readers only. The recommendation for Tube Style 2 is based on the specific tube referenced in Section 6.1.2 and Table 3. Where tubes are not listed with safe sample volumes they have not been tested and their inclusion represents a suggestion only. Application to air sampling is subject to criteria listed in Section 14 of Compendium Method TO-17.

[Note: Combination tubes 1, 2, and 3 referenced in this Appendix are those adsorbent tubes described in Section 9.1.3.]

Compound	Suitable sorbents and SSV's where available

Hydrocarbons

This procedure is suitable for all aliphatic, aromatic and cyclic hydrocarbons less volatile than ethane and more volatile than n-C20. These include:

n-Butane	CS III, C 1000, Combination Tubes 2 or 3 or Spherocarb (SSV 820L).
n-Pentane	CS III, C 1000, Spherocarb (SSV 30,000L), Combination Tubes 2 or 3 or Chromosorb 106 (SSV 5.5L).
n-Hexane	Carbopack™ B, Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 30L).
Benzene	Carbopack™ B, Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 26L) or Tenax (SSV 6L).
n-Heptane	Carbopack™ B, Tenax (SSV 17L), Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 160L).
Toluene	Carbopack™ B, Tenax (SSV 38L), Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 80L).
n-Octane	Carbopack™ B, Tenax (SSV 700L) Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 1000L).
Ethylbenzene	Carbopack™ B, Tenax (SSV 180L), Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 360L).
all Xylenes	Carbopack™ B, Tenax (SSV 300L), Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 770L).
n-Nonane	Carbopack™ C/B, Tenax (SSV 700L), Combination Tubes 1, 2 or 3 or Chromosorb 106 (SSV 7000L).
Styrene	Carbopack™ C/B, Tenax (SSV 300L) or Combination Tubes 1, 2 or 3.
Isopropylbenzene	Carbopack™ C/B, Tenax (SSV 480L) or Combination Tubes 1, 2 or 3.
n-Propylbenzene	Carbopack™ C/B, Tenax (SSV 850L) or Combination Tubes 1, 2 or 3.
1-Methyl-3-ethylbenzene	Carbopack™ C/B, Tenax (SSV 1000L) or Combination Tubes 1, 2 or 3.
1-Methyl-4-ethylbenzene	Carbopack™ C/B, Tenax (SSV 1000L) or Combination Tubes 1, 2 or 3.

Compound	Suitable sorbents and SSV's where available
1,3,5-Trimethylbenzene	Carbopack™ C/B, Tenax (SSV 1800L), Combination Tubes 1, 2 or 3 or Chromosorb 106 (SSV 2800).
Methylstyrene	Carbopack™ C/B, Tenax (SSV 1200L) or Combination Tubes 1, 2 or 3.
Methyl-2-ethylbenzene	Carbopack™ C/B, Tenax (SSV 1000L) or Combination Tubes 1, 2 or 3.
1,2,4-Trimethylbenzene	Carbopack™ C/B, Tenax (SSV 1800L) or Combination Tubes 1, 2 or 3.
n-Decane	Carbopack™ C/B, Tenax (SSV 2100L), Combination Tubes 1, 2 or 3 or Chromosorb 106 (SSV 37,000L).
1,2,3-Trimethylbenzene	Carbopack™ C/B, Tenax (SSV 1800L) or Combination Tubes 1, 2 or 3.
n-Undecane	Carbopack™ C/B, Tenax (SSV 12,000L) or Combination Tubes 1, 2 or 3.
n-Dodecane	Carbopack™ C, Tenax (SSV 63,000L) or Combination Tubes 1 or 3.

Halogenated Hydrocarbons including PCBs

This procedure is suitable for all aliphatic, aromatic and cyclic halogenated hydrocarbons more volatile than n-C20. Examples include:

Dichloromethane	CS III, C 1000, Spherocarb (SSV 200L) or Combination Tubes 2 or 3.
1,2-Dichloroethane	CS III, C 1000, Spherocarb, Chrom. 106 (SSV 17L), Carbopack™ B, Tenax (SSV 5.4L) or Combination Tubes 1, 2 or 3.
1,1,1-Trichloroethane	Spherocarb (SSV 8,000L), Chrom. 106 (SSV 8L), Carbopack™ B, or Combination Tubes 1, 2 or 3.
Carbontetrachloride	Chrom. 106 (SSV 22L), Carbopack™ B, Tenax (SSV 6.2L) or Combination Tubes 1, 2 or 3.
Trichloroethylene	Chrom. 106, Carbopack™ B, Tenax (SSV 5.6L) or Combination Tubes 1, 2 or 3.
1,1,2-Trichloroethane	Chrom. 106, Carbopack™ B, Tenax (SSV 34L) or Combination Tubes 1, 2 or 3.
Tetrachloroethylene	Chrom. 106, Carbopack™ B, Tenax (SSV 48L) or Combination Tubes 1, 2 or 3.
Chlorobenzene	Chrom. 106, Carbopack™ B, Tenax (SSV 26L) or Combination Tubes 1, 2 or 3.
1,1,1,2-Tetrachloroethane	Chrom. 106, Carbopack™ B, Tenax (SSV 78L) or Combination Tubes 1, 2 or 3.
1,1,2,2-Tetrachloroethane	Chrom. 106, Carbopack™ B, Tenax (SSV 170L) or Combination Tubes 1, 2 or 3.

Compound	Suitable sorbents and SSV's where available

Alcohols

This procedure is suitable for alcohols more volatile than n-C20 and sufficiently stable to be analyzed by conventional GC techniques. Examples include:

Methanol	CSIII, C1000, Spherocarb (SSV 130L) or Combination Tubes 2 or 3.
Ethanol	CSIII, C1000, Spherocarb (SSV 3500L) or Combination Tubes 2 or 3.
n-Propanol	Porapak N (SSV 20L), Chrom 106 (SSV 8L), Carbopack™ B or Combination Tubes 1, 2 or 3.
Isopropanol	Chrom 106 (SSV 44L), Carbopack™ B or Combination Tubes 1, 2 or 3.
n-Butanol	Chrom 106 (SSV 50L), Carbopack™ B, Porapak N (SSV 5L), Tenax (SSV 5L) or Combination Tubes 1, 2 or 3.
iso-Butanol	Chrom 106 (SSV 30L), Carbopack™ B, Tenax (SSV 2.8L) or Combination Tubes 1, 2 or 3.
Octanol	Tenax (SSV 1400L), Carbopack™ C or Combination Tubes 1 or 3.

Esters and Gycol Ethers

This procedure is suitable for all esters and glycol ethers more volatile than n-C20 and sufficiently stable to be analyzed by conventional GC techniques. Examples include:

Methylacetate	Chromosorb 106 (SSV 2.6L), Carbopack™ B or Combination Tubes 1, 2 or 3.
Ethylacetate	Chromosorb 106 (SSV 20L), Carbopack™ B, Tenax (SSV 3.6L) or Combination Tubes 1, 2 or 3.
Propylacetate	Chromosorb 106 (SSV 150L), Carbopack™ B, Tenax (SSV 18L) or Combination Tubes 1, 2 or 3.
Isopropylacetate	Chromosorb 106 (SSV 75L), Carbopack™ B, Tenax (SSV 6L) or Combination Tubes 1, 2 or 3.
Butylacetate	Chromosorb 106 (SSV 730L), Carbopack™ B, Tenax (SSV 85L) or Combination Tubes 1, 2 or 3.
Isobutylacetate	Chromosorb 106 (SSV 440L), Carbopack™ B, Tenax (SSV 130L) or Combination Tubes 1, 2 or 3.
Methyl-t-butyl ether	Chromosorb 106 (SSV >6L), Carbopack™ B or Combination Tubes 1, 2 or 3.
t-Butylacetate	Chromosorb 106 (SSV 160L), Carbopack™ B or Combination Tubes 1, 2 or 3.
Methylacrylate	Chromosorb 106, Carbopack™ B, Tenax (SSV 6.5L) or Combination Tubes 1, 2 or 3.

Compound	Suitable sorbents and SSV’s where available
Ethylacrylate	Chromosorb 106, Carbopack™ B, Tenax (SSV 60L) or Combination Tubes 1, 2 or 3.
Methylmethacrylate	Chromosorb 106, Carbopack™ B, Tenax (SSV 27L) or Combination Tubes 1, 2 or 3.
Methoxyethanol	Chromosorb 106 (SSV 5L), Carbopack™ B, Tenax (SSV 3L) or Combination Tubes 1, 2 or 3.
Ethoxyethanol	Chromosorb 106 (SSV 75L), Carbopack™ B, Tenax (SSV 5L) or Combination Tubes 1, 2 or 3.
Butoxyethanol	Chromosorb 106, Carbopack™ B, Tenax (SSV 35L) or Combination Tubes 1, 2 or 3.
Methoxypropanol	Chromosorb 106, Carbopack™ B, Tenax (SSV 13L) or Combination Tubes 1, 2 or 3.
Methoxyethylacetate	Chromosorb 106 (SSV 860L), Carbopack™ B, Tenax (SSV 8L) or Combination Tubes 1, 2 or 3.
Ethoxyethylacetate	Chromosorb 106 (SSV 4000L), Carbopack™ B, Tenax (SSV 15L) or Combination Tubes 1, 2 or 3.
Butoxyethylacetate	Chromosorb 106, Carbopack™ B, Tenax (SSV 150L) or Combination Tubes 1, 2 or 3.

Aldehydes and Ketones

This procedure is suitable for all aldehydes and ketones more volatile than n-C20 and sufficiently stable to be analyzed using conventional GC techniques. Examples include:

Acetone	CSIII, C1000, Spherocarb, Chrom 106 (SSV 1.5L) or Combination Tubes 2 or 3.
Methylethylketone (2-butanone)	Chromosorb 106 (SSV 10L), Tenax (SSV 3.2L), Porapak N (SSV 50L) Carbopack™ B or Combination Tubes 1, 2 or 3.
n-Butanal	Chromosorb 106, Carbopack™ B, Porapak N (SSV 50L) or Combination Tubes 1, 2 or 3.
Methylisobutylketone	Chromosorb 106 (SSV 250L), Tenax (SSV 26L), Carbopack™ B or Combination Tubes 1, 2 or 3.
Cyclohexanone	Chromosorb 106, Tenax (SSV 170L), Carbopack™ B or Combination Tubes 1, 2 or 3.
3,5,5-Trimethylcyclohex-2-enone	Tenax (SSV 5600L), Carbopack™ B or Combination Tubes 1 or 3.
Furfural	Tenax (SSV 300L), Carbopack™ B or Combination Tubes 1, 2 or 3.

Miscellaneous VOCs

This procedure is suitable for the analysis of most VOCs in air. It is generally compatible with all organics less volatile than ethane, more volatile than n-C20 and sufficiently stable to be analyzed using conventional GC techniques. Examples include:

Compound	Suitable sorbents and SSV's where available
Acetonitrile	Porapak N (SSV 3.5L), CSIII, C1000 or Combination Tubes 2 or 3.
Acrylonitrile	Porapak N (SSV 8L), Carbopack™ B or Combination Tubes 1, 2 or 3.
Propionitrile	Porapak N (SSV 11L), Carbopack™ B or Combination Tubes 1, 2 or 3.
Maleic anhydride[a]	Tenax (SSV 88L), Chrom. 106, Carbopack™ B or Combination Tubes 1, 2 or 3.
Pyridine	Tenax (SSV 8L), Porapak N (SSV 200L) Chrom. 106, Carbopack™ B or Combination Tubes 1, 2 or 3.
Aniline	Tenax (SSV 220L), Chrom. 106, Carbopack™ B or Combination Tubes 1, 2 or 3.
Nitrobenzene	Tenax (SSV 14,000L) Carbopack™ C or Combination Tubes 1 or 3.
Acetic acid	Porapak N (SSV 50L), Carbotrap™ B or Combination Tubes 1, 2 or 3.
Phenol	Tenax (SSV 240L) or combination tube 1.

APPENDIX 2.

LINEARITY TESTING OF ONE SORBENT TUBE/FOCUSING TUBE COMBINATION

Introduction

Automated gas chromatographs such as those used at network monitoring stations for hourly updates of volatile organic compounds (VOCs) have a solid adsorbent concentrator for the VOCs. This unit is comparable to the sorbent tubes being discussed in this document. The table below shows the results of sampling a synthetic mixture of the Compendium Method TO-14 target list in humidified zero air (approximately 70% RH at 25°C). Sampling occurred for 6, 12, and 24 min at a rate of 80 mL/min giving a total sampling volume of 480, 960, and 1920 mL. These results are similar to the determination of safe sampling volume and the amount of material collected should be related linearly to the sample period. The results indicate that breakthrough has not occurred to any appreciable extent at a sampling volume of approximately 2 L for the stated experimental conditions. The response measured is the response of chlorine from an atomic emission detector after chromatographic separation. The sorbent tube mix was Carbotrap™ C/Carbotrap™ B/Carboxen™ 1000 and the focusing tube mix was Tenax-TA/Silica Gel/Ambersorb XE-340/Charcoal. The primary tube was 6 mm O.D. with 4 mm I.D., 110 mm in length. The focusing tube was 6 mm O.D., 0.9 mm I.D., 185 mm in length. The packing lengths for the sorbent tube per sorbent type were: 1.27 cm, 2.86 cm, and 3.18 cm, respectively. The packing lengths for the focusing tube per sorbent type were: 5.08 cm, 2.54 cm, and 1.27 cm.

Linearity test

[Note: Actual sampling volumes were 490, 980, and 1960 instead of 1/2,1, and 2L as listed for convenience in the table below. The response is obtained as chlorine response on an atomic emission detector. Compounds corresponding to the numbered compounds in the table are identified on the following page.]

Cpd.	1/2 L	1 L	2 L	2L/1L	2L/(1/2L)	1L/(1/2L)	% Diff (2L/0.5L) vs. 4
1	1255.4	2402.9	5337.2	2.22	4.25	1.91	-6.28
2	711.82	1802.2	3087	1.71	4.34	2.53	-8.42
3	2079.4	4853	9386	1.93	4.51	2.33	-12.85
4	978.14	2381.3	4680.1	1.97	4.78	2.43	-19.62
6	1155.7	2357.1	4725.2	2.00	4.09	2.04	-2.22
7	3072.8	6764.4	13662	2.02	4.45	2.20	-11.15
8	2337.3	4356.1	8697.2	2.00	3.72	1.86	6.97
9	3041.7	5986.6	11525	1.93	3.79	1.97	5.28
10	1061.7	2183.6	4296.5	1.97	4.05	2.06	-1.17
11	3800.5	7726.7	15182	1.96	3.99	2.03	0.13
12	2386.9	4877.5	9669	1.98	4.05	2.04	-1.27
13	2455.4	5063.5	9986.6	1.97	4.07	2.06	-1.68
14	3972.6	8118.4	15985	1.97	4.02	2.04	-0.60
15	2430.9	4947.9	9756.1	1.97	4.01	2.04	-0.33
16	6155.4	9247.4	16942	1.83	2.75	1.50	31.19

Cpd.	1/2 L	1 L	2 L	2L/1L	2L/(1/2L)	1L/(1/2L)	% Diff (2L/0.5L) vs. 4
18	4270.4	9233.8	18721	2.03	4.38	2.16	-9.60
19	2494.8	5115.2	10087	1.97	4.04	2.05	-1.08
20	4023.9	8379.4	16672	1.99	4.14	2.08	-3.58
21	1086.8	2295.4	4611.7	2.01	4.24	2.11	-6.08
22	793.33	1670.1	3375.2	2.02	4.25	2.11	-6.36
23	3708.2	7679	15165	1.97	4.09	2.07	-2.24
26	5094	10582	21139	2.00	4.15	2.08	-3.74
27	1265.1	2615.1	5136.9	1.96	4.06	2.07	-1.51
31	4434.9	9176.4	17975	1.96	4.05	2.07	-1.33
36	2320.7	5015.7	9827.3	1.96	4.23	2.16	-5.87
37	441.17	953.09	1894	1.99	4.29	2.16	-7.33
38	1410.7	3015	5895.2	1.96	4.18	2.14	-4.47
39	2338.7	4974.8	9858.8	1.98	4.22	2.13	-5.39
40	2640.9	6269.4	12495	1.99	4.73	2.37	-18.28
41	6796.5	14938	29274	1.96	4.31	2.20	-7.68

There are no values presented in the above table for hydrocarbons and brominated hydrocarbons (compounds numbered 5, 17, 24, 25, 28, 29, 30, 32, 33, 34, and 35) which do not respond to the chlorine detector used to collect this data.

Compendium Method TO-14
Target Compound List (TCL)

1. Dichlorodifluoromethane
2. Methyl Chloride
3. 1,2-dichloro-1,1,2,2-tetrafluoroethane
4. Vinyl Chloride
5. Methyl Bromide
6. Ethyl Chloride
7. Trichlorofluoromethane
8. 1,1-dichloroethene
9. Dichloromethane
10. 3-chloropropene
11. 1,1,2-trichloro-1,2,2-trifluoroethane
12. 1,1-dichloroethane
13. Cis-1,2-dichloroethene
14. Trichloromethane
15. 1,2-dichloroethane
16. 1,1,1-trichloroethane
17. Benzene
18. Carbon Tetrachloride
19. 1,2-dichloropropane
20. Trichloroethene
21. Cis-1,3-dichloropropene
22. Trans-1,3-dichloropropene
23. 1,1,2-trichloroethane
24. Toluene
25. 1,2-dibromoethane
26. Tetrachloroethene
27. Chlorobenzene
28. Ethylbenzene
29. m,p-xylene
30. Styrene
31. 1,1,2,2-tetrachloroethane
32. o-xylene
33. 4-ethyltoluene
34. 1,3,5-trimethylbenzene
35. 1,2,4-trimethylbenzene
36. m-dichlorobenzene
37. Benzyl Chloride
38. p-dichlorobenzene
39. o-dichlorobenzene
40. 1,2,4-trichlorobenzene
41. Hexachlorobutadiene

APPENDIX D
AIR SAMPLING PHOTOGRAPHS

PHOTOGRAPH 1.

Indoor air sample MFA-IA-1, located within Office #2.

PHOTOGRAPH 2.

Indoor air sample MFA-IA-2, located within the employee lunch room.

PHOTOGRAPH 3.

Indoor air samples MFA-IA-3 and MFA-IA-4, located within the employee lunch room.

PHOTOGRAPH 4.

Employee lunch room with indoor air samples MFA-IA-3 and MFA-IA-4 at left and MFA-IA-2 at right.

PHOTOGRAPH 5.

Ambient air sample MFA-AA-1, located east of the employee lunch room portion of the Mechanics Shop building.

PHOTOGRAPH 6.

Ambient air sample MFA-AA-2, located adjacent to the air intake along the building exterior outside the lunch room.

APPENDIX E
WEATHER STATION HISTORY – MLOPW1

History for MLOPW1

Longview, WA, Rainier, OR — Current Conditions

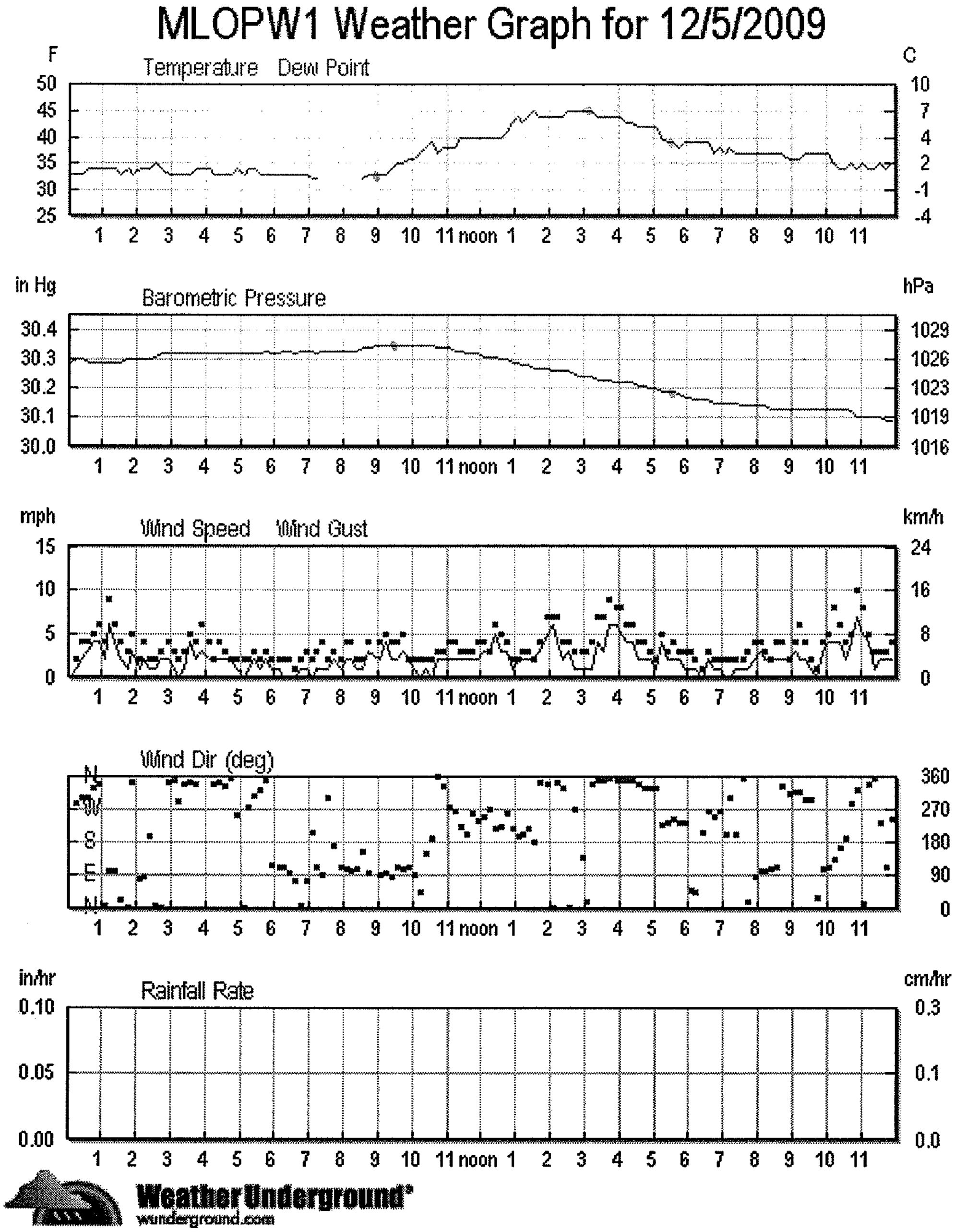
The data provider for this station: NOS_PORTS

Daily Summary for December 5, 2009

	Current:	High:	Low:	Average:
Temperature:	**57.0** °F	**45.0** °F	**32.0** °F	**35.7** °F
Dew Point:	**0.0** °F	**-99.9** °F	**-99.9** °F	**-99.9** °F
Humidity:	0%	0%	100%	0%
Wind Speed:	**13.0**mph	**7.0**mph	-	-
Wind Gust:	**24.0**mph	**10.0**mph	-	-
Wind:	SE	-	-	NNW
Pressure:	**29.04**in	**30.35**in	**30.09**in	-
Precipitation:	**0.00**in			

Statistics for the rest of the month:

	High:	Low:	Average:
Temperature:	**54.0** °F	**13.0** °F	**31.2** °F
Dew Point:	**-99.9** °F	**-99.9** °F	**-99.9** °F
Humidity:	0.0%	100.0%	0.0%
Wind Speed:	**26.0**mph from the South	-	-
Wind Gust:	**35.0**mph from the South	-	-
Wind:	-	-	ESE
Pressure:	**30.48**in	**29.60**in	-
Precipitation:	**0.00**in		



Tabular Data for December 5, 2009

Time	Temp.	Dew Point	Pressure	Wind	Wind Speed	Wind Gust	Humidity	Rainfall Rate (Hourly)
00:06	**33.0** °F	**-99.9** °F	**30.29**in	Calm		**3.0**mph	-%	-
00:14	**33.0** °F	**-99.9** °F	**30.30**in	WNW	**1.0**mph	**2.0**mph	-%	-
00:24	**33.0** °F	**-99.9** °F	**30.30**in	NW	**2.0**mph	**4.0**mph	-%	-
00:34	**34.0** °F	**-99.9** °F	**30.29**in	NW	**3.0**mph	**4.0**mph	-%	-
00:44	**34.0** °F	**-99.9** °F	**30.29**in	NNW	**4.0**mph	**5.0**mph	-%	-
00:54	**34.0** °F	**-99.9** °F	**30.29**in	NNW	**4.0**mph	**6.0**mph	-%	-
01:07	**34.0** °F	**-99.9** °F	**30.29**in	North	**2.0**mph	**4.0**mph	-%	-
01:14	**34.0** °F	**-99.9** °F	**30.29**in	ESE	**6.0**mph	**9.0**mph	-%	-
01:24	**34.0** °F	**-99.9** °F	**30.29**in	East	**4.0**mph	**6.0**mph	-%	-

01:34	**33.0** °F	**-99.9** °F	**30.29**in	NNE	**2.0**mph	**4.0**mph	-%	-
01:45	**34.0** °F	**-99.9** °F	**30.30**in	North	**1.0**mph	**3.0**mph	-%	-
01:54	**33.0** °F	**-99.9** °F	**30.30**in	NNW	**3.0**mph	**5.0**mph	-%	-
02:06	**34.0** °F	**-99.9** °F	**30.30**in	East	**1.0**mph	**2.0**mph	-%	-
02:13	**34.0** °F	**-99.9** °F	**30.30**in	East	**2.0**mph	**4.0**mph	-%	-
02:24	**34.0** °F	**-99.9** °F	**30.30**in	SSW	**1.0**mph	**2.0**mph	-%	-
02:34	**35.0** °F	**-99.9** °F	**30.31**in	North	**1.0**mph	**2.0**mph	-%	-
02:44	**34.0** °F	**-99.9** °F	**30.32**in	North	**2.0**mph	**3.0**mph	-%	-
02:55	**33.0** °F	**-99.9** °F	**30.32**in	NNW	**2.0**mph	**4.0**mph	-%	-
03:06	**33.0** °F	**-99.9** °F	**30.32**in	North	**1.0**mph	**3.0**mph	-%	-
03:14	**33.0** °F	**-99.9** °F	**30.32**in	Calm		**2.0**mph	-%	-
03:24	**33.0** °F	**-99.9** °F	**30.32**in	NNW	**1.0**mph	**3.0**mph	-%	-
03:35	**33.0** °F	**-99.9** °F	**30.32**in	North	**4.0**mph	**5.0**mph	-%	-
03:45	**34.0** °F	**-99.9** °F	**30.32**in	NNW	**2.0**mph	**4.0**mph	-%	-
03:55	**34.0** °F	**-99.9** °F	**30.32**in	North	**3.0**mph	**6.0**mph	-%	-
04:06	**34.0** °F	**-99.9** °F	**30.32**in	NW	**2.0**mph	**4.0**mph	-%	-
04:14	**33.0** °F	**-99.9** °F	**30.32**in	NNW	**2.0**mph	**2.0**mph	-%	-
04:24	**33.0** °F	**-99.9** °F	**30.32**in	NNW	**2.0**mph	**4.0**mph	-%	-
04:35	**33.0** °F	**-99.9** °F	**30.32**in	NNW	**2.0**mph	**3.0**mph	-%	-
04:45	**33.0** °F	**-99.9** °F	**30.32**in	North	**2.0**mph	**2.0**mph	-%	-
04:55	**34.0** °F	**-99.9** °F	**30.32**in	WSW	**1.0**mph	**2.0**mph	-%	-
05:07	**33.0** °F	**-99.9** °F	**30.32**in	Calm		**2.0**mph	-%	-
05:14	**34.0** °F	**-99.9** °F	**30.32**in	West	**1.0**mph	**2.0**mph	-%	-
05:25	**34.0** °F	**-99.9** °F	**30.32**in	NW	**2.0**mph	**3.0**mph	-%	-
05:35	**33.0** °F	**-99.9** °F	**30.32**in	NW	**1.0**mph	**2.0**mph	-%	-
05:45	**33.0** °F	**-99.9** °F	**30.33**in	North	**2.0**mph	**3.0**mph	-%	-
05:55	**33.0** °F	**-99.9** °F	**30.32**in	ESE	**1.0**mph	**2.0**mph	-%	-
06:07	**33.0** °F	**-99.9** °F	**30.32**in	ESE	**1.0**mph	**2.0**mph	-%	-
06:14	**33.0** °F	**-99.9** °F	**30.33**in	Calm		**2.0**mph	-%	-
06:24	**33.0** °F	**-99.9** °F	**30.33**in	Calm		**2.0**mph	-%	-
06:35	**33.0** °F	**-99.9** °F	**30.32**in	Calm		**1.0**mph	-%	-
06:45	**33.0** °F	**-99.9** °F	**30.33**in	North	**1.0**mph	**2.0**mph	-%	-
06:56	**33.0** °F	**-99.9** °F	**30.33**in	ENE	**1.0**mph	**3.0**mph	-%	-
07:05	**32.0** °F	**-99.9** °F	**30.33**in	Calm		**2.0**mph	-%	-
07:13	**32.0** °F	**-99.9** °F	**30.32**in	ESE	**1.0**mph	**3.0**mph	-%	-
07:24	-	**-99.9** °F	**30.33**in	East	**1.0**mph	**4.0**mph	-%	-
07:34	**32.0** °F	**-99.9** °F	**30.33**in	WNW	**1.0**mph	**2.0**mph	-%	-
07:44	-	**-99.9** °F	**30.33**in	South	**2.0**mph	**3.0**mph	-%	-
07:55	-	**-99.9** °F	**30.33**in	ESE	**1.0**mph	**2.0**mph	-%	-
08:06	-	**-99.9** °F	**30.33**in	ESE	**2.0**mph	**4.0**mph	-%	-
08:13	**32.0** °F	**-99.9** °F	**30.33**in	ESE	**2.0**mph	**4.0**mph	-%	-
08:24	-	**-99.9** °F	**30.33**in	ESE	**1.0**mph	**2.0**mph	-%	-
08:34	**32.0** °F	**-99.9** °F	**30.34**in	SSE	**1.0**mph	**2.0**mph	-%	-
08:44	**33.0** °F	**-99.9** °F	**30.34**in	East	**3.0**mph	**4.0**mph	-%	-

	33.0 °F	**-99.9** °F	**30.35**in	East	**2.0**mph	**4.0**mph	-%	-
09:13	**33.0** °F	**-99.9** °F	**30.35**in	East	**4.0**mph	**5.0**mph	-%	-
09:24	**34.0** °F	**-99.9** °F	**30.35**in	East	**2.0**mph	**4.0**mph	-%	-
09:34	**35.0** °F	**-99.9** °F	**30.35**in	ESE	**2.0**mph	**4.0**mph	-%	-
09:45	**35.0** °F	**-99.9** °F	**30.35**in	ESE	**3.0**mph	**5.0**mph	-%	-
09:55	**36.0** °F	**-99.9** °F	**30.35**in	ESE	**2.0**mph	**2.0**mph	-%	-
10:05	**36.0** °F	**-99.9** °F	**30.35**in	East	**1.0**mph	**2.0**mph	-%	-
10:13	**37.0** °F	**-99.9** °F	**30.35**in	Calm		**2.0**mph	-%	-
10:24	**38.0** °F	**-99.9** °F	**30.35**in	SSE	**1.0**mph	**2.0**mph	-%	-
10:34	**39.0** °F	**-99.9** °F	**30.35**in	Calm		**2.0**mph	-%	-
10:45	**37.0** °F	**-99.9** °F	**30.34**in	North	**2.0**mph	**3.0**mph	-%	-
10:55	**38.0** °F	**-99.9** °F	**30.34**in	NNW	**2.0**mph	**3.0**mph	-%	-
11:05	**38.0** °F	**-99.9** °F	**30.34**in	West	**2.0**mph	**4.0**mph	-%	-
11:13	**38.0** °F	**-99.9** °F	**30.33**in	West	**2.0**mph	**4.0**mph	-%	-
11:24	**40.0** °F	**-99.9** °F	**30.33**in	SW	**2.0**mph	**3.0**mph	-%	-
11:35	**40.0** °F	**-99.9** °F	**30.32**in	SSW	**2.0**mph	**3.0**mph	-%	-
11:44	**40.0** °F	**-99.9** °F	**30.32**in	West	**2.0**mph	**3.0**mph	-%	-
11:55	**40.0** °F	**-99.9** °F	**30.32**in	WSW	**2.0**mph	**4.0**mph	-%	-
12:05	**40.0** °F	**-99.9** °F	**30.31**in	WSW	**3.0**mph	**4.0**mph	-%	-
12:14	**40.0** °F	**-99.9** °F	**30.31**in	West	**3.0**mph	**3.0**mph	-%	-
12:24	**40.0** °F	**-99.9** °F	**30.31**in	SW	**5.0**mph	**6.0**mph	-%	-
12:34	**40.0** °F	**-99.9** °F	**30.30**in	SW	**3.0**mph	**5.0**mph	-%	-
12:45	**41.0** °F	**-99.9** °F	**30.30**in	West	**3.0**mph	**4.0**mph	-%	-
12:55	**43.0** °F	**-99.9** °F	**30.29**in	SW	**1.0**mph	**2.0**mph	-%	-
13:06	**44.0** °F	**-99.9** °F	**30.29**in	SSW	**2.0**mph	**2.0**mph	-%	-
13:14	**43.0** °F	**-99.9** °F	**30.28**in	SSW	**2.0**mph	**3.0**mph	-%	-
13:24	**44.0** °F	**-99.9** °F	**30.28**in	SW	**2.0**mph	**3.0**mph	-%	-
13:34	**45.0** °F	**-99.9** °F	**30.27**in	South	**2.0**mph	**2.0**mph	-%	-
13:44	**44.0** °F	**-99.9** °F	**30.27**in	North	**3.0**mph	**4.0**mph	-%	-
13:55	**44.0** °F	**-99.9** °F	**30.27**in	NNW	**5.0**mph	**7.0**mph	-%	-
14:05	**44.0** °F	**-99.9** °F	**30.26**in	North	**6.0**mph	**7.0**mph	-%	-
14:14	**44.0** °F	**-99.9** °F	**30.26**in	NNW	**4.0**mph	**7.0**mph	-%	-
14:24	**44.0** °F	**-99.9** °F	**30.26**in	NNW	**2.0**mph	**4.0**mph	-%	-
14:34	**45.0** °F	**-99.9** °F	**30.26**in	North	**3.0**mph	**4.0**mph	-%	-
14:44	**45.0** °F	**-99.9** °F	**30.25**in	West	**1.0**mph	**3.0**mph	-%	-
14:55	**45.0** °F	**-99.9** °F	**30.24**in	SE	**1.0**mph	**3.0**mph	-%	-
15:05	**45.0** °F	**-99.9** °F	**30.24**in	NNE	**1.0**mph	**3.0**mph	-%	-
15:13	**45.0** °F	**-99.9** °F	**30.24**in	NNW	**1.0**mph	**4.0**mph	-%	-
15:24	**44.0** °F	**-99.9** °F	**30.23**in	North	**4.0**mph	**7.0**mph	-%	-
15:34	**44.0** °F	**-99.9** °F	**30.23**in	North	**3.0**mph	**7.0**mph	-%	-
15:44	**44.0** °F	**-99.9** °F	**30.23**in	North	**6.0**mph	**9.0**mph	-%	-
15:56	**44.0** °F	**-99.9** °F	**30.22**in	North	**6.0**mph	**8.0**mph	-%	-
16:05	**44.0** °F	**-99.9** °F	**30.22**in	North	**5.0**mph	**8.0**mph	-%	-
16:14	**43.0** °F	**-99.9** °F	**30.22**in	North	**4.0**mph	**6.0**mph	-%	-

	43.0 °F	-99.9 °F	30.22in	North	4.0mph	6.0mph	-%	-
16:34	42.0 °F	-99.9 °F	30.21in	NNW	2.0mph	4.0mph	-%	-
16:45	42.0 °F	-99.9 °F	30.21in	NNW	2.0mph	4.0mph	-%	-
16:55	42.0 °F	-99.9 °F	30.20in	NNW	2.0mph	3.0mph	-%	-
17:05	42.0 °F	-99.9 °F	30.20in	NNW	1.0mph	2.0mph	-%	-
17:13	40.0 °F	-99.9 °F	30.19in	SW	4.0mph	5.0mph	-%	-
17:24	39.0 °F	-99.9 °F	30.19in	SW	2.0mph	3.0mph	-%	-
17:34	39.0 °F	-99.9 °F	30.19in	WSW	2.0mph	4.0mph	-%	-
17:44	38.0 °F	-99.9 °F	30.18in	WSW	2.0mph	3.0mph	-%	-
17:55	39.0 °F	-99.9 °F	30.17in	SW	1.0mph	3.0mph	-%	-
18:05	39.0 °F	-99.9 °F	30.17in	NE	1.0mph	3.0mph	-%	-
18:13	39.0 °F	-99.9 °F	30.16in	NE	1.0mph	2.0mph	-%	-
18:24	39.0 °F	-99.9 °F	30.16in	Calm		1.0mph	-%	-
18:34	39.0 °F	-99.9 °F	30.16in	West	2.0mph	3.0mph	-%	-
18:44	37.0 °F	-99.9 °F	30.15in	WSW	1.0mph	2.0mph	-%	-
18:55	38.0 °F	-99.9 °F	30.15in	West	1.0mph	2.0mph	-%	-
19:05	37.0 °F	-99.9 °F	30.15in	Calm		2.0mph	-%	-
19:13	38.0 °F	-99.9 °F	30.15in	Calm		2.0mph	-%	-
19:23	37.0 °F	-99.9 °F	30.15in	SSW	1.0mph	2.0mph	-%	-
19:35	37.0 °F	-99.9 °F	30.14in	North	1.0mph	2.0mph	-%	-
19:44	37.0 °F	-99.9 °F	30.14in	NNE	1.0mph	3.0mph	-%	-
19:55	37.0 °F	-99.9 °F	30.14in	East	2.0mph	4.0mph	-%	-
20:05	37.0 °F	-99.9 °F	30.14in	ESE	3.0mph	4.0mph	-%	-
20:13	37.0 °F	-99.9 °F	30.14in	East	2.0mph	3.0mph	-%	-
20:24	37.0 °F	-99.9 °F	30.13in	ESE	2.0mph	2.0mph	-%	-
20:34	37.0 °F	-99.9 °F	30.13in	ESE	2.0mph	4.0mph	-%	-
20:44	37.0 °F	-99.9 °F	30.13in	NNW	2.0mph	4.0mph	-%	-
20:55	36.0 °F	-99.9 °F	30.13in	NW	2.0mph	2.0mph	-%	-
21:06	36.0 °F	-99.9 °F	30.13in	NW	3.0mph	4.0mph	-%	-
21:14	36.0 °F	-99.9 °F	30.13in	NW	2.0mph	6.0mph	-%	-
21:24	37.0 °F	-99.9 °F	30.13in	WNW	2.0mph	4.0mph	-%	-
21:34	37.0 °F	-99.9 °F	30.13in	WNW	1.0mph	2.0mph	-%	-
21:44	37.0 °F	-99.9 °F	30.13in	Calm		1.0mph	-%	-
21:55	37.0 °F	-99.9 °F	30.13in	ESE	3.0mph	4.0mph	-%	-
22:05	37.0 °F	-99.9 °F	30.13in	ESE	4.0mph	5.0mph	-%	-
22:13	35.0 °F	-99.9 °F	30.13in	SE	4.0mph	8.0mph	-%	-
22:24	34.0 °F	-99.9 °F	30.13in	SSE	4.0mph	6.0mph	-%	-
22:34	34.0 °F	-99.9 °F	30.13in	SSW	2.0mph	4.0mph	-%	-
22:44	35.0 °F	-99.9 °F	30.12in	WNW	4.0mph	5.0mph	-%	-
22:54	34.0 °F	-99.9 °F	30.10in	NNW	7.0mph	10.0mph	-%	-
23:05	35.0 °F	-99.9 °F	30.10in	NNE	5.0mph	8.0mph	-%	-
23:13	34.0 °F	-99.9 °F	30.10in	NNW	4.0mph	5.0mph	-%	-
23:24	34.0 °F	-99.9 °F	30.10in	North	1.0mph	3.0mph	-%	-
23:34	35.0 °F	-99.9 °F	30.10in	SW	2.0mph	3.0mph	-%	-

	34.0 °F	**-99.9** °F	**30.09**in	ESE	**2.0**mph	**3.0**mph	-%	-
23:54	**35.0** °F	**-99.9** °F	**30.09**in	WSW	**2.0**mph	**4.0**mph	-%	-

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History for MLOPW1

Longview, WA, Rainier, OR — Current Conditions

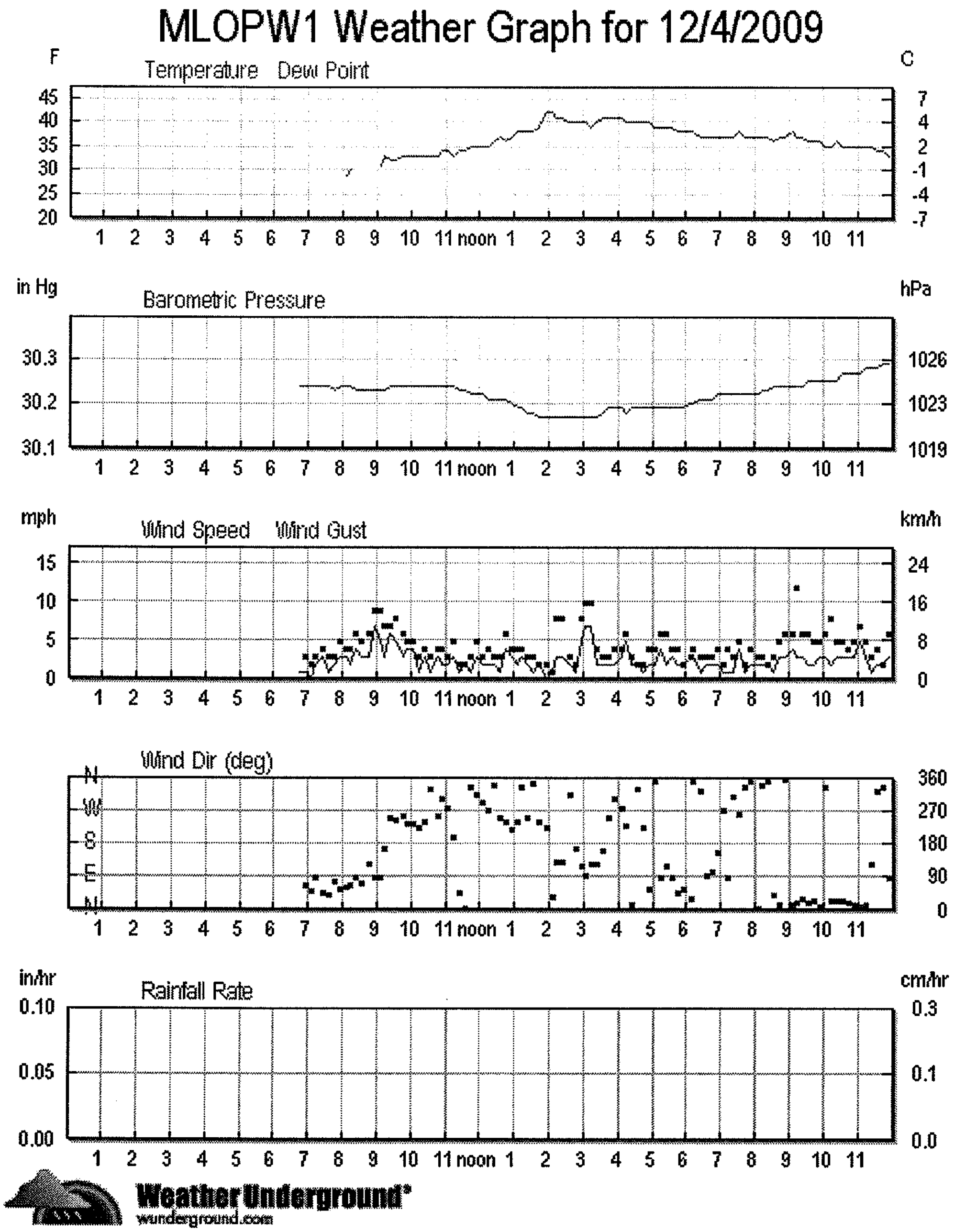
The data provider for this station: NOS_PORTS

Daily Summary for December 4, 2009

	Current:	High:	Low:	Average:
Temperature:	**57.0** °F	**42.0** °F	**29.0** °F	**33.3** °F
Dew Point:	**0.0** °F	**-99.9** °F	**-99.9** °F	**-99.9** °F
Humidity:	0%	0%	100%	0%
Wind Speed:	**13.0**mph	**7.0**mph	-	**2.5**mph
Wind Gust:	**24.0**mph	**12.0**mph	-	-
Wind:	SE	-	-	NNE
Pressure:	**29.04**in	**30.29**in	**30.17**in	-
Precipitation:	**0.00**in			

Statistics for the rest of the month:

	High:	Low:	Average:
Temperature:	**54.0** °F	**13.0** °F	**31.2** °F
Dew Point:	**-99.9** °F	**-99.9** °F	**-99.9** °F
Humidity:	0.0%	100.0%	0.0%
Wind Speed:	**26.0**mph from the South	-	-
Wind Gust:	**35.0**mph from the South	-	-
Wind:	-	-	ESE
Pressure:	**30.48**in	**29.60**in	-
Precipitation:	**0.00**in		


MLOPW1 Weather Graph for 12/4/2009

Tabular Data for December 4, 2009

Time	Temp.	Dew Point	Pressure	Wind	Wind Speed	Wind Gust	Humidity	Rainfall Rate (Hourly)
06:45	-	**-99.9** °F	**30.24**in	ENE	**1.0**mph	**2.0**mph	-%	-
06:56	-	**-99.9** °F	**30.24**in	ENE	**1.0**mph	**3.0**mph	-%	-
07:06	**30.0** °F	**-99.9** °F	**30.24**in	Calm		**2.0**mph	-%	-
07:14	-	**-99.9** °F	**30.24**in	East	**2.0**mph	**3.0**mph	-%	-
07:25	-	**-99.9** °F	**30.24**in	NE	**3.0**mph	**4.0**mph	-%	-
07:36	**29.0** °F	**-99.9** °F	**30.24**in	NE	**1.0**mph	**3.0**mph	-%	-
07:45	-	**-99.9** °F	**30.23**in	ENE	**2.0**mph	**3.0**mph	-%	-
07:55	-	**-99.9** °F	**30.24**in	NE	**3.0**mph	**5.0**mph	-%	-
08:06	**29.0** °F	**-99.9** °F	**30.24**in	ENE	**3.0**mph	**4.0**mph	-%	-

08:14	**30.0** °F	**-99.9** °F	**30.24**in	ENE	**2.0**mph	**4.0**mph	-%	-
08:24	-	**-99.9** °F	**30.23**in	East	**4.0**mph	**6.0**mph	-%	-
08:34	**31.0** °F	**-99.9** °F	**30.23**in	ENE	**3.0**mph	**5.0**mph	-%	-
08:45	-	**-99.9** °F	**30.23**in	SE	**3.0**mph	**6.0**mph	-%	-
08:55	-	**-99.9** °F	**30.23**in	East	**7.0**mph	**9.0**mph	-%	-
09:06	**31.0** °F	**-99.9** °F	**30.23**in	East	**5.0**mph	**9.0**mph	-%	-
09:14	**33.0** °F	**-99.9** °F	**30.23**in	SSE	**3.0**mph	**7.0**mph	-%	-
09:24	**32.0** °F	**-99.9** °F	**30.24**in	WSW	**6.0**mph	**7.0**mph	-%	-
09:35	**32.0** °F	**-99.9** °F	**30.24**in	WSW	**5.0**mph	**8.0**mph	-%	-
09:46	**33.0** °F	**-99.9** °F	**30.24**in	WSW	**3.0**mph	**6.0**mph	-%	-
09:55	**33.0** °F	**-99.9** °F	**30.24**in	WSW	**4.0**mph	**5.0**mph	-%	-
10:05	**33.0** °F	**-99.9** °F	**30.24**in	SW	**4.0**mph	**5.0**mph	-%	-
10:14	**33.0** °F	**-99.9** °F	**30.24**in	SW	**1.0**mph	**3.0**mph	-%	-
10:24	**33.0** °F	**-99.9** °F	**30.24**in	WSW	**3.0**mph	**4.0**mph	-%	-
10:35	**33.0** °F	**-99.9** °F	**30.24**in	NNW	**1.0**mph	**3.0**mph	-%	-
10:46	**33.0** °F	**-99.9** °F	**30.24**in	West	**3.0**mph	**4.0**mph	-%	-
10:56	**34.0** °F	**-99.9** °F	**30.24**in	NW	**2.0**mph	**4.0**mph	-%	-
11:06	**34.0** °F	**-99.9** °F	**30.24**in	West	**2.0**mph	**3.0**mph	-%	-
11:13	**33.0** °F	**-99.9** °F	**30.24**in	SSW	**3.0**mph	**5.0**mph	-%	-
11:25	**34.0** °F	**-99.9** °F	**30.23**in	NE	**1.0**mph	**2.0**mph	-%	-
11:36	**34.0** °F	**-99.9** °F	**30.23**in	North	**2.0**mph	**2.0**mph	-%	-
11:44	**35.0** °F	**-99.9** °F	**30.22**in	NNW	**1.0**mph	**3.0**mph	-%	-
11:55	**35.0** °F	**-99.9** °F	**30.22**in	NW	**3.0**mph	**5.0**mph	-%	-
12:06	**35.0** °F	**-99.9** °F	**30.22**in	WNW	**2.0**mph	**3.0**mph	-%	-
12:14	**35.0** °F	**-99.9** °F	**30.21**in	West	**2.0**mph	**4.0**mph	-%	-
12:24	**36.0** °F	**-99.9** °F	**30.21**in	NNW	**2.0**mph	**3.0**mph	-%	-
12:34	**37.0** °F	**-99.9** °F	**30.21**in	WSW	**1.0**mph	**3.0**mph	-%	-
12:44	**36.0** °F	**-99.9** °F	**30.21**in	WSW	**4.0**mph	**6.0**mph	-%	-
12:56	**37.0** °F	**-99.9** °F	**30.20**in	SW	**3.0**mph	**4.0**mph	-%	-
13:05	**38.0** °F	**-99.9** °F	**30.19**in	WSW	**2.0**mph	**4.0**mph	-%	-
13:14	**38.0** °F	**-99.9** °F	**30.19**in	NNW	**3.0**mph	**4.0**mph	-%	-
13:24	**38.0** °F	**-99.9** °F	**30.18**in	WSW	**2.0**mph	**3.0**mph	-%	-
13:34	**38.0** °F	**-99.9** °F	**30.18**in	NNW	**1.0**mph	**3.0**mph	-%	-
13:44	**39.0** °F	**-99.9** °F	**30.17**in	WSW	**2.0**mph	**2.0**mph	-%	-
13:55	**42.0** °F	**-99.9** °F	**30.17**in	Calm		**2.0**mph	-%	-
14:06	**42.0** °F	**-99.9** °F	**30.17**in	NNE	**1.0**mph	**1.0**mph	-%	-
14:14	**41.0** °F	**-99.9** °F	**30.17**in	SE	**3.0**mph	**8.0**mph	-%	-
14:24	**41.0** °F	**-99.9** °F	**30.17**in	SE	**3.0**mph	**8.0**mph	-%	-
14:35	**40.0** °F	**-99.9** °F	**30.17**in	NW	**2.0**mph	**3.0**mph	-%	-
14:45	**40.0** °F	**-99.9** °F	**30.17**in	SSE	**1.0**mph	**2.0**mph	-%	-
14:56	**40.0** °F	**-99.9** °F	**30.17**in	ESE	**5.0**mph	**8.0**mph	-%	-
15:05	**40.0** °F	**-99.9** °F	**30.17**in	East	**7.0**mph	**10.0**mph	-%	-
15:14	**39.0** °F	**-99.9** °F	**30.17**in	SE	**7.0**mph	**10.0**mph	-%	-
15:24	**40.0** °F	**-99.9** °F	**30.17**in	ESE	**2.0**mph	**4.0**mph	-%	-

	41.0 °F	-99.9 °F	30.18in	SSE	2.0mph	3.0mph	-%	-
15:44	41.0 °F	-99.9 °F	30.19in	WSW	2.0mph	3.0mph	-%	-
15:55	41.0 °F	-99.9 °F	30.19in	NW	2.0mph	4.0mph	-%	-
16:06	41.0 °F	-99.9 °F	30.19in	West	3.0mph	4.0mph	-%	-
16:13	40.0 °F	-99.9 °F	30.18in	SW	5.0mph	6.0mph	-%	-
16:24	40.0 °F	-99.9 °F	30.19in	NNE	2.0mph	3.0mph	-%	-
16:35	40.0 °F	-99.9 °F	30.19in	NNW	2.0mph	2.0mph	-%	-
16:44	40.0 °F	-99.9 °F	30.19in	SW	1.0mph	2.0mph	-%	-
16:55	40.0 °F	-99.9 °F	30.19in	NE	2.0mph	4.0mph	-%	-
17:06	39.0 °F	-99.9 °F	30.19in	North	2.0mph	4.0mph	-%	-
17:13	39.0 °F	-99.9 °F	30.19in	East	4.0mph	6.0mph	-%	-
17:24	39.0 °F	-99.9 °F	30.19in	ESE	2.0mph	6.0mph	-%	-
17:34	39.0 °F	-99.9 °F	30.19in	East	3.0mph	4.0mph	-%	-
17:44	38.0 °F	-99.9 °F	30.19in	NE	2.0mph	4.0mph	-%	-
17:56	38.0 °F	-99.9 °F	30.19in	NE	2.0mph	2.0mph	-%	-
18:08	38.0 °F	-99.9 °F	30.20in	NNE	3.0mph	3.0mph	-%	-
18:13	38.0 °F	-99.9 °F	30.20in	North	3.0mph	4.0mph	-%	-
18:24	37.0 °F	-99.9 °F	30.21in	NW	1.0mph	3.0mph	-%	-
18:34	37.0 °F	-99.9 °F	30.21in	East	2.0mph	3.0mph	-%	-
18:44	37.0 °F	-99.9 °F	30.21in	ESE	2.0mph	3.0mph	-%	-
18:55	37.0 °F	-99.9 °F	30.22in	SSE	2.0mph	4.0mph	-%	-
19:06	37.0 °F	-99.9 °F	30.22in	West	1.0mph	2.0mph	-%	-
19:13	37.0 °F	-99.9 °F	30.22in	East	1.0mph	4.0mph	-%	-
19:24	37.0 °F	-99.9 °F	30.22in	NW	1.0mph	3.0mph	-%	-
19:34	38.0 °F	-99.9 °F	30.22in	West	4.0mph	5.0mph	-%	-
19:44	37.0 °F	-99.9 °F	30.22in	NNW	1.0mph	2.0mph	-%	-
19:54	37.0 °F	-99.9 °F	30.22in	North	2.0mph	4.0mph	-%	-
20:06	37.0 °F	-99.9 °F	30.22in	North	2.0mph	3.0mph	-%	-
20:13	37.0 °F	-99.9 °F	30.23in	NNW	2.0mph	3.0mph	-%	-
20:23	37.0 °F	-99.9 °F	30.23in	North	2.0mph	2.0mph	-%	-
20:34	36.0 °F	-99.9 °F	30.24in	NE	1.0mph	3.0mph	-%	-
20:44	37.0 °F	-99.9 °F	30.24in	NNE	3.0mph	5.0mph	-%	-
20:54	37.0 °F	-99.9 °F	30.24in	North	3.0mph	6.0mph	-%	-
21:06	38.0 °F	-99.9 °F	30.24in	NNE	4.0mph	6.0mph	-%	-
21:14	37.0 °F	-99.9 °F	30.24in	NNE	3.0mph	12.0mph	-%	-
21:24	37.0 °F	-99.9 °F	30.24in	NNE	3.0mph	6.0mph	-%	-
21:35	36.0 °F	-99.9 °F	30.25in	NNE	2.0mph	6.0mph	-%	-
21:44	36.0 °F	-99.9 °F	30.25in	NNE	2.0mph	5.0mph	-%	-
21:55	36.0 °F	-99.9 °F	30.25in	North	3.0mph	5.0mph	-%	-
22:05	35.0 °F	-99.9 °F	30.25in	NNW	3.0mph	6.0mph	-%	-
22:13	35.0 °F	-99.9 °F	30.25in	NNE	2.0mph	8.0mph	-%	-
22:24	36.0 °F	-99.9 °F	30.25in	NNE	3.0mph	5.0mph	-%	-
22:34	35.0 °F	-99.9 °F	30.27in	NNE	3.0mph	5.0mph	-%	-
22:45	35.0 °F	-99.9 °F	30.27in	NNE	3.0mph	4.0mph	-%	-

	35.0 °F	**-99.9** °F	**30.27**in	NNE	**3.0**mph	**5.0**mph	-%	-
23:06	**35.0** °F	**-99.9** °F	**30.27**in	North	**5.0**mph	**7.0**mph	-%	-
23:13	**35.0** °F	**-99.9** °F	**30.28**in	NNE	**3.0**mph	**5.0**mph	-%	-
23:23	**35.0** °F	**-99.9** °F	**30.28**in	SE	**1.0**mph	**3.0**mph	-%	-
23:34	**34.0** °F	**-99.9** °F	**30.28**in	NNW	**2.0**mph	**4.0**mph	-%	-
23:44	**34.0** °F	**-99.9** °F	**30.29**in	NNW	**2.0**mph	**2.0**mph	-%	-
23:54	**33.0** °F	**-99.9** °F	**30.29**in	East	**3.0**mph	**6.0**mph	-%	-

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APPENDIX F
FIELD TEST DATA SHEETS

COMPENDIUM METHOD TO-17
FIELD TEST DATA SHEET (FTDS)

I. GENERAL INFORMATION

224 PCXR7

PROJECT: IP LONGVIEW
SITE: MECH SHOP
LOCATION: LONGVIEW WA
INSTRUMENT MODEL NO.: SKC-?
PUMP SERIAL NO.: 505 767

DATE(S) SAMPLED: 12/5/09
TIME PERIOD SAMPLED: 8 HRS - 9:30 - 5:30
OPERATOR: IAN VERMEEREN
CALIBRATED BY:
RAIN: ____YES X NO

ADSORBENT CARTRIDGE INFORMATION:

	Tube 1	Tube 2
Type:		
Adsorbent:		
Serial No.:		
Sample No.:		

MFA IA-1

II. SAMPLING DATA

IN OFFICE

Tube Identification	Sampling Location	Ambient Temp., °F	Ambient Pressure, in Hg	Flow Rate (Q), mL/min		Sampling Period		Total Sampling Time, min.	Total Sample Volume, L	RELATIVE HUMIDITY
				Tube 1	Tube 2	Start	Stop			
MFA	IA-1	59.4	30.46	22.35		0938	X			32.4%
		62.4	30.29	24.86		X	0538			31.1

III. FIELD AUDIT

	Tube 1	Tube 2
Audit Flow Check Within 10% of Set Point (Y/N)?	pre-	pre-
	post-	post-

CHECKED BY:
DATE:

Figure 1. Compendium Method TO-17 Field Test Data Sheet.

COMPENDIUM METHOD TO-17
FIELD TEST DATA SHEET (FTDS)

I. GENERAL INFORMATION

PROJECT: IP LONGVIEW
SITE: MEGA STOP
LOCATION: LONGVIEW WA
INSTRUMENT MODEL NO.: 224 PCXR4
PUMP SERIAL NO.: 868877

DATE(S) SAMPLED: 12/5/09
TIME PERIOD SAMPLED: 930 - 530
OPERATOR: IAN VERMEEREN
CALIBRATED BY:
RAIN: ____YES [✓ NO]

ADSORBENT CARTRIDGE INFORMATION:

MFA IA-2

	Tube 1	Tube 2
Type:		
Adsorbent:		
Serial No.:		
Sample No.:		

II. SAMPLING DATA

F

Tube Identification	Sampling Location	Ambient Temp., °F	Ambient Pressure, in Hg	Flow Rate (Q), mL/min		Sampling Period		Total Sampling Time, min.	Total Sample Volume, L	RELATIVE HUMIDITY
				Tube 1	Tube 2	Start	Stop			
MFA	IA-2	60.0	30.42	22.13	/	0938	X			32.4 %
		62.3	30.29	24.08		X	0537			31.1

III. FIELD AUDIT

	Tube 1	Tube 2
Audit Flow Check Within 10% of Set Point (Y/N)?	pre-	pre-
	post-	post-

CHECKED BY:
DATE:

Figure 1. Compendium Method TO-17 Field Test Data Sheet.

COMPENDIUM METHOD TO-17
FIELD TEST DATA SHEET (FTDS)

I. GENERAL INFORMATION

PROJECT: IP LONGVIEW
SITE: MECH SHOP
LOCATION: LONGVIEW WA
INSTRUMENT MODEL NO.: 224PCXR7
PUMP SERIAL NO.: 513417

DATE(S) SAMPLED: 12/5/09
TIME PERIOD SAMPLED: 930 - 530
OPERATOR: IAN VERMEEREN
CALIBRATED BY: ↓
RAIN: ____ YES X NO

ADSORBENT CARTRIDGE INFORMATION:

	Tube 1	Tube 2
Type:		
Adsorbent:		
Serial No.:		
Sample No.:		

II. SAMPLING DATA

	Tube Identification	Sampling Location	Ambient Temp., °F	Ambient Pressure, in Hg	Flow Rate (Q), mL/min		Sampling Period		Total Sampling Time, min.	Total Sample Volume, L	RELATIVE HUMIDITY
					Tube 1	Tube 2	Start	Stop			
A	MFA	1A-3	60.6	30.42	21.41	0937 →		X			32.1
			62.4	30.29	23.05		X	0537			31.2

III. FIELD AUDIT

	Tube 1	Tube 2
Audit Flow Check Within 10% of Set Point (Y/N)?	pre-	pre-
	post-	post-

CHECKED BY: ____________________
DATE: ____________________

Figure 1. Compendium Method TO-17 Field Test Data Sheet.

COMPENDIUM METHOD TO-17
FIELD TEST DATA SHEET (FTDS)

I. GENERAL INFORMATION

PROJECT: IP LONGVIEW
SITE: MECH SHOP
LOCATION: LONGVIEW WA
INSTRUMENT MODEL NO.: 224 PCXR7
PUMP SERIAL NO.: ?
DATE(S) SAMPLED: 12/5/09
TIME PERIOD SAMPLED: 930 - 530
OPERATOR: IAN VERMEEREN
CALIBRATED BY:
RAIN: ____ YES X NO

ADSORBENT CARTRIDGE INFORMATION:

MFA - IA - 4

	Tube 1	Tube 2
Type:		
Adsorbent:		
Serial No.:		
Sample No.:		

II. SAMPLING DATA

C

Tube Identification	Sampling Location	Ambient Temp., °F	Ambient Pressure, in Hg	Flow Rate (Q), mL/min		Sampling Period		Total Sampling Time, min.	Total Sample Volume, L	RELATIVE HUMIDITY
				Tube 1	Tube 2	Start	Stop			
MFA	IA 4	61.8	30.43	23.76		0937	X			32.0
		62.3	30.29	24.01		X	0537			31.2

III. FIELD AUDIT

	Tube 1	Tube 2
Audit Flow Check Within 10% of Set Point (Y/N)?	pre-	pre-
	post-	post-

CHECKED BY:
DATE:

Figure 1. Compendium Method TO-17 Field Test Data Sheet.

COMPENDIUM METHOD TO-17
FIELD TEST DATA SHEET (FTDS)

I. GENERAL INFORMATION

PROJECT: IP LONGVIEW
SITE: MECH SHOP
LOCATION: LONGVIEW WA
INSTRUMENT MODEL NO.: 224 PCXR7
PUMP SERIAL NO.: —

DATE(S) SAMPLED: 12/5/09
TIME PERIOD SAMPLED: 930-530
OPERATOR: IAN VERMEEREN
CALIBRATED BY: ↓
RAIN: ____ YES X NO

ADSORBENT CARTRIDGE INFORMATION:

	Tube 1	Tube 2
Type:		
Adsorbent:		
Serial No.:		
Sample No.:		

MFA AA-1

II. SAMPLING DATA

	Tube Identification	Sampling Location	Ambient Temp., °F	Ambient Pressure, in Hg	Flow Rate (Q), mL/min		Sampling Period		Total Sampling Time, min.	Total Sample Volume, L	RELATIVE HUMIDITY
					Tube 1	Tube 2	Start	Stop			
D	MFA	AA1	39.2	30.43	22.02		0936	X			43.2%
			38.2	30.28		25.41	X	0536			54.2

III. FIELD AUDIT

	Tube 1	Tube 2
Audit Flow Check Within 10% of Set Point (Y/N)?	pre- post-	pre- post-

CHECKED BY:
DATE:

Figure 1. Compendium Method TO-17 Field Test Data Sheet.

COMPENDIUM METHOD TO-17
FIELD TEST DATA SHEET (FTDS)

I. GENERAL INFORMATION

PROJECT: IP LONGVIEW
SITE: MEEK SHOP
LOCATION: IP LONGVIEW
INSTRUMENT MODEL NO: 224PCXR7
PUMP SERIAL NO.: 521095

DATE(S) SAMPLED: 12/5/09
TIME PERIOD SAMPLED: 930-530
OPERATOR: IAN VERMEEREN
CALIBRATED BY: ↓
RAIN: ____ YES X NO

ADSORBENT CARTRIDGE INFORMATION:

	Tube 1	Tube 2
Type:		
Adsorbent:		
Serial No.:		
Sample No.:		

MFA AA-2

II. SAMPLING DATA

E

Tube Identification	Sampling Location	Ambient Temp., °F	Ambient Pressure, in Hg	Flow Rate (Q), mL/min		Sampling Period		Total Sampling Time, min.	Total Sample Volume, L
				Tube 1	Tube 2	Start	Stop		
MFA	AA2	39.2	30.43	23.60		0935	X		
		38.2	30.28	24.70		X	0536		

RELATIVE HUMIDITY
43.2%
54.0%

III. FIELD AUDIT

	Tube 1	Tube 2
Audit Flow Check Within 10% of Set Point (Y/N)?	pre-	pre-
	post-	post-

CHECKED BY:
DATE:

Figure 1. Compendium Method TO-17 Field Test Data Sheet.

COMPENDIUM METHOD TO-17
FIELD TEST DATA SHEET (FTDS)

I. GENERAL INFORMATION

PROJECT: IP LONGVIEW
SITE: MEEK STOP
LOCATION: LONGVIEW WA
INSTRUMENT MODEL NO.: —
PUMP SERIAL NO.: —
DATE(S) SAMPLED: 12/5/09
TIME PERIOD SAMPLED: — 0536
OPERATOR: IAN VERMEEREN
CALIBRATED BY:
RAIN: ____YES X NO

ADSORBENT CARTRIDGE INFORMATION:

	Tube 1	Tube 2
Type:		
Adsorbent:		
Serial No.:		
Sample No.:		

II. SAMPLING DATA

Tube Identification	Sampling Location	Ambient Temp., °F	Ambient Pressure, in Hg	Flow Rate (Q), mL/min		Sampling Period		Total Sampling Time, min.	Total Sample Volume, L
				Tube 1	Tube 2	Start	Stop		
MFA	AA3	38.2	30.28			—	0536		

RELATIVE HUMIDITY 54.2%

III. FIELD AUDIT

	Tube 1	Tube 2
Audit Flow Check Within 10% of Set Point (Y/N)?	pre-	pre-
	post-	post-

CHECKED BY:
DATE:

Figure 1. Compendium Method TO-17 Field Test Data Sheet.

APPENDIX G
MODELING EVALUATION OF VAPOR INTRUSION PATHWAY

MODELING EVALUATION OF VAPOR INTRUSION PATHWAY

The vapor intrusion pathway to indoor air is the only potentially currently complete pathway of exposure at this site. Vapor intrusion is the migration of chemicals from the subsurface into overlying buildings (EPA 2002). Chemicals volatilize from affected soil and/or groundwater beneath a site and diffuse toward regions of lower chemical concentration (ITRC 2007). VOCs present in the subsurface migrate upward preferentially through the coarsest and driest material (EPA 2002). The vapor intrusion pathway is complete only for VOCs. Elevated concentrations of COCs have been detected in soil and groundwater beneath the MFA. In addition, occasional observations of a sheen on soil samples collected from site borings, observation of free product within intact soil samples collected from site borings, and observations of DNAPL in groundwater samples collected from site groundwater monitoring wells indicate the presence of DNAPL within the MFA near the building (Figure 2). As shown on Figure 2, PB-59 contains the highest measured concentrations of several PAHs at the site. PB-59 is adjacent to the south-eastern wall of the MFA building. Of the PAHs exceeding the MTCA C soil cleanup levels in PB-59, the following meet the EPA definition of a volatile chemical (EPA 2002) of having a Henry's Law constant (atmosphere – cubic meters per mole) greater than 10^{-5} and a molecular weight less than 200 grams per mole:

- Naphthalene
- Acenapthene
- Fluorene
- Pyrene
- 2-methylnaphthalene

Therefore, the vapor intrusion pathway is only potentially complete for these five chemicals. This section presents a quantitative screening evaluation of the vapor intrusion pathway to determine whether the pathway is significant for workers in the MFA building adjacent to sample location PB-59. The screening evaluation consists of estimating indoor air concentrations and comparing the indoor air concentrations to MTCA Method C Air Cleanup Levels for protection of industrial workers.

1. Estimation of Indoor Air Concentrations

The EPA (2002 and 2004a) suggests using the methodology of Johnson and Ettinger (1991) to predict the intrusion rate of vapors into a building. The Johnson and Ettinger (1991) model (JE Model) simulates the transport of soil vapors in the subsurface by both diffusion and advection into indoor air. The model uses conservative assumptions that are likely to overestimate the amount of soil vapors that reach the indoor air of an enclosed building. Because of the presence of DNAPL in the area of the building, the NAPL version of the JE Model was used to evaluate the vapor intrusion pathway. The NAPL model is specifically designed to handle NAPLs or solids in soils. A residual phase mixture occurs when the sorbed phase, aqueous phase, and vapor phase of each chemical have reached saturation in soil (EPA 2004a). Concentrations above this saturation limit for all of the specified chemicals of a mixture will result in a fourth or residual phase (i.e., NAPL or solid), as is evidenced in the MFA. The JE Model uses the following conservative assumptions:

- Contaminant vapors enter buildings through the cracks and openings in the walls and foundation
- Vapor-phase diffusion is the dominant mechanism for transporting vapors between the source and the building zone of influence (convection is the dominant mechanism directly beneath the building, the building "zone")
- All contaminant vapors originating from directly below the floor will enter the building, unless the floors and walls serve as perfect barriers
- The chemicals are distributed evenly under the entire building

When a residual phase is present, the vapor concentration is independent of the soil concentration but proportional to the mole fraction of the individual component of the residual phase mixture. The user may specify up to 10 soil contaminants in the JE Model, the concentrations of which form a residual phase mixture. For this evaluation, the five VOCs listed above will be used to represent the residual phase mixture. As described by the EPA (2004a), the equilibrium vapor concentration is calculated numerically for a series of time-steps. For each time-step, the mass of each constituent that is volatilized is calculated using Raoult's law and the appropriate mole fraction. At the end of each time-step, the total mass lost is subtracted from the initial mass and the mole fractions are recomputed for the next time-step.

The model predicts an air concentration inside the building when the chemical concentration in the affected media and site-specific information is entered into the model. The building in the MFA is very large and much of the building is open warehouse. The lunch room of the building in the MFA was selected for evaluation, because this part of the building is located nearest the DNAPL. In addition, the lunch room is regularly occupied, and is an enclosed space within the larger structure. The site-specific information entered into the advanced NAPL model is presented in Table G-1. All other parameters used in the model for this assessment were model defaults and chemical-specific physical parameter information. The initial soil concentrations used in the model and the estimated concentrations in indoor air produced by the model are summarized in Table G-2.

2. MTCA Method C Industrial Air Cleanup Levels

Table G-2 summarizes the indoor air concentrations estimated by the JE Model for the VOCs present in the DNAPL beneath the building in the MFA. The indoor air concentrations are evaluated as to whether they exceed various risk-based levels under MTCA. The modeled indoor air concentrations were compared to the MTCA Method C industrial cleanup levels for air to determine whether the air pathway is a potential concern for industrial workers in the MFA. This section discusses derivation of the MTCA Method C industrial cleanup levels.

Because the site is classified as an industrial facility, cleanup levels protective of industrial exposures are appropriate for assessing potential risks to on-site workers and Method C air cleanup levels were calculated consistent with WAC 173-340-750. Method

C air cleanup levels are considered to be protective of industrial exposures, and assume 24 hours of exposure per day for 30 years for an adult industrial worker. Method C industrial cleanup levels for air were calculated using the equations and default exposure parameters for industrial exposures specified in MTCA (WAC 173-340-750). The Method C industrial cleanup levels for noncarcinogenic and carcinogenic chemicals in air are calculated as shown on Table D-3.

All of the inputs to calculating MTCA Method B air cleanup levels are specified in the MTCA regulation with the exception of each chemical's toxicity criteria. Toxicity criteria describe the quantitative relationship between the dose of a chemical and the type and incidence of the toxic effect. This relationship is referred to as the dose-response. From this quantitative dose-response relationship, toxicity criteria are derived that can be used to estimate the potential for adverse health effects as a function of exposure to the chemical. Exposure to chemicals can result in cancer or noncancer effects, which are characterized separately. Essential dose-response criteria are the EPA slope factor (SF) values for assessing cancer risks and the EPA-verified reference dose (RfD) values for evaluating noncancer effects. Recent toxicity criteria available for each chemical were used to calculate the MTCA Method C industrial cleanup levels for air. In general, these criteria were obtained from Ecology's Cleanup Levels and Risk Calculation (CLARC) database(https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx), accessed on April 28, 2009. The following bullets summarize the toxicity criteria used to calculate the Method C air cleanup levels:

- **Naphthalene.** MTCA currently recommends an inhalation RfD for naphthalene of 0.00086 milligrams per kilogram-day (mg/kg-day). This value is consistent with the inhalation RfD recommended by EPA in their on-line database, Integrated Risk Information System (IRIS) (EPA 2009), and is based on a study reporting hyperplasia and metaplasia in respiratory and olfactory epithelium, respectively, in mice exposed to naphthalene concentrations as low as 9.3 milligrams per cubic meter (EPA 2009). This RfD was used to calculate a noncancer cleanup level for naphthalene.

  Ecology's CLARC database does not currently list an inhalation SF for naphthalene; however, recent scientific evidence indicates that naphthalene may be carcinogenic through the inhalation pathway. EPA is currently reviewing the carcinogenic potency of naphthalene through the inhalation pathway, and the IRIS database is expected to be updated with an inhalation SF (EPA 2004b). California EPA (OEHHA 2004) has derived an inhalation SF for naphthalene of 0.12 $(\text{mg/kg-day})^{-1}$. This value is based on data for incidence of nasal respiratory epithelial adenoma and nasal olfactory epithelial neuroblastoma (tumors) in male rats (OEHHA 2004). This SF was used to calculate a cancer-based MTCA Method C air cleanup level for naphthalene.

- **2-methylnaphthalene.** No inhalation toxicity criteria are currently available for 2-methylnaphthalene. However, the MTCA Workbook for Calculating Cleanup Levels for TPH compounds (available at: http://www.ecy.wa.gov/programs/tcp/tools/toolmain.html) uses the noncancer inhalation toxicity criteria for naphthalene as a surrogate for 2-methylnaphthalene. Therefore, the inhalation RfD for naphthalene of 0.00086 mg/kg-day was used to calculate a noncancer-based MTCA Method C air cleanup level for 2-methylnaphthalene. There is no evidence to suggest that 2-methylnaphthalene is carcinogenic through the inhalation pathway. Therefore, a cancer-based cleanup level was not calculated for 2-methylnaphthalene.

- **Flourene, pyrene, and acenaphthene**. No inhalation toxicity criteria are currently available for any of these chemicals. While oral toxicity criteria are available, EPA's National Center for Environmental Assessment, Superfund Technical Support Center does not recommend route-to-route extrapolation for evaluation of these chemicals. Therefore, no Method C air cleanup level can be calculated for these chemicals. See further discussion in the following sections.

Table G-4 summarizes the Method C industrial air cleanup levels calculated for this site and compares them to the modeled indoor air concentrations. Section 3 summarizes the results of the comparison.

3. Results of the Screening Evaluation

As shown on Table G-4, modeled indoor air concentrations of naphthalene and 2-methylnaphthalene both exceed their respective Method C air cleanup levels, indicating that the presence of these two chemicals in the DNAPL beneath the building in the MFA could pose a vapor intrusion concern. An evaluation of fluorene, pyrene, and acenaphthene indoor air concentrations could not be made because no toxicity criteria are available for these chemicals from which to derive an air cleanup level. However, the concentrations of these chemicals were all low relative to naphthalene and 2-methylnaphthalene air concentrations, and are all below the cleanup levels derived for naphthalene, which has a similar toxic potency to these chemicals through the oral pathways (i.e., oral RfDs are on the same order of magnitude). Furthermore, these chemicals, while they technically meet EPA's definition of volatility, are not very volatile and are not expected to result in vapor intrusion concerns.

Although naphthalene and 2-methylnaphthalene exceed their respective industrial air cleanup levels, modeled indoor air concentrations are likely overestimated. The goal of this evaluation as a screening level assessment was to evaluate whether the vapor intrusion pathway is a potential concern at the MFA. Therefore, the indoor air concentrations used for this evaluation are designed to overestimate rather than underestimate indoor air concentrations from the vapor intrusion pathway.

The modeled indoor air concentration for 2-methylnaphthalene exceeded the MTCA Method C cleanup level only slightly (by a factor of approximately 2.5). Considering the degree of conservatism that is built into the JE Model, it is unlikely that 2-methylnaphthalene is present in the DNAPL in concentrations that are a concern for the vapor intrusion pathway. The modeled indoor air concentrations for naphthalene exceeded the cleanup level based on non-carcinogenic effects by an order of magnitude and carcinogenic effects by nearly two orders of magnitude, indicating that the vapor intrusion pathway could be a potential concern at this site for naphthalene.

This evaluation follows MTCA's guidance for cleanup of contaminated sites for the protection of public health. As such, the toxicity criteria used to calculate cleanup levels are derived to be protective of the general public. However, chemical concentrations originating from commercial/industrial operations (that is, chemicals that are actively used on site) are subject to eight-hour permissible exposure limits (PELs) developed under the Washington Industrial Safety and Health Act (WAC 296-62-07515). PELs are air concentrations established as safe for healthy adult workers to breathe eight hours/day, five days/week over a working lifetime that are usually several of orders of magnitude greater than the toxicity criteria used in risk assessment evaluations. The PEL for naphthalene is 10 parts per million (or 52,418 micrograms per cubic meter [$\mu g/m^3$]). Operating facilities are required by state law to maintain indoor air quality consistent with these PELs in order to protect employee health. This site is an operating facility that regularly uses and handles naphthalene-containing products (including diesel fuels). Therefore, because *"…it is difficult and sometimes impossible to eliminate or adequately account for contributions from 'background' sources"* (EPA 2002), the modeled indoor air values also were compared to the PEL. The modeled indoor air concentration for naphthalene was several orders of magnitude below the PEL. Therefore, indoor air concentrations meet the state regulatory requirements for the protection of worker health at an operating facility.

Table G-1
Input Parameter for Johnson and Ettinger (1991) Model for Predicting Vapor Intrusion from Soil Vapor

Input Parameter/Units	Parameter Value	Source
Initial Soil Concentration (mg/kg)	Chemical specific	Maximum detected concentration measured in PB-59 at 8 feet bgs (Table 3-4)
Average Soil Temperature (^{o}C)	10	EPA default value for Washington State (EPA 2004a)
Depth below grade to bottom of enclosed space floor (cm)	15	EPA default value for slab-on-grade (EPA 2004a)
Time Step Parameters		EPA (2004a) recommended values for soil concentrations that moderately exceed saturated soil conditions
Initial Time Step (days)	2	
Maximum Change in Mass (%)	7	
Minimum Change in Mass (%)	4	
Width of Contamination (cm)	766	Dimensions equivalent to the enclosed space (the lunch room) evaluated in the building in the MFA (approximately 25 by 20 feet)
Length of Contamination (cm)	610	
Thickness of Contamination (cm)	76.2	Site-specific value based on soil boring log for PB-59 (approximately 2.5 feet)
Thickness of soil stratum A (cm)	122	Site-specific value based on soil boring for PB-59
Soil type	Sand	Site-specific value based on soil boring for PB-59
Dry bulk density (g/cm^3)	1.66	Recommended average value for specific soil type from EPA (2004a)
Total soil porosity (unitless)	0.375	Recommended average value for specific soil type from EPA (2004a)
Soil water-filled porosity (cm^3/cm^3)	0.054	Recommended average value for specific soil type from EPA (2004a)
Thickness of soil stratum B (cm)	46	Site-specific value based on soil boring for PB-59
Soil type	Loamy Sand	Site-specific value based on soil boring for PB-59
Dry bulk density (g/cm^3)	1.62	Recommended average value for specific soil type from EPA (2004a)
Total soil porosity (unitless)	0.39	Recommended average value for specific soil type from EPA (2004a)
Soil water-filled porosity (cm^3/cm^3)	0.076	Recommended average value for specific soil type from EPA (2004a)
Thickness of soil stratum C (cm)	76	Site-specific value based on soil boring for PB-59
Soil type	Sand	Site-specific value based on soil boring for PB-59
Dry bulk density (g/cm^3)	1.66	Recommended average value for specific soil type from EPA (2004a)
Total soil porosity (unitless)	0.375	Recommended average value for specific soil type from EPA (2004a)
Soil water-filled porosity (cm^3/cm^3)	0.054	Recommended average value for specific soil type from EPA (2004a)
Floor-wall seam gap (cm)	0.1	Default value (EPA 2004a)

Input Parameter/Units	Parameter Value	Source
Building air exchange rate per hour	5	Site-specific value
Soil-building pressure differential (g/cm-s^2)	40	EPA default value (EPA 2004a)
Average vapor flow rate into building (L/min)	5	EPA default value (EPA 2004a)
Enclosed space floor thickness (cm)	30.48	Site-specific value
Enclosed space floor length (cm)	766	Dimensions of the lunch room (approximately 25 by 20 feet with a ceiling height of 12 feet), which was selected for evaluation because this part of the building is located over the DNAPL, is regularly occupied, and is an enclosed space within the larger structure.
Enclosed space floor width (cm)	610	
Enclosed space height (cm)	366	

Notes:
% - percent
bgs – below ground surface
°C – degrees Celsius
cm – centimeter
cm^3/cm^3 – cubic centimeter per cubic centimeter
DNAPL – dense nonaqueous phase liquid
EPA – US Environmental Protection Agency
g/cm^3 – grams per cubic centimeter
g/cm-s^2 – gram per centimeter per second squared
MFA – Maintenance Facility Area
mg/kg – milligrams per kilogram
L/min – liters per minute

Table G-2
Summary of Initial Soil Concentrations and Modeled Indoor Air Concentrations

Chemical	Initial Soil Concentration (mg/kg)	Modeled Indoor Air Concentration (µg/m^3)
Naphthalene	1700	11.3
Fluorene	330	0.0081
2-Methylnaphthalene	720	2.87
Pyrene	210	0.000022
Acenaphthene	390	0.047

Notes:
mg/kg – milligrams per kilogram
ug/m^3 – micrograms per cubic meter

Table G-3
Calculation of MTCA Method C Industrial Air Cleanup Levels

Equations:

Noncancer Method C CUL (ug/m^3) = $\frac{RfD \times THQ \times BW \times AT \times CF}{BR \times ABS \times ED \times EF}$ (WAC 173-340-750 Equation 750-1)

Cancer Method C CUL (ug/m^3) = $\frac{TCR \times BW \times AT \times CF}{CPF \times BR \times ABS \times ED \times EF}$ (WAC 173-340-750 Equation 750-2)

Notes:

Parameter	Definition	Value	Units	Source
THQ	Target hazard quotient	1	unitless	WAC 173-340-750
TCR	Target cancer risk	1 x 10^{-5}	unitless	WAC 173-340-750
RfD	Inhalation reference dose	chemical-specific	mg/kg-day	See Section 3
CPF	Inhalation slope factor	chemical-specific	(mg/kg-day)$^{-1}$	See Section 3
CF	Conversion factor	1,000	µg/mg	Not applicable
BR	Breathing rate	20	m^3/day	WAC 173-340-750
ABS	Inhalation absorption fraction	1	unitless	WAC 173-340-750
EF	Exposure frequency	1	unitless	WAC 173-340-750
ED	Exposure duration			
	noncancer	6	years	WAC 173-340-750
	cancer	30	years	WAC 173-340-750
BW	Body weight	70	kg	WAC 173-340-750
AT	Averaging time			
	noncancer	6	years	WAC 173-340-750
	cancer	75	years	WAC 173-340-750

Table G-4
Comparison of Modeled Indoor Air Concentrations to MTCA Method C Industrial Air Cleanup Levels

Chemical	**Modeled Indoor Air Concentration (µg/m³)**	**MTCA Method C Air Cleanup Level, Noncancer (µg/m³)**	**MTCA Method C Air Cleanup Level, Cancer (µg/m³)**
Naphthalene	11.3	**3**	**0.7**
Fluorene	0.0081	--	--
2-Methylnaphthalene	2.87	3	--
Pyrene	0.000022	--	--
Acenaphthene	0.047	--	--

Notes:
Bolded cells indicate an exceedance over the MTCA Method C air cleanup level
ug/m^3 – micrograms per cubic meter

APPENDIX H
QAPP – AIR SAMPLING ADDENDUM

QUALITY ASSURANCE PROJECT PLAN

AIR SAMPLING ADDENDUM

FORMER INTERNATIONAL PAPER FACILITY
LONGVIEW, WASHINGTON

Prepared for

INTERNATIONAL PAPER
LONGVIEW, WASHINGTON
URS CORPORATION
November 3, 2009

CONTENTS

TABLES

ATTACHMENTS

QUALITY ASSURANCE PROJECT PLAN
AIR SAMPLING ADDENDUM
FORMER INTERNATIONAL PAPER FACILITY
LONGVIEW, WASHINGTON

1.0 PROJECT DESCRIPTION

This document presents the Quality Assurance Project Plan (QAPP) for air sampling activities at the former International Paper (IP) Facility located in Longview, Washington. The QAPP was developed in conjunction with the Vapor Intrusion Assessment Sampling and Analysis Plan (URS 2009) for the IP Longview facility. This QAPP amends the QAPP included in Appendix A of the Performance and Compliance Monitoring Plan (PCMP) dated July 1997 and subsequent amendments. It will serve as the basis for evaluation of data from future environmental air sampling conducted as part of the IP Longview investigation. This QAPP has been prepared in accordance with the Washington Department of Ecology (Ecology) publication *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Ecology, 2004).

The purpose of the QAPP and associated SAP and work plan is to ensure that project data are representative of the conditions in the field and that analytical data are valid and accurately reported. The procedures outlined in this QAPP may also be applied to supplemental investigations, remedial investigations, interim actions, or other actions for which air data collection occurs provided this QAPP is referenced in the specific project plan (monitoring plan, SAP, or work plan). Some field data may also be generated by other sources (weather services, etc.).

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

The project team will consist of personnel from Ecology, IP, URS Corporation (URS) and their subcontractors, and the laboratory Air Toxics, Ltd, of Folsom, CA. The following paragraphs describe the major positions and responsibilities of the laboratory team along with the approach to quality assurance management.

2.1 ANALYTICAL LABORATORY PROJECT MANAGER

- Kelly Buettner

  Air Toxics, Ltd.
  180 Blue Ravine Rd, Ste B
  Folsom, CA 95630
  (800) 985-5955
  Email - k.buettner@airtoxics.com

The analytical laboratory project manager is responsible for reviewing and reporting all analytical data generated during the project, responding to questions or concerns regarding the quality of the data that the project managers, Project QA Manager, or data quality assessment personnel may have, and implementing any corrective actions deemed necessary by these individuals with regards to laboratory operations.

3.0 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are qualitative and/or quantitative statements of the precision (a measure of the random error), bias (a measure of systematic error), representativeness, completeness, and comparability necessary for the data to serve the objectives of previous and future actions and remedial investigations. The objectives of the air investigation are discussed in detail in the associated project plan. During plan implementation, field as well as laboratory data may be generated. The quality of the field data, if any, will be evaluated based on successful calibration of each instrument supplying the data and the stated accuracy and precision by the manufacturer. The quality of laboratory data will be evaluated based on the relative precision, bias, representativeness, completeness, and comparability of the data generated by each type of analysis. Some field data may be generated from a nearby weather station. Weather station data will be accepted as reported. These terms are defined below:

Precision	Precision is a measure of the scatter in the data due to random error. For most environmental measurements, the major sources of random error are sampling and analytical procedures. Sampling and analytical precision is expressed as the relative percent difference (RPD) of duplicates.
Accuracy	Accuracy indicates a measure of the degree to which the data collected may vary from the true value due to such factors as contamination during the sampling process and loss of sample from improper collection or handling, or analytical method bias. Analytical method bias is determined by calculating percent recovery from spiked samples and is usually expressed in terms of (high or low) bias. Accuracy can be affected by sample contamination in the field or laboratory or during storage and processing of the sample.
Representativeness	Representativeness of the environmental conditions at the time of sampling is achieved by selecting sampling locations, methods and times so that the data sufficiently describes the site conditions that the project seeks to evaluate.
Comparability	Comparability refers to the ability to compare the data from the project to other data.
Completeness	Completeness refers to the amount of valid usable data produced in the project.

Sensitivity	Sensitivity indicates the ability of an analytical method to detect contaminates at the lower end of the range of concentrations of concern. This ability is expressed by the detection limit. It is often discussed together with a closely allied concept, that of specificity. Specificity is the ability of an analytical technique to differentiate between a certain substance and other similar chemicals.
Bias	Bias is a measure of the difference between the analytical result for a parameter and the true value due to systematic errors. Potential sources of systematic errors include sample collection, physical/chemical instability of samples, interference effects, calibration of the measurement system, and artificial contamination. Bias is expressed as the percent recovery of surrogates.

Project DQOs for method detection limits (MDLs) and laboratory reporting limits (RLs) are summarized in Table 1. The analytical methods and RLs provided in Table 1 were selected to achieve data that was equal to or below regulatory screening levels. MDLs are statistically calculated values under clean matrix conditions that should support RLs. For this project, results between the MDL and RL will be reported as estimated ('J' flagged). As methods are developed that are able to achieve lower RLs, they will be assessed for project usability and presented to Ecology for approval. Upon approval, revisions will be made to the method selections in the QAPP. As laboratory control limits change during the project, the new control limits will be used as DQOs.

Reporting limit goals are based on the cleanup goals for this project. For air, the goals are based on the Model Toxics Control Act (MTCA) Method C. Further information regarding the cleanup levels is addressed in the SAP.

The DQOs for precision and bias are assessed based on the laboratory control limits provided in Attachment 1. Representativeness of the data collected will be ensured by using sampling procedures that represent the actual site conditions at the time of sampling. Field sampling procedures are discussed in detail in the SAP. In addition, representative samples will also be ensured through following proper protocols for sample handling (storage, preservation, packaging, custody, and transportation), sample documentation, and laboratory sample handling and documentation procedures.

Comparability of the data will be ensured by selecting standard USEPA and/or state analytical methodologies for sample analysis. Data will be reported from the laboratory to URS both electronically and in paper copy form. The laboratory data will be provided in a suitable database format specified by URS. The electronic and paper copy analytical reports will be checked by URS to ensure reporting accuracy. Data quality will be assessed in terms of precision, bias, representativeness, completeness and comparability using specific data quality assessment procedures outlined in Section 10 of the QAPP. Results of these assessments, along with any data that is qualified, will be submitted to the Project QA Manager in a data review memorandum for review and, if necessary, additional assessment.

4.0 SAMPLING PROCEDURES

Specific sampling procedures are discussed in the SAP. Pertinent information obtained during sample collection - including field measurements, physical description of the sample, time and date collected and person collecting the sample - will be recorded in a log book. The Work Plan describes the format for field data entry and field procedures for assuring accuracy.

Containers, sample size, preservation, and holding times are listed in Table 2 for Method TO-17. Samples will be identified according to the sample designation system described in the applicable project plan. Sample custody will be tracked with a chain-of-custody (COC) form in accordance with the procedures outlined in the applicable project plan. Samples will remain in the custody of the sample collector until transport to the laboratory, unless a secure storage area is available.

Sample coolers and packing materials will be supplied by the laboratory. Upon delivery to the lab, the coolers will contain ice of sufficient quantity to maintain the samples at approximately 4 degrees Celsius (2° to 6° C) for 12 hours.

5.0 ANALYTICAL PROCEDURES

The analytical procedures that may be used in the field and by the contract laboratory are outlined in Table 1 and discussed in Sections 5.1 below.

5.1 LABORATORY ANALYTICAL PROCEDURES

The analytical methodology, including MDLs and laboratory RLs, are listed in Table 1. This method is derived from *US EPA Compendium Ambient Air Methods*. The laboratory will perform the analyses in general accordance with the appropriate specific USEPA methodology. Method-required QC will be completed by the laboratory conducting the analyses/tests and reported along with the analytical and testing results.

6.0 QUALITY CONTROL PROCEDURES

Quality control procedures provide the means of evaluating and controlling the precision and bias of the analytical results. Careful adherence to established procedures for sample collection, preservation, and storage will minimize errors due to sampling and sample instability.

6.1 FIELD QC PROCEDURES

The types of field QC samples that will be collected and their purpose in relation to the DQOs are listed below.

6.1.1 Field Blanks

Field blanks and/or trip blanks can indicate bias in analytical results caused by artificially introduced contamination from sample containers, sampling equipment, transportation and storage practices, and other samples. Field blanks will be collected at a frequency of one per sampling event or 10%, whichever is greater. Field blank sorbent tubes will be uncapped and immediately resealed at the monitoring site.

6.1.2 Field Duplicates

A field duplicate is being collected for the air investigation. Field duplicates are samples that are collected at the same time and location, and are preserved, stored, and analyzed under identical conditions as the parent sample. Evaluation of the difference between the analytical results of field duplicates can provide an estimate of the sampling error for project samples. A good estimate of the random error due to sampling can only be made if the results of the field duplicates are significantly above the RL for a particular analysis. Hence, samples selected for duplication should be those expected to produce positive results, if possible. Field duplicates will be collected at a frequency of one per sampling event or 10%, whichever is greater.

6.1.3 Field Personnel Training

Proper sampling technique will be ensured by training field personnel prior to field mobilization. Training of project personnel will be provided by URS personnel experienced with TO-17 sampling methodology. Brian Nichols is currently identified as the URS personnel trainer.

6.2 LABORATORY QC PROCEDURES

Laboratory QC samples are used to assess if analytical results are within quality control limits and documented. The types of QC samples the laboratory will employ depend on the particular analytical methodology that will be used to analyze the samples. Each analytical method has required QC that must meet laboratory developed acceptance limits in order for the data to be considered valid. In addition, as part of the laboratory's annual accreditation program, performance evaluation samples and MDL studies are conducted to evaluate the laboratory's capability of performing the method accurately and precisely. Specific types of QC samples and corresponding control or acceptance limits for each analyte with respect to the particular analytical methodology are presented in Attachment 1. Matrix spike/matrix spike duplicates samples are not performed on air samples. An LCS and a Continuing Calibration Verification (CCV) sample are analyzed instead.

The control limits provided in Attachment 1, Table 14-11 were obtained from the laboratory during formulation of this QAPP. In general, these control limits were statistically calculated for each analytical method and matrix in accordance with EPA guidance based on actual sample results. In some cases, the control limits are defined by the analytical method. The control limits therefore represent the normal laboratory variability associated with analysis of samples from many sites and are not specific to IP Longview samples. Laboratory control sample (LCS) and surrogate recoveries associated with analyses of IP Longview samples are reviewed by the laboratory to assess whether the recoveries indicate an out-of-control situation and to determine if corrective action is necessary. The laboratory will document the findings of their QC review and the corrective actions performed in the case narrative for the analytical reports.

As laboratory control limits changes during the project, the new control limits will be used as DQOs.

Specific QC or acceptance limits for certain modified USEPA methods have not been established historically. RLs and QC results obtained for these methods at the time of sample analysis will be reported with the analytical results and the QC results will be evaluated against default control limits.

7.0 REFERENCES

URS, 2008, Additional Investigation Work Plan, prepared for International Paper, Longview, Washington, June 6, 2008.

URS, 2009, Vapor Intrusion Assessment Sampling and Analysis Plan, prepared for International Paper, Longview, Washington, October , 2009.

U.S. Environmental Protection Agency (USEPA), 1999, USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, EPA 540/R-99/008, October 1999.

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U.S. Environmental Protection Agency (USEPA), 2005, Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), 3rd Ed., September 1986; Final Update I, July 1992; Final Update IIA, August 1993; Final Update II, September 1994; Final Update IIB, January 1995, Final Update IIIB, April 1998, Draft Final Update IV, June 2005.

Woodward-Clyde, 1997, Performance and Compliance Monitoring Plan, Former Treated Wood Products Area, International Paper Facility, Longview, Washington, July 1997.

Washington State Department of Ecology (Ecology), 1997, Analytical Methods for Petroleum Hydrocarbons, Publication No. ECY 97-602, June 1997.

Washington Department of Ecology (Ecology), 2007, Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation (CLARC), Updated October 2007. Revised MTCA Method B and C values from Ecology website CLARC tables downloaded May 2008 (https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx)

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ATTACHMENT 1

ENSURING A VALID SAMPLE BY METHOD TO-17

&

QUALITY CONTROL AND ACCEPTANCE LIMITS

PROVIDED BY AIR TOXICS LTD

TABLE 1
Parameters of Interest and Overall Project Data Quality Objectives - Air
Vapor Intrusion Assessment Quality Assurance Project Plan Addendum
Intenational Paper - Longview, Washington

Parameter	Method	MDL	RL	MTCA Cleanup Levels[1] Method C
		Air	Air	Air
Volatile Organic Compounds	**USEPA TO-17**	ng	ng	µg/m3
2-Methylnaphthalene		1.56	5.0	NA
Naphthalene		NA	5.0	3.0

Notes:

1 - Model Toxics Control Act (MTCA) Cleanup Regulation, WAC 173-340. MTCA Method C values are from Ecology website CLARC tables downloaded as of May 2008. (https://fortress.wa.gov/ecy/clarc/reporting/CLARCReporting.aspx).

Note that the units for the cleanup level and the reporting limits are different. The RL will be converted to µg/m^3 after sample collection, which will determine sample volume.

MDL - Method Detection Limit

RL - Reporting Limit

COLLECTING A **VALID** TO-17 SAMPLE

What is the best way to ensure success?

Because the composition of the sample is often unknown, it is best to collect a series of samples using 2 or 3 different sample volumes. This is referred to as distributive volume sampling. The method specifies that a 1 and 5L sample be collected; however, this may not meet project DQO. If calculations indicate that the sample volume should be 10 L, it is best to collect a 5 L, a 10 L and a 20 L sample. The laboratory will first analyze the 5 L sample to determine if this is sufficient sample volume to provide the high quality data. Often the data from the 5 L is sufficient to satisfy project objectives. Distributive sampling results in an additional analysis, but it may eliminate the need for re-sampling by ensuring usable, defensible data.

What kind of compounds is amenable to this technique?

When using a CarboTrap 300 sorbent tube, the compounds should have boiling points between -25 (chloromethane) and 317 °C. If the boiling point is less than -25 °C, there is a concern about breakthrough (a common problem with VOCs). If the boiling point is greater than 300 °C, it is difficult to quantitatively thermally desorb the compound from the sorbent. In addition, the compound(s) must be thermally stable so that no degradation or decomposition occurs during desorption.

How is the sample actually collected?

There are mg quantities of sorbents used in the multi-bed CarboTrap 300 TO-17 tube; consequently the sorbent tube has very little pressure drop. This means that a portable industrial hygiene pump can be used. These pumps are battery powered and can be used for extended periods of time. One must record the sampling time and rate to determine the sample volume “pulled” through the tube.

What flow rate should be used?

The flow rate through the sorbent tube is generally kept below 1 L/minute. Rates of 0.1- 0.5 L/min. are common. There is no lower limit to the flow; rates as low as 0.005 L/min. have been used to extend the sampling interval.

What about water and acid in the sample?

Ambient air normally does not contain enough water or acid to render the technique unusable. When analyzing high moisture samples like landfill gas or stationary sources, water and acid do not normally pose a problem given the low volumes (1 - 5 L) sampled. Of course water, as such, should not be allowed to enter the tube. If it is raining, cover the tube inlet. Should the tube become saturated with water, there is danger that it will effectively “deactivate” the surface of the sorbent. This will prevent the adsorption of the organics and possibly invalidate the sample. Excessive water or the presence of acid may also interfere with the analysis.

How should the tubes be stored and shipped?

The sorbent tube should always be stored in a glass transport tube containing a bit of activated charcoal. Tubes should be stored and transported at 4 °C.

What is the sample hold time?

Our data indicates that samples are stable on the sorbent (if properly stored) in excess of 60 days. The compounds are adsorbed on a high energy surface; they are not “free” to react. The tubes are cool and the sorbent area is dark; consequently, there is little energy available to either catalyze a reaction with another species or initiate decomposition.

For more information refer to Air Toxics’ *Guide to Sorbent-Based Sampling: Volatiles and Semi-volatiles*

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14.0 TO-17 VOLATILE ORGANIC COMPOUNDS

This method is an alternative to the canister based sampling and analysis methods that are presented in EPA Compendium Methods TO-14 and TO-15. Samples are collected by drawing a volume of air through a sorbent packed tube. The sample cartridges are thermally desorbed by heating and purging with organic-free Helium. The resulting gaseous effluent is then trapped on the secondary trap. The secondary trap is then thermally desorbed for GC/MS analysis.

The procedures in this method outline the use of EPA Method TO-17 protocols to determine the concentrations of volatile organic compounds in air samples collected on sorbent tubes.

Air Toxics Ltd. performs a modified version of this method. The method modifications, standard target analyte list, Limit of Quantitation, QC criteria, and QC summary can be found in the following tables.

Table 14-1. Summary of Method Modifications

Requirements	EPA Method TO-17	Air Toxics Ltd. Modifications
Lab Blank	At least 2 tubes from the same cleaning batch as the samples are analyzed at the beginning and end of the analytical sequence. Do not dry purge Lab Blanks.	Tubes used for daily lab blank may or may not be from the same batch or sampling media. Only 1 lab blank is analyzed prior to sample analysis. Lab blanks are dry purged to eliminate the possibility of sample anomaly attributed to Dry purge process.
*Tune Check	BFB.	Modification applies only to semivolatile lists such as PAHs in which a DFTPP tune check is more appropriate to demonstrate accurate spectral performance.
*Sample desorption	Method involves primary and secondary desorption.	Modification applies only when using a Tekmar P&T system. After primary desorption, the stream of effluent gas is passed through 5ml of clean purged D.I. water before the secondary desorption. D.I. water acts as a filter for excessive acidic moisture in the samples.

*Modifications are dependent on application.

Table 14-2. Summary of Sorbent Applications

Sorbent	Typical Analyte Range	Water management	Primary Applications
Carbotrap 300	C3 – C12	High levels of moisture may interfere with analysis.	Indoor air and outdoor air.
Tenax TA	C7 – C26	Hydrophobic.	All vapors including soil gas.
Tenax GR	C7 – C30	Hydrophobic.	All vapors including soil gas.

Table 14-3. TO-17 Carbotrap 300 Analyte List

Analytes	RL (ng)	Acceptance Criteria		
		ICAL (%RSD)	LCS (% R)	CCV (%D)
1,1,1-Trichloroethane	10	30	70 – 130	30
1,1,1,2-Tetrachloroethane	10	30	70 – 130	30
1,1,2,2-Tetrachloroethane	10	30	70 – 130	30
1,1,2-Trichloroethane	10	30	70 – 130	30
1,1-Dichloroethane	10	30	70 – 130	30
1,1-Dichloroethene	10	30	70 – 130	30
1,1-Dichloropropene	10	30	70 – 130	30
1,2,3-Trichlorobenzene	50	30	70 – 130	30
1,2,3-Trichloropropane	10	30	70 – 130	30
1,2,4-Trichlorobenzene	50	30	70 – 130	30
1,2,4-Trimethylbenzene	10	30	70 – 130	30
1,2-Dibromo-3-chloropropane	50	30	70 – 130	30
1,2-Dichlorobenzene	10	30	70 – 130	30
1,2-Dichloroethane	10	30	70 – 130	30
1,2-Dichloropropane	10	30	70 – 130	30
1,3,5-Trimethylbenzene	10	30	70 – 130	30
1,3-Butadiene	50	30	50 – 150	30
1,3-Dichlorobenzene	10	30	70 – 130	30
1,3-Dichloropropane	10	30	70 – 130	30
1,4-Dichlorobenzene	10	30	70 – 130	30
2,2-Dichloropropane	10	30	70 – 130	30
2-Chloropropane	10	30	70 – 130	30
2-Chlorotoluene	10	30	70 – 130	30
Allyl chloride	10	30	70 – 130	30
4-Chlorotoluene	10	30	70 – 130	30
Acrylonitrile	10	30	70 – 130	30
Benzene	10	30	70 – 130	30
Bromobenzene	10	30	70 – 130	30
Bromochloromethane	10	30	70 – 130	30
Bromodichloromethane	10	30	70 – 130	30
Bromoform	10	30	70 – 130	30
Bromomethane	10	30	50 – 150	30
Butylbenzene	10	30	70 – 130	30
Carbon Disulfide	10	30	70 – 130	30
Carbon Tetrachloride	10	30	70 – 130	30
Chlorobenzene	10	30	70 – 130	30
Chloroethane	10	30	50 – 150	30
Chloroform	10	30	70 – 130	30
Chloromethane	10	30	50 – 150	30
cis-1,2-Dichloroethene	10	30	70 – 130	30

Analytes	RL (ng)	Acceptance Criteria		
		ICAL (%RSD)	LCS (% R)	CCV (%D)
cis-1,3-Dichloropropene	10	30	70 – 130	30
cis-1,4-Dichloro-2-butene	50	30	70 – 130	30
Cumene	10	30	70 – 130	30
Dibromochloromethane	10	30	70 – 130	30
Dibromomethane	10	30	70 – 130	30
Dichlorodifluoromethane	10	30	50 – 150	30
Ethylbenzene	10	30	70 – 130	30
Ethylene Dibromide	10	30	70 – 130	30
Freon 11	10	30	70 – 130	30
Freon 113	10	30	70 – 130	30
Hexachlorobutadiene	50	30	70 – 130	30
Hexane	10	30	70 – 130	30
Iodomethane	10	30	70 – 130	30
Methylene Chloride	10	30	70 – 130	30
Methyl t-butyl ether (MTBE)	10	30	70 – 130	30
Naphthalene	50	30	70 – 130	30
m,p-Xylene	10	30	70 – 130	30
o-Xylene	10	30	70 – 130	30
p-Cymene	10	30	70 – 130	30
Propylbenzene	10	30	70 – 130	30
sec-Butylbenzene	10	30	70 – 130	30
Styrene	10	30	70 – 130	30
tert-Butylbenzene	10	30	70 – 130	30
Tetrachloroethene	10	30	70 – 130	30
Toluene	10	30	70 – 130	30
trans-1,2-Dichloroethene	10	30	70 – 130	30
trans-1,3-Dichloropropene	10	30	70 – 130	30
trans-1,4-Dichloro-2-butene	50	30	70 – 130	30
Trichloroethene	10	30	70 – 130	30
Vinyl Bromide *	50	30	50 – 150	30
Vinyl Chloride	10	30	50 – 150	30

* *Independent Source Verification Check not available for this compounds.*

Table 14-4. Internal Standard Recovery Limits Limits (Carbotrap 300)

Analyte	CCV IS (%R)	Sample IS (%R)
1,4-Dichlorobenzene-d_4	50 – 200	60 – 140
Chlorobenzene-d_5	50 – 200	60 – 140
Fluorobenzene	50 – 200	60 – 140

Table 14-5. Surrogate Recovery (Carbotrap 300)

Analyte	Accuracy (%R)
1,2-Dichloroethane-d_4	70 – 130
4-Bromofluorobenzene	70 – 130
Dibromofluoromethane	70 – 130
Toluene-d_8	70 – 130

Table 14-6. TO-17 (Tenax GR/TA)

Analytes	Reporting Limit (ng)	Acceptance Criteria		
		ICAL (%RSD)	LCS (% R)	CCV
1,1,1-Trichloroethane	5.0	30	70 – 130	30
1,1,1,2-Tetrachloroethane	5.0	30	70 – 130	30
1,1,2,2-Tetrachloroethane	5.0	30	70 – 130	30
1,1,2-Trichloroethane	5.0	30	70 – 130	30
1,1-Dichloropropene	5.0	30	70 – 130	30
1,2,3-Trichlorobenzene	5.0	30	70 – 130	30
1,2,3-Trichloropropane	5.0	30	70 – 130	30
1,2,4-Trichlorobenzene	5.0	30	70 – 130	30
1,2,4-Trimethylbenzene	5.0	30	70 – 130	30
1,2-Dibromo-3-chloropropane	5.0	30	70 – 130	30
1,2-Dichlorobenzene	5.0	30	70 – 130	30
1,2-Dichloroethane	5.0	30	70 – 130	30
1,2-Dichloropropane	5.0	30	70 – 130	30
1,3,5-Trimethylbenzene	5.0	30	70 – 130	30
1,3-Dichlorobenzene	5.0	30	70 – 130	30
1,3-Dichloropropane	5.0	30	70 – 130	30
1,4-Dichlorobenzene	5.0	30	70 – 130	30
2-Chlorotoluene	5.0	30	70 – 130	30
4-Chlorotoluene	5.0	30	70 – 130	30
Benzene	5.0	30	70 – 130	30
Bromobenzene	5.0	30	70 – 130	30
Bromodichloromethane	5.0	30	70 – 130	30
Bromoform	5.0	30	70 – 130	30
Butylbenzene	5.0	30	70 – 130	30
Carbon Tetrachloride	5.0	30	70 – 130	30
Chlorobenzene	5.0	30	70 – 130	30
Chloroform	5.0	30	70 – 130	30
cis-1,3-Dichloropropene	5.0	30	70 – 130	30
cis-1,4-Dichloro-2-butene	5.0	30	70 – 130	30
Cumene	5.0	30	70 – 130	30
Dibromochloromethane	5.0	30	70 – 130	30
Dibromomethane	5.0	30	70 – 130	30
Ethylbenzene	5.0	30	70 – 130	30
Ethylene Dibromide	5.0	30	70 – 130	30
Hexachlorobutadiene	5.0	30	70 – 130	30
Naphthalene	5.0	30	70 – 130	30
m,p-Xylene	10	30	70 – 130	30
o-Xylene	5.0	30	70 – 130	30
p-Cymene	5.0	30	70 – 130	30
Propylbenzene	5.0	30	70 – 130	30
sec-Butylbenzene	5.0	30	70 – 130	30

Analytes	**Reporting Limit (ng)**	**Acceptance Criteria**		
		ICAL (%RSD)	**LCS (% R)**	**CCV**
Styrene	5.0	30	70 – 130	30
tert-Butylbenzene	5.0	30	70 – 130	30
Tetrachloroethene	5.0	30	70 – 130	30
Toluene	5.0	30	70 – 130	30
trans-1,3-Dichloropropene	5.0	30	70 – 130	30
trans-1,4-Dichloro-2-butene	5.0	30	70 – 130	30
Trichloroethene	5.0	30	70 – 130	30

Table 14-7. Internal Standard Recovery Limits Limits (Tenax GR/TA)

Analyte	**CCV IS (%R)**	**Sample IS (%R)**
1,4-Dichlorobenzene-d_4	50 – 200	60 – 140
Chlorobenzene-d_5	50 – 200	60 – 140
Fluorobenzene	50 – 200	60 – 140

Table 14-8. Surrogate Recovery (Tenax GR/TA)

Analyte	**Accuracy (%R)**
1,2-Dichloroethane-d_4	70 – 130
4-Bromofluorobenzene	70 – 130
Dibromofluoromethane	70 – 130
Naphthalene-d8 (optional)	70 – 130

Table 14-9. TO-17 TPH External Calibration (Tenax GR/TA)

Analytes	**Reporting Limit (ng)**	**Acceptance Criteria**		
		ICAL (%RSD)	**LCS (% R)**	**CCV**
Mineral Spirits (C9 – C12 range)	500	30	70 – 130	30
Surrogates	**% Recovery**			
Chlorobenzene-d5 Naphthalene – d8	70 – 140 70 - 140			
Analytes	**Reporting Limit (ng)**	**Acceptance Criteria**		
		ICAL (%RSD)	**LCS (% R)**	**CCV**
Diesel	1000	30	70 – 130	30
Surrogates	**% Recovery**			
Toluene-d8 4-Bromofluorobenzene Naphthalene – d8	70 – 140 70 - 140 70 - 140			

Table 14-10. TO-17 (Tenax TA - Passive)

Analytes	**Reporting Limit (ng)**	**Acceptance Criteria**		
		ICAL (%RSD)	**LCS (% R)**	**CCV**
Benzene	5.0	30	70 – 130	30

Toluene	5.0	30	70 – 130	30
Ethyl benzene	1.0	30	70 – 130	30
m,p-xylene	2.0	30	70 – 130	30
o-Xylene	1.0	30	70 – 130	30
Trichloroethene	1.0	30	70 – 130	30
Tetrachloroethene	1.0	30	70 – 130	30
Cis-1,2-Dichloroethene	1.0	30	70 – 130	30
Trans-1,2-Dichloroethene	1.0	30	70 – 130	30
1,1-Dichloroethene	1.0	30	70-130	30
Internal Standards				
Analyte	**CCV IS % Recovery**		**Sample IS % Recovery**	
1,4-Dichlorobenzene-d_4	50 – 200		60 – 140	
Chlorobenzene-d_5	50 – 200		60 – 140	
Fluorobenzene	50 – 200		60 – 140	
Surrogates				
Analyte	**% Recovery**			
1,2-Dichloroethane-d_4	70 – 130			
4-Bromofluorobenzene	70 – 130			
Dibromofluoromethane	70 – 130			

Table 14-11. TO-17 (Tenax GR-SVOC)

Analytes	**Reporting Limit (ng)**	**Acceptance Criteria**		
		ICAL (%RSD)	**LCS (% R)**	**CCV**
Naphthalene	5.0	30	70 – 130	30
2-Methylnaphthalene	5.0	30	70 – 130	30
Acenaphthylene	5.0	30	70 – 130	30
Acenaphthene	5.0	30	70 – 130	30
Fluorene	5.0	30	70 – 130	30
Phenanthrene	5.0	30	70 – 130	30
Anthracene	5.0	30	70 – 130	30
Fluoranthene	5.0	30	70 – 130	30
Pyrene	10	30	70 – 130	30
Internal Standards				
Analyte	**CCV IS % Recovery**		**Sample IS % Recovery**	
Naphthalene-d8	50 – 200		60 – 140	
Acenaphthene-d10	50 – 200		60 – 140	
Phenanthrene-d10	50 – 200		60 – 140	
Surrogates				
Analyte	**% Recovery**			
Fluorene-d10	70 – 130			
Pyrene-d10	70 – 130			

Table 14-12. Summary of Calibration and QC Procedures for Method TO-17 (Volatile Organic Compounds)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
Tuning Criteria	Every 24 hours, or every 12 hours if project requires.	SW - 846 tune criteria.	Correct problem then repeat tune.
5-Point Calibration	Prior to sample Analysis.	%RSD ≤ 30%, 2 allowed out up to 40%	Correct problem then repeat Initial Calibration Curve.
LCS	After each initial Calibration Curve and daily prior to analysis.	Recovery 70- 130% or 50- 150% as noted in Table 14-3.	Check the system and reanalyze the standard. Re-prepare the standard if necessary. Re-calibrate the instrument if the criteria cannot be met.
Continuing Calibration Verification (CCV)	At the start of each day and, if required by a specific project, every 12 hours.	70 - 130 %	If project specified risk drivers exceed this criteria, more than 5% of the compounds exceed this criteria, or any VOC exceeds 50-150% recovery, maintenance is performed and the CCV test repeated. If the system still fails the CCV, perform a new 5-point Calibration Curve.
Laboratory Blank	After the CCV.	Results less than the RL.	Inspect the system and re-analyze the Blank.
Internal Standard (IS)	As each standard, Blank, and sample is being loaded.	**CCVs:** area counts 50% - 200%, RT w/in 30 sec of mid-point in ICAL. **Blanks and samples**: Retention time (RT) must be within ±0.33 minutes of the RT in the CCV. The IS area must be within ±40% of the CCV's IS area for the Blanks and samples.	**CCV:** inspect and correct system prior to sample analysis. **Blanks:** inspect the system and re-analyze the Blank. **Samples:** samples cannot be re-analyzed due to the nature of the sorbent cartridges. However investigate the problem by reviewing the data. If necessary, run a Lab Blank to check the instrument performance. Report the data and narrate.
Surrogates	As each standard, Blank, and sample is being loaded.	70 – 130%.	**For blanks:** inspect the system and re-analyze the Blank. **For samples:** samples cannot be re-analyzed due to the nature of sorbent cartridges. However investigate the problem by reviewing the data. If necessary, run a Lab Blank to check the instrument performance. Report the data and narrate the problem.

APPENDIX I
DATA QUALITY REVIEW MEMORANDUM

URS

Memo

1501 4th Avenue, Suite 1400
Seattle, WA 98101-1616
206-438-2700 Telephone
406-438-2699 Fax

To: Paul Kalina, Project Manager

Info: **FINAL**

From: Alison M. Rohde, Chemist
Jennifer Garner, Chemist

Date: February 3, 2010

RE: **Quality Assurance Review**
IP Longview – Vapor Assessment
Air Toxics Ltd. SDG 0912177R1

The summary data quality review of 7 vapor samples collected on December 5, 2009 has been completed. The samples were submitted to Air Toxics Ltd. (Air Toxics), a Washington State Department of Ecology (Ecology) accredited laboratory, located in Folsom, California. Samples were analyzed for polynuclear aromatic hydrocarbons (PAHs, naphthalene and 2-methylnaphthalene only) by Environmental Protection Agency (EPA) Method TO-17-modified. The analysis was performed in general accordance with methods specified in EPA's *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition*, January 1999. The following samples are associated with Air Toxics sample delivery group (SDG) 0912177R1:

Sample ID	Air Toxics ID
MFA-IA-1	0912177R1-01
MFA-IA-2	0912177R1-02
MFA-IA-3	0912177R1-03
MFA-IA-4	0912177R1-04
MFA-AA-1	0912177R1-05
MFA-AA-2	0912177R1-06
MFA-AA-3	0912177R1-07

Upon receipt by Air Toxics, the sample container information was compared to the chain-of-custody (COC). No discrepancies relating to sample identification were noted by the laboratory and the sample canisters were received in good condition.

Data validation is based on method performance criteria and QC criteria as documented in the *Draft Quality Assurance Project Plan (QAPP), Maintenance Facility Area, Former International Paper Facility, Longview, Washington, June 2008* (URS Corporation, 2008) and current Air Toxics control limits. The laboratory provided EPA Contract Laboratory Program-equivalent validatable data packages. The data review conducted on this sample delivery group (SDG) included a review of summarized results and QA/QC data, per the requirements set forth in Section A.10 of the QAPP. Hold times, initial and continuing calibrations, method blanks, surrogate recoveries, laboratory control sample (LCS) results, matrix duplicate results, matrix spike/matrix spike duplicate (MS/MSD) results, field duplicates, and reporting limits were reviewed to assess compliance with applicable methods. Calculation checks and review of the raw data were not included in the data review. If data qualification was required, data were qualified in accordance with *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, October 1999.

Organic Analysis

Samples were analyzed for select PAHs by Method TO-17-modified.

1. Holding Times – Acceptable

2. Instrument Performance (Tunes) – Acceptable

3. Initial Calibrations – Acceptable

4. Continuing Calibrations – Acceptable

5. Blanks – Acceptable

6. Surrogates – Acceptable

7. Internal Standards (applicable to GC/MS only) – Acceptable

8. Laboratory Control Samples (LCS) – Acceptable

9. Matrix Spike/Matrix Spike Duplicate (MS/MSD)

   An MS/MSD was not performed in association with this analysis. Precision was assessed using the LCS results. Accuracy was not assessed.

10. Reporting Limits – Acceptable

Overall Assessment

The data reported in this SDG, as qualified, are considered to be usable for meeting project objectives. The completeness for SDG 0912177R1 is 100%.

Data Qualifier Definitions:

U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.
DNR	Do Not Report. Another result is available that is more reliable or appropriate.

Table 1. Summary of Qualified Data

Sample ID	Laboratory ID	Analyte	Laboratory Result	Units	Final Result
No data were qualified during the review of SDG 0912177R1.					

APPENDIX J
LABORATORY ANALYTICAL REPORT

Air Toxics LTD.
Laboratory Services Since 1989

1/28/2010
Mr. Paul Kalina
URS Corporation
1501 4th Avenue
Suite 1400
Seattle WA 98101-1616

Project Name: IP Longview
Project #: 33759250
Workorder #: 0912177R1

Dear Mr. Paul Kalina

The following report includes the data for the above referenced project for sample(s) received on 12/8/2009 at Air Toxics Ltd.

The data and associated QC analyzed by Modified TO-17 are compliant with the project requirements or laboratory criteria with the exception of the deviations noted in the attached case narrative.

Thank you for choosing Air Toxics Ltd. for your air analysis needs. Air Toxics Ltd. is committed to providing accurate data of the highest quality. Please feel free to contact the Project Manager: Kelly Buettner at 916-985-1000 if you have any questions regarding the data in this report.

Regards,

Kelly Buettner

Kelly Buettner
Project Manager

WORK ORDER #: 0912177R1

Work Order Summary

CLIENT:	Mr. Paul Kalina URS Corporation 1501 4th Avenue Suite 1400 Seattle, WA 98101-1616	**BILL TO:**	Accounts Payable Austin URS Corporation P.O. BOX 203970 Austin, TX 78720-1088
PHONE:	206-438-2700	**P.O. #**	221189-US
FAX:	206-438-2699	**PROJECT #**	33759250 IP Longview
DATE RECEIVED:	12/08/2009	**CONTACT:**	Kelly Buettner
DATE COMPLETED:	12/14/2009		
DATE REISSUED:	01/28/2010		

FRACTION #	**NAME**	**TEST**
01A	MFA-IA-1	Modified TO-17
02A	MFA-IA-2	Modified TO-17
03A	MFA-IA-3	Modified TO-17
04A	MFA-IA-4	Modified TO-17
05A	MFA-AA-1	Modified TO-17
06A	MFA-AA-2	Modified TO-17
07A	MFA-AA-3	Modified TO-17
08A	Lab Blank	Modified TO-17
08B	Lab Blank	Modified TO-17
09A	CCV	Modified TO-17
09B	CCV	Modified TO-17
10A	LCS	Modified TO-17
10B	LCS	Modified TO-17

CERTIFIED BY: Linda L. Freeman DATE: 01/28/10

Laboratory Director

SORBENT SAMPLE COLLECTION

Air Toxics LTD.

CHAIN-OF-CUSTODY RECORD

Sample Transportation Notice
Relinquishing signature on this document indicates that sample is being shipped in compliance with all applicable local, State, Federal, national, and international laws, regulations and ordinances of any kind. Air Toxics Limited assumes no liability with respect to the collection, handling or shipping of these samples. Relinquishing signature also indicates agreement to hold harmless, defend, and indemnify Air Toxics Limited against any claim, demand, or action, of any kind, related to the collection, handling, or shipping of samples. D.O.T. Hotline (800) 467-4922.

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX (916) 985-1020

Page 1 of 1

Project Manager PAUL KALINA
Collected by: (Print and Sign) IAN VERMEEREN
Company URS SEATTLE Email PAUL_KALINA@URSCORP
Address 1501 4TH AVE SUITE 1400 City SEATTLE State WA Zip 98101
Phone 206 438 2700 Fax

Project Info:
P.O. #
Project # 33759250
Project Name IP LONGVIEW

Turn Around Time:
☑ Normal
☐ Rush
specify

Circle Reporting Units:
ppbv ppmv [✓ ug/m3] mg/m3

Lab I.D.	Field Sample I.D. (Location)	Tube # / Cartridge #	Date of Collection	Start Time	End Time	Duration	Final Volume	Analysis Requested
01A	MFA-IA-1	Mi 119817	12/5/09	930	530	8 HR	11.3L	TO-17 (NAPHTHALENE +
02A	MFA-IA-2	Mi 106109					11.1L	2-METHYLNAPHTHALENE
03A	MFA-IA-3	Mi 095574					10.7L	ONLY)
04A	MFA-IA-4	G0122807					11.5L	
05A	MFA-AA-1	Mi 130461					11.4L	
06A	MFA-AA-2	G0122898					11.5L	
07A	MFA-AA-3	Mi 113122	↓	↓	↓	↓	11.3L	↓

Relinquished by: (signature) Date/Time 12/5/09
Received by: (signature) Monica Grogan ATL Date/Time 12/8/09 925
Relinquished by: (signature) Date/Time
Received by: (signature) Date/Time
Relinquished by: (signature) Date/Time
Received by: (signature) Date/Time

Pump Calibration Information
Pre-test Flow Rate: ~21 ML/MIN
Post-test Flow Rate: ~23 ML/MIN
Average Flow Rate: ~22 ML/MIN
Notes:

Lab Use Only	Shipper Name	Air Bill #	Temp (°C)	Condition	Custody Seals Intact?	Work Order #
	FedEx	798198220648	30	Good	[✓ Yes] No None	0912177

LABORATORY NARRATIVE
TO-17 - Markes ATD
URS Corporation
Workorder# 0912177R1

Seven TO-17 Tube (Tenax-TA) samples were received on December 08, 2009. The laboratory performed the analysis via modified EPA Method TO-17 using GC/MS in the full scan mode. TO-17 sorbent tubes are thermally desorbed onto a secondary trap. The trap is thermally desorbed to elute the components into the GC/MS system for further separation.

Method modifications taken to run these samples are summarized in the below table. Specific project requirements may over-ride the ATL modifications.

Requirement	*TO-17*	*ATL Modifications*
Laboratory Blank	At least 2 tubes from the same cleaning batch as the samples are analyzed at the beginning and end of the analytical sequence. Do not dry purge Lab Blanks.	Tubes used for daily lab blank may or may not be from the same batch or sampling media. Only 1 lab blank is analyzed prior to sample analysis. Lab blanks are dry purged to eliminate the possibility of sample anomaly attributed to dry purge process.
Method Detection Limit	Follow 40CFR Pt.136 App. B	The MDL met all relevant requirements in Method TO-17 (statistical MDL less than the LOQ). The concentration of the spiked replicate may have exceeded 10X the calculated MDL in some cases

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

A sampling volume of 11.5 L was used to convert ng to ug/m3 for the associated Lab Blank.

PER CLIENT REQUEST, DATA WAS REISSUED ON JANUARY 28, 2010 TO QUANTIFY RESULTS USING CORRECTED SAMPLE VOLUMES.

Definition of Data Qualifying Flags

Eight qualifiers may have been used on the data analysis sheets and indicates as follows:

B - Compound present in laboratory blank greater than reporting limit (background subtraction not performed).
J - Estimated value.
E - Exceeds instrument calibration range.
S - Saturated peak.
Q - Exceeds quality control limits.
U - Compound analyzed for but not detected above the reporting limit.
UJ- Non-detected compound associated with low bias in the CCV
N - The identification is based on presumptive evidence.

File extensions may have been used on the data analysis sheets and indicates as follows:

a-File was requantified
b-File was quantified by a second column and detector
r1-File was requantified for the purpose of reissue

Summary of Detected Compounds
MODIFIED METHOD TO-17

Client Sample ID: MFA-IA-1

Lab ID#: 0912177R1-01A
No Detections Were Found.

Client Sample ID: MFA-IA-2

Lab ID#: 0912177R1-02A
No Detections Were Found.

Client Sample ID: MFA-IA-3

Lab ID#: 0912177R1-03A

Compound	Rpt. Limit (ng)	Rpt. Limit (ug/m3)	Amount (ng)	Amount (ug/m3)
Naphthalene	5.0	0.49	5.0	0.49

Client Sample ID: MFA-IA-4

Lab ID#: 0912177R1-04A
No Detections Were Found.

Client Sample ID: MFA-AA-1

Lab ID#: 0912177R1-05A
No Detections Were Found.

Client Sample ID: MFA-AA-2

Lab ID#: 0912177R1-06A
No Detections Were Found.

Client Sample ID: MFA-AA-3

Lab ID#: 0912177R1-07A
No Detections Were Found.

Client Sample ID: MFA-IA-1

Lab ID#: 0912177R1-01A

MODIFIED METHOD TO-17

File Name:	**j120921**	**Date of Extraction: NA**	**Date of Collection: 12/5/09 5:30:00 AM**
Dil. Factor:	**1.00**		**Date of Analysis: 12/10/09 02:36 AM**

Compound	**Rpt. Limit (ng)**	**Rpt. Limit (ug/m3)**	**Amount (ng)**	**Amount (ug/m3)**
Naphthalene	5.0	0.46	Not Detected	Not Detected
2-Methylnaphthalene	5.0	0.46	Not Detected	Not Detected

Air Sample Volume(L): 10.8
Container Type: TO-17 Tube (Tenax-TA)

Surrogates	**%Recovery**	**Method Limits**
Fluorene-d10	109	70-130

Client Sample ID: MFA-IA-2

Lab ID#: 0912177R1-02A

MODIFIED METHOD TO-17

File Name:	**j120928**	**Date of Extraction: NA**	**Date of Collection: 12/5/09 5:30:00 AM**
Dil. Factor:	**1.00**		**Date of Analysis: 12/10/09 09:08 AM**

Compound	Rpt. Limit (ng)	Rpt. Limit (ug/m3)	Amount (ng)	Amount (ug/m3)
Naphthalene	5.0	0.47	Not Detected	Not Detected
2-Methylnaphthalene	5.0	0.47	Not Detected	Not Detected

Air Sample Volume(L): 10.6

Container Type: TO-17 Tube (Tenax-TA)

Surrogates	%Recovery	Method Limits
Fluorene-d10	106	70-130

Client Sample ID: MFA-IA-3

Lab ID#: 0912177R1-03A

MODIFIED METHOD TO-17

File Name:	**j120929**	**Date of Extraction: NA**	**Date of Collection: 12/5/09 5:30:00 AM**
Dil. Factor:	**1.00**		**Date of Analysis: 12/10/09 09:49 AM**

Compound	Rpt. Limit (ng)	Rpt. Limit (ug/m3)	Amount (ng)	Amount (ug/m3)
Naphthalene	5.0	0.49	5.0	0.49
2-Methylnaphthalene	5.0	0.49	Not Detected	Not Detected

Air Sample Volume(L): 10.2
Container Type: TO-17 Tube (Tenax-TA)

Surrogates	%Recovery	Method Limits
Fluorene-d10	106	70-130

Client Sample ID: MFA-IA-4

Lab ID#: 0912177R1-04A

MODIFIED METHOD TO-17

File Name:	**j121019**	**Date of Extraction: NA**	**Date of Collection: 12/5/09 5:30:00 AM**
Dil. Factor:	**1.00**		**Date of Analysis: 12/10/09 10:46 PM**

Compound	Rpt. Limit (ng)	Rpt. Limit (ug/m3)	Amount (ng)	Amount (ug/m3)
Naphthalene	5.0	0.45	Not Detected	Not Detected
2-Methylnaphthalene	5.0	0.45	Not Detected	Not Detected

Air Sample Volume(L): 11.0
Container Type: TO-17 Tube (Tenax-TA)

Surrogates	%Recovery	Method Limits
Fluorene-d10	102	70-130

Client Sample ID: MFA-AA-1

Lab ID#: 0912177R1-05A

MODIFIED METHOD TO-17

File Name:	**j120925**	**Date of Extraction: NA**	**Date of Collection: 12/5/09 5:30:00 AM**
Dil. Factor:	**1.00**		**Date of Analysis: 12/10/09 05:19 AM**

Compound	**Rpt. Limit (ng)**	**Rpt. Limit (ug/m3)**	**Amount (ng)**	**Amount (ug/m3)**
Naphthalene	5.0	0.44	Not Detected	Not Detected
2-Methylnaphthalene	5.0	0.44	Not Detected	Not Detected

Air Sample Volume(L): 11.4
Container Type: TO-17 Tube (Tenax-TA)

Surrogates	**%Recovery**	**Method Limits**
Fluorene-d10	102	70-130

Client Sample ID: MFA-AA-2

Lab ID#: 0912177R1-06A

MODIFIED METHOD TO-17

File Name:	**j121020**	**Date of Extraction: NA**	**Date of Collection: 12/5/09 5:30:00 AM**
Dil. Factor:	**1.00**		**Date of Analysis: 12/10/09 11:28 PM**

Compound	Rpt. Limit (ng)	Rpt. Limit (ug/m3)	Amount (ng)	Amount (ug/m3)
Naphthalene	5.0	0.43	Not Detected	Not Detected
2-Methylnaphthalene	5.0	0.43	Not Detected	Not Detected

Air Sample Volume(L): 11.5
Container Type: TO-17 Tube (Tenax-TA)

Surrogates	%Recovery	Method Limits
Fluorene-d10	103	70-130

Client Sample ID: MFA-AA-3

Lab ID#: 0912177R1-07A

MODIFIED METHOD TO-17

File Name:	**j121021**	**Date of Extraction: NA**	**Date of Collection: 12/5/09 5:30:00 AM**
Dil. Factor:	**1.00**		**Date of Analysis: 12/11/09 12:09 AM**

Compound	Rpt. Limit (ng)	Rpt. Limit (ug/m3)	Amount (ng)	Amount (ug/m3)
Naphthalene	5.0	0.45	Not Detected	Not Detected
2-Methylnaphthalene	5.0	0.45	Not Detected	Not Detected

Air Sample Volume(L): 11.2
Container Type: TO-17 Tube (Tenax-TA)

Surrogates	%Recovery	Method Limits
Fluorene-d10	108	70-130

Client Sample ID: Lab Blank

Lab ID#: 0912177R1-08A

MODIFIED METHOD TO-17

File Name:	**j120909**	**Date of Extraction: NA**	**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 12/9/09 02:38 PM**

Compound	**Rpt. Limit (ng)**	**Rpt. Limit (ug/m3)**	**Amount (ng)**	**Amount (ug/m3)**
Naphthalene	5.0	0.43	Not Detected	Not Detected
2-Methylnaphthalene	5.0	0.43	Not Detected	Not Detected

Air Sample Volume(L): 11.5
Container Type: NA - Not Applicable

Surrogates	**%Recovery**	**Method Limits**
Fluorene-d10	104	70-130

Client Sample ID: Lab Blank

Lab ID#: 0912177R1-08B

MODIFIED METHOD TO-17

File Name:	**j121011**	**Date of Extraction: NA**	**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 12/10/09 05:13 PM**

Compound	Rpt. Limit (ng)	Rpt. Limit (ug/m3)	Amount (ng)	Amount (ug/m3)
Naphthalene	5.0	0.43	Not Detected	Not Detected
2-Methylnaphthalene	5.0	0.43	Not Detected	Not Detected

Air Sample Volume(L): 11.5
Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Fluorene-d10	106	70-130

Client Sample ID: CCV

Lab ID#: 0912177R1-09A

MODIFIED METHOD TO-17

File Name:	**j120904**	**Date of Extraction: NA**	**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 12/9/09 11:47 AM**

Compound	%Recovery
Naphthalene	73
2-Methylnaphthalene	119

Air Sample Volume(L): 1.00
Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Fluorene-d10	99	70-130

Client Sample ID: CCV

Lab ID#: 0912177R1-09B

MODIFIED METHOD TO-17

File Name:	**j121006**	**Date of Extraction: NA**	**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 12/10/09 02:23 PM**

Compound	%Recovery
Naphthalene	84
2-Methylnaphthalene	116

Air Sample Volume(L): 1.00
Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Fluorene-d10	94	70-130

Client Sample ID: LCS

Lab ID#: 0912177R1-10A

MODIFIED METHOD TO-17

File Name:	**j120905**	**Date of Extraction: NA**	**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 12/9/09 12:10 PM**

Compound	%Recovery
Naphthalene	87
2-Methylnaphthalene	107

Air Sample Volume(L): 1.00
Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Fluorene-d10	104	70-130

Client Sample ID: LCS

Lab ID#: 0912177R1-10B

MODIFIED METHOD TO-17

File Name:	**j121007**	**Date of Extraction: NA**	**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 12/10/09 02:46 PM**

Compound	%Recovery
Naphthalene	88
2-Methylnaphthalene	107

Air Sample Volume(L): 1.00
Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Fluorene-d10	103	70-130