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VAPOR INTRUSION INVESTIGATION WORK PLAN

FLINT GROUP PIGMENTS HUNTINGTON FACILITY, HUNTINGTON, WEST VIRGINIA

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ABBREVIATIONS AND ACRONYMS

AOC	Area of Concern
AST	Aboveground Storage Tank
BGS	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
cis-1,2-DCE	cis-1,2-dichloroethene
COC	Compound of Concern
CSM	Conceptual Site Model
ELMSS	ELM Site Solutions
ft/day	feet per day
ft/ft	feet per foot
GWDMS	WVDEP Groundwater De Minimis Standard
HI	Hazard Index
HQ	Hazard Quotient
HVAC	heating, ventilation, and air conditioning
ISDMS	WVDEP Industrial Soil De Minimis Standard
K	hydraulic conductivity
MCL	Maximum Contaminant Level
MGWDMS	WVDEP Migration to Groundwater De Minimis Standard
MSL	mean sea level
μg/L	microgram per liter
$\mu g/m^3$	microgram per cubic meter
PCE	tetrachloroethene
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
Facility	Flint Group Pigments Huntington Facility
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compound
1,2,4-TCB	1,2,4-trichlorobenzene

TCE	trichloroethene
TCR	Target Cancer Risk
1,1,2,2-PCA	1,1,2,2-tetrachloroethane
THA	Task Hazard Analysis
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VI	Vapor Intrusion
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
WVDEP	West Virginia Department of Environmental Protection

1. INTRODUCTION

Geosyntec Consultants (Geosyntec) has prepared this Vapor Intrusion (VI) Investigation Work Plan (Work Plan) on behalf of BASF Corporation (BASF) for the Flint Group Pigments Huntington Facility (Facility) located at 2401 5th Avenue in Huntington, West Virginia (Figure 1). The Facility is being investigated through the Resource Conservation and Recovery Act (RCRA) Facility Lead Corrective Action Program, under enforcement of the United States Environmental Protection Agency (USEPA), Region 3. This Work Plan is specific to the VI investigation and is intended to be an addendum to the existing RCRA Facility Investigation (RFI) Work Plan, Phase II RFI Work Plan, and RFI Completion Work Plan.

The objective of the proposed VI investigation is to further evaluate the potential human health risk to on-site and off-site workers and off-site residential occupants via the subsurface to indoor air migration pathway. The investigation will be conducted in phases, with initial priority given to the areas where previous groundwater sampling results have projected a potential risk that indoor air in adjacent structures may exceed acute and chronic indoor air screening levels. Sampling results from each phase of investigation will be evaluated using the VI decision framework described in this Work Plan (Section 2.1), which was developed to guide the iterative process of evaluating VI risks to human health.

The VI sample results and physical site data collected during the investigation will help strengthen the conceptual site model (CSM) and address concerns raised by the USEPA in their January 2017 comments on BASF's December 2016 RFI Completion Work Plan. This VI Investigation Work Plan is intended to be implemented in tandem with the existing site investigation work plans to build a comprehensive understanding of the nature and extent of contamination associated with the Facility, as well as define the potential risks to on- and off-site human and ecological receptors.

This Work Plan has been developed to present the proposed scope of work for VI sampling activities at on-site and off-site commercial/industrial buildings and off-site residential locations downgradient of the Facility.

Initial VI sampling activities at off-site residential properties will involve:

- Outdoor and indoor air sampling, and
- Crawlspace sampling (or sub-slab vapor sampling if basements are encountered).

Initial sampling activities at on-site and off-site commercial/industrial buildings will involve:

- Outdoor and indoor air sampling,
- Sub-slab vapor sampling, and
- Differential pressure monitoring.

Based on initial sampling results and the decision matrix described in this Work Plan (Section 2.1), follow-on sampling may be expanded to include any of the following:

- Soil gas sampling
- Soil sampling (physical properties and VOCs)
- High-volume soil gas sampling
- Building pressure cycling
- Real time GC/MS screening-level analyses (e.g. HAPSITE® or other field portable GC/MS)

Sampling methodologies and standard operating procedures (SOPs) for all potential sampling activities are presented in this Work Plan. Thus, this Work Plan will remain valid for any follow-on sampling determined to be necessary based on initial sampling results and the decision framework presented herein.

1.1 Facility Background

The Facility was constructed in 1909 and has been actively manufacturing dyestuffs and pigments since 1912. The primary pigment manufactured at the facility is alkali blue; however, a variety of pigments have been produced at the facility throughout its operational history. The facility was operated by the Holland-SUCo Color Company (formerly the Standard Ultramarine Company) from 1912 to 1964. The facility was acquired by Chemetron Corporation in 1964 and then by the Pigments and Dyestuffs Division of BASF Wyandotte Corporation in 1979, which was re-named BASF Corporation in 1986. Since 2004, the facility has operated under the ownership of Flint Group Pigments (owned by XSYS Printing Systems), which was formed by the merger of BASF Printing Systems and ANI Printing Inks following their respective acquisitions by CVC Capital Partners (a private equity firm).

1.2 Facility Description

The Facility is an active industrial facility with controlled access (fencing and security) in an industrial and residential area of Huntington, West Virginia (Figure 1). Residential properties bound the facility to the northeast (25th Street); industrial/commercial properties bound the facility to the north, south and west. A CSX Transportation Locomotive Shop Yard lies directly south of BASF. The Facility is currently listed as a hazardous waste generator under USEPA ID WVD000068601 and is broken into the following areas of concern (AOCs) (Figure 2):

- AOC1 – 25th Street Landfill
- AOC2 – Former Process Sewers
- AOC3 – On-Site Railroad Line
- AOC4 – Former Gasoline Station
- AOC5 – On-Site Wastewater Treatment System
- AOC6 – Aboveground Storage Tanks
- AOC7 – Electrical Transformers
- AOC8 – Former Coal Storage Area
- AOC9 – Site-Wide Groundwater
- AOC10 – North Parking Lot

- AOC11 – Warehousing Area

The Facility is entirely paved with asphalt and concrete, except for the 25th Street Landfill (AOC1, which has a vegetated soil cap) and the Warehousing Area (AOC11, which has a mixture of asphalt, gravel, and grass). AOC9, AOC10, and AOC11 are the primary focus of the VI Investigation.

1.3 Site Hydrogeology

According to ELM Site Solutions (ELMSS)' 2016 RFI Data Gap Report, the Facility is underlain by unconsolidated alluvial deposits consisting of interbedded gravel, sand, silt and clay. The ground surface to approximately 5 to 10 feet below ground surface (bgs) is dominated by a dense, silty clay, which is underlain by approximately 10 feet of dense, plastic clay. This deposit is underlain by a layer of very dense sand with clay and silt, and a small amount of gravel that is also approximately 10 feet thick. A sand and gravel deposit, approximately 10 feet thick, underlies the silty sand and extends to bedrock, which is present at a depth of approximately 55 to 60 feet bgs.

Groundwater at the facility occurs in the unconsolidated alluvial sediments at approximately 25 to 30 feet bgs, under unconfined conditions. The potentiometric groundwater elevation at the Facility is approximately 523 feet mean sea level (MSL). The groundwater flow direction is generally to the north/northeast toward the Ohio River. The average hydraulic gradient for the Facility has ranged from 0.0004 to 0.0025 feet/foot (ft/ft) based on groundwater depth measurements conducted from 2002 to 2016 (ELM Site Solutions [ELMSS], 2016). The hydraulic conductivity (K) of the aquifer ranges from 1.1 x 10^{-2} to 1.9 x 10^{-2} cm/sec (31-55 ft/day), based on hydraulic (slug) tests conducted during a February 2003 groundwater investigation. Based on the measured hydraulic gradient and conductivity, and an assumed porosity of 0.3, the groundwater velocity is calculated to range from 0.04 ft/day to 1.5 ft/day, with an average velocity of 0.15 ft/day.

1.4 Previous Environmental Activities

The following summarizes the history of and regulatory drivers for the Facility investigation activities to date:

- BASF entered into the Facility Lead Corrective Action Program in December 1999, in response to USEPA's identification of the Facility as "high priority" under RCRA.
- BASF submitted an initial RFI Work Plan to USEPA in July 2001 and USEPA granted approval to start work in April 2002. The work was completed in 2002.
- Approval for BASF to perform an additional groundwater investigation was granted by USEPA in February 2003. This work was completed in 2003 and 2005.
- The initial RFI and Supplemental Groundwater Monitoring Reports were submitted to USEPA in August 2003 and September 2005, respectively.
- USEPA approved a Phase II RFI Work Plan for further groundwater investigation; the work was performed from 2009 to 2010.

- BASF submitted the RFI Phase II Report to USEPA in May 2010.
- An additional groundwater sampling event was conducted in November 2013.
- ELMSS submitted an RFI Data Gap Work Plan to USEPA in October 2015, which was approved on December 2, 2015. The data gap investigation was conducted between July and September 2016 with the RFI Data Gap Report being submitted by ELMSS in December 2016.
- USEPA issued comments on the RFI Data Gap Report in January 2017 and, therein, required BASF to "take prompt and aggressive action" to address the potential risks to "onsite workers and offsite residents," and develop a plan to address potential VI risks.

1.4.1 Summary of RFI

The initial RFI was conducted from 2002-2005 to assess the potential for unacceptable human exposure to site contaminants. Soil was investigated at AOC1, AOC3, AOC4, AOC7, and AOC8 in 2002. A human exposure pathway via soil was determined to be incomplete at each AOC. Although hexachlorobenzene was detected in soil at AOC1, this AOC is surrounded by a fence effectively inhibiting direct human exposure to soil. All other detected contaminants, other than arsenic, which was determined to be naturally-occurring, were below West Virginia Department of Environmental Protection (WVDEP)'s De Minimis values for industrial soil (ISDMS).

Site-wide groundwater (AOC9) was investigated through multiple rounds of sampling in 2002, 2003, and 2005 using 11 monitoring wells and 9 temporary well points monitoring wells installed for that purpose. All site monitoring wells are shown on Figure 3. Based on these investigations, four categories of constituents were found at concentrations exceeding WVDEP De Minimis Standards for Groundwater (GWDMS) and USEPA's maximum contaminant levels (MCLs): chlorinated volatile organic compounds (VOCs); aromatic compounds and benzene, toluene, ethylbenzene, and xylenes (BTEX); semi-volatile organic compounds (SVOCs); and metals. Groundwater to indoor air modeling using the Johnson and Ettinger model (Johnson, 2002) indicated VI of chlorinated hydrocarbons would not result in risk to human health.

1.4.2 Summary Phase II of RFI

Soil investigations were completed at the remaining three AOCs (AOC2, AOC5, and AOC6). At AOC2 (Former Process Sewers), arsenic, lead, trichloroethene (TCE), 1,2,4-trichlorobenzene (TCB) and PCBs were detected at concentrations greater than their respective ISDMS, and aniline was detected at concentrations greater than WVDEP's Migration to Groundwater De Minimis Standard (MGWDMS). At AOC5 (On-site Wastewater Treatment System), no contaminants were detected at a concentration greater than their respective ISDMS; thus, no further investigation was recommended. At AOC6 (Aboveground Storage Tanks [ASTs]), BTEX constituents were detected exceeding their respective ISDMS and MGWDMS. SVOCs (primarily analine) and metals were also detected at levels exceeding their MGWDMS.

A site-wide groundwater sampling event was conducted using 11 existing wells in July 2009. Chlorinated VOCs, primarily TCE and cis-1,2-dichloroethene (cis, 1,2-DCE), were detected at concentrations exceeding their WVDEP GWDMS in the northern, downgradient portion of the Facility and within the 25th Street Landfill. Some BTEX and SVOC constituents were also detected above their GWDMS in the southern, upgradient portion of the Facility. Concentrations of BTEX in the thousands of micrograms per liter (μg/L) were indicative of source material in the southern portion of the Facility. A subsequent groundwater sampling event, conducted in November 2013, yielded similar results to the results from 2009. During this sampling event, elevated chlorinated VOC concentrations were detected in AOC11 (Warehousing Operation), which had not been detected during previous groundwater sampling events.

1.4.3 Summary of RFI Data Gap Investigation (December 2016)

Additional soil, groundwater and soil gas results were obtained during the RFI Data Gap Investigation activities completed at the Facility in 2016.

Soil

Constituents in soils at AOC1 (25th Street Landfill) were not detected at concentrations greater than their respective ISDMS. At AOC2 (Former Process Sewers), 1,2,4-trichlorobenzene was detected above its ISDMS in multiple soil samples and above its GWDMS in groundwater. At AOC6 (Aboveground Storage Tanks), toluene, ethylbenzene, and xylenes were detected in soil at concentrations exceeding their respective ISDMS and in water at concentrations exceeding their GWDMS.

Groundwater

Additional wells (TMW-13 through TMW-17 in AOC1 and TMW-26 through TMW-31 in AOC10) were installed (Figure 3) and all site wells were sampled as part of this investigation. Chlorinated VOCs were detected at concentrations greater than their respective GWDMS, EPA MCLs, or groundwater vapor intrusion screening levels (VISLs) in AOC1 (25th Street Landfill), AOC10 (North Parking Lot), and AOC11 (Shipping/Warehouse Area). Aromatic VOCs were detected at concentrations greater than their respective GWDMS and USEPA MCLs in AOC6.

Soil Gas

Deep soil gas samples in AOC10 (North Parking Lot) had concentrations of carbon tetrachloride, PCE, and TCE detected at concentrations exceeding their respective soil gas VISLs.

1.5 Preliminary VI Conceptual Site Model

Geosyntec reviewed the existing site data that were obtained as part of the investigations listed in Section 1.4 and regulatory data provided by due diligence provider, EDR, to characterize the potential sources of contaminants and contaminant impacts at and downgradient of the Facility. These data were used to develop an initial VI CSM that describes the contaminant sources, contaminant migration pathways, and potential environmental receptor exposure to contaminants. The CSM will continue to be updated and revised as new data are collected during VI investigation activities.

1.5.1 Compounds of Concern

Compounds of concern (COC) for the VI pathway of exposure at the Facility are primarily chlorinated solvents and fuel constituents. The list of VI COCs developed for this Work Plan includes all analytes that have exceeded USEPA groundwater or soil gas VISLs (Table 1) in at least one sampling location. Benzene is also being included as a COC because the method detection limits for benzene in groundwater samples from AOC2 and AOC6 exceeded groundwater VISLs.

Table 1. USEPA Default Vapor Intrusion Screening Levels (VISLs) for Groundwater and Soil Gas

		Residential		Commercial/Industrial	
Compound of Concern (COC)	CAS No.	Soil Gas[1] (µg/m^3)	Groundwater[2] (µg/L)	Soil Gas[1] (µg/m^3)	Groundwater[2] (µg/L)
		TCR=1E^{-6}; THQ=1	TCR=1E^{-6}; THQ=1	TCR=1E^{-6}; THQ=1	TCR=1E^{-6}; THQ=1
Carbon Tetrachloride	56-23-5	16	0.41	68	1.8
Tetrachloroethene	127-18-4	360	15	1,600	65
Trichloroethene	79-01-6	16	1.2	100	7.4
Vinyl Chloride	75-01-4	5.6	0.15	93	2.5
1,1,2,2-Tetrachloroethane	79-34-5	1.6	3.2	7	14
Benzene	71-43-2	12	1.6	52	6.9
Ethylbenzene	100-41-4	37	3.5	160	15
1,2,4-Trichlorobenzene	120-82-1	70	36	290	150
Toluene	108-88-3	170,000	19,000	730,000	81,000
Xylenes, Total	1330-20-7	3,500	380	15,000	1,600

Notes:
TCR = Target Cancer Risk
THQ = Target Hazard Quotient
1. Soil gas VISLs calculated using default attenuation factor of 0.03.
2. Groundwater VISLs calculated using default attenuation factor of 0.001.
Source: USEPA VISL Version 3.5.1 updated July 2016

The groundwater locations with VISL exceedances of a COC are shown on Figure 3. Carbon tetrachloride is the only COC that exceeds soil gas VISLs.

1.5.2 Sources

The exceedances of COC VISLs are largely concentrated in the North Parking Lot (AOC10 – northeastern portion of the Facility) and the Aboveground Storage Tank (AST) area (AOC6 – along the southern Facility boundary). BTEX contaminants at AOC6 are likely due to releases from ASTs in AOC6, as BTEX concentrations exceeding regulatory standards have been detected in soil as well as groundwater in this area. The source of chlorinated solvents in groundwater at AOC10 is currently unknown.

A summary of all documented spills, releases, and environmental contamination within a one mile radius of the Facility was compiled by property due diligence provider, EDR. EDR searched Federal, State and local regulatory databases relating federal and state-registered cleanup sites, waste storage and disposal, registered ASTs and underground storage tanks (USTs), known releases, and registered automotive shops and dry cleaners. Eleven sites are reported as having leaking storage tanks within a half mile upgradient or side-gradient of the Facility (EDR, 2017). These tanks were largely reported to contain petroleum products including gasoline, diesel, and used oil. These petroleum releases have the potential to contribute to the BTEX concentrations reported in site groundwater. No releases of chlorinated solvents were reported within one mile radius of the Facility. One dry cleaner was reported less than 1/8-mile downgradient of the Facility; however, it closed in 2010 and did not have reported chlorinated solvent releases.

1.5.3 Pathways

Groundwater flow in the vicinity of the Facility is to the north. Thus, the groundwater observed to have elevated COC concentrations in monitoring wells at the northern Facility boundary likely is migrating off-site to the north. VOCs in these groundwater plumes may volatilize and the vapor may migrate through the vadose zone via diffusion through soil pores or larger pathways, such as fractures in rock or soil, and enter into overlying structures through vapor penetration points in the structure foundations (i.e. cracks or holes). The vapors may also migrate into anthropogenic “preferential pathways” (e.g., utility conduits) and from there directly into structures (bypassing portions of the vadose zone) via improperly sealed utility penetrations in structure foundations or walls.

Current site characterization data indicate the aquifer is generally separated from the overlying structures by an approximately 5- to 20-foot thick layer of silts and clays (Table 2), which has the potential to significantly attenuate vapor migration. However, upon reviewing soil boring logs from the various investigations, it appears this layer was thin or absent from some boreholes in AOC1 (25th Street Landfill) and AOC6, south of the acid tank farm, indicating that it may not be entirely contiguous across the Facility or beneath the off-site structures. Boreholes drilled in the North Parking Lot area show that a moist silty to sandy clay is continuously present above the aquifer in this area. Overall, this low-conductivity layer is present in most boreholes across the Facility and appears to be fairly laterally continuous.

1.5.4 Receptors

Potential receptors include residents of off-site properties as well as on-site and off-site workers in buildings within 100 feet of groundwater samples with VISL exceedances. Figure 3 shows all structures that fall within a 100-foot radius of a well that had reported groundwater contaminant concentrations exceeding USEPA VISLs.

Table 2. Summary of Facility Borehole Geology

AOC	Boring Location	Boring ID	Depth of Silt/Clay Range (ft)	Depth of Sand Range (ft)
AOC1	Former 25th Street Landfill	AOC1-06	0.7-4.5	4.5-30
		AOC1-07	0-5	5-30
		AOC1-08	0-7.5	7.5-30
		AOC1-09	0-8.5	8.5-30
		AOC1-10	0-7.5	7.5-30
		AOC1-11	0-5	5-30
		AOC1-12	0-24	24-30
		AOC1-13	0-28	28-30
		TMW-13	0-4	4-40
		TMW-14	0-15	15-35
		TMW-15	0-27.5	27.5-35
		TMW-16	0-29	29-35
		TMW-17	0-25	25-40
AOC2	In between control building and opal storage area	AOC2-04B	7.5-23	0.8-7.5; 23-30
		AOC2-40	7.5-23	0.8-7.5; 23-25
		AOC2-41	7.5-23	0.8-7.5; 23-25
AOC2	North of fire truck garage	AOC2-16	0-20	20-25
		AOC2-21	0-19.5	19.5-20
		AOC2-22	0-4; 5-24	4-5; 24-30
	North of waste treatment plant	AOC2-17	0-4; 6-20	4-6
		AOC2-18	0-24	24-30
		AOC2-20	0.5-20	NP
		AOC2-27	0.5-20	NP
		AOC2-28	0.5-20	NP
		AOC2-29	0.5-20	NP
		AOC2-30	0-4; 6-20	4-6
		AOC2-31	0-4; 6-20	4-6
		AOC2-32	0-4; 6-20	4-6
		AOC2-33	0-4; 6-20	4-6
		AOC2-34	0-4; 6-20	4-6
		AOC2-35	0-20	NP
		AOC2-36	0-20	NP
		AOC2-37	0-20	NP
		AOC2-38	0-20	NP
		AOC2-39	0-20	NP
AOC6	In between electrical substation and aniline tank farm	AOC6-08	5.0-25	0.7-5; 25-30
		AOC6-22	5.0-20	1-5
	Mid plant tank farm	AOC6-09	5.0-22	22.0-25
	North of mid plant tank farm	AOC6-10	0.5-23.5	23.5-30
	South of acid tank farm	AOC6-19	NP	0.7-20
		AOC6-20	NP	0.8-20
		AOC6-07	0.5-16	16-30
		AOC6-17	NP	0.5-25
		AOC6-18	0.5-7.5	7.5-11.5
		AOC6-21	NP	0.8-30
		AOC6-23	0.8-10	10-20
AOC10	North Parking Lot	TMW-26	0-19	19-35
		TMW-27	0.5-18.5	18.5-35
		TMW-28	0.5-17; 18-22	17-18; 22-35
		TMW-29	0.5-23	23-35
		TMW-30	0.4-19.5	19.5-35
		TMW-31	0.5-20	20-35
AOC11	North of Warehouse	TMW-19 / AOC11-01	0-21	23-30
	East of Warehouse	TMW-20 / AOC11-02	0-18; 19-24	18-19; 24-25

Notes:

NP Not present in boring

2. OBJECTIVES AND SCOPE OF WORK

The goal of the VI assessment program is to identify all structures where the VI-related concentrations of site-related COCs could reasonably exceed their respective indoor air risk-based screening levels, and to take appropriate actions to reduce VI-related exposures to those COCs. To achieve this goal, multiple lines of evidence will be used to evaluate the distribution of VOCs within, outside and below the investigated buildings and to evaluate factors that could influence the attenuation of vapor concentrations between the subsurface and the indoor air space of the buildings.

The specific objectives of the study are to:

- Collect relevant and appropriate data in sufficient locations and of sufficient quality to reliably characterize the potential for unacceptable VI-related cancer and non-cancer risks to building occupants in existing structures.
- Evaluate the data in the context of the site-specific VI CSM using a multiple lines of evidence approach.
- Identify appropriate response actions and follow-on characterization activities using the decision framework outlined in this Work Plan;
- Employ specialized characterization methods, as needed, to minimize uncertainties associated with the common challenges of temporal variability, spatial variability, background sources and very low screening levels;
- Comply with regulatory guidelines and policies related to the assessment and protection of public health for building occupants attributable to vapor intrusion;
- Gain knowledge to help inform decisions regarding any additional future VI assessments; and,
- Maintain appropriate communication with interested parties and stakeholders, with the assistance of the USEPA.

Geosyntec will use an iterative assessment approach that initially focuses on off-site areas near the former BASF facility and on-site areas adjacent to elevated concentrations of COCs in the groundwater.

The area of VI investigation will expand as necessary based on the information collected during the initial and any subsequent phase of the investigation until the program goal has been achieved. The VI CSM will serve as the framework for integrating site information into a comprehensive portrayal of site conditions and identifying structures that may potentially be adversely impacted by VI. As new information is developed, the CSM will be updated to more effectively shape the course of the investigation.

2.1 Decision Framework

Geosyntec will use a decision framework consisting of Structure Sampling Decision Matrices to identify appropriate actions to address the VI potential at each sampled structure, and a VI Investigation Flow Chart to determine the appropriate next steps in the assessment program. The sections below provide detailed descriptions of each of these decision framework components.

2.1.1 Structure Sampling Decision Matrices

Structure Sampling Decision Matrices will be used to identify appropriate actions to address the VI potential at each sampled building based on comparison of measured concentrations of COCs in indoor air to corresponding concentrations in sub-slab soil gas or crawl space air. The measured indoor air COC concentrations will be compared to USEPA's respective risk-based indoor air screening levels (IASLs) (Table 3) and the sub-slab soil gas and crawlspace air concentrations will be compared to screening levels derived from the USEPA recommended generic attenuation factors of 0.03 and 1.0 for sub-slab soil gas and crawlspace air, respectively.

Table 3. USEPA Indoor Air Screening Levels and Project Action Levels for Residential and Commercial/Industrial Buildings.

		Residential			**Commercial/Industrial**		
Compound of Concern (COC)	CAS No.	Carcinogenic SL TR=1E-06 (µg/m^3)	Noncarcinogenic SL THQ=1 (µg/m^3)	Action Level TR=1E-04 or THQ=3	Carcinogenic SL TR=1E-06 (µg/m^3)	Noncarcinogenic SL THQ=1 (µg/m^3)	Action Level TR=1E-04 or THQ=3
Benzene	71-43-2	3.6E-01	3.1E+01	3.60E+01	1.6E+00	1.3E+02	1.60E+02
Carbon Tetrachloride	56-23-5	4.7E-01	1.0E+02	4.7E+01	2.0E+00	4.4E+02	2.0E+02
Ethylbenzene	100-41-4	1.1E+00	1.0E+03	1.1E+02	4.9E+00	4.4E+03	4.9E+02
Tetrachloroethane, 1,1,2,2-	79-34-5	4.8E-02		4.8E+00	2.1E-01		2.1E+01
Tetrachloroethylene	127-18-4	1.1E+01	4.2E+01	1.3E+02	4.7E+01	1.8E+02	5.4E+02
Toluene	108-88-3		5.2E+03	1.6E+04		2.2E+04	6.6E+04
Trichlorobenzene, 1,2,4-	120-82-1		2.1E+00	6.3E+00		8.8E+00	2.6E+01
Trichloroethylene	79-01-6	4.8E-01	2.1E+00	2.1E+00	3.0E+00	8.8E+00	8.8E+00
Vinyl Chloride	75-01-4	1.7E-01	1.0E+02	1.7E+01	2.8E+00	4.4E+02	2.8E+02
Xylenes	1330-20-7		1.0E+02	3.0E+02		4.4E+02	1.3E+03

Notes:
SL = Screening Level
THQ = Target Hazard Quotient
TR = Target Risk
The Action Levels are the lower of either the Carcinogenic SL=1E^{-4} or a THQ=3; TCE is based on a THQ of 1.
Source: USEPA RSLs updated May 2016

Generic Structure Sampling Decision Matrices for buildings with slabs (Table 4) and buildings with crawlspaces (Table 5) are presented below to illustrate how the sampling results will be used to identify a recommended action. Appendix A contains COC-specific decision matrices that depict the recommended actions to address measured indoor air/sub-slab, or indoor air/crawl space sample concentration combinations. The recommended actions associated with any given pair of results reflect the relative risk posed by the presence of a COC in indoor air and the likelihood that its presence is due to VI rather than a background source. For example, indoor concentrations of a COC greater than the IASL are less likely to be due to VI in buildings where the sub-slab concentrations are below the sub-slab screening level (i.e., < 30 x IASL) and more likely to be due to VI in buildings where the sub-slab concentrations are substantially greater than the sub-slab screening value (i.e., > 3,000 X IASL). In cases where the potential risk due to VI is minimal, no further action is recommended. The use of 0.3 x IASL as a basis for recommending no further action is considered to be conservative because the decision would be based on the combination of both the indoor air concentrations and the sub-slab/crawl space concentrations meeting this criterion. In cases where VI is the likely cause of IASL exceedances, mitigation is the recommended course of action. Mitigation should be implemented as rapidly as practicable where COC action levels are exceeded.[1] In cases where the role of VI is uncertain, forensic methods are recommended to clarify the VI potential, although alternatives such as continued monitoring and or pre-emptive mitigation may be appropriate.

The sub-slab decision matrix (Table 4) uses the recommended generic attenuation factor of 0.03 for sub-slab soil gas.

Table 4. Generic Structure Sampling Decision Matrix for Buildings with Slabs

Sub-Slab COC Concentration[1]	**Indoor Air COC Concentration** [1]			
	< 0.3 IASL[2]	0.3 IASL to IASL	>IASL to 100 X IASL	> 100 X IASL or > Action Level[3]
< 30 X IASL	No Further Action	Monitor	Background Eval.	Background Eval.
30 X IASL to 300 X IASL	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
> 300 X IASL to 3000 X IASL	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	Forensics or Mitigate	Forensic or Mitigate	Mitigate	Mitigate—Rapid Response

Notes:

1. Indoor Air and Soil gas concentrations in µg/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10^{-6}.
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10^{-4} or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

The crawl space decision matrix (Table 5) uses the recommended generic attenuation factor of 1.0 for crawl space air, which means little attenuation is expected between the crawl space and the indoor space (USEPA 2015) due to the minimally restricted air exchange between the crawl space and the living space above. The relatively open exchange between the crawlspace and indoor space can confound interpretation of sampling results where background sources are present, because air from a building with background sources in the living space can flow into the crawl space and, conversely, air in crawlspaces with background sources can flow into the living space. Multiple lines of evidence become particularly important for determining the likely source of COCs exceeding screening levels. As with the sub-slab matrix, mitigation is the recommended course of action where VI is determined to be the cause of IASL exceedances, forensic methods are recommended where the role of VI is uncertain, and no further action is recommended where the potential risk due to VI is minimal.

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[1] A target hazard quotient (HQ) of 3 is used for individual COCs to define rapid response action levels (except for TCE which uses an HQ of 1); however, clean-up levels will be based on a cumulative hazard index (HI) of 1.

Table 5. Generic Structure Sampling Decision Matrix for Buildings with Crawl Spaces

Crawl Space COC Concentration[1]	**Indoor Air COC Concentration** [1,2]			
	< 0.3 IASL[2]	0.3 IASL to IASL	>IASL to 100 X IASL	> 100 X IASL or > Action Level[3]
<IASL	No Further Action	Monitor	Background Eval.	Background Eval.
>IASL	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

Notes:

1. Indoor Air and Soil gas concentrations in µg/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10^{-6}.
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10^{-4} or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

Recommended Response Actions:

No Further Action: Vapor intrusion is not expected to significantly affect indoor air quality, and no additional actions are needed to address indoor air exposures.

Monitor: Additional sampling is needed to develop an appropriate risk management approach. Depending on the building-specific concentrations of COCs in the indoor air and sub-slab (or crawl space), the recommended sampling could include additional rounds of sampling using conventional methods or application of forensic tests to enhance conditions conducive to VI and more quickly assess the vapor intrusion potential.

Mitigate: Mitigation is recommended to minimize current or future vapor intrusion related exposures. Mitigation approaches are described in Section 2.1.2.

Background Evaluation: The ratios of the indoor and sub-slab COC concentrations (compound ratio comparisons) indicate that a background source (indoor or outdoor) is likely responsible for the presence of the COC in indoor air. Multiple lines of evidence, including outdoor air concentrations, the results from nearby structures, and/or soil gas and groundwater concentrations from nearby monitoring points support this assessment. Reassessment of the building may be warranted using, for example, field instruments or building pressure cycling. Regulators and building occupants will be informed of this outcome as soon as possible so that they can consider ways to reduce indoor air exposures.

Forensics: Depending on the building-specific concentrations of COCs in the indoor air relative to sub-slab soil gas or crawlspace air, forensic testing is recommended. The results of the forensics analyses will be used to develop an appropriate risk management approach. The forensic testing may include:

- Any of the background evaluation techniques described above;
- Building Pressure Cycling to identify the relative contribution of vapor intrusion related and background indoor sources;
- High Volume Sampling to obtain spatially averaged sub-slab concentrations (and obtain sub-slab venting system design parameters if mitigation is needed);

- Collection of soil gas and/or groundwater samples adjacent to structures to confirm the vapor pathway is complete; and/or
- Weight of evidence evaluation of all applicable data, including considering the results from nearby structures.

Rapid Response: The indoor air concentrations of COCs indicate a rapid response is warranted to identify and reduce the source(s). Multiple lines of evidence, including soil gas and groundwater concentrations from nearby monitoring points and the results from nearby structures support an assessment that VI is responsible for the elevated levels. Measures to reduce exposures should be implemented as rapidly as practicable.

2.1.2 Mitigation Approaches

The need for mitigation of individual structures will be based on recommended actions described in the Structure Sampling Decision Matrices. Any of the following rapid response actions may be considered to mitigate potential VI- related short-term TCE exposure or other exceedances of Action Levels, based on applicability and feasibility for the given structure:

- Increasing building pressurization and/or ventilation mechanically with fans or by increasing outdoor air intake of the building ventilation system
- Sealing and/or ventilating potential conduits where vapors may be entering building
- Installing indoor air purifiers or adsorption systems such as carbon filtration.

The following VI mitigation measures may be considered to address potential long-term exposures:

- Sealing and/or ventilating potential conduits where vapors may be entering building
- Installing vapor barriers beneath buildings with crawlspaces
- Installing and operating engineered sub-floor exposure controls (sub-slab or sub-membrane depressurization/venting and/or crawl space venting).

Evaluation of VI mitigation alternatives will be based on multiple criteria that include overall protection of human health and environment, long-term or short-term effectiveness, owner/occupant acceptance, and implementability. Further evaluation of the long-term alternatives will be addressed, if necessary, in a separate feasibility study submittal to the USEPA.

2.1.3 VI Investigation Flow Chart

The VI Investigation Flow Chart depicted below (Figure 4) will be used to integrate the structure sampling results with other lines of evidence to determine whether expansion of the area of the VI assessment program is needed. If the structure sampling results from a given phase of the investigation indicate that mitigation is needed to address indoor air risks posed by the presence of VI-related COCs, then the scope of the program will be expanded to evaluate adjacent structures in a subsequent phase. The newly acquired structure-related data and any associated groundwater and/or soil gas data will be used to update the CSM and define the scope of subsequent phases of investigation. To expedite the VI assessment program, information will be provided to USEPA on an ongoing basis in the form of informal data reports and discussed with the agency to seek feedback prior to implementing the next phase of the investigation. At key milestones, fact sheets and public meetings may be developed in consultation with USEPA to keep local officials, the public, and other stakeholders apprised of the project status. Once the VI assessment program is complete, the results will be formally presented in a report to USEPA.

2.2 Initial VI Assessment

The vapor intrusion investigation will initially focus on AOC9, AOC10, and AOC11, the off-site area near the North Parking Lot, Phase 1 Area (Figure 2), and on three apparently-occupied on-site structures (Building 66, Building 69, and Building 92) and one commercial off-site structure (restaurant approximately 100-feet north of monitoring well TMW-7D). These areas are within a 100-foot radius of an existing monitoring point where groundwater concentrations exceed the screening levels that USEPA indicates warrant vapor intrusion investigation (Figure 3). The scope of any follow-on activities will be based on the decision framework described above.

The scope of work will include:

- Notification and selection of properties for sampling (residential properties)
    - Prepare and transmit notifications to property owners within the Phase 1 Area of the proposed sampling program
    - Obtain access agreements with property owners that agree to allow sampling
- Building inventory and preferential pathway assessment
    - Conduct a records review of subsurface utility services
    - Perform preliminary building inspections
    - Prepare location-specific work plan for sampling
- Indoor air sampling and analysis (includes residential crawl space sampling) (all properties)
    - Collect samples of indoor air, penetration pathways, and outdoor air
    - Collect quality assurance/quality control (QA/QC) samples
    - Submit samples to certified laboratory for analysis
- Sub-slab vapor sampling and analysis (slab on grade structures and structures with basements)
    - Install sub-slab vapor pins
    - Collect samples of sub-slab vapor and QA/QC samples
    - Submit samples to certified laboratory for analysis
- Differential Pressure Logging (at structures where sub-slab samples are collected)
    - Collect sub-slab pressure differential data from sub-slab vapor pins
- Data evaluation and reporting (all properties)
    - Review analytical results and provide informal data report and recommendations for future sampling to the USEPA

- Discuss any proposed mitigation measures with the USEPA

3. RESIDENTIAL VI ASSESSMENT METHODS

This section discusses the methods and procedures that will be used to conduct the VI assessment in the off-site residential structures. This Work Plan includes all possible sampling methodologies that may be employed during any phase of the iterative VI sampling process. Some of the methodologies may not be used during an investigation. Structure sampling activities will be conducted in phases to allow early-round sampling results to direct further step-out sampling and later phases to incorporate the results of the ongoing groundwater investigation and site characterization activities. The Facility characterization activities not included in this VI Work Plan are being conducted under the 2015 version of the RFI Work Plan and QAPP; however, characterization data relevant to the VI pathway collected will be used to update the VI CSM.

3.1 Notification and Selection of Residential Properties for Sampling

The initial off-site investigation is expected to include (with the permission of building owner/occupants) concurrent 24-hour time-averaged sampling of the crawl space, indoor and outdoor air in the following 10 residences located downgradient or cross-gradient of the North Parking Lot (Phase I Area – Figure 2):

House Number	VI Sample	Basement (Y or N)	Construction Type
Elaine Court			
338	X	N	Crawl Space
Homestead Place			
401	X	N	Crawl Space
403	X	N	Crawl Space
405	X	N	Crawl Space
407	X	N	Crawl Space
409	X	N	Crawl Space
411	X	N	Crawl Space
421	X	N	Crawl Space
423	X	N	Crawl Space
425	X	N	Crawl Space

In addition to above residences, any garages within the 100-foot radius that are confirmed to have tenant occupied apartments above them will also be evaluated in the initial phase (Phase I) of investigation using sub-slab samples in lieu of crawl space samples.

Geosyntec will also conduct a records review of subsurface utility services for residences in the Phase 1 Area to assist in the identification of potential preferential pathways (utility services) as part of the initial scope of work. The results of this survey and its implications on the need to modify or expand the initial phase of sampling will be discussed with USEPA prior to finalizing the sampling list.

Geosyntec, acting on behalf of BASF and in consultation with the USEPA, will deliver (via certified mail or in person) sampling request letters to owners and occupants of each structure proposed for sampling. The letters will provide background information and request that the owners contact Geosyntec via a toll-free phone number or a pre-addressed postage paid post card (included) within 30 days of receipt to verify whether they wish to participate in the sampling program. Within 14 days after delivery of the sampling request letter, Geosyntec will follow up with a phone call to building occupants to answer any questions they may have and encourage them to participate in the program. At the end of the 30-day post-delivery period, Geosyntec will discuss the status of the responses with the USEPA, finalize the list of structures to be sampled, and schedule the building inspections and sampling with willing property owners.

3.2 Residential Building Inventory and Preferential Pathway Assessment

Before indoor air sampling is performed, Geosyntec will obtain a signed access agreement from property owners/occupants. Thereafter, Geosyntec will conduct a preliminary inspection at each structure where the owner/occupant agrees to participate in the VI sampling program. The preliminary inspection will be conducted using a building survey form designed to evaluate characteristics of the building use and ventilation systems that may impact indoor air quality (see Appendix B for all field sampling SOPs). Each preliminary inspection will be scheduled at a date and time agreed to by a building owner/occupant. The completion of the survey will include a consultation, if possible, with an owner, tenant, or landlord with working knowledge of the building design and storage locations for household cleaning products and other chemicals. The Geosyntec employee conducting the inspection will describe the household products on the building survey forms and explain to building owner/occupant how the presence of those and other products or activities could potentially impact or bias the sample results. Owner/occupants will be asked to temporarily store household products containing COCs is areas outside of the home, if practicable, and to refrain from using them for several days prior to sample collection. Owner/occupants will also be asked not to bring home dry-cleaned clothes or engage in home construction activities immediately prior to and during VI sampling.

A sketch of the construction and layout of the building will be made during the inspection. The sketch will document all observed foundation types (slab on grade, crawl spaces, mixed, etc.), potential penetration pathways (e.g., utility closets, piping pass-through, etc.) and chemical storage locations. The sketch will also note whether the crawl space is encapsulated by a skirt, which may affect the potential for vapor intrusion into the home.

3.3 Building-Specific Work Plan for Residential Structures

After conducting the preliminary inspections, Geosyntec will prepare a supplemental building-specific work plan to guide field staff, which will consist of a memorandum, tables and figures. This work plan will summarize the results of the inspections and will include:

- Indoor air, crawl space, and sub-slab sampling locations (as applicable for the foundation type(s) of each structure).
- Outdoor air sampling locations.
- Penetration pathway sampling locations (as applicable).
- Preferential pathway (utility service) sampling locations (as applicable).
- Copies of the building survey checklists.

A copy of each building-specific work plan will be submitted to the USEPA for their records. Geosyntec will seek work plan approval if building conditions require sampling procedures outside the scope of this VI Investigation Work Plan.

3.4 Residential Air Samples

3.4.1 Indoor Air Samples

Residential indoor air samples will be collected at locations that are representative of occupied areas of slab-on-grade and crawl space buildings, or in the basements of buildings that include them. A minimum of one 24-hour time integrated indoor air sample will be collected at each residence for each round of sampling. The indoor air samples will be collected in individually certified clean 6-L Summa® canisters equipped with individually certified clean flow controllers designed to collect a sample over a 24-hour period. A digital vacuum gauge will be used to verify that the Summa® canister has an adequate vacuum (27 in Hg) prior to sampler deployment, and that a small vacuum (e.g., 2 to 5 inches Hg) remains at the end of the sampling period. After sample collection, the canisters will be shipped to a certified laboratory (Eurofins Air Toxics, Folsom CA) via chain of custody for analysis by USEPA Method TO-15 SIM for the COCs. Appendix C includes a description of the Summa® can sampling SOP and a list of the compounds and reporting limits included in the TO-15 SIM analysis.

Indoor air samples will be collected under normal occupational conditions including the operation of the heating, ventilation, and air conditioning (HVAC) system. Indoor air samples are intended to be representative of inhalation exposure point concentrations for the residential occupants. Therefore, indoor air samples will be collected at breathing zone height approximately 3 to 5 feet above the floor. The indoor air sampling locations and deployment heights will be summarized in the location-specific work plan, and documented in the field records.

Some residences may have multiple foundation types. For those structures with more than one foundation type, at least one indoor air sample will be collected in each building area underlain by a different foundation type. The building-specific work plan will identify the foundation type(s) of each structure.

The building owners and occupants will be advised to temporarily cease activities involving the use of products that typically contain TCE (e.g., painting, waxing, polishing floors) at least 72 hours before any indoor air sampling event. Residential occupants will also be requested to maintain their usual operation of the ventilation systems during sampling.

3.4.2 Residential Outdoor Air Samples

Outdoor air samples will be collected upwind of each residential structure, and away from possible confounding sources such as roads, to determine whether COCs in ambient air serve as a background source. One outdoor air sampling location may serve as background for more than one residential structure. Outdoor air samples will be collected over the same sampling period as the associated indoor air sample(s) using the same sampling and analytical protocols used for the indoor samples. The location and number of outdoor air samples will be proposed in the location-specific work plan.

3.4.3 Crawl Space Samples

Most residences (based on those known to be in the Phase I sampling area) downgradient of the BASF parking lot have crawlspaces or subfloor areas that are generally not accessed by occupants. Where possible, a 24-hour time integrated Summa® can sample will be collected from below the subfloor area using the same techniques used for indoor air samples, except the height at which the sample is collected will be adjusted based on the configuration of the crawlspace. Proposed sampling locations and structures will be documented in the location-specific work plan.

3.4.4 Penetration Pathway Samples

Penetration pathways are locations where conduits pierce underlying residential structures (e.g., slab, subflooring) in areas of the residence not routinely occupied for extended periods (e.g., electrical closets). These areas may be a potential vapor intrusion pathway to the adjoining routinely occupied areas of the building. Potential penetration pathway areas will be evaluated either by collecting one 24-hour time integrated sample at breathing level or, alternatively, by collecting a grab sample within the penetration pathway in cases where it is possible to temporarily seal the pathway (for example, by taping plastic sheeting over a drain or floor penetration and inserting ¼-inch tubing beneath the seal to collect a grab sample. The penetration pathway grab sample would provide a more representative sample of the source strength of the vapor entering the building via the pathway. This information would be useful when considering mitigation options for the building, should they be necessary. Both types of samples would be collected in individually certified clean Summa® canisters with appropriate flow controllers using the same techniques used for indoor air samples.

3.4.5 Sub-Slab Vapor Samples

If the residential building foundation includes a slab, a sub-slab sample will be collected at a location near the center of the slab. Upon arrival at the building, Geosyntec will conduct a building walk through with building owner/occupant to identify and mark out proposed sub-slab probe locations. A photographic log of marked locations and distance measurements between sample points and distinct building features will also be collected to aid in relocating sample points if an additional round of sampling is needed A geophysical survey will be used to confirm whether utilities are present in locations where sub-slab probes are proposed. If a utility may be present in the immediate vicinity of a proposed sample point it will be moved to a suitable location nearby. Temporary sub-slab monitoring probes will be installed using Vapor Pin sampling ports.

The sub-slab vapor probes will be installed with compression-style tubing connectors following the SOP for Vapor Pins (Appendix B). They will be temporarily sealed with a cap to prevent indoor/sub-slab air exchange across the point when testing is not in progress. Upon completion of sub-slab probe installation, pneumatic testing will be performed on the probes to provide information on the soil gas permeability surrounding the probes (Appendix B).

Prior to collecting samples for VOC analysis, sub-slab probes will be purged via a vacuum box fitted with a Tedlar™ bag and field screened with a PID (PhoCheck Tiger or equivalent) to measure total VOC concentrations and a GEM 2000 Landfill Gas meter (or equivalent) to measure oxygen, carbon dioxide and methane concentrations. A minimum of three purge volumes, (or more if field readings have not stabilized) will be removed from the probe prior to collection of a batch certified 1 L Summa® can grab sample connected to the probe via a tee fitting. A water dam will be placed around the probe to prevent air from entering the sub-slab environment along the annular space between the tubing and the slab, and a shut-in test of the sampling train will be performed prior to purging to verify that there are no leaks in the tubing or connections. A detailed description of the sub-slab purging and sampling SOPs are included in Appendix B. After sampling, the Summa® canister will be shipped via chain of custody to Eurofins Air Toxics for analysis of VOCs by USEPA Method TO-15 Open Scan (Appendix C).

3.4.6 Differential Pressure Monitoring

Measurement and logging of the cross-slab differential pressure at the temporary sub-slab probes will be performed using a DG-700 differential pressure meter (or equivalent) to assess the role of HVAC operations and the building stack effect on the vapor migration potential across the slab. Monitoring will be conducted over the 24-hour period when indoor air samples are collected. Once the differential pressure monitoring is complete, the sub-slab sample will be collected as described above and, afterwards, the vapor pin will be removed and the hole in the slab will be filled with expanding cement.

3.4.7 Utility Corridor Preferential Pathway Samples

A utility survey will be used to identify potential preferential pathways along subsurface conduits attached to residences. Subsurface structures that have a direct connection from the known groundwater contaminant plume to residences may be sampled, as they could potentially bypass the attenuation provided by the silt/clay layer in the vadose zone. The location and number of utility corridor samples will be proposed in the location-specific work plan.

4. ON-SITE BUILDING AND COMMERCIAL\INDUSTRIAL BUILDING VI ASSESSMENT METHODS

Phase I sub-slab and indoor air sampling of on-site structures will be performed at Building 66, Building 69, and Building 92. Based on recent Site plans, Buildings 66 and 92 are active storage areas and Building 69 is used for refrigeration. Sampling of on-site industrial properties will be similar to the residential sampling approach except that the air sampling time intervals will be adjusted to reflect average occupancy/work hours (i.e. 8-hour sample) rather than the 24-hour period used for residential buildings. Also, commercial screening levels will be used in the decision matrices rather than residential screening levels to account for the shorter exposure durations associated with occupational exposures. Sub-slab differential pressure data will also be logged during the sampling period at all on-site structures. In addition to the on-site structures, a commercial building VI assessment will be conducted for the off-site restaurant located approximately 100-feet north of monitoring well TMW-7D. Before sampling, the property owner and/or tenant will be notified and access obtained per Section 3.1.

4.1.1 Commercial Building Survey

Before developing the location-specific work plan, Geosyntec staff will conduct a commercial building survey to determine building construction characteristics, HVAC and ventilation characteristics, building occupancy, and identify potential indoor contaminant sources and preferential pathways. The survey will be completed using the form included in Appendix B.

4.1.2 Location-Specific Work Plan

After conducting the building survey, Geosyntec will prepare a supplemental location-specific work plan to guide field staff, which will consist of a memorandum, tables and figures. This work plan will summarize the results of the survey and will include:

- Indoor air and penetration pathway (as applicable) sampling locations for each building.
- Sub-slab sampling and differential pressure monitoring locations.
- Outdoor air sampling locations.
- Preferential pathway (utility service) sampling locations (as applicable).
- Average times and durations of building occupancy.
- Copies of the building survey checklists.

A copy of each building-specific work plan will be submitted to the USEPA for their records. Geosyntec will seek work plan approval if building conditions require sampling procedures outside the scope of this VI Investigation Work Plan.

4.1.3 Indoor Air Samples

The selection of indoor air sampling locations will be based on identifying areas that are most representative of occupancy and with site-specific building characteristics that might facilitate vapor intrusion. Indoor air samples will be collected using the same protocols and equipment used for residential structures except the Summa® can flow controllers will be set to collect time weighted samples over the average occupancy (work day) time of the building occupants. A minimum of one time integrated sample will be collected at Building 66, Building 69, and Building 92 and other industrial/commercial buildings (as appropriate) for each sampling event. If the building survey indicates workers occupy the building in multiple shifts, a sample may be collected for each shift.

4.1.4 Outdoor Air Samples

Outdoor air samples will be collected upwind of each sampled structure to determine whether COCs in ambient air serve as a background source. Outdoor air samples will be collected over approximately the same sampling period as the associated indoor air sample(s) using the same sampling and analytical protocols used for the indoor samples. The location and number of outdoor air samples will be proposed in the location-specific work plan.

4.1.5 Penetration Pathway Samples

Penetration pathway areas will be sampled using either a one 8-hour time integrated sample, or the pathway-specific grab sampling approach described for residential structures if practicable.

4.1.6 Sub-Slab Vapor Samples

Upon arrival at the building, Geosyntec will conduct a building walk through with building management personnel to identify and mark out proposed sub-slab probe locations. A photographic log of marked locations and distance measurements between sample points and distinct building features will also be collected to aid in relocating sample points if an additional round of sampling is needed. During the walk-through, Geosyntec will avoid selecting probe locations where building personnel indicate that they would hinder workplace activities or where utilities are present within the floor slab or the upper few inches of the fill below. A geophysical survey will be used to confirm whether utilities are present in locations where sub-slab probes are proposed and identify metal reinforcement structures (i.e., rebar grid) in the slab. If a utility may be present in the immediate vicinity of a proposed sample point it will be moved to a suitable location nearby.

Temporary sub-slab monitoring probes will be installed using Vapor Pin sampling ports and sampled following the procedures described for residential structures.

4.1.7 Differential Pressure Monitoring

Measurement and logging of the cross-slab differential pressure at the temporary sub-slab probes will be performed to assess the role of HVAC operations and the building stack effect on the vapor migration potential across the slab. Monitoring will be conducted over a one week (or longer) period starting soon after installation of the probe and will continue through the collection of indoor air samples. Geosyntec will consult with building personnel to confirm that the placement of the differential pressure meters does not interfere with building operations.

4.1.8 Utility Corridor Preferential Pathway Samples

Geosyntec will conduct a utility survey in the vicinity on the on-site structures to identify potential preferential pathways. The location and number of utility corridor samples will be proposed in the location-specific work plan.

5. VI ASSESSMENT FORENSIC TECHNIQUES

The VI assessment techniques described below are alternative methods of sampling or testing that may provide additional lines of evidence to more effectively evaluate VI risks at on- and off-site structures. Not all methods listed in this section may be used during the VI investigation. Decisions to use a particular technique will be made in accordance with the decision framework described in Section 2.1 on a case-specific basis after assessing the sample results from Phase I and any subsequent phases that may be necessary to complete the investigation.

5.1.1 Building Pressure Cycling

Building pressure differentials are known to vary with time due to, for example, changes in the temperature difference between the inside and outside of the structure (i.e., the stack effect), wind speed, and rates of natural or mechanical ventilation. This temporal variability creates uncertainty in VI assessment because indoor air concentrations measured at one point in time may differ from those measured at another.

Building Pressure Cycling (BPC) reduces the uncertainty associated with temporal variability in indoor air concentrations sampled using conventional methods by controlling the building pressure to promote reasonable worst-case "stack effect" conditions that naturally occur at some points in time (typically in the winter) and could lead to elevated concentrations of VI-related COCs in indoor air. BPC testing uses a blower door, or a building's HVAC system to alternately depressurize and pressurize the building while collecting samples of indoor air. During periods when the building is continuously maintained at a pressure lower than the sub-slab pressure (under-pressurized), VI via advective flow through building foundation cracks and penetrations is promoted. During periods of over-pressurization, VI is inhibited but emission of COCs from indoor sources is not, which allows for determination of building-specific background concentrations. Comparison of the measured concentrations in indoor air under both negative and positive pressure conditions provides a basis for distinguishing VI-related impacts from those due to background sources.

5.1.2 High-Volume Soil Gas Sampling

High Volume Sampling Soil Gas Sampling (HVS) is used to reduce uncertainty associated with variability in the spatial distribution of subsurface concentrations. It provides an alternative line of evidence to evaluate VI source strength in cases where the concentrations of COCs in indoor air are greater than expected based on the measured sub-slab concentrations or the building space is too large to effectively evaluate with conventional sub-slab sampling methods. HVS additionally provides information that can facilitate design of an effective sub-slab mitigation system.

The HVS Test method consists of extracting and sampling soil vapor at a high flow rate (hundreds or thousands of liters per minute) over an extended period of time (typically 30 to 60 minutes). The extracted soil gas is continuously monitored using a PID and landfill gas meter to assess the trend of vapor concentrations as a function of volume purged to infer the distribution of vapor concentrations at progressively further distances from the point of extraction. For example, if concentrations increase with increasing volume purged, this indicates that higher concentrations are present at some distance from the point of extraction. Depending on the leakance of the slab, the HVS Test method removes a pore-volume of soil gas from a 6-inch gravel layer with thirty percent (30%) porosity (typical large building slab sub-grade fill) beneath the slab over a radial distance of about twenty-five to sixty (25 to 60) feet. Unlike conventional sub-slab sampling (which provides essentially a "point measurement"), HVS testing provides information over a broader area by removing a larger volume of soil vapor. The HVS Test method also minimizes the risk of failing to identify elevated VOC concentrations that may exist between or beyond probe locations (which are often randomly located or constrained by access limitations). The method also avoids the risk of a single small sample with an anomalously high or low concentration skewing the analysis of possible exposures and risk.

Communication test points drilled through the slab are commonly included in HVS testing to measure the vacuum field that develops below the slab in response to gas extraction. Tracer tests (typically helium injection) are sometimes used during HVS tests to measure the travel time between a communication test point and the extraction point. The vacuum and tracer test data are especially useful for design of a sub-slab mitigation system should one be needed.

5.1.3 Soil Gas Sampling

Soil gas samples may be collected from below or adjacent to residences to determine what compounds may be migrating upward through the soil from the groundwater. Soil gas sampling could be used to reduce uncertainty regarding the source of measured COCs and to fill in data gaps identified during the VI assessment program. Soil gas probe installation will follow a Geosyntec SOP (Appendix B) involving direct push soil coring and geologic logging (soil sampling, if applicable), and installation of a stainless-steel sampling point and screen connected to Nylaflow tubing. Soil gas sampling will then be completed using the same procedures presented for sub-slab vapor sampling. However, a helium tracer test will be used instead of a water dam to detect sample train leaks.

5.1.4 Portable GC/MS Sampling

A portable GC/MS (e.g., HAPSITE®) could be used to provide real-time compound-specific screening level analysis of COC concentrations in air. A field-portable GC/MS can be used to:

- Identify background sources of VOCs and screen utility entry points and other possible preferential pathways; and
- During BPC testing to monitor indoor air to verify that COC concentrations have stabilized prior to Summa® can sample collection, and to look for potential vapor entry points during periods when the building is depressurized.

5.1.5 CSM Confirmation Samples (soil or groundwater sampling)

Additional groundwater and soil data may be collected to help build a more robust CSM. The data that may be collected include:

- VOC concentrations in groundwater samples collected from wells screened across the water-table,
- VOC concentrations in soil (collected from strategically located boreholes),
- Vertical profiling of VOC concentrations in soil gas, and
- Bulk soil properties that influence vapor transport (e.g., grain density, porosity, moisture content, total organic carbon).

Bulk soil and soil gas profiling may occur in conjunction with drilling efforts for any phase of VI or groundwater sampling. CSM confirmation samples will be collected in accordance with the most current version of the RFI Work Plan and QAPP (ELMSS), as well as the sampling procedures (for soil vapor collection) outlined in this Work Plan.

5.1.6 Passive Sampling

Passive air samples may also be collected at some buildings to supplement Summa® can sample data. Typically, a passive sampler would be used to collect time-averaged samples for periods of 24 hours or more, or to collect samples for analysis of compounds such as naphthalene that could have TO-15 reporting limits greater than the project-specific data quality objective. The location-specific work plans will describe where passive samplers, if any, would be deployed at any given building. If passive sampling is warranted, Radiello samplers will be used unless circumstances indicate that a different passive sampler would be more appropriate for a particular application. Radiello sampler deployment, retrieval and shipping via chain of custody will follow the Laboratory SOPs described in Appendix C.

6. QUALITY ASSURANCE/QUALITY CONTROL

This section discusses the procedures and processes that will be used to maintain an acceptable level of QA/QC in the VI investigation. Full QA/QC procedures are presented in the QAPP (Appendix D).

6.1.1 Field Duplicates

A co-located duplicate sample will be collected for 1 in every 10 primary samples. Duplicate samples are intended to evaluate analytical variability between samples and will be collected over the same time interval as the original sample and at the same flow rate. Duplicate Summa® canister samples will be collected by connecting two Summa® canisters (each with individual flow controllers) to a sampling tee (i.e., split samples).

6.1.2 Field Blanks

One field blank sample will be obtained during each sampling event (mobilization). Field blank results are intended to verify sample integrity during field sample collection and shipping. The field blank canister will remain in its original packaging and will be shipped along with the other samplers to the Facility and back to the laboratory for analysis.

6.1.3 Laboratory Control Samples

Laboratory blanks, laboratory control spikes, and analytical surrogates will be provided and analyzed by the laboratory operating the instrument as described in the analytical method protocol (see Appendix D – QAPP). The laboratory control samples are independent source reference standards used to validate the accuracy of the initial calibration of the instrumentation used to analyze the samples.

6.1.4 Equipment Calibration

Instruments and equipment used during field testing and sampling will be calibrated and maintained according to the manufacturer’s guidelines and recommendations, with operation/calibration being performed by qualified field personnel. Instruments requiring field calibration are the PID and HAPSITE® portable GC/MS.

Calibration information will be documented throughout the implementation of field testing. Field calibrations will be performed at the beginning of each day, and checked at the middle and end of each day. If field instruments report values with greater than 10% difference from calibration standards or if an instrument fails instrument-specific calibration quality control (QC) criteria, corrective action steps will be implemented as described below.

- Check the instrument.
- Investigate the cause of failure.
- Recalibrate the instrument.
- If instrument recalibration fails, call the instrument manufacturer or rental company for technical support.
- If recalibration and technical support actions do not result in acceptable instrument accuracy, remove the instrument from operation and send to the rental office or manufacturer for service.
- If the instrument is a rental, the rental office should be contacted immediately in order to obtain a replacement instrument.

6.1.5 Sample Documentation

Analytical samples will be tracked from their arrival at the field site until analysis has been completed at the respective laboratories through the use of Chain of Custody. Arriving shipments of sample containers will be checked for completeness and integrity. The sample containers will be clearly marked by the laboratory (note that Summa® canisters have unique numbers engraved on them) or by field staff with laboratory-supplied labels using indelible ink (not a Sharpie) at the time of sample collection. Samples will be shipped with a custody seal and under chain-of-custody to the laboratory performing the analysis.

7. HEALTH AND SAFETY

A health and safety plan that will be used to maintain safe conditions for workers and building occupants is provided in Appendix E.

8. DATA ANALYSIS

The data acquired through this assessment program will be analyzed and presented as follows:

1) The results of the data collection activities will be evaluated in accordance with the decision framework described in Section 2.1.
2) The data and observations will be summarized in a quantitative site VI conceptual model that integrates information collected under this assessment program with other environmental data collected by BASF and its contractors.

9. REPORTING PROGRAM

The VI assessment program is designed to identify all structures where the VI-related concentrations of site-related COCs could reasonably exceed their respective indoor air risk-based screening levels as quickly as practicable. It is an iterative process by design and includes decision matrices that describe how structure-sampling results will be used to recommend building-specific response actions and how data from each phase of the investigation will be used to determine whether additional phases are needed. The assessment program will rely on informal data/letter reports and discussions with USEPA rather than submittal of a series of formal reports. At key project milestones, in consultation with the USEPA, fact sheets/public meetings will be used to keep local officials and interested stakeholders apprised of the project status. A VI Assessment Summary Report will be submitted to USEPA as a part of the RFI Report once the assessment program is complete. This report will include the following:

- Discussion of property selection process;
- List of properties sampled;
- Preliminary building inspections including field observations;
- Sample collection procedures;
- Tables summarizing the analytical results;
- Figures depicting the sampling results;
- Confirmation sampling results, if required;
- Summary of decisions made based on the decision frame work;
- Mitigation evaluation, if required;
- Conclusions and recommendations regarding the path forward; and
- Appendices with laboratory analytical reports.

10. SCHEDULE

BASF is prepared to initiate public notification and work to obtain site-specific access agreements within 15 days following USEPA approval of this work plan. The schedule for field implementation of the sampling program will proceed as quickly as practicable depending on the response of the affected building owners/occupants. Once the 30-day response period is over and access agreements are obtained, BASF will coordinate site-specific inspection, work plan development, and sampling activities with USEPA staff.

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11. REFERENCES

EDR. 2017. The EDR Radius Map Report with GeoCheck. March 2017.

ELM Site Solutions (ELMSS). 2003a. Initial Phase RCRA Facility Investigation Report. Environmental Liability Management, Inc. August 2003.

ELMSS. 2010. RCRA Facility Investigation Phase II Report. Environmental Liability Management, Inc. May 2010.

ELMSS. 2015. RCRA Facility Investigation Field Sampling Plan and Quality Assurance Project Plan. Environmental Liability Management, Inc. October 2015.

ELMSS. 2016. RCRA Facility Investigation Data Gap Report. Environmental Liability Management, Inc. December 2016.

USEPA. 2015. OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, OSWER Publication 9200.2-154. June 2015.

USEPA. 2016. EPA Vapor Intrusion Screening Level (VISL) Calculator, Version 3.5.1. July 2016.

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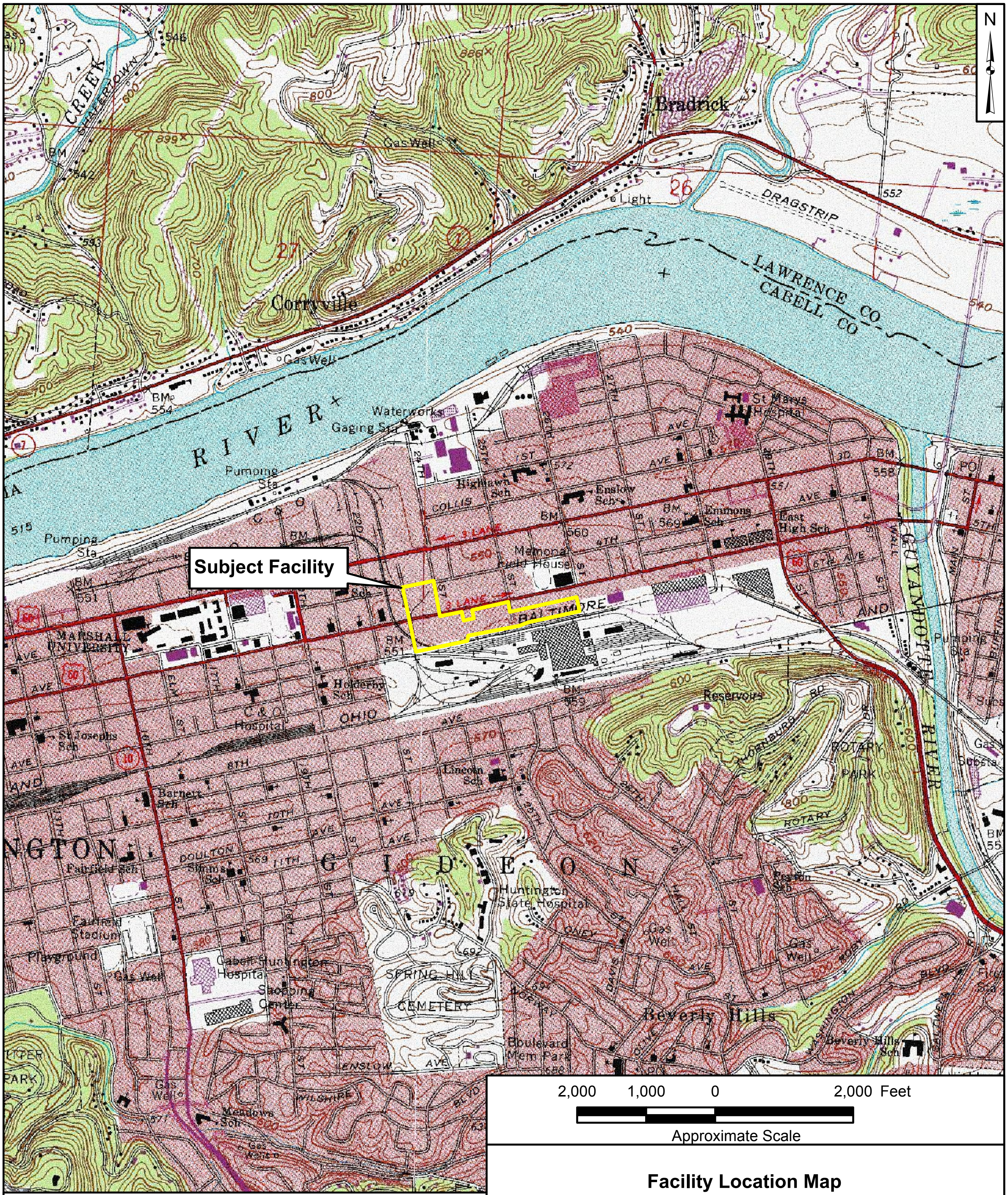
FIGURES



Facility Location Map

Flint Group Pigments Huntington Facility
2401 5th Avenue
Huntington, WV

Legend

▭ Approximate Subject Site Boundary

Notes:
1. Source of Huntington, WV USGS 7.5 Minute Quadrangle: United States Department of Agriculture's (USDA's) GeoSpatial Data Gateway.
2. Parcel boundary information provided by the Cabell County Assesor's Office.

Geosyntec consultants

Columbia, MD

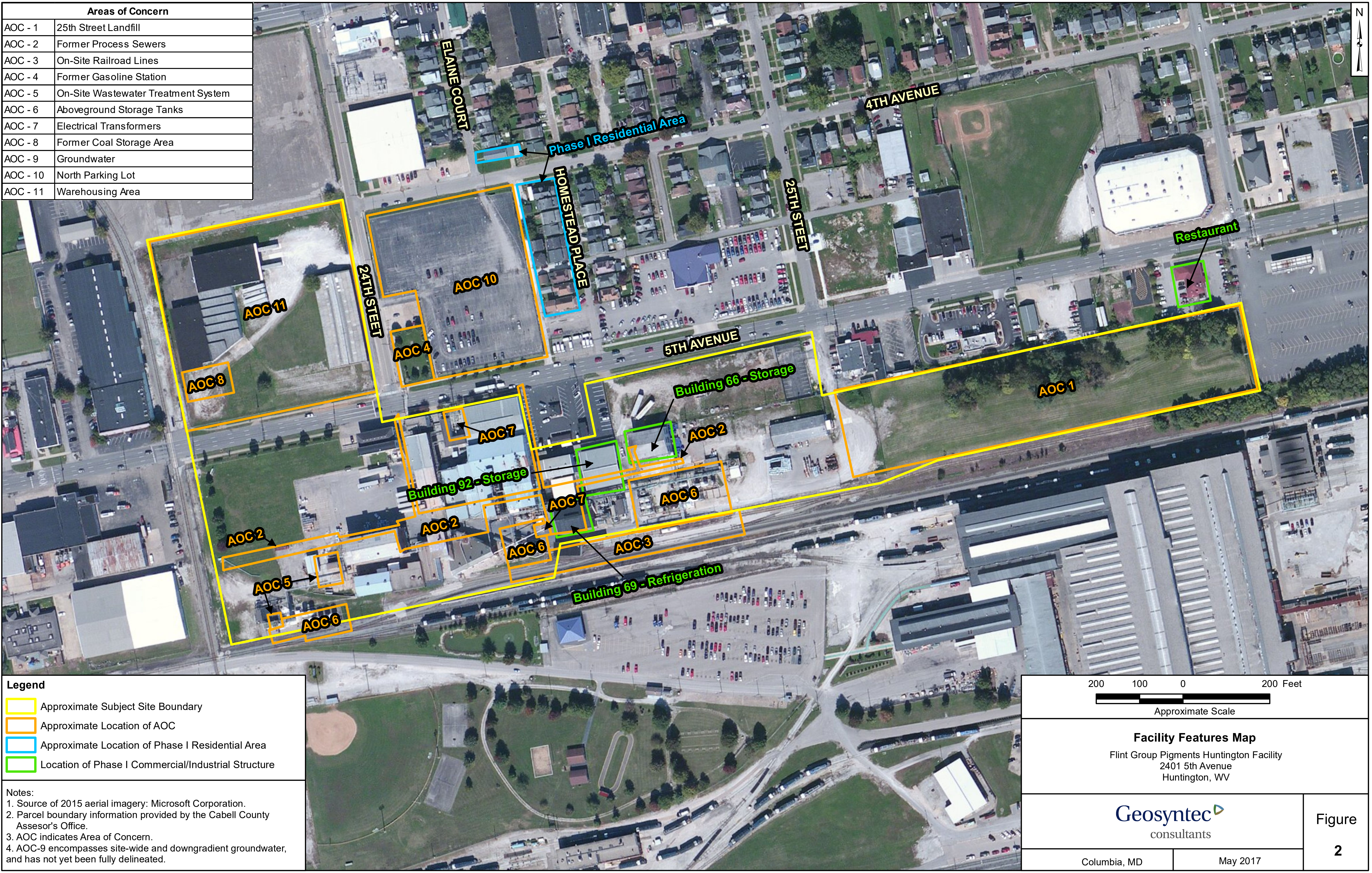
April 2017

Figure

1

Path: P:\GIS\MP1480\Fig 1-1 - Topo.mxd 27 March 2017 JBP

Areas of Concern	
AOC - 1	25th Street Landfill
AOC - 2	Former Process Sewers
AOC - 3	On-Site Railroad Lines
AOC - 4	Former Gasoline Station
AOC - 5	On-Site Wastewater Treatment System
AOC - 6	Aboveground Storage Tanks
AOC - 7	Electrical Transformers
AOC - 8	Former Coal Storage Area
AOC - 9	Groundwater
AOC - 10	North Parking Lot
AOC - 11	Warehousing Area



Legend

🟨	Approximate Subject Site Boundary
🟧	Approximate Location of AOC
🟦	Approximate Location of Phase I Residential Area
🟩	Location of Phase I Commercial/Industrial Structure

Notes:
1. Source of 2015 aerial imagery: Microsoft Corporation.
2. Parcel boundary information provided by the Cabell County Assesor's Office.
3. AOC indicates Area of Concern.
4. AOC-9 encompasses site-wide and downgradient groundwater, and has not yet been fully delineated.

Facility Features Map

Flint Group Pigments Huntington Facility
2401 5th Avenue
Huntington, WV

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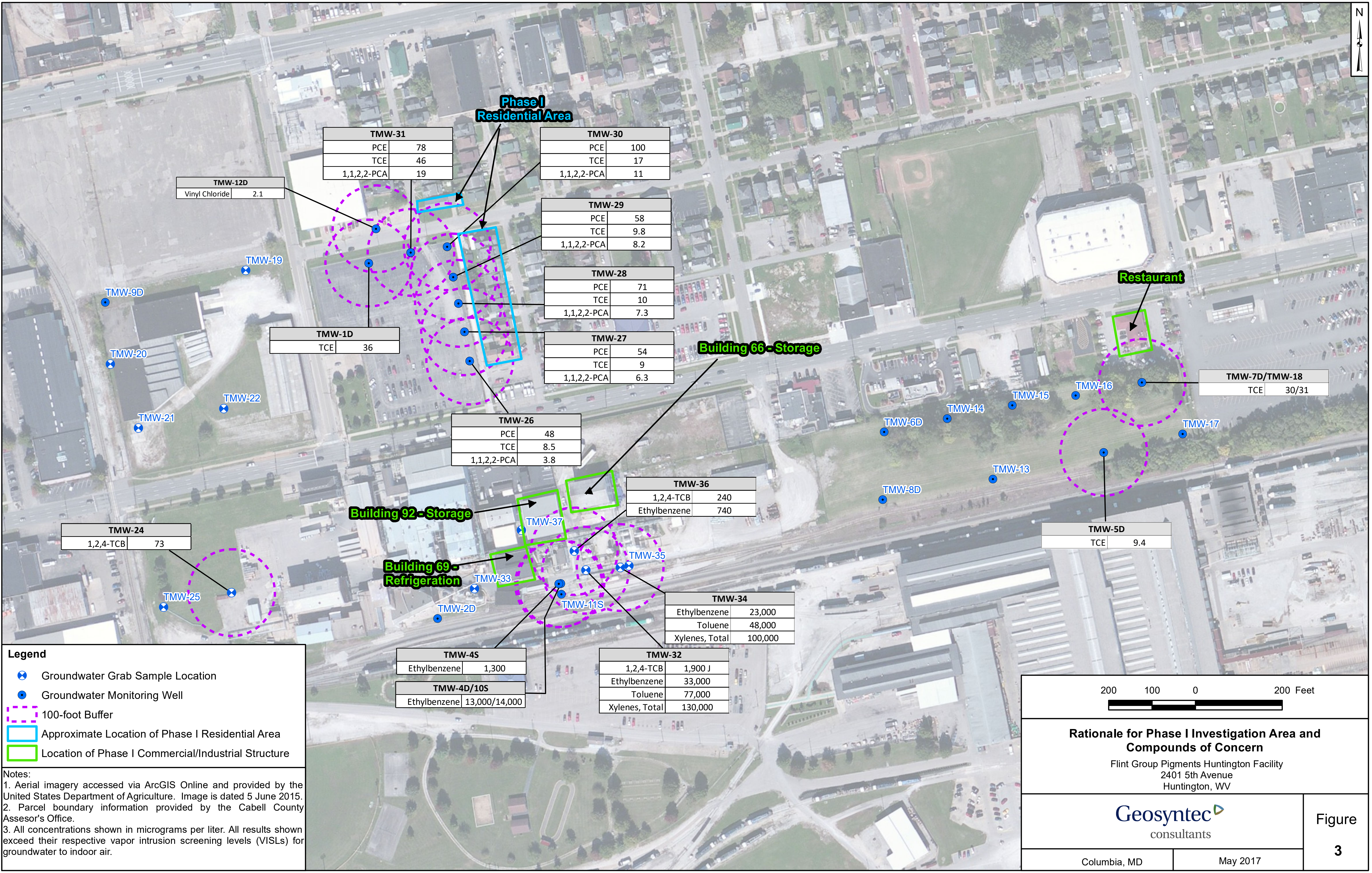
May 2017

Figure
2

Path: P:\GIS\MP1480\Fig 2 - Facility Features.mxd 17 May 2017 JBP



Legend

- ⊗ Groundwater Grab Sample Location
- ● Groundwater Monitoring Well
- ⬚ 100-foot Buffer
- 🟦 Approximate Location of Phase I Residential Area
- 🟩 Location of Phase I Commercial/Industrial Structure

Notes:
1. Aerial imagery accessed via ArcGIS Online and provided by the United States Department of Agriculture. Image is dated 5 June 2015.
2. Parcel boundary information provided by the Cabell County Assesor's Office.
3. All concentrations shown in micrograms per liter. All results shown exceed their respective vapor intrusion screening levels (VISLs) for groundwater to indoor air.

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Rationale for Phase I Investigation Area and Compounds of Concern

Flint Group Pigments Huntington Facility
2401 5th Avenue
Huntington, WV

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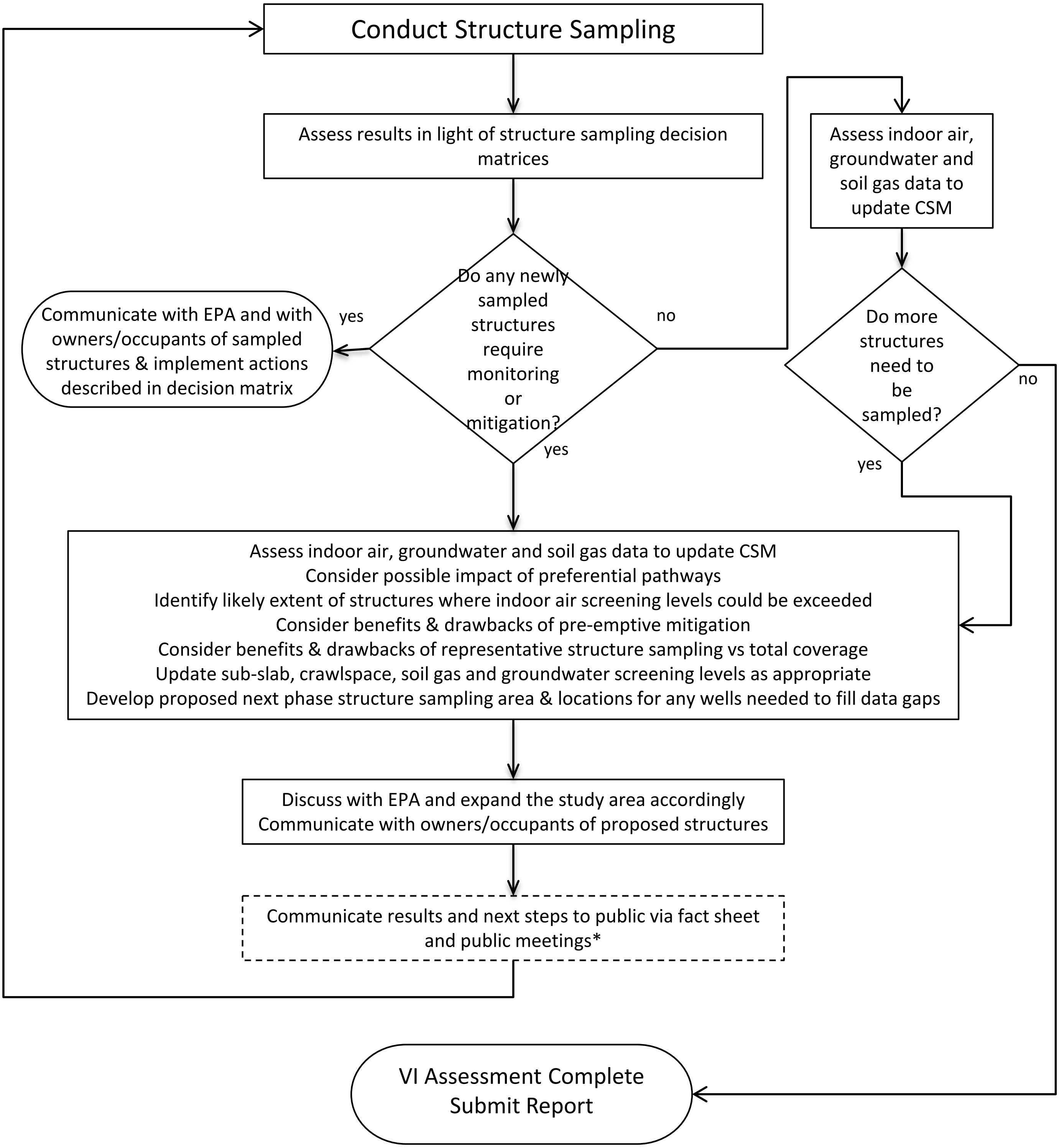
Columbia, MD | May 2017

Figure 3

Figure 4 - VI Scope of Investigation Decision Framework

The goal of the VI assessment program is to identify all structures where the VI-related concentration of site-related COCs could reasonably exceed their respective indoor air screening level, and to take appropriate actions to reduce VI-related exposures.



**The nature and frequency of the communication will be developed in consultation with EPA whenever key milestones are achieved.*

APPENDIX A

COC-Specific Structure Sampling Decision Matrices

RESIDENTIAL

Benzene Residential	**IASL**	**3.60E-01**	Indoor Air Screening Concentration of COC [1]			
	Action Level	**3.60E+01**	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]			**<** 1.1E-01	1.1E-01 **to** 3.6E-01	3.6E-01 **to** 3.6E+01	3.6E+01
< 30 X IASL	<	1.1E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	1.1E+01 to	1.1E+02	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	1.1E+02 to	1.1E+03	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	>	1.1E+03	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Benzene Residential	**IASL**	**3.60E-01**	Indoor Air Screening Concentration of COC [1]			
	Action Level	**3.60E+01**	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]			**<** 1.1E-01	1.1E-01 **to** 3.6E-01	3.6E-01 **to** 3.6E+01	3.6E+01
< IASL	<	3.6E-01	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	>	3.6E-01	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

Benzene Commercial/Industrial	**IASL**	**1.60E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level	**1.60E+02**	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]			**<** 4.8E-01	4.8E-01 **to** 1.6E+00	1.6E+00 **to** 1.6E+02	1.6E+02
< 30 X IASL	<	4.8E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	4.8E+01 to	4.8E+02	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	4.8E+02 to	4.8E+03	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	>	4.8E+03	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Benzene Commercial/Industrial	**IASL**	**1.60E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level	**1.60E+02**	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]			**<** 4.8E-01	4.8E-01 **to** 1.6E+00	1.6E+00 **to** 1.6E+02	1.6E+02
< IASL	<	1.6E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	>	1.6E+00	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

RESIDENTIAL

Carbon Tetrachloride Residential	**IASL 4.70E-01** **Action Level 4.70E+01**	Indoor Air Screening Concentration of COC [1]			
		< 0.3 IASL[2]	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 1.4E-01	1.4E-01 **to** 4.7E-01	4.7E-01 **to** 4.7E+01	4.7E+01
< 30 X IASL	< 1.4E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	1.4E+01 to 1.4E+02	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	1.4E+02 to 1.4E+03	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 1.4E+03	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Carbon Tetrachloride Residential	**IASL 4.70E-01** **Action Level 4.70E+01**	Indoor Air Screening Concentration of COC [1]			
		< 0.3 IASL[2]	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 1.4E-01	1.4E-01 **to** 4.7E-01	4.7E-01 **to** 4.7E+01	4.7E+01
< IASL	< 4.7E-01	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 4.7E-01	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

Carbon Tetrachloride Commercial/Industrial	**IASL 4.40E+02** **Action Level 2.00E+02**	Indoor Air Screening Concentration of COC [1]			
		< 0.3 IASL[2]	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 1.3E+02	1.3E+02 **to** 4.4E+02	4.4E+02 **to** 4.4E+04	2.0E+02
< 30 X IASL	< 1.3E+04	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	1.3E+04 to 1.3E+05	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	1.3E+05 to 1.3E+06	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 1.3E+06	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Carbon Tetrachloride Commercial/Industrial	**IASL 4.40E+02** **Action Level 2.00E+02**	Indoor Air Screening Concentration of COC [1]			
		< 0.3 IASL[2]	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 1.3E+02	1.3E+02 **to** 4.4E+02	4.4E+02 **to** 4.4E+04	2.0E+02
< IASL	< 4.4E+02	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 4.4E+02	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

RESIDENTIAL

Ethylbenzene Residential	IASL 1.10E+00	Indoor Air Screening Concentration of COC [1]			
	Action Level 1.10E+02	< 0.3 IASL[2]	0.3 IASL to IASL	> IASL to 100 X IASL	> 100 X IASL or > Action Level[3]
Sub-Slab COC Concentration[1]		< 3.3E-01	3.3E-01 to 1.1E+00	1.1E+00 to 1.1E+02	1.1E+02
< 30 X IASL	< 3.3E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	3.3E+01 to 3.3E+02	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	3.3E+02 to 3.3E+03	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 3.3E+03	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Ethylbenzene Residential	IASL 1.10E+00	Indoor Air Screening Concentration of COC [1]			
	Action Level 1.10E+02	< 0.3 IASL[2]	0.3 IASL to IASL	> IASL to 100 X IASL	> 100 X IASL or > Action Level[3]
Crawl Space COC Concentration[1]		< 3.3E-01	3.3E-01 to 1.1E+00	1.1E+00 to 1.1E+02	1.1E+02
< IASL	< 1.1E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 1.1E+00	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

Ethylbenzene Commercial/Industrial	IASL 4.40E+03	Indoor Air Screening Concentration of COC [1]			
	Action Level 4.90E+02	< 0.3 IASL[2]	0.3 IASL to IASL	> IASL to 100 X IASL	> 100 X IASL or > Action Level[3]
Sub-Slab COC Concentration[1]		< 1.3E+03	1.3E+03 to 4.4E+03	4.4E+03 to 4.4E+05	4.9E+02
< 30 X IASL	< 1.3E+05	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	1.3E+05 to 1.3E+06	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	1.3E+06 to 1.3E+07	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 1.3E+07	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Ethylbenzene Commercial/Industrial	IASL 4.40E+03	Indoor Air Screening Concentration of COC [1]			
	Action Level 4.90E+02	< 0.3 IASL[2]	0.3 IASL to IASL	> IASL to 100 X IASL	> 100 X IASL or > Action Level[3]
Crawl Space COC Concentration[1]		< 1.3E+03	1.3E+03 to 4.4E+03	4.4E+03 to 4.4E+05	4.9E+02
< IASL	< 4.4E+03	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 4.4E+03	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

RESIDENTIAL

1,1,2,2-Tetrachloroethane Residential	**IASL**	**4.80E-02**	Indoor Air Screening Concentration of COC [1]			
	Action Level	**4.80E+00**	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]			**<** 1.4E-02	1.4E-02 **to** 4.8E-02	4.8E-02 **to** 4.8E+00	4.8E+00
< 30 X IASL		< 1.4E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	1.4E+00	to 1.4E+01	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	1.4E+01	to 1.4E+02	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL		> 1.4E+02	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

1,1,2,2-Tetrachloroethane Residential	**IASL**	**4.80E-02**	Indoor Air Screening Concentration of COC [1]			
	Action Level	**4.80E+00**	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]			**<** 1.4E-02	1.4E-02 **to** 4.8E-02	4.8E-02 **to** 4.8E+00	4.8E+00
< IASL		< 4.8E-02	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL		> 4.8E-02	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

1,1,2,2-Tetrachloroethane Commercial/Industrial	**IASL**	**2.10E-01**	Indoor Air Screening Concentration of COC [1]			
	Action Level	**2.10E+01**	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]			**<** 6.3E-02	6.3E-02 **to** 2.1E-01	2.1E-01 **to** 2.1E+01	2.1E+01
< 30 X IASL		< 6.3E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	6.3E+00	to 6.3E+01	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	6.3E+01	to 6.3E+02	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL		> 6.3E+02	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

1,1,2,2-Tetrachloroethane Commercial/Industrial	**IASL**	**2.10E-01**	Indoor Air Screening Concentration of COC [1]			
	Action Level	**2.10E+01**	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]			**<** 6.3E-02	6.3E-02 **to** 2.1E-01	2.1E-01 **to** 2.1E+01	2.1E+01
< IASL		< 2.1E-01	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL		> 2.1E-01	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

RESIDENTIAL

Tetrachloroethylene Residential	IASL	1.10E+01	Indoor Air Screening Concentration of COC [1]			
	Action Level	1.26E+02	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]			< 3.3E+00	3.3E+00 to 1.1E+01	1.1E+01 to 1.1E+03	1.3E+02
< 30 X IASL	<	3.3E+02	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	3.3E+02 to	3.3E+03	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	3.3E+03 to	3.3E+04	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	>	3.3E+04	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Tetrachloroethylene Residential	IASL	1.10E+01	Indoor Air Screening Concentration of COC [1]			
	Action Level	1.26E+02	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]			< 3.3E+00	3.3E+00 to 1.1E+01	1.1E+01 to 1.1E+03	1.3E+02
< IASL	<	1.1E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	>	1.1E+01	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

Tetrachloroethylene Commercial/Industrial	IASL	4.70E+01	Indoor Air Screening Concentration of COC [1]			
	Action Level	5.40E+02	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]			< 1.4E+01	1.4E+01 to 4.7E+01	4.7E+01 to 4.7E+03	5.4E+02
< 30 X IASL	<	1.4E+03	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	1.4E+03 to	1.4E+04	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	1.4E+04 to	1.4E+05	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	>	1.4E+05	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Tetrachloroethylene Commercial/Industrial	IASL	4.70E+01	Indoor Air Screening Concentration of COC [1]			
	Action Level	5.40E+02	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]			< 1.4E+01	1.4E+01 to 4.7E+01	4.7E+01 to 4.7E+03	5.4E+02
< IASL	<	4.7E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	>	4.7E+01	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

RESIDENTIAL

Toluene Residential	**IASL 5.20E+03**	Indoor Air Screening Concentration of COC [1]			
	Action Level 1.56E+04	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 1.6E+03	1.6E+03 **to** 5.2E+03	5.2E+03 **to** 5.2E+05	1.6E+04
< 30 X IASL	< 1.6E+05	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	1.6E+05 to 1.6E+06	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	1.6E+06 to 1.6E+07	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 1.6E+07	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Toluene Residential	**IASL 5.20E+03**	Indoor Air Screening Concentration of COC [1]			
	Action Level 1.56E+04	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 1.6E+03	1.6E+03 **to** 5.2E+03	5.2E+03 **to** 5.2E+05	1.6E+04
< IASL	< 5.2E+03	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 5.2E+03	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

Toluene Commercial/Industrial	**IASL 2.20E+04**	Indoor Air Screening Concentration of COC [1]			
	Action Level 6.60E+04	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 6.6E+03	6.6E+03 **to** 2.2E+04	2.2E+04 **to** 2.2E+06	6.6E+04
< 30 X IASL	< 6.6E+05	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	6.6E+05 to 6.6E+06	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	6.6E+06 to 6.6E+07	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 6.6E+07	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Toluene Commercial/Industrial	**IASL 2.20E+04**	Indoor Air Screening Concentration of COC [1]			
	Action Level 6.60E+04	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 6.6E+03	6.6E+03 **to** 2.2E+04	2.2E+04 **to** 2.2E+06	6.6E+04
< IASL	< 2.2E+04	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 2.2E+04	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

RESIDENTIAL

1,2,4-Trichlorobenzene Residential	**IASL 2.10E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 6.30E+00	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 6.3E-01	6.3E-01 **to** 2.1E+00	2.1E+00 **to** 2.1E+02	6.3E+00
< 30 X IASL	< 6.3E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	6.3E+01 to 6.3E+02	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	6.3E+02 to 6.3E+03	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 6.3E+03	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

1,2,4-Trichlorobenzene Residential	**IASL 2.10E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 6.30E+00	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 6.3E-01	6.3E-01 **to** 2.1E+00	2.1E+00 **to** 2.1E+02	6.3E+00
< IASL	< 2.1E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 2.1E+00	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

1,2,4-Trichlorobenzene Commercial/Industrial	**IASL 8.80E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 2.64E+01	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 2.6E+00	2.6E+00 **to** 8.8E+00	8.8E+00 **to** 8.8E+02	2.6E+01
< 30 X IASL	< 2.6E+02	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	2.6E+02 to 2.6E+03	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	2.6E+03 to 2.6E+04	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 2.6E+04	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

1,2,4-Trichlorobenzene Commercial/Industrial	**IASL 8.80E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 2.64E+01	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 2.6E+00	2.6E+00 **to** 8.8E+00	8.8E+00 **to** 8.8E+02	2.6E+01
< IASL	< 8.8E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 8.8E+00	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

RESIDENTIAL

Trichloroethylene Residential	**IASL 4.80E-01**	Indoor Air Screening Concentration of COC [1]			
	Action Level 2.10E+00	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		< 1.4E-01	1.4E-01 to 4.8E-01	4.8E-01 to 4.8E+01	2.1E+00
< 30 X IASL	< 1.4E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	1.4E+01 to 1.4E+02	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	1.4E+02 to 1.4E+03	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 1.4E+03	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Trichloroethylene Residential	**IASL 4.80E-01**	Indoor Air Screening Concentration of COC [1]			
	Action Level 2.10E+00	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		< 1.4E-01	1.4E-01 to 4.8E-01	4.8E-01 to 4.8E+01	2.1E+00
< IASL	< 4.8E-01	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 4.8E-01	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

Trichloroethylene Commercial/Industrial	**IASL 3.00E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 8.80E+00	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		< 9.0E-01	9.0E-01 to 3.0E+00	3.0E+00 to 3.0E+02	8.8E+00
< 30 X IASL	< 9.0E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	9.0E+01 to 9.0E+02	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	9.0E+02 to 9.0E+03	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 9.0E+03	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Trichloroethylene Commercial/Industrial	**IASL 3.00E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 8.80E+00	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		< 9.0E-01	9.0E-01 to 3.0E+00	3.0E+00 to 3.0E+02	8.8E+00
< IASL	< 3.0E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 3.0E+00	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

RESIDENTIAL

Vinyl Chloride Residential	**IASL 1.70E-01**	Indoor Air Screening Concentration of COC [1]			
	Action Level 1.70E+01	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 5.1E-02	5.1E-02 **to** 1.7E-01	1.7E-01 **to** 1.7E+01	1.7E+01
< 30 X IASL	< 5.1E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	5.1E+00 to 5.1E+01	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	5.1E+01 to 5.1E+02	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 5.1E+02	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Vinyl Chloride Residential	**IASL 1.70E-01**	Indoor Air Screening Concentration of COC [1]			
	Action Level 1.70E+01	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 5.1E-02	5.1E-02 **to** 1.7E-01	1.7E-01 **to** 1.7E+01	1.7E+01
< IASL	< 1.7E-01	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 1.7E-01	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

Vinyl Chloride Commercial/Industrial	**IASL 2.80E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 2.80E+02	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 8.4E-01	8.4E-01 **to** 2.8E+00	2.8E+00 **to** 2.8E+02	2.8E+02
< 30 X IASL	< 8.4E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	8.4E+01 to 8.4E+02	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	8.4E+02 to 8.4E+03	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 8.4E+03	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Vinyl Chloride Commercial/Industrial	**IASL 2.80E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 2.80E+02	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 8.4E-01	8.4E-01 **to** 2.8E+00	2.8E+00 **to** 2.8E+02	2.8E+02
< IASL	< 2.8E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 2.8E+00	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

RESIDENTIAL

Xylenes Residential	**IASL 1.00E+02**	Indoor Air Screening Concentration of COC [1]			
	Action Level 3.00E+02	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 3.0E+01	3.0E+01 **to** 1.0E+02	1.0E+02 **to** 1.0E+04	3.0E+02
< 30 X IASL	< 3.0E+03	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	3.0E+03 to 3.0E+04	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	3.0E+04 to 3.0E+05	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 3.0E+05	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Xylenes Residential	**IASL 1.00E+02**	Indoor Air Screening Concentration of COC [1]			
	Action Level 3.00E+02	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 3.0E+01	3.0E+01 **to** 1.0E+02	1.0E+02 **to** 1.0E+04	3.0E+02
< IASL	< 1.0E+02	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 1.0E+02	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

COMMERCIAL/INDUSTRIAL

Xylenes Commercial/Industrial	**IASL 2.80E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 1.32E+03	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Sub-Slab COC Concentration[1]		**<** 8.4E-01	8.4E-01 **to** 2.8E+00	2.8E+00 **to** 2.8E+02	1.3E+03
< 30 X IASL	< 8.4E+01	No Further Action	Monitor	Background Evaluation	Background Evaluation
30 X IASL to 300 X IASL	8.4E+01 to 8.4E+02	Monitor	Monitor or Forensics	Forensics or Mitigate	Forensics or Rapid Response
300 X IASL to 3000 X IASL	8.4E+02 to 8.4E+03	Forensics or Monitor	Forensics or Monitor	Forensics or Mitigate	Forensics or Rapid Response
> 3000 X IASL	> 8.4E+03	Forensics or Mitigate	Forensics or Mitigate	Mitigate	Mitigate-Rapid Response

Xylenes Commercial/Industrial	**IASL 2.80E+00**	Indoor Air Screening Concentration of COC [1]			
	Action Level 1.32E+03	**< 0.3 IASL[2]**	**0.3 IASL to IASL**	**> IASL to 100 X IASL**	**> 100 X IASL or > Action Level[3]**
Crawl Space COC Concentration[1]		**<** 8.4E-01	8.4E-01 **to** 2.8E+00	2.8E+00 **to** 2.8E+02	1.3E+03
< IASL	< 2.8E+00	No Further Action	Monitor	Background Evaluation	Background Evaluation
> IASL	> 2.8E+00	Monitor	Forensics or Monitor	Forensics or Mitigate	Rapid Response/Forensics

1. Indoor Air and Soil gas concentrations in ug/m3.
2. The Indoor Air Screening Level (IASL) = the COC concentration associated with an excess lifetime cancer risk of 10-6
3. The Action Level = the COC concentration associated with an excess lifetime cancer risk of 10-4 or a hazard quotient of 3 (HQ of 1 for TCE), whichever is smaller.

APPENDIX B
Field Sampling SOPs

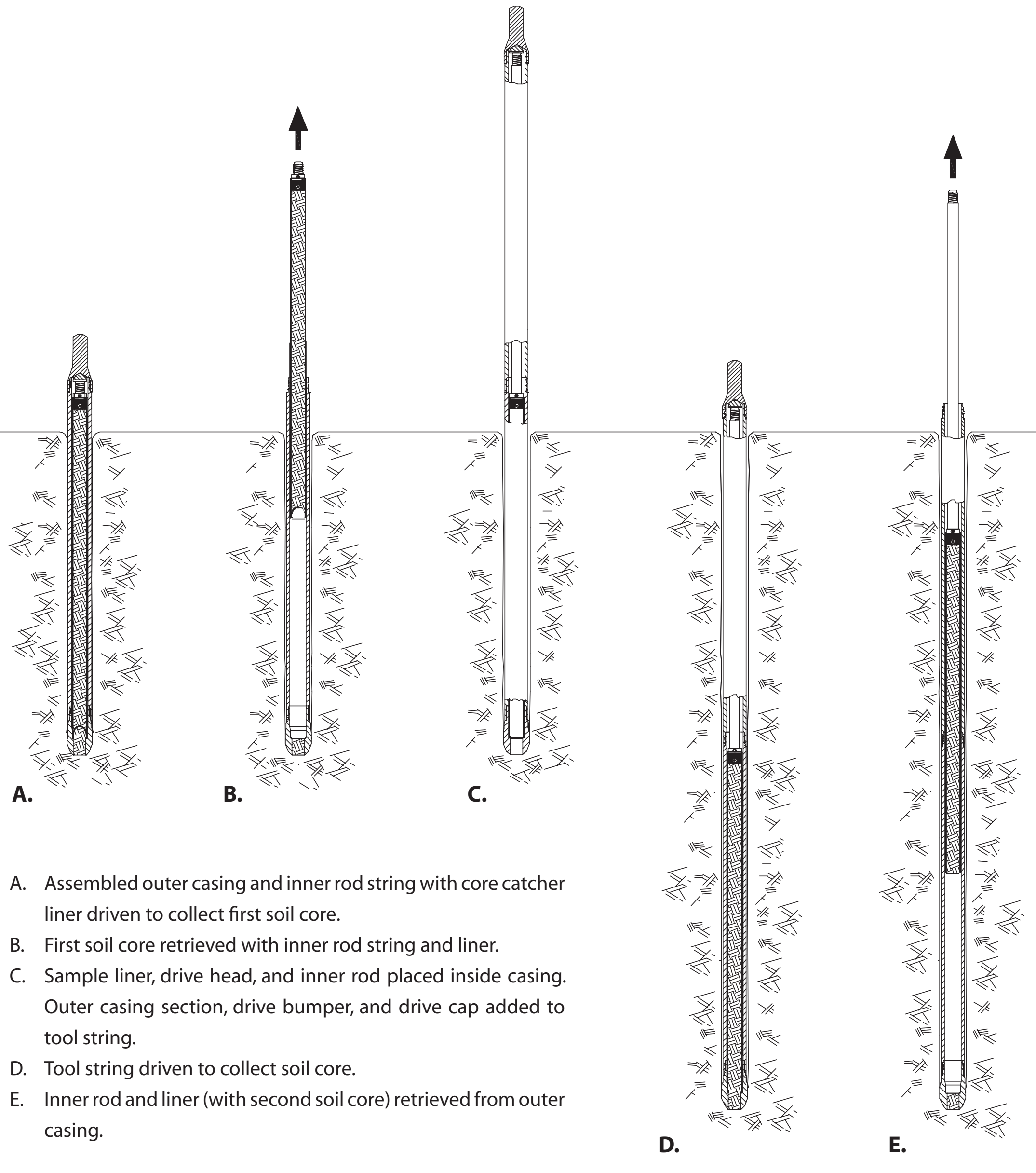
Geoprobe® DT22 Dual Tube Soil Sampling System

Continuous Core Soil Sampler

Standard Operating Procedure

Technical Bulletin No. MK3140

PREPARED: November, 2006
REVISED: January, 2013



A. Assembled outer casing and inner rod string with core catcher liner driven to collect first soil core.
B. First soil core retrieved with inner rod string and liner.
C. Sample liner, drive head, and inner rod placed inside casing. Outer casing section, drive bumper, and drive cap added to tool string.
D. Tool string driven to collect soil core.
E. Inner rod and liner (with second soil core) retrieved from outer casing.

OPERATION OF THE DUAL TUBE 22 SOIL SAMPLING SYSTEM

Geoprobe Systems®

Geoprobe® and Geoprobe Systems® are
Registered Trademarks of Kejr, Inc., Salina, Kansas

Geoprobe® Prepacked Screens are manufactured under
U.S. Patent No. 7,735,553B2.

1.0 OBJECTIVE

The objective of this procedure is to collect a representative soil sample at depth through an enclosed casing and recover it for visual inspection and/or chemical analysis.

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling, soil conductivity and contaminant logging, grouting, and materials injection.
** Geoprobe® and Geoprobe Systems® are registered trademarks of Kejr Engineering, Inc., Salina, Kansas*

Dual Tube 22 Soil Sampling System: A direct push system for collecting continuous core samples of unconsolidated materials from within a sealed casing of Geoprobe® 2.25-inch (57 mm) outside diameter (OD) probe rods. Samples are collected and retrieved within a liner that is threaded onto the leading end of a string of Geoprobe® 1.25-inch (32 mm) OD Light-Weight Center Rods and inserted to the bottom of the outer casing. Collected samples measure up to approximately 980 ml in volume in the form of a 1.125-inch x 60-inch (29 mm x 1524 mm) core.

Liner: A 1.375-inch (35 mm) OD thin-walled, PVC tube that is inserted into the outer casing on the leading end of the inner rod string for the purpose of containing and retrieving core samples. Liners are available in two configurations; a simple open tube or a tube with a core catcher permanently attached to the leading end. Nominal liner lengths include 36 inches, 1 meter, 48 inches, and 60 inches.
***Nominal liner length identifies the length of tools with which the liner is used (see Page 8). The actual end-to-end lengths of the various DT22 liners will differ from the specified nominal lengths.*

Core Catcher: A dome-shaped device positioned at the leading end of a liner to prevent loss of collected soil during retrieval of the liner and soil core. Flexible fingers at the top of the core catcher are pushed outward by soil entering the liner during advancement of the tool string. As the filled liner is subsequently retrieved, the fingers of the core catcher move back inward, effectively closing off the end of the liner and limiting soil loss. The core catcher designed for the DT22 system is made of PVC material and is permanently fused to the liner.

2.2 Discussion

Dual tube sampling gets its name from the fact that two sets of probe rods are used to retrieve continuous soil core samples from the subsurface. One set of rods is driven into the ground as an outer casing (Fig. 2.1). These rods receive the driving force from the hammer and provide a sealed casing through which soil samples may be recovered. The second, smaller set of rods are placed inside the outer casing with a sample liner attached to the leading end of the rod string (Fig. 2.1). These smaller rods hold the liner in place as the outer casing is driven to fill the liner with soil. The inner rods are then retracted to retrieve the full liner.

Standard Geoprobe® 2.25-inch OD probe rods provide the outer casing for the DT22 Dual Tube Soil Sampling System. A cutting shoe is threaded into the leading end of the rod string. When driven into the subsurface, the cutting shoe shears a 1.125-inch OD soil core which is collected inside the casing in a clear plastic liner.

The second set of rods in the DT22 system are Geoprobe® 1.25-inch OD Light-Weight Center rods. A sample liner is attached to the end of these smaller rods and then inserted into the casing. The 1.25-inch rods hold the liner tight against the cutting shoe as the outer casing is driven to collect the soil core. Once filled with soil, the liner is removed from the bottom of the outer casing by lifting out the 1.25-inch rods.

The outer, 2.25-inch probe rods provide a cased hole through which to sample. The main advantage of sampling through a cased hole is that there is no side slough to contend with. In addition, the outer casing effectively seals the probe hole when sampling through perched water tables. These factors mean that sample cross-contamination is eliminated. The DT22 sampling system is therefore ideal for continuous coring in both saturated and unsaturated zones.

Solid Drive Tip

A DT22 Discrete Point 1.25 pin (22956) can be placed on the leading end of the 1.25 inner rod string in place of a sample liner (Fig. 2.2). When installed in the outer casing, the drive tip firmly seats within the cutting shoe and effectively seals the tool string as it is driven into the subsurface. This enables the operator to advance the outer casing to the bottom of a pre-cored hole or through undisturbed soil to reach the top of the sampling interval.

Grouting

The DT22 system allows bottom-up grouting through the primary tool string. This means that a cement or bentonite grout mix can be pumped through the outer casing as it is withdrawn from the ground. This is in contrast to most other soil samplers which require driving a second set of tools back down the probe hole in order to deliver the grout mix.

Monitoring Well Installation

An expendable cutting shoe enables the operator to install a Geoprobe® Prepacked Screen Monitoring Well through the outer casing of the DT22 Dual Tube System. After the collection of continuous soil cores to the desired depth, prepacked screens can be inserted to the bottom of the outer casing on the leading end of a PVC riser string. The well is finished, complete with grout barrier, bentonite well seal, and a high-solids bentonite slurry/neat cement grout, during retrieval of the outer casing.

SP22 Groundwater Sampler

The Screen Point 22 (SP22) Groundwater Sampler can be used in conjunction with the DT22 Dual Tube System to perform soil sampling, groundwater sampling, and slug testing at multiple depth intervals in one probe push.

With the SP22 sampler, a stainless steel or PVC screen is lowered to the bottom of the DT22 outer casing on the leading end of a string of either 1.25-inch OD light-weight center rods or 0.75-inch schedule 40 flush-thread PVC riser. The outer casing is then retracted while the SP22 screen is held in place with the 1.25-inch rods or PVC riser. This exposes the screen to the formation for groundwater sampling or slug testing. When sampling or testing is complete, the SP22 screen is removed with the inner rod or riser string and DT22 sampling may continue.

For specific information on using the SP22 sampler, refer to *Geoprobe® Screen Point 22 Groundwater Sampler - Standard Operating Procedure* (Geoprobe® Technical Bulletin No. MK3173).

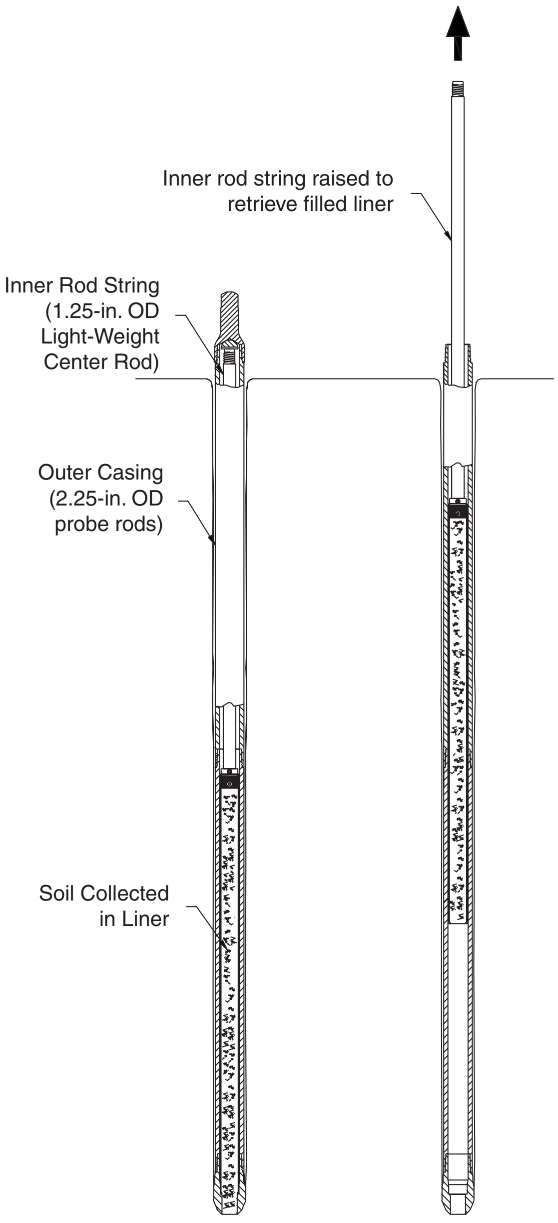


FIGURE 2.1
Outer Casing Driven With Liner

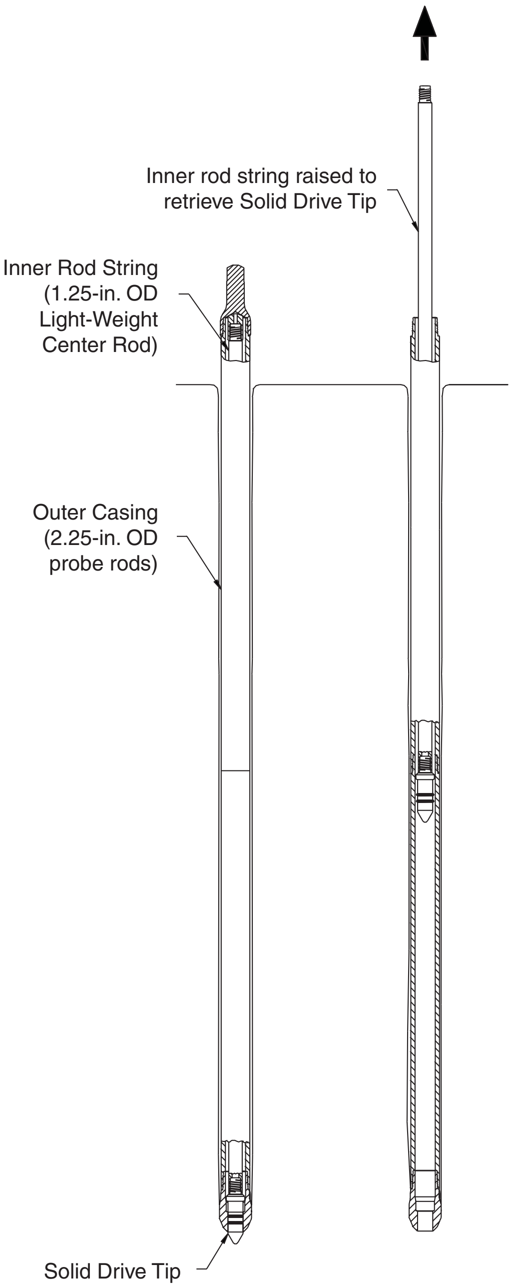


FIGURE 2.2
Outer Casing Driven With Solid Drive Tip

3.0 REQUIRED EQUIPMENT

The following equipment is used to recover samples with the Geoprobe® Dual Tube 22 Soil Sampling and probing systems. Refer to Figure 3.1 for parts identification.

DUAL TUBE 22 SAMPLER PARTS	QUANTITY	PART NUMBER
DT22 Drive Bumper	-10-	DT4010
DT22 Drive Head Cushion Assembly	-1-	42236
DT22 Drive Cushion Assist Handle	-1-	45425
DT22 Threadless Drive Cap, for 1.25-inch rods	-1-	22955
DT22 Liner Drive Head Assembly, for 1.25-inch rods	-1-	DT4052
DT22 Thread Cutting Drive Head Assembly, for 1.25-inch rods	-1-	41675
Rebuild Kit for DT22 Liner Drive Head	-1-	DT4051K
DT22 Solid Drive Tip, for 1.25-inch rods	-1-	22956
O-rings for Solid Drive Tip, Pkg. of 25	variable	DT4070R
DT22 Liner, 60-inch, Box of 50*	variable	DT4061K
DT22 Liner, 48-inch, Box of 50*	variable	DT4048K
DT22 Liner, 1-meter, Box of 50*	variable	DT4039K
DT22 Liner, 36-inch, Box of 50*	variable	DT4036K
DT22 Liner with Core Catcher, 60-inch, Box of 50*	variable	DT4161K
DT22 Liner with Core Catcher, 48-inch, Box of 50*	variable	DT4148K
DT22 Liner with Core Catcher, 1-meter, Box of 50*	variable	DT4139K
DT22 Liner with Core Catcher, 36-inch, Box of 50*	variable	DT4136K
DT22 Liner Cutter	-1-	28751
DT22 Vinyl End Caps, Pkg. of 100 (50 pair)	variable	DT4026K
Universal Liner Holder	-1-	22734
DT22 Cutting Shoe, Standard	-1-	25341
DT22 Expendable Cutting Shoe Holder	-1-	50271
DT22 Expendable Cutting Shoe, 2.375-inch OD	variable	50726
O-rings for Expendable Cutting Shoe, Pkg. of 50	variable	DT4045R

CENTER RODS AND CENTER ROD ACCESSORIES	QUANTITY	PART NUMBER
Light-Weight Center Rod, 1.25-inch OD x 60 inches*	variable	27600
Light-Weight Center Rod, 1.25-inch OD x 48 inches*	variable	21900
Light-Weight Center Rod, 1.25-inch OD x 36 inches*	variable	43012
Light-Weight Center Rod, 1.25-inch OD x 1 meter*	variable	32318
Leaf Puller Assembly, for 1.25-inch rods	-1-	31499
Adjustable Rod Clamp	-1-	27216

PROBE RODS AND PROBE ROD ACCESSORIES	QUANTITY	PART NUMBER
Probe Rod, 2.25-inch OD x 60 inches*	variable	25301
Probe Rod, 2.25-inch OD x 48 inches*	variable	25300
Probe Rod, 2.25-inch OD x 1 meter*	variable	25352
Probe Rod, 2.25-inch OD x 36 inches*	variable	33245
O-rings for 2.25-inch rods, Pkg. of 25	variable	AT2100R
GH60 Threadless Drive Cap, for 2.25-inch rods**	-1-	31530
GH60 Threaded Drive Cap, for 2.25-inch rods**	-1-	25363
GH40 Threadless Drive Cap, for 2.25-inch rods	-1-	31405
GH40 Threaded Drive Cap, for 2.25-inch rods	-1-	25362
Pull Cap, for 2.25-inch rods	-1-	33622
Rod Grip Pull System, for GH40 Hammer and 2.25-inch rods	-1-	29461
Rod Grip Pull Handle, for GH60 Hammer and 2.25-inch rods	-1-	29385

* Match length of rods to desired liner length. Use 60-inch rods with 60-inch liners, 48-inch rods with 48-inch liners, etc.

** The considerable percussive force of the GH60 Hydraulic Hammer may result in reduced tool life for components such as the DT22 Drive Bumper and rod string as compared to operation with the GH40 Hydraulic Hammer.

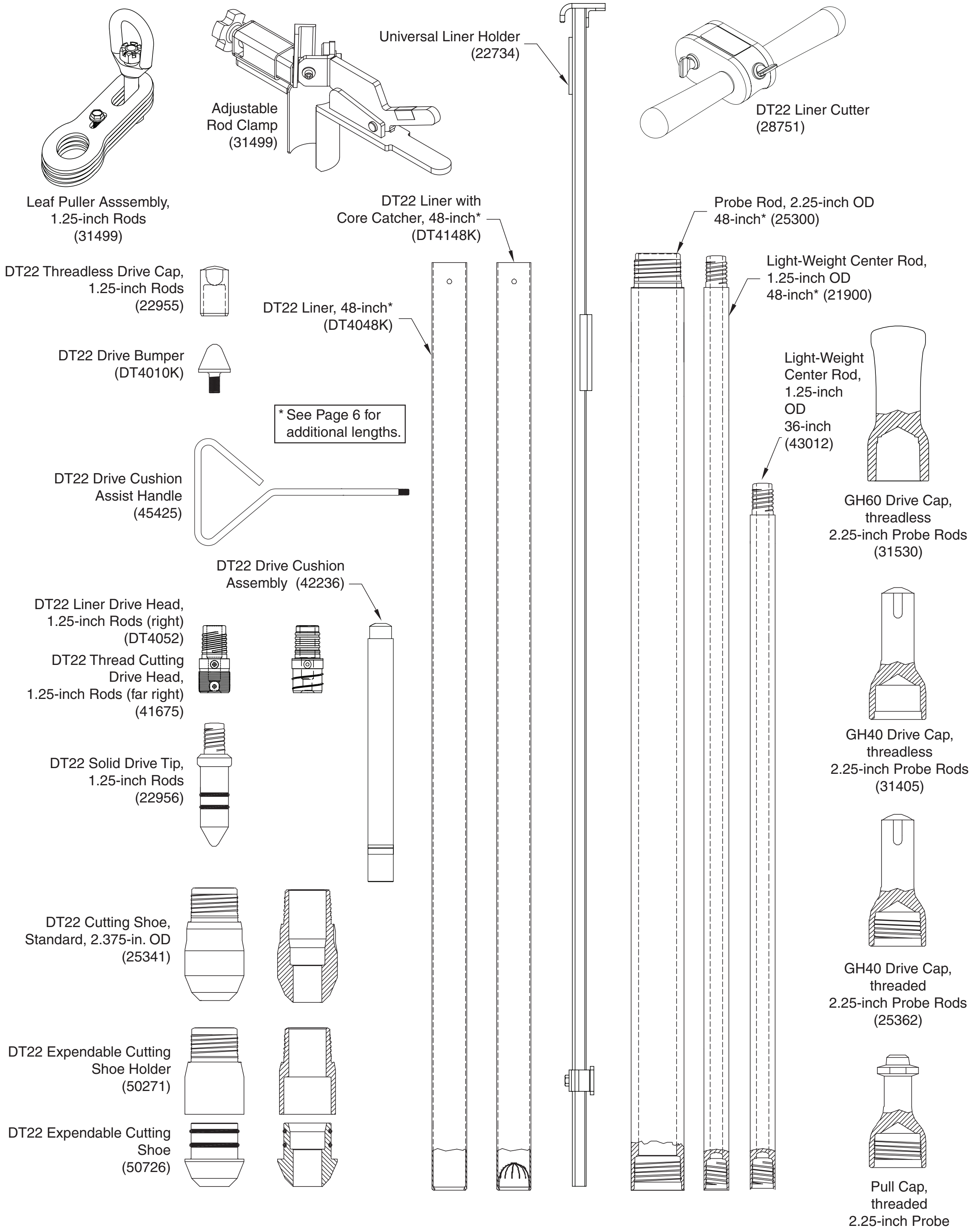


FIGURE 3.1
Dual Tube 22 Soil Sampling System Parts

3.1 Tool Options

Three major components of the DT22 Soil Sampling System are probe rods, sample liners, and cutting shoes. These items are manufactured in a variety of sizes to fit the specific needs of the operator. This section identifies the specific tool options available for use with the DT22 Dual Tube System.

Probe Rods

Geoprobe® 1.25-inch (32 mm) OD Light-Weight Center Rods and 2.25-inch (57 mm) OD probe rods are required to operate the DT22 Soil Sampling System. Both rod sets (1.25-inch and 2.25-inch) must be of the same length.

Sample Liners

Sample liners are made of a heavy-duty clear plastic for convenient inspection of the soil sample. Lengths of 36, 48, 60 inches, and 1 meter are available with an OD of 1.375 inches (35 mm).

Sample liners with integral core catchers are available in lengths of 36, 48, 60 inches, and 1 meter. Utilize the core catcher liners when sampling flowing sands, noncohesive soils, extremely dry soils, or any other materials that fall from the liner during retrieval. DT22 core catcher liners are used with the same equipment as open sample liners. No special tooling or adapters are required.

Cutting Shoes

The standard DT22 Cutting Shoe is available for use with the DT22 Dual Tube System (Fig. 3.2). The DT22 sampling system may also employ an expendable cutting shoe. In this arrangement, a DT22 Expendable Cutting Shoe Holder (50271) is threaded into the leading end of the outer casing. A DT22 Expendable Cutting Shoe (50726) is then inserted into the holder. Upon completion of soil sampling, the outer casing is withdrawn slightly. The expendable cutting shoe detaches from the holder, leaving an open casing through which a prepacked screen monitoring well may be installed. Dimensions for the expendable cutting shoe are the same as the standard cutting shoe (ID = 1.125 in. (29 mm) and OD = 2.375 in. (60 mm)).

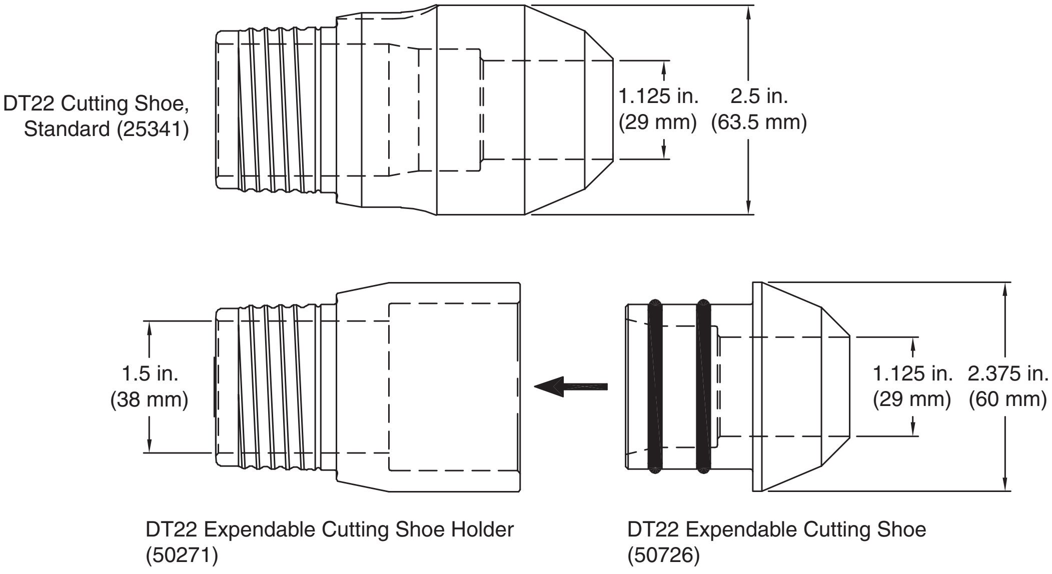


FIGURE 3.2
Cutting Shoe Options for the DT22 Dual Tube Soil Sampling System

4.0 OPERATION

4.1 Decontamination

Before and after each use, thoroughly clean all parts of the sampling system according to project requirements. Parts should also be inspected for wear or damage. During sampling, a clean new liner is used for each soil core.

4.2 Operational Overview

The DT22 Soil Sampling System is designed to collect continuous soil cores. Sampling may begin either from ground surface or a predetermined depth below ground. Once sampling begins, consecutive soil cores must be removed as the outer casing is advanced to greater depths.

When sampling is to begin at the ground surface, the first soil core should be collected using a core catcher liner to maximize sample recovery (Fig. 4.1-A). This is especially true when the first core is composed of dry, loose soil. Upon removal of the first liner and soil core (Fig. 4.1-B), a new liner is inserted to the bottom of the outer casing on the end of an inner rod. A section of outer casing is added to the tool string (Fig. 4.1-C) and the entire tool string is driven to fill the liner with soil (Fig. 4.1-D). The filled liner is removed from the outer casing to retrieve the second soil core (Fig. 4.1-E). A new liner is then inserted to the bottom of the outer casing and the process is repeated over the entire sampling interval.

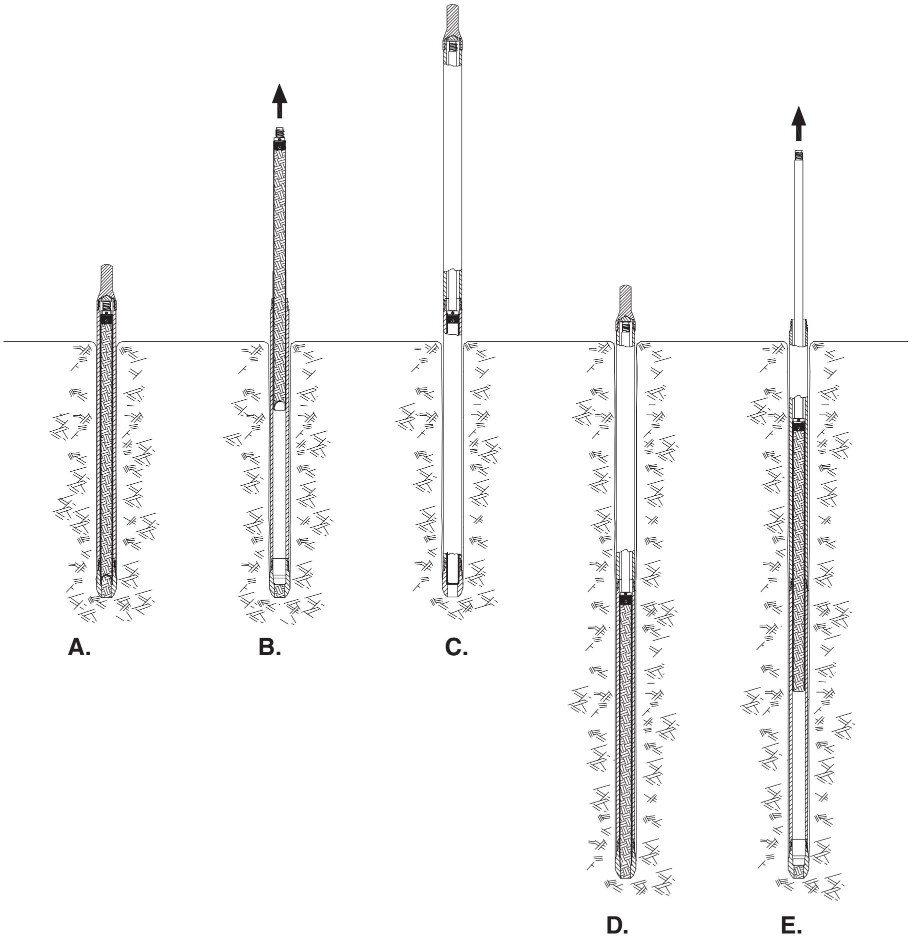


FIGURE 4.1
Continuous Core Sampling From Ground Surface with Dual Tube 22 System

When the sampling interval begins at some depth below ground surface, a DT22 Solid Drive Tip is installed in the outer casing and the entire assembly is driven from ground surface directly through undisturbed soil (Fig. 4.2-A). This enables the operator to reach the top of the sampling interval without stopping to remove unwanted soil cores. Once the interval is reached, the solid drive tip is removed (Fig 4.2-B) and sampling continues as described in the preceding paragraphs (Fig. 4.2-C, Fig. 4.2-D, and Fig. 4.2-E).

Specific instructions for the assembly and operation of the DT22 Dual Tube Soil Sampling System are given in the following sections.

FIGURE 4.2
Outer Casing Driven Through Undisturbed Soil to Begin Sampling with DT22 System

4.3 Assembling and Driving the Outer Casing Using a DT22 Solid Drive Tip

If soil sampling is to begin at some depth below ground surface, the outer casing of the DT22 Dual Tube System can be driven to the top of the sampling interval with a DT22 Solid Drive Tip installed in the leading end. The solid drive tip seals the outer casing as it is driven to depth. Once the desired sampling interval is reached, the solid drive tip is removed to allow collection of the first soil core. This section describes assembling and driving the outer casing using the DT22 Solid Drive Tip.

1. When using a DT22 Standard Cutting Shoe (25341) install an O-ring (AT2100R) at the base of the threads as shown in Figure 4.3. If using an expendable cutting shoe, install an AT2100R O-ring on the DT22 Expendable Cutting Shoe Holder (50271) and two DT4045R O-Rings on the DT22 Expendable Cutting Shoe (50726) (Fig. 4.3).

2. Thread the DT22 Cutting Shoe or DT22 Expendable Point Holder into the leading end of a 2.25-inch OD Probe Rod (25300). Completely tighten the cutting shoe or cutting shoe holder using a pipe wrench.

3. Install an O-ring (DT4070R) in both grooves of the DT22 Solid Drive Point (22956) (Fig.4.4).

4. Thread the solid drive point into the female end of a 1.25-inch OD Light-Weight Center Rod of the same length as the 2.25-inch probe rod (outer casing).

5. Lubricate the O-rings on the solid drive point with a small amount of deionized water. Insert the point and probe rod into the outer casing until the point partially extends from the bottom of the cutting shoe.

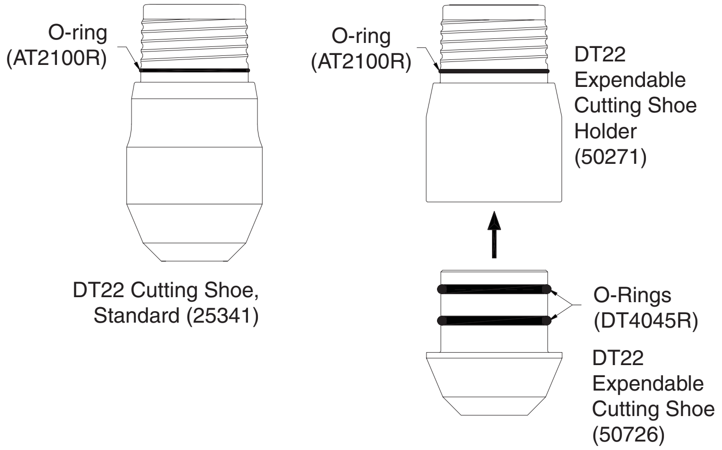


FIGURE 4.3
DT22 Cutting Shoes Utilize O-ring Seals

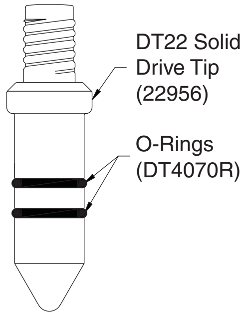


FIGURE 4.4
Solid Drive Point Utilizes Two O-Rings

6. Place a DT22 Threadless Drive Cap (22955) on top of the inner rod (Fig. 4.5). This drive cap is threadless for quick installation/removal, yet still provides protection for the probe rod threads.

7. Install a GH40 Threadless Drive Cap (31405) or GH60 Threadless Drive Cap (31530) on the 2.25-inch probe rod (outer casing) as shown in Figure 4.5.

   Certain soil conditions may allow the outer casing to advance slightly ahead of the inner rod string when using a threadless drive cap on the outer casing. The result is poor sample recovery and alignment problems when adding rods to the tool string. Utilizing a threaded drive cap on the 2.25-inch probe rods may solve this issue. The GH40 Series (25362) and GH60 Series (25363) threaded drive caps secure the inner rod string of the DT22 system during percussion so that the outer casing and inner rod string are advanced as one assembly.

   NOTE: Do not allow the threaded drive cap to unthread while driving the tool string. Failure to keep the drive cap tight during percussion will fuse the drive cap to the outer casing and permanently damage the threads of both the drive cap and top probe rod.

8. Place the assembled outer casing section under the direct push machine for driving. Position the casing directly under the hammer with the cutting shoe centered between the toes of the probe foot.

9. Lower the hydraulic hammer onto the drive cap and advance the outer casing into the subsurface.

10. Raise the hydraulic hammer and remove the drive cap from the outer casing and the threadless drive cap from the inner rod string.

11. Place an O-ring (AT2100R) on the outer casing section that extends from the ground (Fig. 4.6).

12. Thread a 1.25-inch Light-Weight Center Rod onto the inner rod string. Place a 2.25-inch probe rod over the inner rods and thread it onto the outer casing (Fig. 4.7). Completely tighten the outer casing using a pipe wrench.

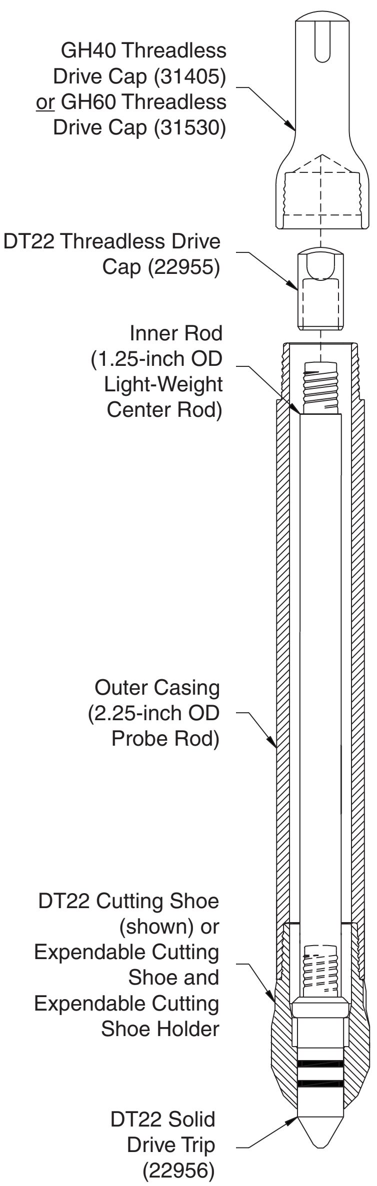


FIGURE 4.5
Outer Casing with Solid Drive Tip

13. Place the threadless drive cap on top of the inner rod. Thread the 2.25-inch drive cap over the threadless drive cap and onto the outer casing.

14. Lower the hydraulic hammer onto the drive cap and advance the outer casing into the subsurface.

    Repeat Steps 10-13 until the leading end of the outer casing is at the top of the proposed sampling interval. Continue with Step 15 to remove the DT22 Solid Drive Point for sampling.

15. Raise the hydraulic hammer and retract the probe derrick to provide access to the top of the tool string.

16. Unthread the 2.25-inch drive cap and remove the threadless drive cap from the inner rods.

17. Thread a 1.25-inch OD Light-Weight Center Rod onto the inner rod string. Lift and remove the inner rods from the outer casing. The DT22 Solid Drive Point is removed from the leading end of the casing with the inner rods.

    The outer casing is now ready for sampling.

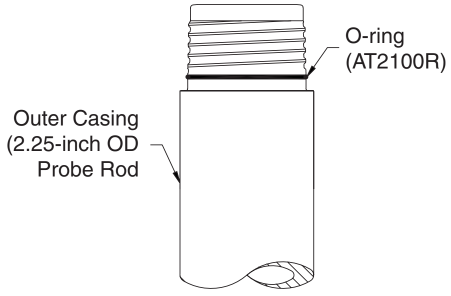


FIGURE 4.6
Outer Casing Joints are Sealed with O-Rings

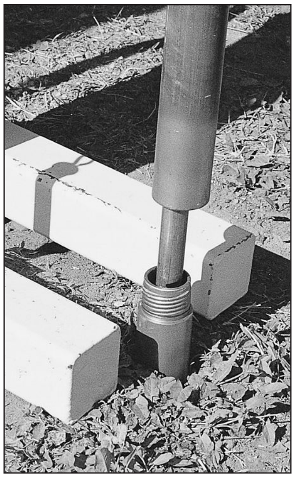


Figure 4.7. Thread a 2.25-inch probe rod onto the outer casing string.

4.4 Liner Drive Head Assembly

There are two liner drive heads for the DT22 System - the DT4052 DT22 Liner Drive Head (Fig. 4.8) and the 41675 DT22 Thread Cutting Drive Head (Fig. 4.9). The main function of both liners drive heads is to connect a liner to the leading end of the inner rod string. This enables the inner rods to hold the liner tight against the cutting shoe to fill the liner with soil as the outer casing is driven. The inner rods are then used to retrieve the liner and soil core from within the outer casing.

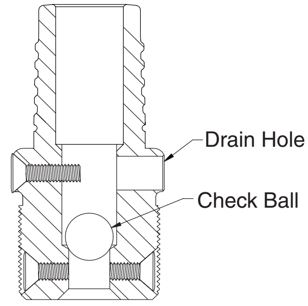


FIGURE 4.8
DT22 Liner Drive Head Features
(DT4052 shown)

The liner drive head assembly includes an internal check ball to improve sample recovery (Fig. 4.8) Vacuum is created below the filled liner as it is lifted from the bottom of the outer casing. Because the inner rod string and liner drive head are hollow, atmospheric air can travel through the rods creating a positive pressure differential above the soil core during retrieval. The check ball seals the liner drive head to eliminate air flow into the liner which could otherwise push the soil sample out of the liner. The check ball also allows air to escape through the liner drive head and inner rod string when lowering a new liner down the outer casing and as soil enters the liner during sampling.

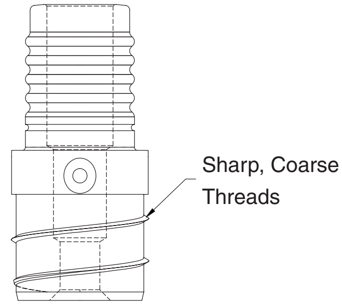


FIGURE 4.9
DT22 Thread Cutting Drive Head
(41675)

Saturated conditions can also challenge sample recovery. Water enters the outer casing either from the saturated formation or is deliberately poured from the ground surface to keep flowing sands out of the casing. As with air in unsaturated formations, the check ball lets water pass through the liner drive head as a new liner is lowered to the bottom of the casing and during sampling as the liner is filled with soil. The check ball then seals the drive head during retrieval so that water draining from the inner rods does not wash the sample out the bottom of the liner. A drain hole located on the side of the liner drive head (Fig. 4.8) allows water to exit the inner rods and travel harmlessly along the outside of the liner.

The DT4052 is the primary liner drive head for the DT22 system. The 41675 DT22 Thread Cutting Drive Head has the advantage of quicker assembly/disassembly due to the fact that the liner is simply twisted onto/off of the sharp, coarse threads on the end of the drive head (Fig. 4.9). But this is at the cost of reduced holding force on the liner. Because of this, the 41675 liner drive head should be limited to shallow depths and mild sampling conditions.

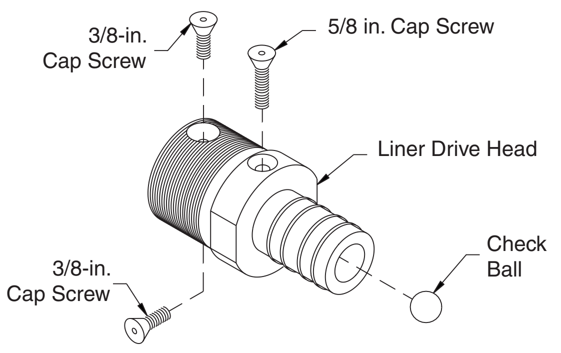


FIGURE 4.10
DT4052 Liner Drive Head Components

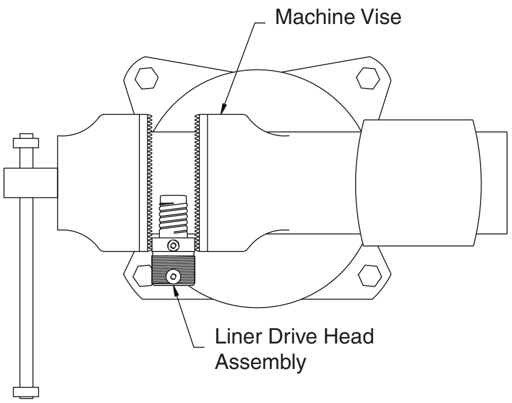
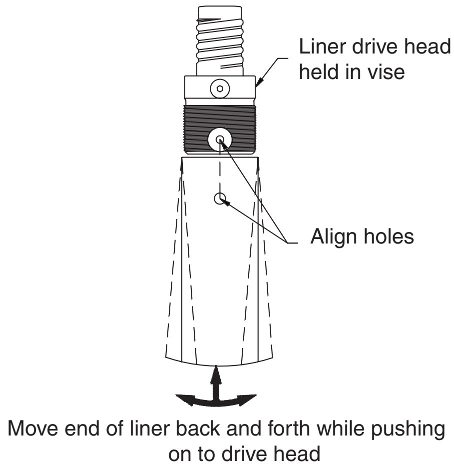


FIGURE 4.11
Place Liner Drive Head in Vise

The DT4052 Liner Drive Head Assembly is made up of five parts as shown in Figure 4.10. The two 3/8-inch flat head socket cap screws are used to attach liners to the liner drive head. The longer 5/8-inch flat head socket cap screw holds the stainless steel check ball within the liner drive head. To disassemble the liner drive head for cleaning, simply unthread the 5/8-inch cap screw and remove the check ball.



Move end of liner back and forth while pushing on to drive head

FIGURE 4.12
Push Liner Onto Liner Drive Head

Instructions for attaching a liner to the DT22 Liner Drive Head Assembly (DT4052) are given below.

1. Visually inspect the liner drive head assembly to ensure that the check ball moves freely within the drive head and the drain hole is unobstructed.

2. Place the liner drive head assembly in a machine vise so that either one of the 3/8-inch caps screws is on top as shown in Figure 4.11.

NOTE: Only one 3/8-inch cap screw is used to attach a liner to the liner drive head assembly. Two 3/8-inch cap screws are included on the drive head to provide a backup in case one incurs thread damage. Either cap screw may be used to attach the liner.

3. Remove the 3/8-inch cap screw using a 3/32-inch hex key.

4. Place the open end of a DT22 Liner against the bottom of the liner drive head. Align the hole in the liner with the hole in the liner drive head as shown in Figure 4.12. Wiggle the free end of the liner back-and-forth while pushing the liner onto the drive head (Fig. 4.12).

5. Thread the 3/8-inch cap screw through the liner and back into the liner drive head (Fig. 4.13). Tighten the cap screw with the 3/32-inch hex key.

The DT22 Liner is now attached to the DT22 Liner Drive Head Assembly (Fig. 4.14).

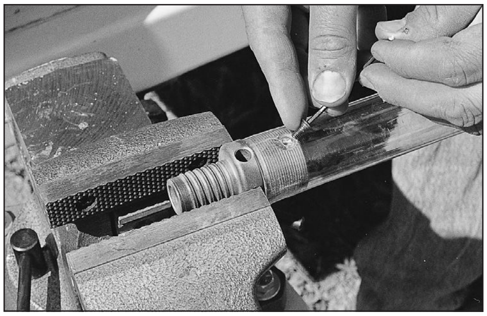


Figure 4.13. Thread cap screw into liner drive head to secure liner.

Figure 4.14. Liner attached to liner drive head and ready for sampling.

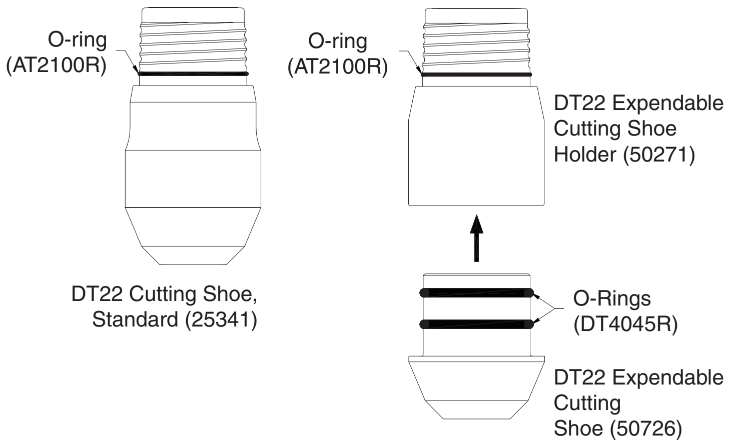


FIGURE 4.15
DT22 Cutting Shoes Utilize O-ring Seals

Figure 4.16. Place probe rod (outer casing) in a vise and tighten the cutting shoe with a pipe wrench.

4.5 Soil Core Collection

This section describes collection of continuous soil core samples from within the sealed outer casing of the DT22 Dual Tube Soil Sampling System. The procedure is written for a sampling series that begins at the ground surface. If sampling is to begin after driving the outer casing through undisturbed soil using a DT22 Solid Drive Tip, skip ahead to Step 13 of this section.

1. Install an O-ring (AT2100R) at the base of the threads on the Standard Cutting Shoe (25341) as shown in Figure 4.15. If using an expendable cutting shoe, install an AT2100R O-ring on the expendable cutting shoe holder and two DT4045R O-Rings on the expendable cutting shoe (Fig. 4.15).

2. Thread the DT22 Cutting Shoe or DT22 Expendable Point Holder into the leading end of a 2.25-inch OD Probe Rod (25300). Completely tighten the cutting shoe or cutting shoe holder using a machine vise and pipe wrench as shown in Figure 4.16.

3. Attach a DT22 Liner Drive Head Assembly (DT4052) of DT22 Thread Cutting Drive Head (41675) to a new liner as described in Section 4.4. A core catcher liner is recommended for when the first soil core begins at ground surface as this configuration will provide maximum sample recovery.

4. Insert the liner and drive head into the 2.25-inch OD probe rod such that the core catcher contacts the cutting shoe as shown in Figure 4.17.

5. Place a DT22 Drive Bumper (DT4010) on top of the liner drive head (Figure 4.17).

6. Install a GH40 Threadless Drive Cap (31405) or GH60 Threadless Drive Cap (31530) onto the 2.25-inch probe rod (outer casing) as shown in Figure 4.17.

   NOTE: See Step 7 of Section 4.3 for additional drive cap options.

7. Place the assembled outer casing section under the direct push machine for driving. Position the casing directly under the hydraulic hammer with the cutting shoe centered between the toes of the probe foot.

8. Lower the hydraulic hammer onto the drive cap and advance the outer casing into the subsurface using continuous percussion.

9. Raise the hydraulic hammer and move the probe assembly back to provide access to the top of the tool string.

10. Remove the drive cap and drive bumper.

11. Thread a 1.25-inch Light-Weight Center Rod onto the liner drive head. Rotate the probe rod and liner assembly two or three revolutions to shear the soil core at the bottom of the liner. Lift the probe rod and filled liner from the outer casing to retrieve the first soil core.

12. Remove the filled liner from the liner drive head as described in Section 4.6. Prepare the soil core for subsampling or storage as specified by the project plan.

13. Place an O-ring (AT2100R) in the groove just below the male threads on the top section of the outer casing (Fig. 4.18).

14. Thread a 1.25-inch Light-Weight Center Rod onto an assembled DT22 Liner Drive Head (or DT22 Thread Cutting Drive Head) and DT22 Liner (Fig. 4.19).

15. Insert the liner and probe rod into the outer casing (Fig. 4.20). The inner rod will extend past the top of the outer casing if only one section of casing was previously driven into the ground. If the casing was driven to a greater depth, continue adding 1.25-inch Light-Weight Center Rods until the last rod extends from the casing.

16. Place a 2.25-inch probe rod over the inner rods and thread it onto the outer casing (Fig. 4.21). Completely tighten the outer casing using a pipe wrench.

17. Place a DT22 Drive Cushion Assembly on top of the inner rod as shown in Figure 4.22.

18. Install a drive cap (31405 or 31530) onto the 2.25-inch probe rod (Fig. 4.22).

19. Lower the hydraulic hammer onto the drive cap and advance the outer casing one liner length into the subsurface to collect the first soil core. Apply hammer percussion to the tool string as this helps move soil through the cutting shoe and into the liner for increased sample recovery.

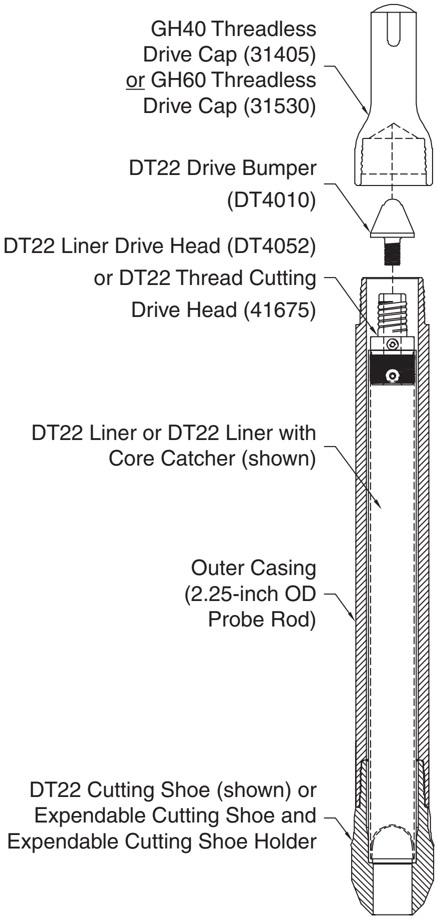


FIGURE 4.17
Outer Casing with DT22 Liner

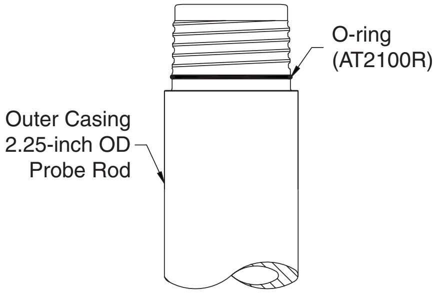


FIGURE 4.18
Outer Casing Joints are Sealed with O-Rings

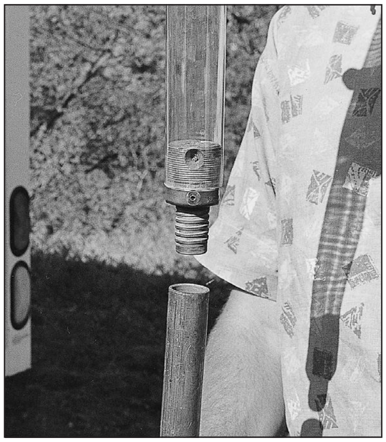


Figure 4.19. Thread liner and liner drive head into 1.25-inch Light-Weight Center Rod.

Figure 4.20. Lower liner to bottom of outer casing on leading end of inner rods.

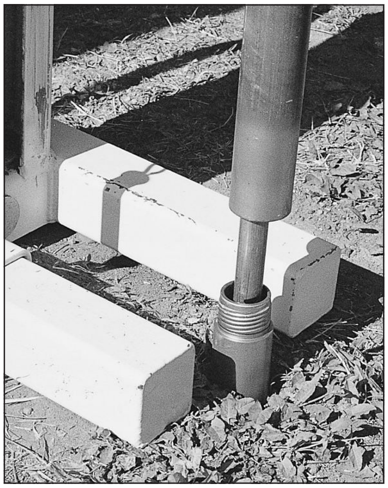


Figure 4.21. Place a 2.25-inch probe rod over the 1.25-inch inner rod and thread it onto the outer casing string.

Figure 4.22. Place a DT22 Drive Cushion Assembly on top of the inner rods and a drive cap onto the outer casing.

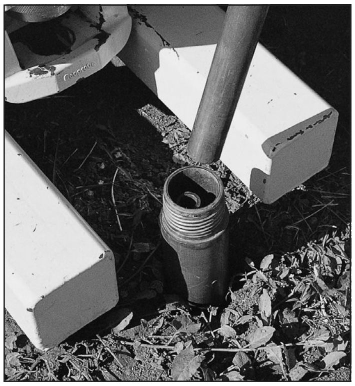


Figure 4.23. Thread a 1.25-inch Light-Weight Center Rod onto inner rod string to retrieve filled liner.

20. Raise the hydraulic hammer and retract the probe derrick to provide access to the top of the tool string.

21. Unthread the drive cap and remove the DT22 Drive Cushion Assembly.

22. Thread a 1.25-inch Light-Weight Center Rod onto the inner rod (Fig. 4.23). Rotate the inner rods two or three revolutions to shear the soil core at the bottom of the liner. Raise the inner rods to retrieve the filled liner.

23. Remove the filled liner from the liner drive head as described in Section 4.6.

(Repeat Steps 13-23 to collect consecutive soil core samples.)

4.6 Removing the DT22 Liner Drive Head (DT4052) from a Filled DT22 Liner

The liner drive head remains attached to the filled liner after retrieval from the outer casing (Fig. 4.24). In order to decontaminate the drive head for further sampling, it must first be removed from the filled liner. The DT22 Thread Cutting Drive Head (41675) is removed by simply placing the drive head in a vise and manually unthreading the liner. The process is slightly more involved for the DT22 Liner Drive Head (DT4052), but is easily accomplished using a machine vise and sharp utility knife as described below.

Place the liner drive head in the machine vise such that the 3/8-inch cap screw threaded through the liner is positioned on top. Remove the cap screw with a 3/32-inch hex key.

Using a utility knife, score a line from the top of the liner to the bottom of the drive head (Fig. 4.25). Move the free end of the liner side-to-side until the top of the liner splits and releases from the drive head (Fig. 4.26). The soil core may now be prepared for storage or analysis according to project guidelines.

Figure 4.24. Liner drive head remains attached to filled liner after retrieval from outer casing.

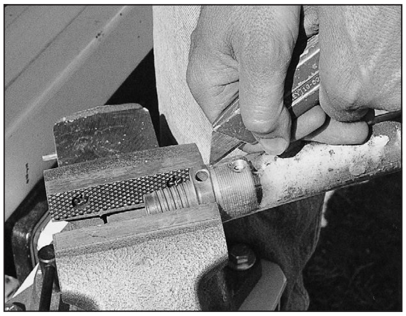


Figure 4.25. Score a line from top of liner to base of liner drive head using a utility knife.

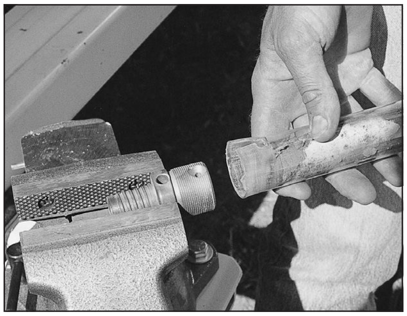


Figure 4.26. Move free end of liner back-and-forth to split liner and free it from the liner drive head.

Cutting the Liner Open

The DT22 Liner Cutter (28751) is a light-weight cutter that safely and efficiently slices an approximately 1.125-inch wide strip the entire length of a filled polymer liner. Two hooked cutting blades, one mounted on each side of the cutter as show in Figure 4.27, make a lengthwise opening in the liner for easy access and viewing of the sample material. The cutter features guards (covers) for each blade to maximize operator safety. However, care should always be used when operating this device.

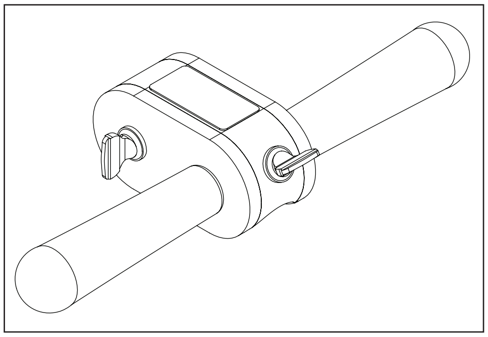


Figure 4.27. The DT22 Liner Cutter (28751) safely removes an approximately 1.125-inch wide strip the entire length of a filled polymer liner.

Suggested Equipment

- DT22 Liner Cutter (28751)
- Universal Liner Holder (22734)
- Filled polymer DT22 Liner

Safety

- Always grasp the cutter by the handles to avoid accidental contact with the cutter blades.
- Apply slight downward pressure on the cutter while drawing it down the length of the liner. This will help maintain contact with the liner and avoid having the cutter unexpectedly slip off of the liner.
- Wear leather gloves while operating the liner cutter.
- Utilize a Universal Liner Holder to secure the liner for cutting. Never attempt to hold the liner by hand while cutting.
- Replace dull or damaged blades immediately. Do not operate the cutter with dull or damaged blades.

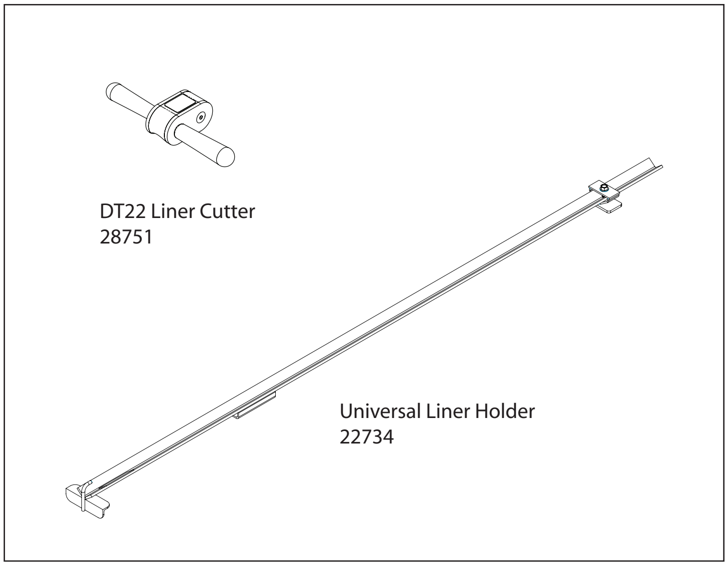


Figure 4.28: A universal liner holder is used to secure the liner when operating the liner cutter.

Operation

1. Place the universal liner holder on a solid surface such as a sturdy work table.
2. Install the liner in the liner holder. Adjust the stop on the liner holder to secure the liner tightly to the holder.
3. Grasping the cutter by the handles, place the cutter on the liner beginning at the end of the holder which has the bent rod. Ensure that the cutter blades are positioned over the end of the liner to initiate the cut.
4. With slight downward pressure on the cutter, draw the cutter slowly and smoothly along the liner as shown in Figure 4.29. It will not take a great deal of force to cut the liner. If excessive force is required, the cutter blades may be dull and require replacement.
5. When the cutter has been drawn the entire length of the liner, the cut section of liner may be removed to access the sample material.

⚠ **CAUTION**

Cutting Hazard!

Always grasp the cutter by the handles.

Figure 4.29. Secure the liner with the universal liner holder for cutting. Always place the liner holder on a solid surface such as the work table shown here.

4.8 Dual Tube Soil Sampling Tips

Saturated sands are the most difficult formations to sample with the DT22 system. Saturated conditions place positive pressure on the soil outside of the outer casing. When sampling in noncohesive formations (e.g. sands) below the water table, it may be necessary to add water to the outer casing to prevent formation heave. Adding water to the probe rods puts a positive head on the system and may keep formation material from flowing into the rods as the liner and soil sample are retracted. If a small amount of formation material is still drawn into the outer casing as the soil core is retrieved, the material may be displaced by slightly raising the outer casing while lowering the next new liner to depth. Water must be maintained within the outer casing during this process to overcome the hydraulic head imparted by the formation fluid.

DT22 core catcher liners will provide the best sample recovery in saturated noncohesive formations.

DT22 core catcher liners will help considerably with sample recovery in noncohesive soils and other materials that do not fill the liner diameter. Core catcher liners are not recommended for cohesive or expansive soils as the core catchers may actually inhibit soil movement into the liner.

Some formation materials may extrude during sampling and cause problems due to overfilled liners. If such conditions are encountered, try using a shorter sample interval such as driving the tool string 36 inches when using a 48-inch liner. This can help avoid overfilling the liners and may improve sample recovery.

4.9 Outer Casing Retrieval

The outer casing of the DT22 Dual Tube System may be retrieved in one of three ways:

1. Casing pulled then probe hole sealed from ground surface with granular bentonite.

The outer casing may be pulled from the ground with the probe machine and a Pull Cap (25298) or a Rod Grip Pull System (for GH40 Hammers [29461] or for GH60 Hammers [29385]) if the probe hole is to be sealed with granular bentonite from the ground surface (Fig. 4.30). This method is used for shallow probe holes in stable formations only. Such conditions allow the entire probe hole to be sealed with granular bentonite.

2. Casing pulled with probe hole sealed from bottom-up during retrieval.

Bottom-up grouting should be performed during casing retrieval in unstable formations where side slough is probable. Such conditions create void spaces in the probe hole if granular bentonite is installed from the ground surface.

A Geoprobe® Grout System is used to deliver a sealing material (high-solids bentonite slurry or neat cement grout) to the bottom of the outer casing through flexible tubing. The grout mix is pumped through the tubing to seal the void remaining as the outer casing is retrieved (Fig. 4.31). This is an advantage of the DT22 Dual Tube System as other soil samplers require a second set of tools to deliver grout to the bottom of the probe hole. Contact Geoprobe Systems® for more information on bottom-up grouting.

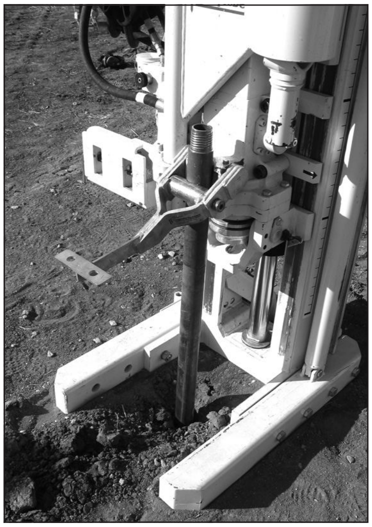


Figure 4.30 Outer casing may be retrieved with a pull cap or rod grip pull system if the probe hole is sealed with granular bentonite.

Figure 4.31. A grout machine and flexible tubing allow bottom-up grouting as the outer casing is retrieved.

3. **3.** Casing pulled with Geoprobe® Prepacked Screen Well installed during retrieval.

   The final option is to install a 1.4-inch OD Geoprobe® Prepacked Screen Monitoring Well in the probe hole during retrieval of the outer casing. A DT22 Expendable Cutting Shoe Holder (50271) and a DT22 Expendable Cutting Shoe (50726) allow the operator to collect continuous soil cores as the outer casing is driven to depth. When sampling is complete, the outer rods are raised and the expendable cutting shoe is removed from the leading rod. This leaves an open casing through which a set of prepacked screens is lowered on the leading end of a PVC riser string (Fig. 4.32). The well is finished, complete with grout barrier, bentonite well seal, and a high-solids bentonite slurry/neat cement grout, during retrieval of the outer casing.

   Refer to *Geoprobe® 0.5-in. x 1.4-in. OD and 0.75-in. x 1.4-in. OD Prepacked Screen Monitoring Wells Standard Operating Procedure* (Geoprobe® Technical Bulletin No. 962000) for specific information on well installation.

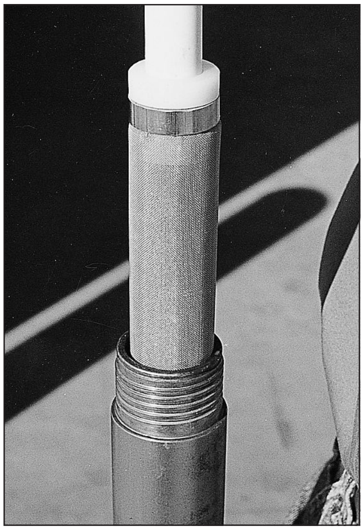


Figure 4.32. Geoprobe® prepacked screens may be installed through the outer casing when an expendable cutting shoe is used.

5.0 REFERENCES

Geoprobe Systems®, *Geoprobe® 0.5-in. x 1.4-in. OD and 0.75-in. x 1.4-in. OD Prepacked Screen Monitoring Wells - Standard Operating Procedure.* Technical Bulletin No. 962000, 2010.

Geoprobe Systems®, *Geoprobe® Screen Point 22 Groundwater Sampler - Standard Operating Procedure.* Technical Bulletin No. MK3173, 2010

Geoprobe Systems®, *Geoprobe Systems® Tools Catalog,* Vol. 6, 2003.

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SUGGESTED OPERATING PROCEDURE

SOIL GAS PROBE INSTALLATION

Geosyntec Consultants, Inc.

1 INTRODUCTION

This suggested operating procedure (SOP) describes the design and methods for the installation of soil gas probes of sufficient quality to assess potential human health risks due to subsurface vapor intrusion to indoor air and subsequent inhalation exposures.

2 SOIL GAS PROBE DESIGN AND INSTALLATION

2.1 Compliance with Site Dig Permits and Utility Clearances

Site specific permits may be required prior to subsurface activities. Necessary permits will be secured in advance of any drilling activities. Underground utilities (water, sewer, electricity, gas, cable, telephone, etc.) will be reviewed prior to drilling.

2.2 Soil Coring via GeoProbe®

Soil core will be collected with a GeoProbe® direct push system (or equivalent). This method minimizes the disturbance to the geologic materials surrounding a soil gas probe subsequently installed in the core-hole. A 2-inch diameter core barrel will be used, since this provides sufficient core volume for field screening, geologic logging, and selected laboratory analyses (if required).

2.3 Geologic Logging

Soil cores will be photographed and inspected to record details of the color, texture, moisture, density, cohesion, plasticity, staining, and odor.

2.4 Soil Samples for Analysis of Physical Properties (if required)

After geologic logging of the soil core, soil samples will be collected for laboratory analysis of moisture content, grain-size distribution, porosity and bulk density by laboratory methods:

Soil Moisture Content: ASTM D2216
Grain Size: ASTM D422
Porosity: API RP40
Bulk density: API RP40

Samples will be selected to represent each distinct geologic layer. The number of samples to be collected will be determined by the geologist after inspection of the soil core and consideration of the degree of heterogeneity in the geologic materials.

2.5 Soil Gas Probe Installation

Each soil gas probe will consist of ¼-inch diameter Nylaflow® or Teflon® tubing connected with a compression fitting to a ¼-inch-diameter stainless steel sampling point. Probes will be installed inside the borehole and a sand filter pack will be placed in the annulus to a height of 6 inches above the top of the screen. Granular bentonite will be placed in two lifts of 3 inches above the filter pack and hydrated with a small amount of distilled water after each lift. A thick slurry of powdered bentonite and water will be added to seal the remainder of the borehole annulus to ground surface. The top of the probe will be fitted with a compression-fit brass or stainless steel ball valve to maintain an air-tight seal between installation and sampling. Permanent probes will be completed with a traffic rated flush mount protective casing.

3 DOCUMENTATION

Field documentation will include the following information:

- name and number of project;
- name of field personnel;
- date and time of sampling event;
- list of the primary activities performed;
- identification of probes drilled and installed;
- relevant information (weather, attendees, equipment problems, departures from standard procedures and the reasons and responses) observed throughout the day;
- field instrument information and calibration data (includes time and reading for each instrument calibration check; and
- volume of probe dead space volume for each soil gas probe.

SOIL GAS PROBE CONSTRUCTION

Geosyntec consultants

Probe ID ____________________
Site Location ____________________
Project Name ____________________
Field Personnel ____________________
Project Number ____________________
Recorded By ____________________

Permit Number ____________________
Drilling Contractor ____________________
Installation Date(s) ____________________
Driller ____________________
Drilling Method ____________________
Borehole Diameter ____________________

Materials Used

Riser Pipe:
Diameter __________ cm/inches
Construction __________
☐ PVC schedule __________
☐ Stainless Steel
☐ Other __________

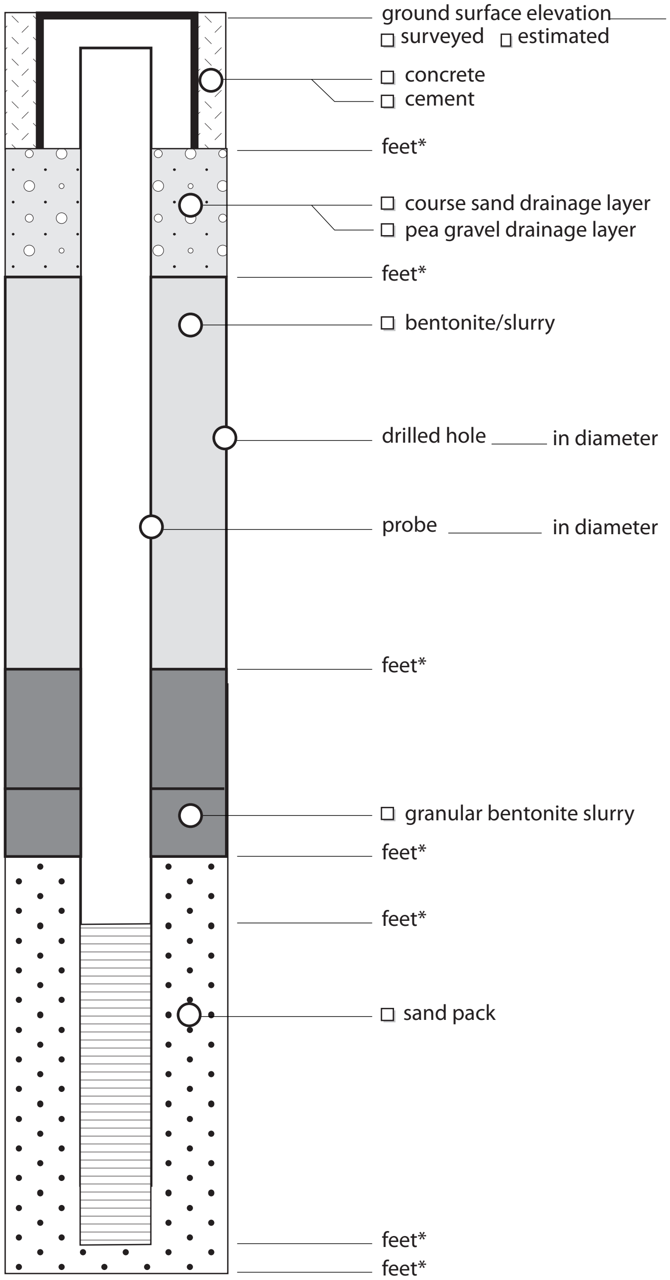
Screen :
Length __________ cm/inches
Diameter __________ cm/inches

Construction
☐ PVC schedule __________
☐ Stainless Steel
☐ Other __________

Top Cap: ☐ Brass ☐ Stainless ☐ PVC

Protective Casing:
☐ Flush mount
☐ Above grade
Length __________ cm/inches
Stickup __________ cm/inches
Construction
☐ Cast Aluminum
☐ Cast Steel
☐ Other __________

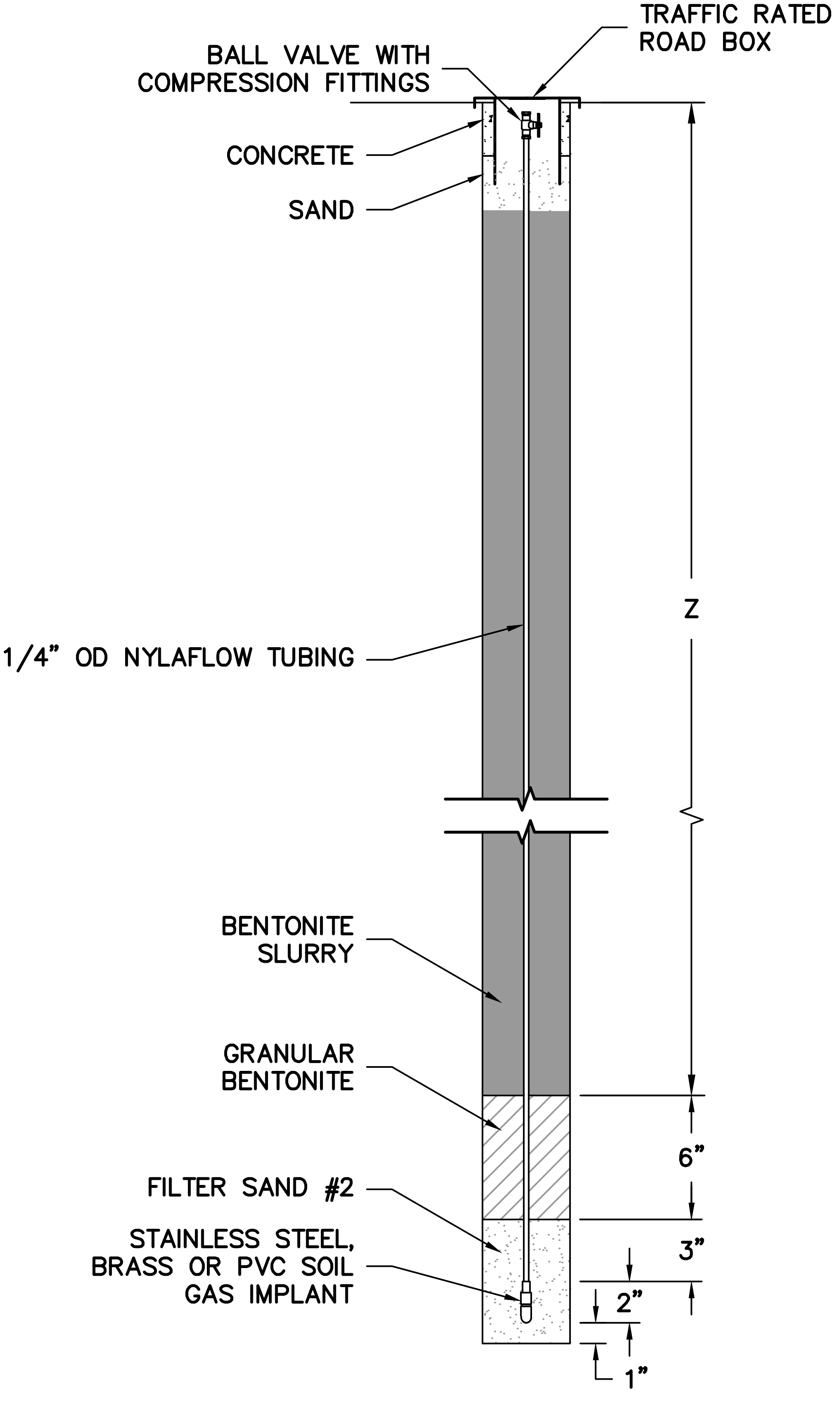
Casing Installation:
Depth __________ cm/inches
Diameter __________ cm/inches



Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

Soil Gas Probe Construction.ai



TEMPORARY SOIL GAS PROBE DETAIL

Geosyntec consultants

DATE:	NOV 2013	SCALE:	N.T.S.
PROJECT NO.	DETAIL	FILE NO.	SOILGASPROBE
DOCUMENT NO.		FIGURE NO.	

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Cox-Colvin
& ASSOCIATES, INC.
ENVIRONMENTAL SERVICES

Standard Operating Procedure Installation and Extraction of the Vapor Pin™

December 3, 2013

Scope:

This standard operating procedure describes the installation and extraction of the Vapor Pin™ for use in sub-slab soil-gas sampling.

Purpose:

The purpose of this procedure is to assure good quality control in field operations and uniformity between field personnel in the use of the Vapor Pin™ for the collection of sub-slab soil-gas samples.

Equipment Needed:

- Assembled Vapor Pin™ [Vapor Pin™ and silicone sleeve (Figure 1)];
- Hammer drill;
- 5/8-inch diameter hammer bit (Hilti™ TE-YX 5/8" x 22" #00206514 or equivalent);
- 1½-inch diameter hammer bit (Hilti™ TE-YX 1½" x 23" #00293032 or equivalent) for flush mount applications;
- ¾-inch diameter bottle brush;
- Wet/dry vacuum with HEPA filter (optional);
- Vapor Pin™ installation/extraction tool;
- Dead blow hammer;
- Vapor Pin™ flush mount cover, if desired;
- Vapor Pin™ protective cap; and
- VOC-free hole patching material (hydraulic cement) and putty knife or trowel.

Figure 1. Assembled Vapor Pin™.

Installation Procedure:

1) Check for buried obstacles (pipes, electrical lines, etc.) prior to proceeding.

2) Set up wet/dry vacuum to collect drill cuttings.

3) If a flush mount installation is required, drill a 1½-inch diameter hole at least 1¾-inches into the slab.

4) Drill a 5/8-inch diameter hole through the slab and approximately 1-inch into the underlying soil to form a void.

5) Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.

6) Place the lower end of Vapor Pin™ assembly into the drilled hole. Place the small hole located in the handle of the extraction/installation tool over the Vapor Pin™ to protect the barb fitting and cap, and tap the Vapor Pin™ into place using a dead blow hammer (Figure 2). Make sure

the extraction/installation tool is aligned parallel to the Vapor Pin™ to avoid damaging the barb fitting.

Figure 2. Installing the Vapor Pin™.

For flush mount installations, unscrew the threaded coupling from the installation/extraction handle and use the hole in the end of the tool to assist with the installation (Figure 3).

Figure 3. Flush-mount installation.

During installation, the silicone sleeve will form a slight bulge between the slab and the Vapor Pin™ shoulder. Place the protective cap on Vapor Pin™ to prevent vapor loss prior to sampling (Figure 4).

Figure 4. Installed Vapor Pin™.

7) For flush mount installations, cover the Vapor Pin™ with a flush mount cover, using either the plastic cover or the optional stainless-steel Secure Cover.

8) Allow 20 minutes or more (consult applicable guidance for your situation) for the sub-slab soil-gas conditions to equilibrate prior to sampling.

9) Remove protective cap and connect sample tubing to the barb fitting of the Vapor Pin™ (Figure 5).

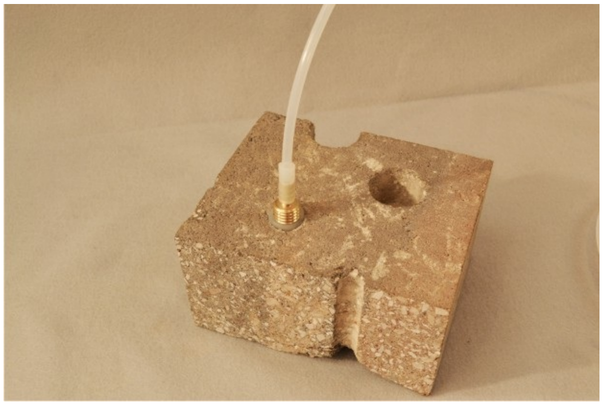


Figure 5. Vapor Pin™ sample connection.

10) Conduct leak tests in accordance with applicable guidance. If the method of leak testing is not specified, an attractive alternative can be the use of a water dam and vacuum pump, as described in SOP Leak Testing the Vapor Pin™ via Mechanical Means (Figure 6).

Figure 6. Water dam used for leak detection.

11) Collect sub-slab soil gas sample. When finished sampling, replace the protective cap and flush mount cover until the next sampling event. If the sampling is complete, extract the Vapor Pin™.

Extraction Procedure:

1) Remove the protective cap, and thread the installation/extraction tool onto the barrel of the Vapor Pin™ (Figure 7). Continue turning the tool to assist in extraction, then pull the Vapor Pin™ from the hole.

2) Fill the void with hydraulic cement and smooth with the trowel or putty knife. Urethane caulk is widely recommended for installing radon systems and can provide a tight seal, but it could also be a source of VOCs during subsequent sampling.

Figure 7. Removing the Vapor Pin™.

3) Prior to reuse, remove the silicone sleeve and discard. Decontaminate the Vapor Pin™ in a hot water and Alconox® wash, then heat in an oven to a temperature of 130° C.

The Vapor Pin™ to designed be used repeatedly; however, replacement parts and supplies will be required periodically. These parts are available on-line at www.CoxColvin.com.

Replacement Parts:

Vapor Pin™ Kit Case - VPC001
Vapor Pins™ - VPIN0522
Silicone Sleeves - VPTS077
Installation/Extraction Tool - VPIE023
Protective Caps - VPPC010
Flush Mount Covers - VPFM050
Water Dam - VPWD004
Brush - VPB026
Secure Cover - VPSCSS001
Spanner Wrench - VPSPAN001

SOP
Installation and Sampling of Vapor Pin Sub-Slab Probes

Purpose: This SOP describes the procedures for installation and samplimg of sub-slab soil vapor monitoring probes equippedwith Vapor Pins.

Pre-Installation

1. Prior to installation, confirm that the building owner/occupants are aware of the reason for installation of the probe(s) and that you have been granted permission to install the probes at the designated locations by the appropriate parties.
2. Prior to installation, confirm that the floor covering in the location where probes will be installed is free of asbestos containing materials (ACM). If ACM are known or suspected, take appropriate steps to relocate the probe to a location free of ACM when practicable or, alternatively, have the floor covering sampled by a licensed inspector and removed by a licensed abatement contractor (when necessary).
3. Prior to installation, confirm that the installation of the probe(s) at the selected locations does not present a hazard (i.e. confirm that electrical or utility lines will not be encountered when drilling, and that drilling will not impact the structural integrity of the slab).
4. Prior to installation of permanent or semi-permanent probes, confirm that you have permission to leave the probe in place, and that the design of the probe cover does not pose a trip or slip hazard.

Installation

Follow the installation protocols specified in the most recent Vapor Pin SOPs

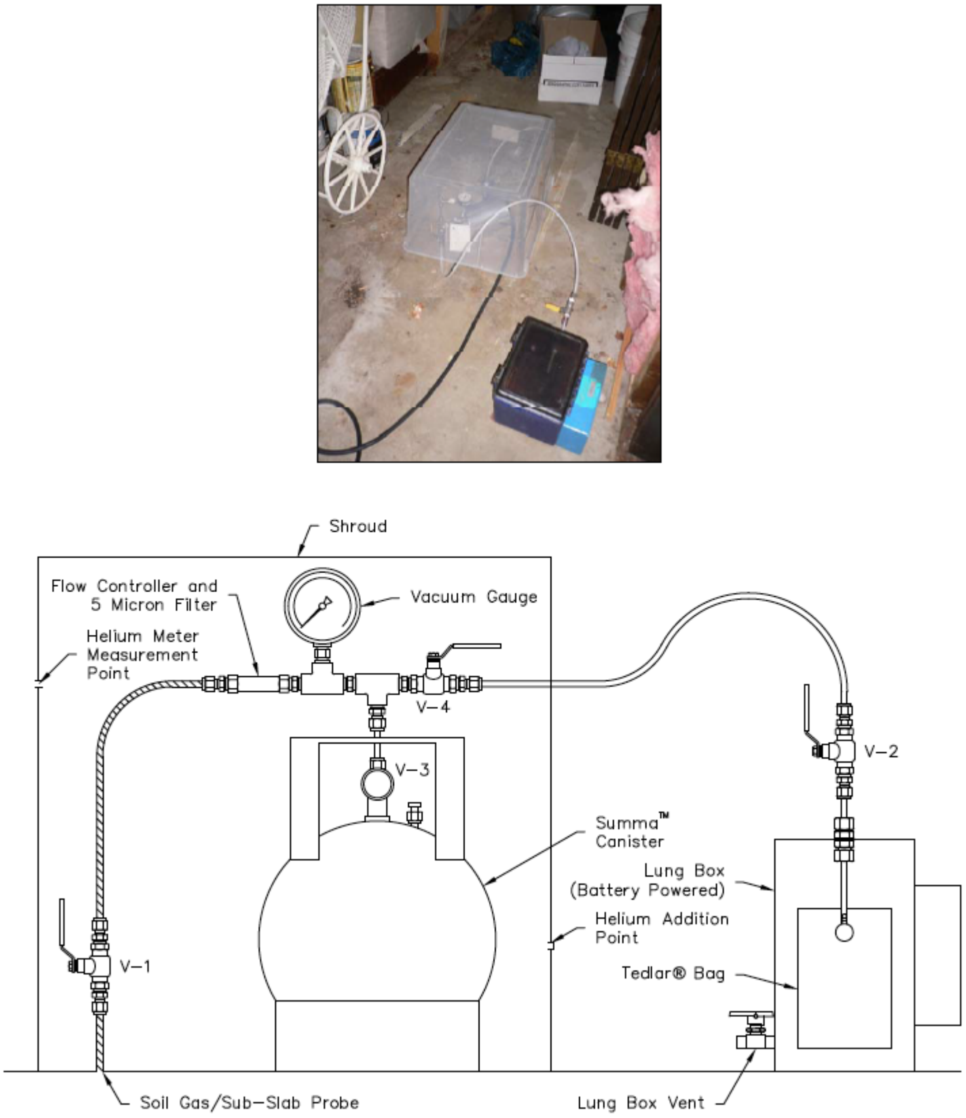
Sampling

This SOP describes the methods for sampling sub-slab to assess potential human health risks due to subsurface vapor intrusion to indoor air and subsequent inhalation exposures.

1. VACUUM SHUT-IN LEAK TEST

The sampling equipment will be assembled as shown in Figure 2, and will be checked for leaks by conducting a “shut-in” test prior to purging. Valves V-1 and V-3 will be closed (valves V-2 and V-4 open) and then the lung box and Tedlar® bag will be used to exert a vacuum on the sampling train (80 - 100 inches of water [in-H2O]). Valve V-2 will then be closed and the vacuum observed for at least 60 seconds to ensure it does not dissipate. The vacuum gauge should be calibrated and sensitive enough to indicate a water pressure change of 0.5 inches.

If the test indicates a leak, the connections should be disconnected and carefully reconnected one at a time until the leak is fixed. The leak test must be repeated until all leaks have been fixed.



Legend

▨ New Nylaflow® Tubing

═ Non-Dedicated Tubing

Soil Gas Purging and Sampling Assembly

Geosyntec consultants

Figure 2

Guelph | July 2009

2. Water Dam

A water dam as described below is used for sub-slab sampling in lieu of a Helium Leak Test when sampling with a Vapor Pin .

Pass NylaFlow™ tubing through the water dam andn connect it to the compression fitting of the probe. The compression fitting and the seal around the annular space of the probe is verified using a water dam. The water dam consists of a cylinder (e.g., a 2-inch diameter PVC coupling) sealed to the floor using a doughnut of "Sticky-Tac™". The region inside the cylinder is partially-filled with water (1 to 2 cm height of water above the floor slab is sufficient) during sampling or monitoring activities. If the seal is not effective, the water will drain relatively quickly (< a minute or two). As long as water remains in the dam, air cannot enter the subslab along the annular space between the tubing and the slab; therefore, visual inspection of the water level is sufficient to verify the integrity of the seal. Note that some relatively slow water loss is expected as a result of permeation into the surface of the concrete slab. The water dam is shown in Figure 3 (blue base is Sticky-Tac™)

Figure 3. Water dam above slab, temporarily sealed to the floor with Sticky-Tac™

As with the Helium Leak Test, the probe should be purged with a lung-box and tedlar bag before collecting the Summa sample. If water is observed in the tubing or tedlar bag, sampling should cease, and a new probe installed.

2. SUMMA CANISTER LEAK TEST

Valve V-1 and V-4 will be closed and then valve V-3 (summa canister valve) will be opened to induce a vacuum on the sample train. The vacuum in the sample train will be observed for a short duration (30 seconds) to ensure it does not dissipate as a final check that the sample train does not contain any leaks. Valve V-1 will then be opened and the sample collection time recorded. The vacuum gauge on the Summa canister should be monitored and closed when the residual vacuum in the canister is about 5 in Hg.

Decommissioning

Once the sampling program is complete, the probe assembly should be removed and the hole should be filled with hydraulic cement. The floor surface will be restored to a condition suitable to School officials.

SUGGESTED OPERATING PROCEDURE

PNEUMATIC TESTING

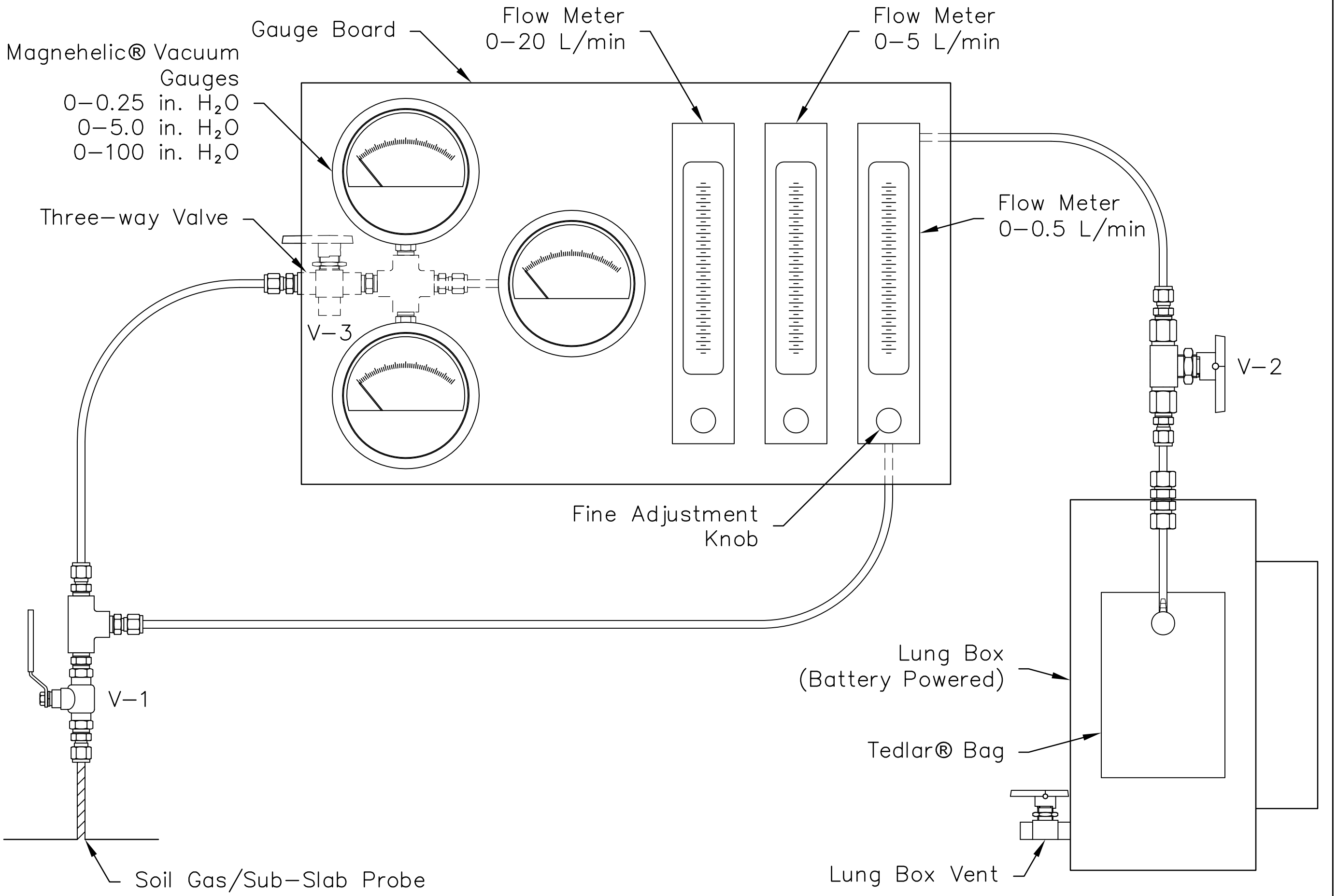
Geosyntec Consultants, Inc.

Last revision: August 2011

1 PNEUMATIC TESTING

Pneumatic testing is the procedure for measuring the flow and vacuum, which can be used to calculate the soil gas permeability of the surrounding geologic materials.

To measure the soil gas flow and corresponding vacuum, the equipment will be assembled as shown on Figure 1. The fine adjustment knob on the rotameter will be closed. Valves V-1 and V-2 will be opened as the lung box is turned on. The fine adjustment knob is then slowly opened until there is a measurable flow of 100 milliliters per minute (mL/min). The corresponding vacuum, as well as the flow rate, will be recorded. The rotameters must be vertical to accurately measure flow. Depending on the gas permeability of the subsurface materials, it may be necessary to switch to a higher scale vacuum gauge (0-5 in H_2O or 0-100 in H_2O) using the three-way valve (V-3). Both flow and vacuum should be clearly measurable within the scales of the vacuum gauge and rotameter. The flow rate will be increased to 200 mL/min and the vacuum observed will be recorded. This will be repeated at a flow rate of 500 mL/min. The flow and vacuum readings will stabilize almost instantaneously; therefore, the total volume of soil gas removed during the flow and vacuum test will be typically less than 1 L.



Legend

▨ New Nylaflow® Tubing

═ Non–Dedicated Tubing

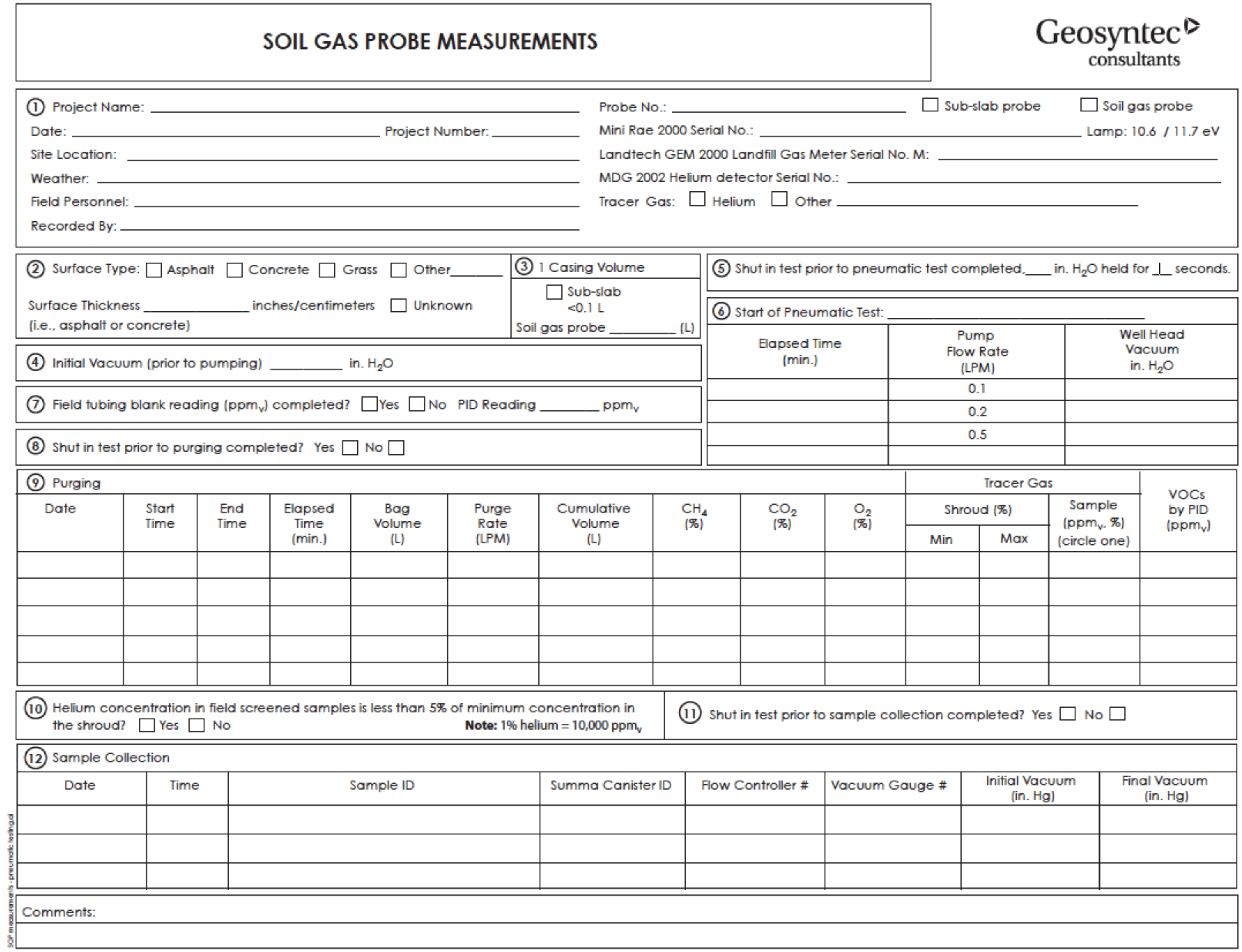
Pneumatic Testing Assembly

Geosyntec consultants

Figure 1

Guelph | July 2009

P:\PRJ\Marketing-Sales\Indoor Air Quality\SOPs\AutoCAD Figures\Pneumatic Testing Assembly.dwg



SOIL GAS PROBE MEASUREMENTS

Geosyntec
consultants

① Project Name: ____________________

Date: ____________ Project Number: ________

Site Location: ____________________

Weather: ____________________

Field Personnel: ____________________

Recorded By: ____________________

Probe No.: ____________ ☐ Sub-slab probe ☐ Soil gas probe

Mini Rae 2000 Serial No.: ____________ Lamp: 10.6 / 11.7 eV

Landtech GEM 2000 Landfill Gas Meter Serial No. M: ____________

MDG 2002 Helium detector Serial No.: ____________

Tracer Gas: ☐ Helium ☐ Other ____________

② Surface Type: ☐ Asphalt ☐ Concrete ☐ Grass ☐ Other______

Surface Thickness ________ inches/centimeters ☐ Unknown
(i.e., asphalt or concrete)

③ 1 Casing Volume
☐ Sub-slab
<0.1 L
Soil gas probe ________ (L)

④ Initial Vacuum (prior to pumping) ________ in. H_2O

⑤ Shut in test prior to pneumatic test completed,____ in. H_2O held for __ seconds.

⑥ Start of Pneumatic Test: ____________

Elapsed Time (min.)	Pump Flow Rate (LPM)	Well Head Vacuum in. H_2O
	0.1	
	0.2	
	0.5	

⑦ Field tubing blank reading (ppm_v) completed? ☐Yes ☐No PID Reading ______ ppm_v

⑧ Shut in test prior to purging completed? Yes ☐ No ☐

⑨ Purging

Date	Start Time	End Time	Elapsed Time (min.)	Bag Volume (L)	Purge Rate (LPM)	Cumulative Volume (L)	CH_4 (%)	CO_2 (%)	O_2 (%)	Tracer Gas			VOCs by PID (ppm_v)
										Shroud (%)		Sample (ppm_v, %) (circle one)	
										Min	Max		

⑩ Helium concentration in field screened samples is less than 5% of minimum concentration in the shroud? ☐ Yes ☐ No **Note:** 1% helium = 10,000 ppm_v

⑪ Shut in test prior to sample collection completed? Yes ☐ No ☐

⑫ Sample Collection

Date	Time	Sample ID	Summa Canister ID	Flow Controller #	Vacuum Gauge #	Initial Vacuum (in. Hg)	Final Vacuum (in. Hg)

Comments:

SGP measurements - pneumatic testing.gd

HAPSITE® PORTABLE GC/MS

A portable HAPSITE® ER gas chromatograph and mass spectrometer (GC/MS) (HAPSITE®) (built by Inficon) can be valuable in the evaluation of VI from subsurface sources to indoor air (Beckley et al., 2013). Specifically, it is a tool that can be used during forensic analysis of a home to evaluate the origins of VOCs detected in a building, such as consumer products.

When necessary, a HAPSITE® will be used to collect and analyze air samples at subject buildings to assist with identifying sources of VOCs previously detected in indoor and/or crawlspace air samples. The capability of this tool to analyze samples rapidly (about 15 minutes per sample) with precision and accuracy similar to that of a laboratory GC/MS analysis makes it useful in locating indoor sources of VOCs and/or entry points for subsurface VI into indoor air along a building's foundation (i.e. preferential pathways). On-site GC/MS analysis can be used either as part of an initial building investigation or at buildings where a potential for VI has already been identified, but the source of detected VOCs is not clear.

Use of the HAPSITE®

Prior to the day of the field investigation, the available analytical data, as well as the information in the building survey and occupant questionnaire from prior sampling event(s), will be reviewed. Based on that review, a list of likely consumer product types consistent with the VOCs detected in prior sampling events will be provided to the HAPSITE® field crews. A list of approximately 10-12 target VOCs will be provided to the HAPSITE® technician for calibration of the equipment. It should be noted that the longer the analyte list is, or inclusion of relatively heavy compounds with long elution times, such as naphthalene, will increase the instrument run time per sample and reduce the number of samples that can be processed during each building visit.

On-site investigations with the HAPSITE® need to be flexible to respond to analytical results as they come available in real time. On the day of investigation, the following general procedure will be used:

- collect an outdoor air sample approximately upwind from the subject building (often referred to as a method blank);
- collect indoor air samples in each room or separate airspace to assess the indoor air distribution of target compounds;
- using current and historical analytical results for the subject building, identify potential indoor air sources of the compounds;
- if a specific consumer product can be identified, isolate the potential source(s) in a flux chamber (i.e., stainless steel bowl, plastic bucket, etc.) for 15 minutes, and sample the headspace inside the flux chamber with the HAPSITE® to test for elevated concentrations; and/or
- remove the potential sources from the building, so that indoor air samples can be collected subsequently for VI assessment.

Field documentation of the HAPSITE® investigation will include the following information:

- on-site instrument type, manufacturer, model;
- calibration gas specifications, if applicable;
- QA/QC measures;
- GC/MS instrument settings (e.g., temperature and other settings, identifying ions for target compounds, predicted elution time as indicated in field notes or instrument reports);
- descriptions of sampling locations, including observations of storage conditions in the area/room being sampled;
- descriptions of identified indoor air VOC sources (product type, brand name, ingredients listed on labels); and
- photographs of specific indoor VOC sources, product labels, and storage areas (subject to approval from the property owner).

Sample Collection and Analysis

Air samples are collected through a sampling nozzle which can be pointed at the object being investigated or in the room being sampled. A 200-milliliter sample is collected at 50 milliliters per minute (mL/min) onto the HAPSITE's preconcentrator. Analysis is then very similar to TO-15, with the analytes being thermally desorbed from the preconcentrator onto a gas chromatography column, where the analytes are separated and identified by their retention time, followed by a mass spectrometer, where the compounds are identified by their mass spectral pattern, and then quantified as a concentration.

Reporting

The HAPSITE data are reported in an Excel spreadsheet, with columns for each analyte presenting the predicted and actual retention time, the fit of the mass spectral data to the ideal, the purity and the area of the peak, the concentration of the analyte in parts per billion by volume (ppbv), and any flags associated with the results. A summary of the HAPSITE field investigation, interpretations of the collected data, and conclusions/recommendations will be included in the building specific forensic analysis technical memorandum.

Field Meter Specification Sheets

Kit and Accessories

Ion Science provides a range of PhoCheck Tiger kits to suit your requirements, along with an exclusive range of accessories. Further details can be found below. For more information and prices contact Ion Science or your local Distributor.

PhoCheck Tiger Kit (part no. PTXSLBME-0000) Contains:

- PhoCheck Tiger
- Rechargeable Battery (Li-ion)
- Battery Charger and Mains Adaptor
- Rubber Boot
- Explorer Case
- USB Memory Stick
- Zero Filter Assembly
- PTFE Filter Disc (dust filter)
- Removal Tool miniPID Stack
- Probe Tube (60mm)
- Sample Cleaning Compound Assembly
- Cleaning buds
- Lanyard (wrist strap)
- USB Cable
- Instrument Manual

Instrument Accessories Include:

- Rechargeable Battery (Li-ion)
- Alkaline Battery
- 2.1mm DC jack - Cigar Lighter Plug Car Charger Lead
- Leather Instrument Holster
- Leather Instrument Harness
- Drager Tube Holder for Selective Detection of Benzene
- Flexible Probe Assembly
- 5m & 10m Extension Hose
- 9.8eV, 10.6eV and 11.7eV PID lamps

Note: PhoCheck is a US registered trademark, no. 2880994, and UK registered trademark, no. 2212457. Fence Electrode Technology is produced by Ion Science Ltd, and protected by U.S. Patent No. 7,046,012.. EP 1474681, other patents pending. PhoCheck is a registered trademark of Ion Science Ltd.

TECHNICAL SPECIFICATION

MINIMUM RESOLUTION *

1 ppb or 0.001 mg/m^3

MAXIMUM READING * *

20,000 ppm or 20,000 mg/m^3

ACCURACY *

± 5% display reading ± one digit

LINEARITY *

± 5% to 100 ppm

INTRINSICALLY SAFE APPROVALS

ATEX Ex II 2G Ex ib IIC T4 (-15 °C ≤ Ta ≤ +45 °C)
IECEx ITS 10.0036X
US and Canadian approved

BATTERY LIFE

Li-ion: life up to 24 hours, charge time 6.5 hours
Alkaline: 3 x AA, up to 8.5 hours life

LAMPS

10.6 eV Krypton PID lamp (standard) 9.8eV and 11.7eV lamps available

DATA LOGGING *

> 120,000 data log points including date and time stamp (33 hours at 1 log per second)

COMMUNICATION

USB 1.1

CALIBRATION

Via calibration kit accessory

ALARM

Flashing LED and 95 dBA at 300mm (12") audible sounder
Selectable vibrating alarm
Pre-programmed TWA and STEL*
Pre-programmed with 350 gases*

FLOW RATE

220 ml/min with flow fail alarm

TEMPERATURE

Operating: -20 to 60 °C, -4 to 140 °F (non Intrinsically Safe)
Humidity: 0-99% RH (non condensing)

PROTECTION

Designed to IP65 (heavy rain)
CE 1180
EMC tested to EN61326-1:2006, EN50270:2006 & CFR 47:2008 Class A

WEIGHT & DIMENSIONS

Instrument without probe
Width: 340 x Height: 90 x Depth: 60 mm (13.4 x 3.6 x 2.4")
Standard case
420 x 320 x 97 mm (16.5 x 12.5 x 3.8")
Instrument weight 0.72 kg (25 oz)
Packed weight: 5 kg (176 oz)

All specifications are against isobutylene calibration at 20 °C, 90% RH and up to 3000 ppm unless otherwise stated. *Model and gas dependent. **Maximum reading is achieved with certain analytes such as ethanol.

PhoCheck TIGER

Instrument User Manual V2.6

Register your instrument online to receive your Extended 5 year Warranty. See page 44 for details.

PhoCheck TIGER Instrument Manual Part Number: 861265

Ion Science Ltd, The Way, Fowlmere, Cambs., SG8 7UJ, U.K.
Tel: +44 (0) 1763 208 503 Fax: +44 (0) 1763 208 814
Email: info@ionscience.com Web: www.ionscience.com

Advanced Gas Sensing Technologies

WARNINGS

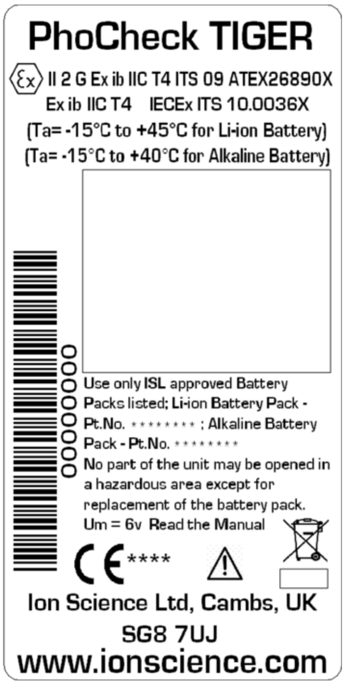
USER MANUAL:	Read and understand this user manual completely before operating the PhoCheck Tiger instrument.
Intrinsically Safe:	**Instrument and been designed and certified intrinsically safe**
STATIC HAZARDS:	Do not use abrasive or chemical detergents to clean the PhoCheck Tiger instrument as this may reduce the antistatic properties of the materials used, clean it using a damp cloth only.
MATERIAL EXPOSURE	The PhoCheck Tiger must not be exposed to atmospheres known to have an adverse effect on Thermoplastic polyolefin or Anti-static PC/ABS
SERVICING:	No part of the PhoCheck Tiger may be opened in a hazardous area except for replacement of the battery pack. The PhoCheck Tiger must be serviced in a Non Hazardous environment and by Ion Science authorised service centres only. Do not service the instrument live; Remove battery pack before servicing Substitution of components may impair intrinsic safety.
BATTERY CHARGING:	Charge PhoCheck Tiger and its Lithium ion battery packs in a Non Hazardous environment only.
BATTERY REPLACEMENT:	Never replace primary Alkaline battery cells while in a potentially explosive or hazardous location. Use only Duracell Procell Alkaline batteries MN1500.
BATTERY CONNECTION:	The PhoCheck Tigers Lithium ion and Alkaline battery packs have been specially designed to allow connection to the PhoCheck Tiger Instrument while in potentially hazardous atmospheres. The PhoCheck Tiger instruments ingress protection rating is reduced to IP 20 when its battery pack is removed so avoid changing batteries in dusty or wet environments.
FUNCTIONAL TEST	The PhoCheck Tiger must be functionally checked prior to entering a hazardous area after every occasion when a connection has been made to the USB port. The instrument must complete its start up routine and display legible readings. If the LCD display fails to show an intelligible and uncorrupted display the instrument must not enter a hazardous area.”

Proper Use	If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Declaration of Conformity

Manufacturer: Ion Science Ltd, The Way, Fowlmere, Cambridge, UK. SG8 7UJ

Product: PhoCheck TIGER



PhoCheck TIGER
Ex II 2 G Ex ib IIC T4 ITS 09 ATEX26890X
Ex ib IIC T4 IECEx ITS 10.0036X
(Ta= -15°C to +45°C for Li-ion Battery)
(Ta= -15°C to +40°C for Alkaline Battery)
00000000
Use only ISL approved Battery Packs listed; Li-ion Battery Pack - Pt.No. ******** ; Alkaline Battery Pack - Pt.No. ********
No part of the unit may be opened in a hazardous area except for replacement of the battery pack.
Um = 6v Read the Manual
CE****
Ion Science Ltd, Cambs, UK
SG8 7UJ
www.ionscience.com

Product description: Intrinsically safe photo-ionisation gas detector for detecting volatile organic compounds

Directive 94/9/EC **Required Coding-** Ex II 2 G Ex ib IIC T4
Cert Number- IECEx ITS 10.0036X

$T_{amb.}$ = -15ºC to +45 ºC (with Lithium ion Battery pack)
$T_{amb.}$ = -15 ºC to +40 ºC (with Alkaline Battery pack)

Notified body Intertek – Report number: 08036757A1
Standards

EN 60079-0: 2006 Electrical apparatus for explosive gas atmospheres. General requirements

EN 60079-11: 2007 Explosive atmospheres . Equipment protection by intrinsic safety "i"

EN61326-1:2006 Electrical equipment for measurement, control and laboratory use - EMC requirements. Group 1, Class B equipment - (emissions section only)

EN61326-1:2006 Electrical equipment for measurement, control and laboratory use - EMC requirements. Industrial location immunity - (immunity section only)

EN50270:2006 Electromagnetic compatibility - Electrical apparatus for the detection and measurement of combustible gases, toxic gases or oxygen. Immunity Type 2 - industrial environments.

CFR 47:2008 Class A
Code of Federal Regulations: 15 Subpart B- Radio Frequency Devices - Unintentional Radiators.

Other Standards

EN ISO 9001: 2008 Quality Management System - Requirements

EN 13980: 2002 Potentially Explosive Atmospheres - Application of Quality Systems

On behalf of Ion Science Ltd, I declare that, on the date this product accompanied by this declaration is placed on the market, the product conforms to all technical and regulatory requirements of the above listed directives.

Name: Mark Stockdale **Position:** Technical Director

Signature: **Date:** 20th January 2010

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Statements

Responsibility for Use

PhoCheck Tiger instruments detect a large range of gases which are potentially dangerous from both a poisoning and/or an explosive perspective. PhoCheck Tiger instruments have many adjustable and selectable features allowing the detector to be used in a variety of ways. Ion Science Ltd can accept no responsibility for the incorrect adjustment of features that cause harm or damage to persons or property. PhoCheck Tiger can be used as a personal safety device. It is the user's responsibility to respond appropriately to an alarm situation.

Inadequate performance of the gas detection equipment described in this manual may not necessarily be self-evident and consequently equipment must be regularly inspected and maintained. Ion Science recommends that personnel responsible for equipment use institute a regime of regular checks to ensure it performs within calibration limits, and that a record be maintained which logs calibration check data. The equipment should be used in accordance with this manual, and in compliance with local safety standards.

!CAUTION!

It is essential that the PhoCheck TIGER is always used with a supplied PTFE 0.5 micron filter fitted to the front of the instrument. Without a filter, particles of debris and dust can be drawn into the detector inhibiting the function of the instrument. These filters are consumable and should be changed after every 100 hours of use. The frequency of replacement should be increased for dusty or moisture laden environments. Filters are available from your distributor or at www.ionscience.com .

Quality Assurance

PhoCheck TIGER has been manufactured in compliance with ISO9001:2008, which ensures that the equipment supplied to our customers has been designed and assembled reproducibly, from traceable components, and leaves Ion Science calibrated to stated standards.

Disposal

Dispose of PhoCheck TIGER, its components and any used batteries in accordance with all local and national safety and environmental requirements. This includes the European WEEE (Waste Electrical and Electronic Equipment) directive. Ion Science Ltd offers a take back service. Please contact us for more information. The PhoCheck TIGER field case material is recyclable polypropylene.

Calibration Facility

Ion Science Ltd offers a calibration service including the issue of certification confirming calibration with equipment traceable to national standards. A PhoCheck TIGER calibration kit is available from your distributor or service centre or at www.ionscience.com . Ion Science recommends annual return of all instruments for yearly service and calibration.

Legal Notice

Whilst every attempt is made to ensure the accuracy of the information contained in this manual, Ion Science accepts no liability for errors or omissions, or any consequences deriving from the use of information contained herein. It is provided "as is" and without any representation, term, condition or warranty of any kind, either express or implied. To the extent permitted by law, Ion Science shall not be liable to any person or entity for any loss or damage which may arise from the use of this manual. We reserve the right at any time and without any notice to remove, amend or vary any of the content which appears herein.

Introduction to PhoCheck TIGER

PhoCheck TIGER is a portable gas detector that uses Photo-ionization technology to detect a large range of Volatile Organic Compounds (VOC's) which can be dangerous from both a poisoning and explosive perspective.

The TIGER uses a Photo-Ionization Detector (PID) to measure gas concentrations. The patented fence electrode technology minimises the effects of moisture and contamination, avoiding the need for compensation.

Survey is the default mode of operation. This mode is often used in applications such as Head Space Sampling and Leak Detection where several areas (or Zones) are to be monitored and readings data logged. All sensor readings are real time measurements and alarm levels are set manually.

Health & Safety mode is used to check for conformity of short-term exposure levels (STEL) or time-weighted averages (TWA) that are specific for particular hazardous environments (for example EH40 in the UK and OSHA in the USA). In this mode of operation STEL's and TWA's are continually calculated and compared to levels set in the instrument's gas table.

The TIGER can be upgraded from the users own desk top. Additional features can be added without the need to return the instrument to a service centre.

Like it's predecessor, PhoCheck+, the TIGER also has an intuitive graphical interface allowing easy access to instrument settings. Two soft keys can be configured to suit the user's application, so many functions can be selected without entering the main menu structure. This improves efficiency of use, particularly with repeatable tasks.

TIGER PC (the TIGER's PC Software) maintains the intuitive look and feel by adopting the same graphical symbols. TIGER PC also helps manage logged data files and multiple instrument settings in a clear and concise way.

The TIGER uses a Lithium-ion battery that not only boasts an impressive running time and short charge time, but also allows battery packs to be replaced in potentially hazardous environments. Field replaceable alkaline battery packs (non-rechargeable) are also available for when power to charge is unavailable.

The TIGER has true USB capability so the instrument can be connected directly to a PC via a standard USB cable. It also offers fast data download.

A loud audio output, vibration and bright LED's indicate alarm conditions. Orange and Red LED's indicate High and Low conditions respectively. This colour scheme is used within TIGER PC to offer clear indication of alarm levels within logged data.

Getting Started

Thank you for choosing TIGER from Ion Science Limited. We hope that your TIGER will give you many years of active and trouble-free service.

The Manual
Ion Science Ltd recommend that you familiarise yourself with this manual before using your TIGER. The 'Statements' and 'Introduction to PhoCheck Tiger' sections contain important information, which should be read before you turn your TIGER on for the first time.

Probes
Ensure that the probe supplied is fitted to your TIGER. Details on how to fit and change probes is detailed in the 'Maintenance' section. If the supplied probe is unsuitable for your application, details of alternative probes can be found in the 'Maintenance' section as well.

Turn On.
Press the ON/OFF / ENTER key once to turn TIGER on.

Turn Off
Press and hold the ON/OFF / ENTER key for three seconds, indicated by a 3 second countdown, to turn TIGER off. (NOTE If the TIGER fails to shut down, press the ESCAPE key once or twice to return to the main screen, then press and hold the ON/OFF / ENTER key again.)

Batteries
Check that your TIGER has sufficient charge for use. The battery icon (see 'Understanding the display screen') should show at least two full segments.

Rechargeable Batteries
TIGER instruments leave the factory with the rechargeable battery fully charged. However prolonged periods of storage may result in the battery pack discharging. We recommend charging the instrument for seven hours before use. See the 'Batteries' section of this manual.

Alkaline Batteries
An alkaline battery pack is also supplied with the PhoCheck TIGER. For more information please see the 'Batteries' section of this manual.

Select the gas
TIGER instruments leave Ion Science pre-set for gas type TVOC (total volatile organic compounds). Instruments are factory calibrated against isobutylene and all response factors are equivalent to this. By changing the gas from the internal gas table all readings will be given using that gas's response factor.

- Turn the TIGER on by pressing the On/Off / Enter key once.
- Press the information icon i (see 'Using your Tiger') and check the correct gas, alarm levels and flow rate are selected.
- Change the gas (if necessary) as instructed under Gas Selection in the 'Using your Tiger' section.

Set alarm levels
We recommend that alarm levels are set to user specifications as soon as possible before the TIGER is used for the first time. Please see the 'Using your Tiger' section of the manual for details of how to set alarm levels.

TIGER PC
The full functionality of your TIGER can only be realised through the TIGER PC software.
Ion Science Ltd recommend that you load the software supplied with your instrument and set up your TIGER according to the instructions in the 'Tiger PC Software' section of this manual.

Understanding the Keypad

General description

The keypad comprises two soft keys: A and B, 'up' and 'down' arrow keys, an escape key, and an 'on/off' button, which also serves also as an enter key. In general, setup and application settings are selected and adjusted via the soft keys, options are selected by the arrow keys and confirmed by the enter key. A single press is used as a switching operation. A continuous press is used to adjust numbers or change gas selections by automatically rolling.

Keypad function descriptions

Soft keys A & B rely on graphical prompts on the display to indicate their functionality.
NOTE: Pressing both soft keys together switches the torch on and off.

Up & Down keys are used to adjust settings and navigate through the menu structure.

Enter / On/Off key is used to accept adjustments and select functions; also to turn the TIGER on and off.

Escape (**Esc**) key is used to abort an adjustment or exit from a menu.

Understanding the display screen

Screen display

The display is divided into four sections.
Fixed LCD Status icons fill the top of the screen offering instrument status at a glance. The Icons display only when a function is selected. The main central viewing screen will display readings in large numbers only, 4 digits and decimal place will display 0.001 ppm to 19,999 ppm. Two soft key areas have been set aside as soft key indicators. The area between the soft key indicators displays the measurement units.

Left is the default display with no functions active.

Right is the display with all functions active.

Status icons

Health & Safety: The icon consists of a single part and will flash in an alarm condition and when health and safety readings are being collected.

Peak Hold: When peak hold is switched on, the icon appears.

Memory status: This icon only appears if the instrument has the data logging functionality. Four sections within the border fill as the data log memory is filled.
Empty border = 100% memory available through to full, where all segments are present.

USB: The icon will appear when connected to a host device.

Battery status: This icon consists of a border and four segments. The segments fill or empty to indicate 0-25, 26-50, 51-75 & 76-100% full. When discharging, the border will flash for 1 minute before the instrument shuts down. When charging, the segments will successively fill until 100% charge is reached.

Understanding the display screen (continued)

Back light: Light beam lines appear when the backlight is on.

Sound: The main body of the icon is present at all times.
The disable lines appear if all 3 alarm sounders are disabled and the volume is at 0%.
Three sound projection lines indicate the volume level.
However there are four sound levels and the quietest level has no line.

Alarm bell: The icon consists of 2 parts, the Bell and the sound bars. When the instrument reaches a 'Low alarm' the Bell and one sound bar will flash; when a 'High alarm' is reached the Bell and both sound bars flash.

Flash light / Torch: When the flashlight is illuminated the light beams appear.

Lock: The Lock icon will appear when the configuration of the TIGER has been locked in Tiger PC. Softkeys in Button A column are enabled and Buttons in column B disabled.

Main Screen Area

During normal operation this area displays the readings in four large numbers, with the units of measurement below.

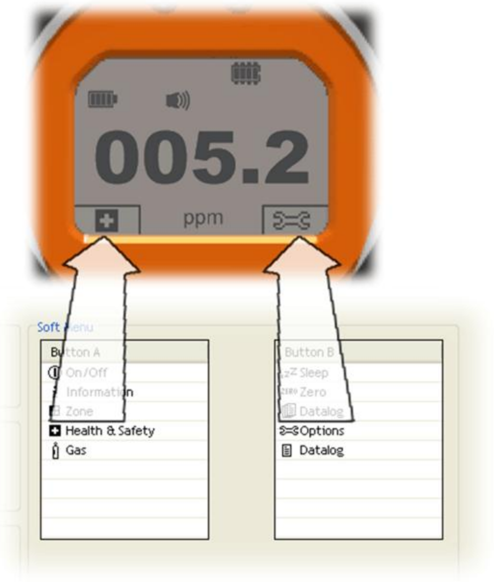
During setup and adjustment, a function bar overlays the main screen.

Understanding the display screen (continued)

Soft key areas

The following icons will appear in the soft key areas as soft key options. They are selected using the UP and DOWN keys. Those labelled 'optional' will only appear if your TIGER has that functionality.

These icons can be reorganised using the TIGER PC software.



Button A	A	***Button B***	B
i	Information	zZZ	Sleep
⊞	Zone(s)	ZERO	Zeroing
⚲	Gas selection	Λ	Peak hold
⚯	Options	⩲	Average
✚	Health & safety (optional)	▤	Data log (optional)
▤	Multiple data logging (optional)		

Using your TIGER

Instrument functionality is broken into two parts; Application and Setup. Application settings are initially selected via the soft keys. Setup functions like backlight, sound, calibration and alarm setting are adjusted within the Adjust soft key setting. Many of the screens have a 2 second time out which returns to the main screen if no other keys are pressed.

ON

To switch the TIGER on press the On/Off and Enter key once. Start up screen 1 appears showing the TIGER logo. Start up screen 2 contains variable text sent from the TIGER PC configuration screen. The lower half of the screen contains the instrument IRN (Internal Reference Number) and firmware version. The third screen shows TIGER checking that the lamp has 'struck'. When 'OK' appears, the working screen will follow. If the lamp fails to strike, turn TIGER off, wait for 30 seconds and try again. If the problem persists, change the lamp or contact Ion Science Ltd or your distributor.

OFF

To switch the TIGER off press and hold the On/Off / Enter key. A three-second count down takes place before the instrument shuts down. During this count down the instrument activates the upper alarm. viz. RED LED's flash and audible alarm sounds. This is done to alert the user to avoid accidental switch off.

zzZ SLEEP

Press and hold the Zzz soft key to send the TIGER to sleep. A three-second count down takes place before entering sleep mode. This function is not available when the instrument is locked. All peripherals switch off. Only 'Zzz' remains on screen. Press ESC key to awaken the instrument. (The instrument can also enter 'Sleep mode' during data logging when the duration between logs exceeds 2 minutes. This is a power saving function which only occurs when a tick box is set in TIGER PC.)

ZERO Zeroing

Pressing the Zero soft key presents two zero options selected with the UP or DOWN keys. The upper symbol represents an absolute zero. The lower symbol represents a relative zero which follows the drift of the PID detector. Having made your selection, press Esc. If the relative zero has been selected TIGER will zero itself before returning to the main screen.

ZONES

Press the Zone soft key to display the currently selected Zone: ROOM 2 The TIGER's default is 'Zone 1' Zones are set up in TIGER PC only and the name given to the zone(s) will appear on the screen.. Use Up and Down keys to select alternative zones.

DATA-LOGGING

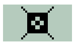
Press the Single Data log soft key to take a single data log reading. The single data log symbol appears with a tick: √ Press Esc to return to the main screen. Press the Single Data log soft key again to take another reading. The fixed LCD memory icon flashes off when a single log is taken.

MULTIPLE DATA-LOGGING

Pressing the Multiple Data log soft key results in the multiple log symbol appearing with a question mark: ? Press the ENTER key to start the data logging process based on TIGER PC set-up. A tick appears beside the question mark, confirming that data logging has started. The fixed LCD memory icon flashes at 1 Hz while continuous data logging is in progress. Press Esc to return to the main screen. To stop data logging, press the soft key again. A crossed out data log symbol is presented with a question mark. Press the ENTER key to confirm the action. A tick appears beside the question mark, confirming that data logging has stopped and the LCD memory icon ceases to flash. Press Esc to return to the main screen.

Using your TIGER (continued)

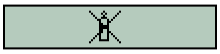
HEALTH & SAFETY readings

Press the Health & Safety (H&S) soft key to display the H&S symbol with a question mark to ask if the user wishes to proceed:  Press ENTER to start the calculation. The STEL (Short Term Exposure Level) and TWA (Time Weighted Average) values are shown. The fixed LCD H&S icon will continually flash while calculating. Pressing the ENTER key while the values are displayed presents the user with a screen asking if the calculation should stop. Press ENTER again to stop the calculation. Press Esc to return to the main screen. If a gas has no STEL and TWA level allocated in the gas table the following symbol will appear: .

IMPORTANT: Tiger STEL.

While the Tiger calculates the 15 minute STEL the instrument displays the ongoing STEL as it is calculated. This ongoing calculation is for indication purposes only to allow the user to gauge how the calculation is progressing. Only the final reading at the end of the calculation is logged by the instrument and should be referenced by the user.

GAS SELECTION

Press the Gas soft key to display an alphabetical letter which can be changed using the Up and Down keys:  Press the ENTER key to present the gases beginning with that letter. Using the Up and Down keys scroll through the gases starting with that letter to find the subject gas. Press enter to select the chosen gas. If a tick appears, press Enter again and TIGER will use the relevant data for the chosen gas from the gas table for alarms and response factor etc. Should the selected gas have no numeric response factor then a warning screen  will appear. The message can be cleared by pressing the ENTER key and the gas will still be selected. An alternative lamp type may then be selected to match the chosen gas. Should an incompatible gas/lamp combination be selected the instrument will show the warning screen again.

PEAK HOLD

Press the Peak Hold soft key to present the screen  When 'Peak hold' is selected the sub display will appear and this will continue to display the peak reading until peak hold is no longer required. To deselect the peak hold function press Esc.

Average

Press the Average soft key to display a rolling average over 10 seconds. A tick appears when time is up. Pressing the 'Average soft key' again resets the calculation even if there is an average already running. Press ESCAPE to return to the main screen.

STEALTH

When selected all audible and visual alarms are disabled except for the alarm indicator on screen. This function may help avoid triggering panic in public places.

OPTIONS

Press the Options soft key to give access to various adjustable features, selected with the UP and DOWN keys. Press ENTER to confirm selection.

Backlight

Four options are presented: 'Permanently Off', 'Permanently On', 'On in low ambient light' and 'Timed'. (Set the time in TIGER PC). Select the preferred option with the UP and DOWN keys and confirm with ENTER.

Using your TIGER (continued)

SOUND

The sound options are presented as set up in Tiger PC. Use the DOWN arrow to select either keypad beep, alarm sound, crescendo or percentage volume. Press ENTER to turn selection on or off. For percentage volume, press ENTER again to confirm selection. The frame will flash. Use UP and DOWN arrows to change the percentage volume and press ENTER to confirm the chosen value. Press Esc twice to return to the main screen.

Calibration

Only two options are presented: Factory calibration and Custom calibration. Select the preferred option with the UP and DOWN keys and confirm with ENTER. Whichever calibration standard is selected, the TIGER will operate against that calibration. Readings taken against unsatisfactory calibrations may be unreliable.

Factory Calibration Not for operator use.
Return to Ion Science Ltd or your distributor for calibration. (see the 'Maintenance' section of the manual)

Custom Calibration see under the 'Maintenance' section of the manual.

ALARMS Upper and Lower alarm settings are displayed. Select the subject alarm using the UP and DOWN keys and press ENTER. The arrow(s) on the chosen alarm will flash. Adjust the level using the UP and DOWN keys and press ENTER. Repeat, if necessary for the other alarm. Press Esc twice to return to the main screen.

NOTE: The Lower alarm setting must never be greater than the Higher alarm.

INFORMATION

Pressing the Information soft key allows access to a number of other information screens. Use the DOWN key to scroll through the screens. Press ESCAPE to return to the main screen:

First Screen	Gas selected Response Factor	
	Upper alarm	
	Lower alarm	
Second screen	Lamp selected	
	Date of Factory calibration	
	Date of Custom calibration	
Third Screen	SPAN 1	ESPAN 1 (gas concentration set in TIGER PC)
	SPAN 2	ESPAN 2 (gas concentration set in TIGER PC)
	PID detector A/D reading	
	Temperature	Temp

Using your TIGER (continued)

Fourth Screen STEL
TWA
IRN number (Internal Reference Number)
Firmware version
Bootloader version
Battery type and status

Fifth Screen Memory Status
Gas Table Date.
Date and time

Sixth Screen Features. A icon will appear for each feature available.

Features
ppb

TIGER PC Software

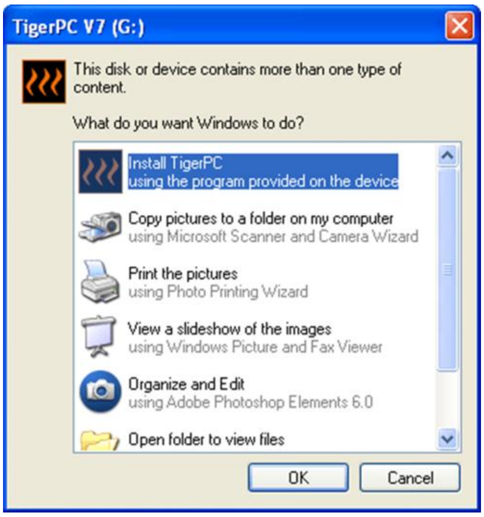
PC Requirements

TIGER PC Software must be used in conjunction with a PC or laptop using Windows XP, Windows Vista or Windows 7. The software is supplied on a USB memory stick.

Installation of TIGER PC Software

When the memory stick is plugged into a USB socket the flowing screen (Below left) should appear. If it doesn't, view the content of the memory stick and double click the file named:
` ion_cd_Tiger.exe `.

On the TigerPC screen (below),
select 'Install TigerPC' and click OK.



This disk or device contains more than one type of content.

What do you want Windows to do?

On the Ion Science screen (below), select 'Install Tiger Software'

Thank you

Thank you for purchasing your Ion Science instrument. We trust that it will exceed your gas detection requirements.

On the Welcome screen (below), click 'Next' to proceed.

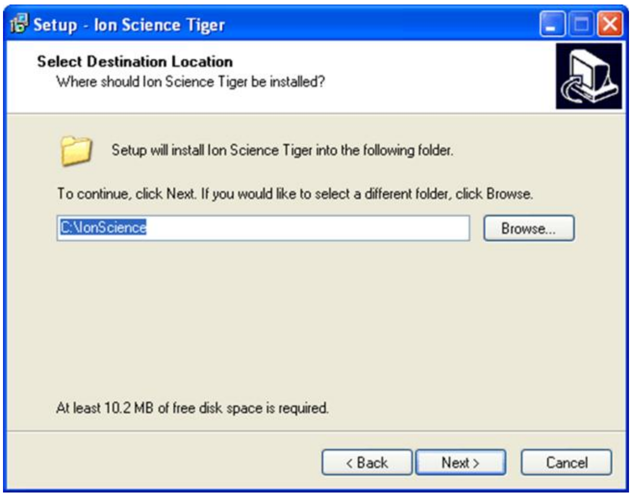
Welcome to the Ion Science Tiger Setup Wizard

This will install Ion Science Tiger on your computer.

It is recommended that you close all other applications before continuing.

Click Next to continue, or Cancel to exit Setup.

On the select destination location screen (below), click 'Next' to create an 'Ion Science' folder on your C drive.



Select Destination Location

Where should Ion Science Tiger be installed?

Setup will install Ion Science Tiger into the following folder.

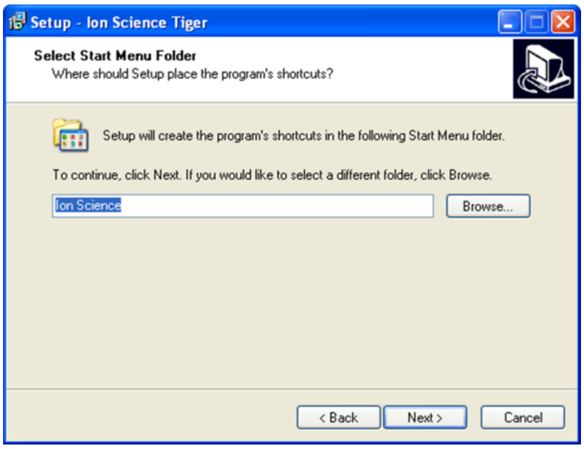
To continue, click Next. If you would like to select a different folder, click Browse.

C:\IonScience

At least 10.2 MB of free disk space is required.

TIGER PC Software (continued)

On the set up screen (below) click 'Next' to create an 'Ion Science' start up folder.



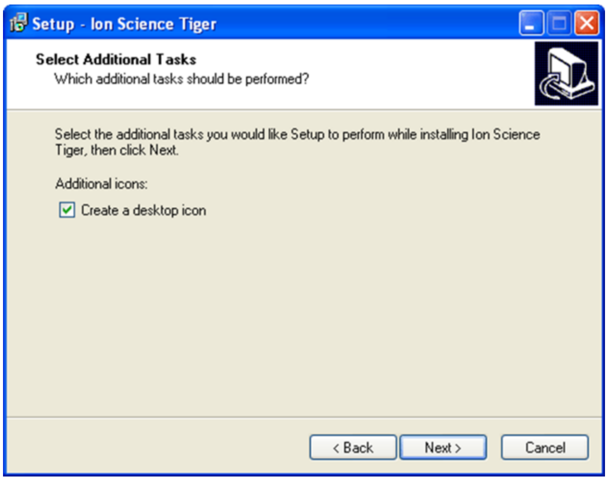
Select Start Menu Folder
Where should Setup place the program's shortcuts?

Setup will create the program's shortcuts in the following Start Menu folder.

To continue, click Next. If you would like to select a different folder, click Browse.

Ion Science

On the additional tasks screen (below) tick the box and click 'Next' to create a desktop icon.

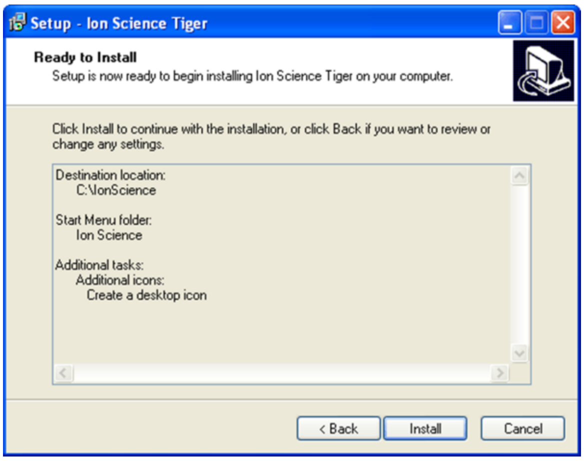


Select Additional Tasks
Which additional tasks should be performed?

Select the additional tasks you would like Setup to perform while installing Ion Science Tiger, then click Next.

Additional icons:
☑ Create a desktop icon

On the ready to install screen (below), click 'Install'.



Ready to Install
Setup is now ready to begin installing Ion Science Tiger on your computer.

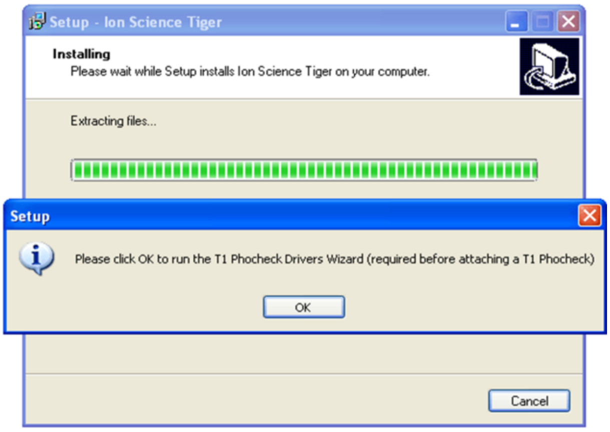
Click Install to continue with the installation, or click Back if you want to review or change any settings.

Destination location:
    C:\IonScience

Start Menu folder:
    Ion Science

Additional tasks:
    Additional icons:
        Create a desktop icon

On the install screen (below) Click 'OK'.

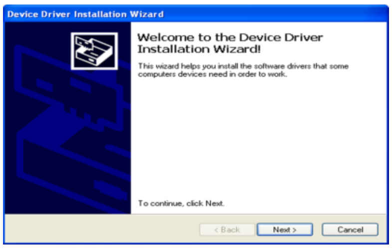


Installing
Please wait while Setup installs Ion Science Tiger on your computer.

Extracting files...

Please click OK to run the T1 Phocheck Drivers Wizard (required before attaching a T1 Phocheck)

Click 'Next' on the Device Driver screen,

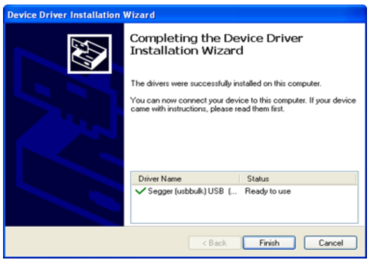


Welcome to the Device Driver Installation Wizard!

This wizard helps you install the software drivers that some computers devices need in order to work.

To continue, click Next.

'Finish' on the installation wizard



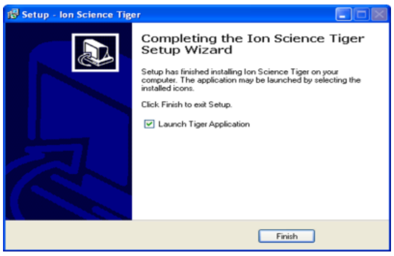
Completing the Device Driver Installation Wizard

The drivers were successfully installed on this computer.

You can now connect your device to this computer. If your device came with instructions, please read them first.

Driver Name	Status
✓ Segger (usbbulk) USB (...	Ready to use

and 'Finish' on the Setup wizard.



Completing the Ion Science Tiger Setup Wizard

Setup has finished installing Ion Science Tiger on your computer. The application may be launched by selecting the installed icons.

Click Finish to exit Setup.

☑ Launch Tiger Application

Finally Exit the Ion Science screen.

The Tiger icon should appear on your desktop.

TIGER PC Software (continued)

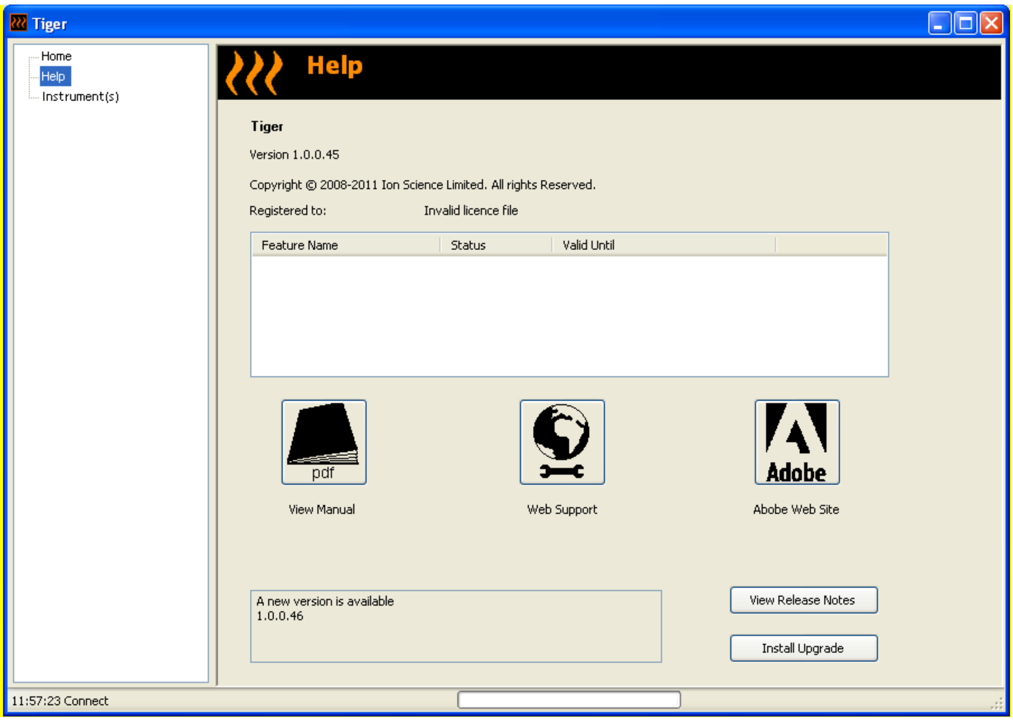
Connecting TIGER to a PC

1. Double click the TIGER icon on your desktop and open TIGER PC.
   The Home page should appear.

PhoCheck Tiger
Manufactured by Ion Science Ltd,
The Way,
Fowlmere,
Cambridgeshire,
UK, SG8 7UJ
+44 (0) 1763 208503

14:13:40 Connect

Help Screen – This screen will show you if a new version of PC software is available. You can then install the upgrade if required.



Tiger

Version 1.0.0.45

Copyright © 2008-2011 Ion Science Limited. All rights Reserved.

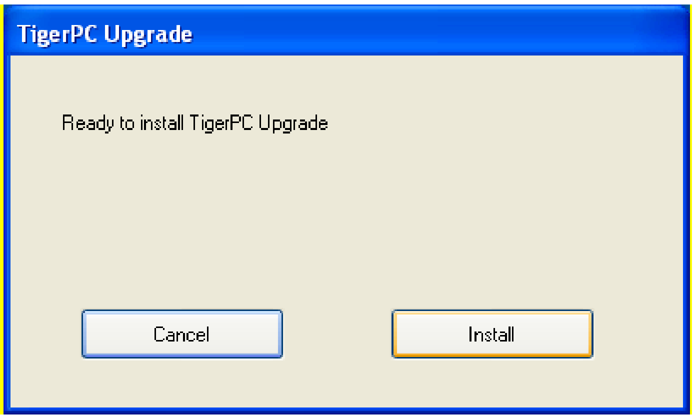
Registered to: Invalid licence file

Feature Name	Status	Valid Until

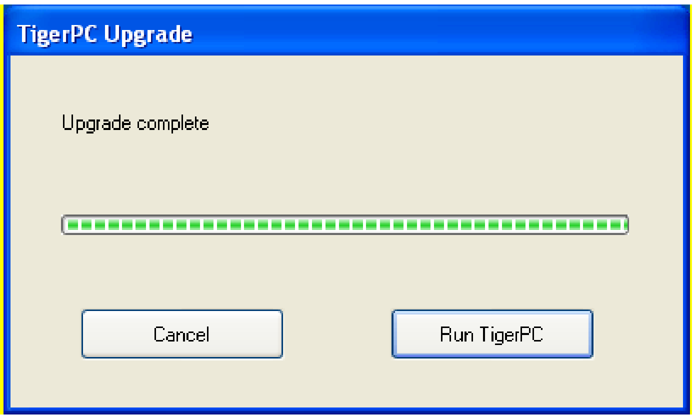
A new version is available
1.0.0.46

11:57:23 Connect

TIGER PC Software (continued)



Ready to install TigerPC Upgrade

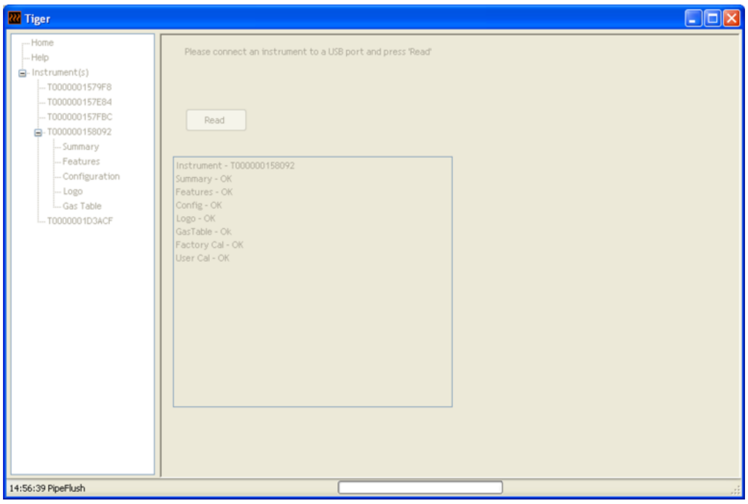


Upgrade complete

2. Click on ‘Instrument(s)’. If your TIGER has previously been connected to your PC your instruments IRN (Internal **Reference** Number) will appear.
Note: If, while using this software your TIGER should inadvertently be turned off or disconnected from your computer, click on ‘Instrument(s) again and proceed as below.

3. Switch TIGER on and when fully booted up connect to a USB socket on your PC using the USB cable supplied. If the ‘Found New Hardware’ screen appears, follow the prompts to install your instrument on your PC.

4. Click on ‘Read’. Your instrument number will appear under ‘instrument(s)’ (if it was not there already) and the Instrument Summary page will appear.



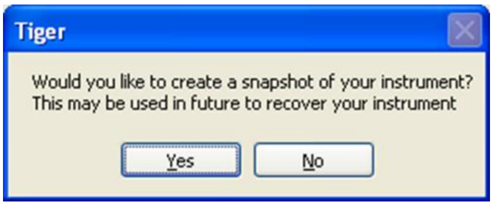
Please connect an instrument to a USB port and press 'Read'

```
Instrument - T000000158092
Summary - OK
Features - OK
Config - OK
Logo - OK
GasTable - Ok
Factory Cal - OK
User Cal - OK
```

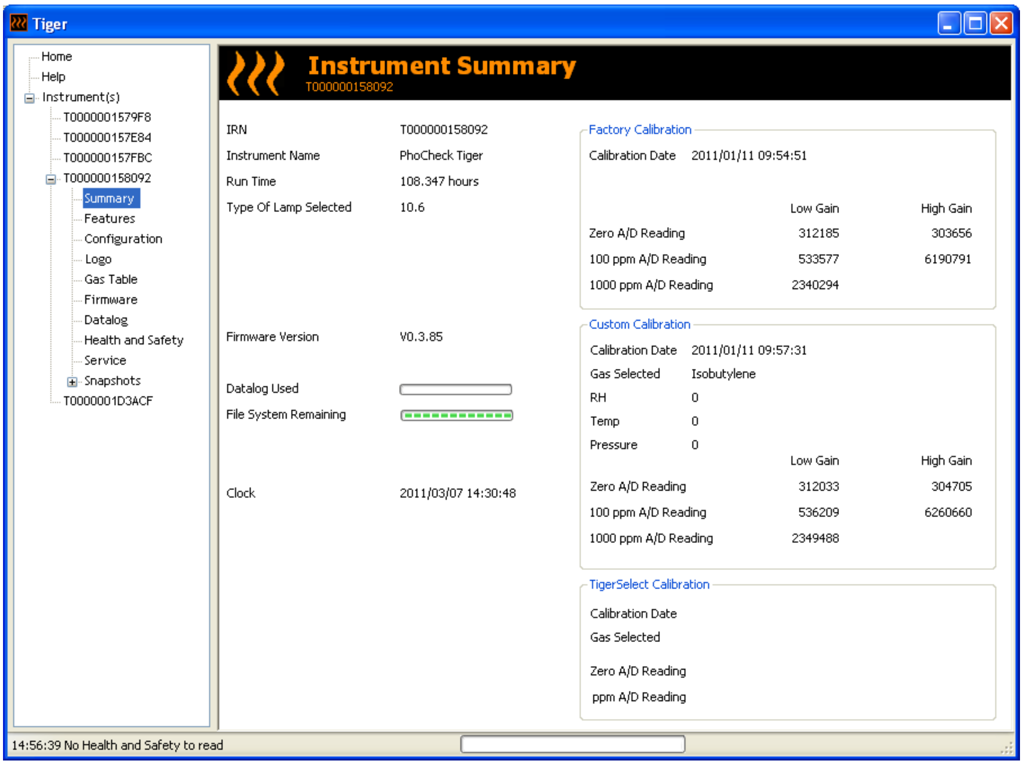
14:56:39 PipeFlush

TIGER PC Software (continued)

5. This page gives the current status of your TIGER. If the 'snapshot' screen appears click 'Yes'. You can delete the snapshot later if you wish (see 'Tiger PC Software').



Would you like to create a snapshot of your instrument? This may be used in future to recover your instrument



Instrument Summary
T000000158092

IRN T000000158092
Instrument Name PhoCheck Tiger
Run Time 108.347 hours
Type Of Lamp Selected 10.6
Firmware Version V0.3.85
Datalog Used
File System Remaining
Clock 2011/03/07 14:30:48

Factory Calibration
Calibration Date 2011/01/11 09:54:51

	Low Gain	High Gain
Zero A/D Reading	312185	303656
100 ppm A/D Reading	533577	6190791
1000 ppm A/D Reading	2340294	

Custom Calibration
Calibration Date 2011/01/11 09:57:31
Gas Selected Isobutylene
RH 0
Temp 0
Pressure 0

	Low Gain	High Gain
Zero A/D Reading	312033	304705
100 ppm A/D Reading	536209	6260660
1000 ppm A/D Reading	2349488	

TigerSelect Calibration
Calibration Date
Gas Selected
Zero A/D Reading
ppm A/D Reading

14:56:39 No Health and Safety to read

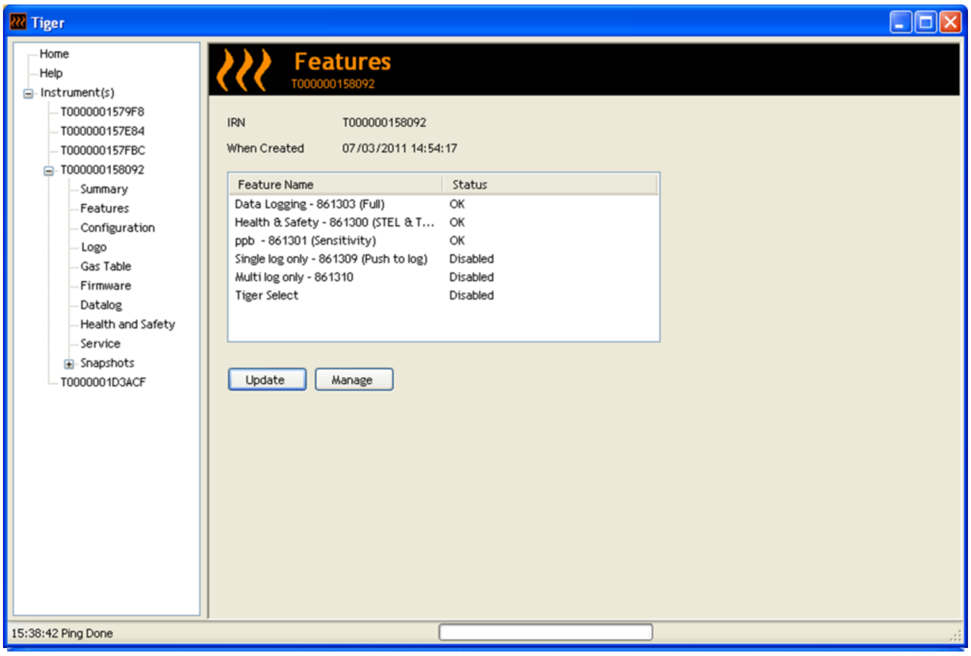
The Features Screen

The 'Features' screen indicates which of the available updates has been added to your TIGER.

Should you wish to purchase additional features, contact Ion Science Ltd or your Distributor.

Some updates may be available on the website www.ionscience.com .

Once the transaction is complete and confirmed, click on Update to add the relevant features to your TIGER.



Features
T000000158092

IRN T000000158092
When Created 07/03/2011 14:54:17

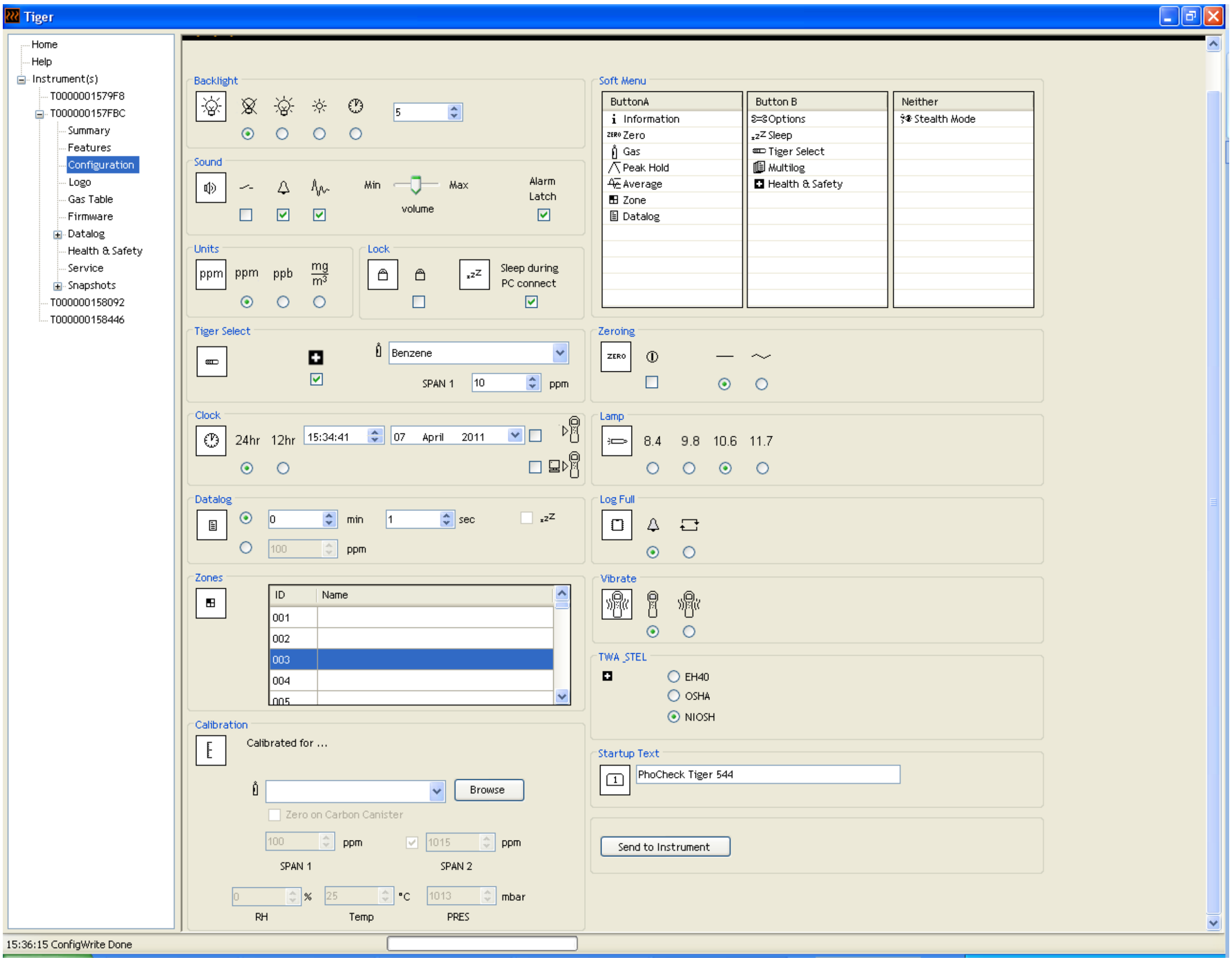
Feature Name	Status
Data Logging - 861303 (Full)	OK
Health & Safety - 861300 (STEL & T...	OK
ppb - 861301 (Sensitivity)	OK
Single log only - 861309 (Push to log)	Disabled
Multi log only - 861310	Disabled
Tiger Select	Disabled

15:38:42 Ping Done

TIGER PC Software (continued)

The Configuration Screen

Use this screen to configure your TIGER.



Backlight: ● ○ ○ ○ 5

Sound: ☐ ☑ ☑; Alarm Latch ☑

Units: ● ppm ○ ppb ○ mg/m³

Lock: ☐; Sleep during PC connect ☑

Tiger Select: ☑ Benzene SPAN 1 10 ppm

Clock: ● 24hr ○ 12hr 15:34:41 07 April 2011 ☐ ☐

Datalog: ● 0 min 1 sec; ○ 100 ppm

ID	Name
001	
002	
003	
004	
005	

Calibration: 100 ppm SPAN 1; ☑ 1015 ppm SPAN 2; 0 % RH; 25 °C Temp; 1013 mbar PRES

ButtonA	Button B	Neither
Information	Options	Stealth Mode
Zero	Sleep	
Gas	Tiger Select	
Peak Hold	Multilog	
Average	Health & Safety	
Zone		
Datalog		

Zeroing: ☐ ● ○

Lamp: ○ 8.4 ○ 9.8 ● 10.6 ○ 11.7

Log Full: ● ○

Vibrate: ● ○

TWA_STEL: ○ EH40 ○ OSHA ● NIOSH

Startup Text: PhoCheck Tiger 544

15:36:15 ConfigWrite Done

Backlight

Choose from 'Permanently Off', 'Permanently On', 'On in low ambient Light', or 'On For Limited Time'. The Backlight Timeout can be set from 1 to 99 seconds.

Sound

The three icons represent: key press; alarm; and crescendo. Crescendo increases the sound as the upper alarm is approached. Sound on each of these may be enabled or disabled by ticking or un-ticking the box. Sound volume is adjusted with the slider.

Units

The units of measurement may be chosen as parts per million (ppm), parts per billion (ppb) or milligrammes per cubic metre (mg/m^3).

Soft Menu

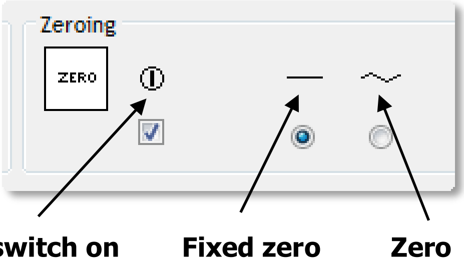
The various functions may be allocated to the soft buttons in any order of preference by dragging and dropping the icons.

TIGER PC Software (continued)

Lock
The TIGER may be locked in any configuration to avoid unauthorised changes by the operator. A tick in the box locks the instrument. Soft keys in Button A column are enabled and Buttons in column B disabled.

Sleep during PC connect will send the instrument into sleep mode while it is connected to the PC software. The instrument will awaken as soon as it is disconnected from the PC software.

Zeroing
There are various options for zeroing a PhoCheck Tiger or Tiger Select. The symbols below are found on the configuration screen of Tiger PC.



Zero at switch on

When selected, the Tiger will automatically set a zero level based on the ambient air when the instrument is switched on. When switched off the instrument will use its calibration zero.

Fixed Zero
When selected, Tiger uses the fixed calibration Zero. If used in conjunction with the 'Zero at switch on' feature the instrument will zero at switch on and then remain at that level.

Zero tracking
When selected, the Zero level will move negative if ambient air is cleaner than the zero being used. This ensures 0.0 ppm is displayed in clean air and helps when detecting low levels of VOC.

Zero options on the instrument
When selected 'Absolute mode' uses fixed calibration zero (either Factory or Custom calibration).

When selected, 'Relative mode' sets the zero level to the ambient.

Clock
Select 24 or 12 hour format using the radio buttons. Set the time and date and tick the box on the right to set the time on your TIGER. Alternatively, tick the lower box to synchronise your TIGER with the time on your computer.

Lamp
Enables the selection of different lamp types you may have purchased to use with your instrument. Ensure that the lamp selected is the same as that fitted in your TIGER. If not, select the correct lamp from the options provided.

If you have purchased the instrument with the 11.7eV lamp, there are a number of things related to applications that you must take into consideration before using the lamp.

1. It is important for the lamps to be stored in their desiccated vials in cool conditions (15-25°C).
2. The lamps should not be used in:

- Chemically severe environments, i.e. those containing significant concentrations of acids and strong solvents such as dichloromethane.
- Conditions of condensing humidity; always pass dry cool air through the instrument before storage. For long storage periods, remove the lamp and return it to the desiccated vial.
- Physically severe environments: large temperature changes may initiate lamp failure.

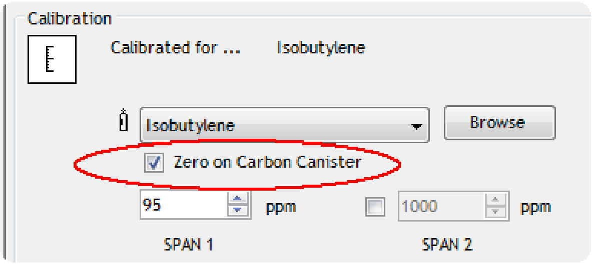
TIGER PC Software (continued)

11.7 lamps may not strike/illuminate first time and result in a 'lamp fail' alarm on the Tiger instrument, particularly if the lamps are unused for an extended period. If the Tiger instrument raises a lamp fail alarm please switch the instrument off and then switch on again. Several start cycles may be required.

11.7 eV lamps have a relatively short life partly due to the type of lamp window material. Prolonged exposure to airborne moisture slowly degrades the lamp window. Therefore the lamps should be removed from the PhoCheck Tiger and stored in their desiccated vial when not in use.

11.7 eV lamps have quite different characteristics to the standard 10.6 eV lamps.
In applications where the detected gas levels are expected to be below 100 ppm then only a two point calibration (Zero and 100 ppm IE) is necessary however in applications that require measurement above 100 ppm (IE) a three point calibration (Zero, 100 ppm and 1,000 ppm IE) should be carried out.

When setting up the custom calibration on Tiger PC's configuration screen select the 'Zero on carbon canister' option, this will ensure a near zero reading after calibration.



Calibration

Calibrated for ... Isobutylene

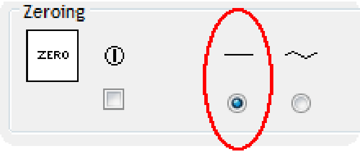
Isobutylene

☑ Zero on Carbon Canister

95 ppm ☐ 1000 ppm

SPAN 1 SPAN 2

The fixed zero option should also be selected on the configuration screen, do not select 'Zero at switch on' .



Zeroing

☐ ● ○

Datalog

Use this area to set the interval between readings. The minimum time permitted is one second. If you wish your TIGER to switch to sleep mode during data-logging, tick or un-tick the sleep box to enable or disable the function. The sleep mode will only operate for datalog intervals of 2 minutes or greater.

Log full

If you select the bell symbol your TIGER will alarm when the memory log is full. Alternatively, if you wish new data to overwrite the oldest stored data in the memory and continue to store new data during data-logging, select the recycle symbol.

Zones

Use this table to define and name up to 128 separate zones. The name field is limited to eight characters including spaces.

Vibrate

To set your TIGER to vibrate under alarm conditions select the 'vibrate' symbol.

TWA STEL

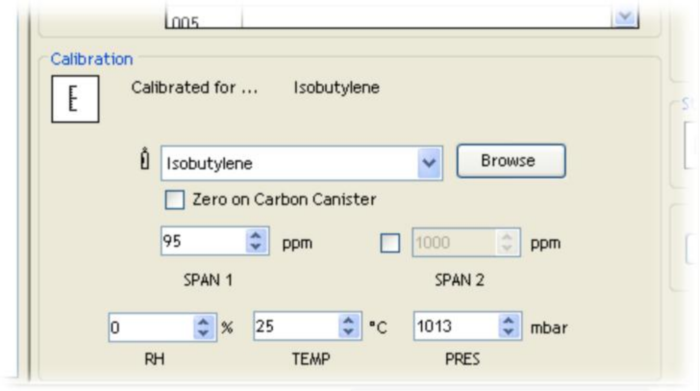
Select the appropriate regulatory code to which you are working.

TIGER PC Software (continued)

Calibration

Use this area to define your Custom Calibration parameters.
First connect TIGER to your PC as detailed above under 'Connecting your TIGER to a PC'.

If no gas is shown in the drop down box, browse your system to find the gas table for your instrument. Go to the location where the TIGER PC software files are saved. Follow the path: IonScience/Tiger/software/instruments/ serial no./gastable
Select the appropriate instrument number and open the gas table.
Select the calibration gas using the drop-down box.



Calibrated for ... Isobutylene

Isobutylene

☐ Zero on Carbon Canister

SPAN 1: 95 ppm

SPAN 2: ☐ 1000 ppm

RH: 0 %

TEMP: 25 °C

PRES: 1013 mbar

TIGER PC offers a two-point calibration (zero + span 1) or three-point (zero + span 1 + span 2) calibration. Enter the SPAN 1 concentration. For two-point calibration ensure that the box is un-ticked. For three-point calibration tick the box and enter the SPAN 2 concentration. Send this information to your TIGER. The calibration procedure is detailed under the 'Maintenance' section of this manual.

Startup Text

Enter the text you wish to appear on the start-up screen of your TIGER.

Send to Instrument

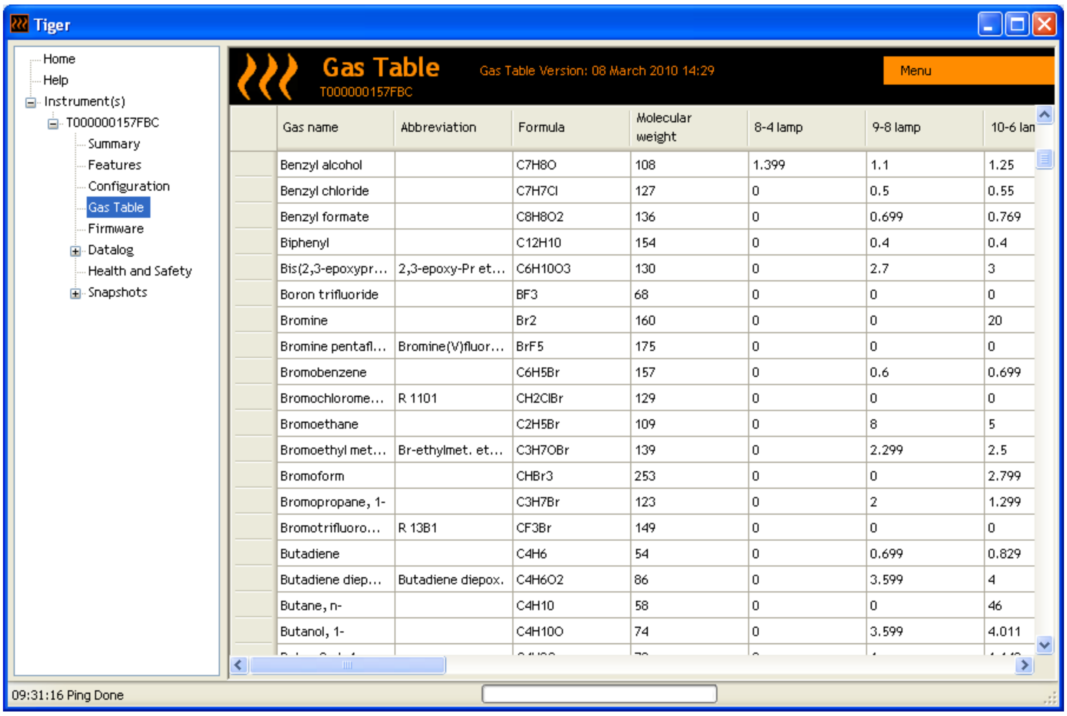
When you have configured your instrument or completed your changes, send them to your TIGER by clicking the 'Send to Instrument' box. If the message 'There was a problem sending to the instrument' appears, click OK and return to the Home screen. Repeat the procedure under 'Connecting your TIGER to a PC' above. If the 'Summary' screen for your TIGER appears, visit the configuration screen again. If not, repeat the entire procedure. If your PC still fails to read or write to your TIGER seek advice from your distributor or from Ion Science.

TIGER PC Software (continued)

The Gas Table Screen (including setting alarm levels)

Connect your TIGER to your PC as described previously. Any fresh data-logged readings will be down loaded as the software 'reads' your TIGER.

Select Gas Table from the menu to display the Gas Table



Gas Table Version: 08 March 2010 14:29

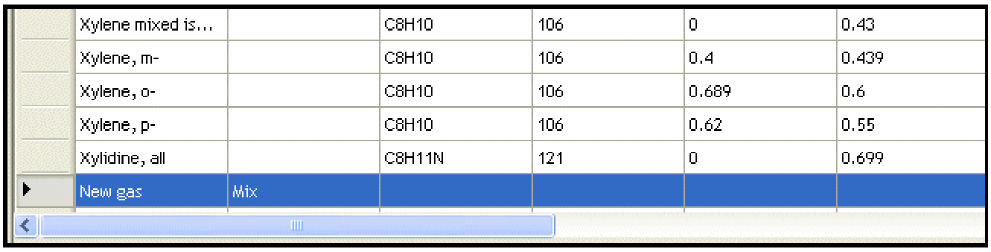
Gas name	Abbreviation	Formula	Molecular weight	8-4 lamp	9-8 lamp	10-6 lan
Benzyl alcohol		C7H8O	108	1.399	1.1	1.25
Benzyl chloride		C7H7Cl	127	0	0.5	0.55
Benzyl formate		C8H8O2	136	0	0.699	0.769
Biphenyl		C12H10	154	0	0.4	0.4
Bis(2,3-epoxypr…	2,3-epoxy-Pr et…	C6H10O3	130	0	2.7	3
Boron trifluoride		BF3	68	0	0	0
Bromine		Br2	160	0	0	20
Bromine pentafl…	Bromine(V)fluor…	BrF5	175	0	0	0
Bromobenzene		C6H5Br	157	0	0.6	0.699
Bromochlorome…	R 1101	CH2ClBr	129	0	0	0
Bromoethane		C2H5Br	109	0	8	5
Bromoethyl met…	Br-ethylmet. et…	C3H7OBr	139	0	2.299	2.5
Bromoform		CHBr3	253	0	0	2.799
Bromopropane, 1-		C3H7Br	123	0	2	1.299
Bromotrifluoro…	R 13B1	CF3Br	149	0	0	0
Butadiene		C4H6	54	0	0.699	0.829
Butadiene diep…	Butadiene diepox.	C4H6O2	86	0	3.599	4
Butane, n-		C4H10	58	0	0	46
Butanol, 1-		C4H10O	74	0	3.599	4.011

09:31:16 Ping Done

You are now able to modify this table and then download it to your instrument.

If you wish to add new gases to the table, select the 'Menu' tab, and from the drop down menu select 'Allow Insert/Delete'.

This will add an additional line at the bottom of the Gas table which allows the user to add new gas types as below.



Xylene mixed is…		C8H10	106	0	0.43
Xylene, m-		C8H10	106	0.4	0.439
Xylene, o-		C8H10	106	0.689	0.6
Xylene, p-		C8H10	106	0.62	0.55
Xylidine, all		C8H11N	121	0	0.699
New gas	Mix				

Upper and lower alarm levels in Survey mode can be adjusted via the gas table. Type the desired alarm level in the appropriate column (either high or low alarm) against the gas you wish to change. Always save modified gas tables under a different file name, keeping the original complete.

To send the gas table to the instrument, select 'Send to Instrument' from the dropdown menu shown above.

TIGER PC Software (continued)

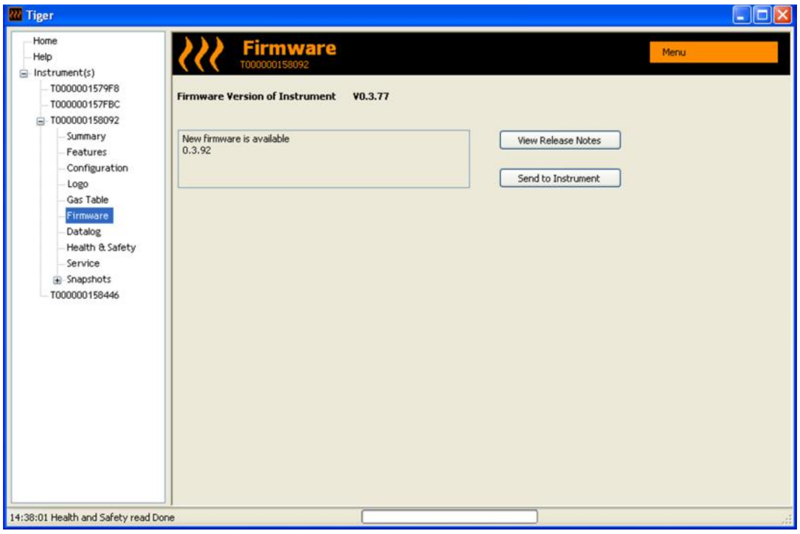
The Firmware Screen

This screen displays the current firmware version installed on your TIGER. It also provides a facility to download updated versions to your TIGER.

At this point you can also check the 'Release Notes' information which is a description
of the changes in the new version as shown here.

To download a firmware update, connect TIGER to your computer as detailed previously. Ensure that your instrument is in normal Survey mode, is not in an alarm condition and that no datalogging or Health & Safety readings are being collected. Check that the battery is sufficiently charged (at least two bars).

IMPORTATNT: The Firmware Upgrade process will delete all data from the instrument. To avoid loss of any data during the upgrade process, take a snapshot of the instrument before proceeding. The snapshot can be re-installed after the update process is complete.



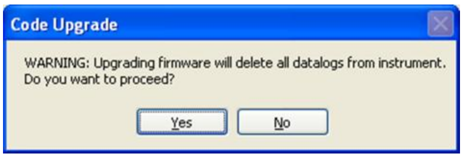
Firmware Version of Instrument V0.3.77

New firmware is available
0.3.92

14:38:01 Health and Safety read Done

When you are ready to send the new Firmware to the instrument. Select 'Send'.

You will now see a message that will warn you that all the
Data will be lost on your instrument. If you are happy
To continue confirm with 'Yes'.



WARNING: Upgrading firmware will delete all datalogs from instrument.
Do you want to proceed?

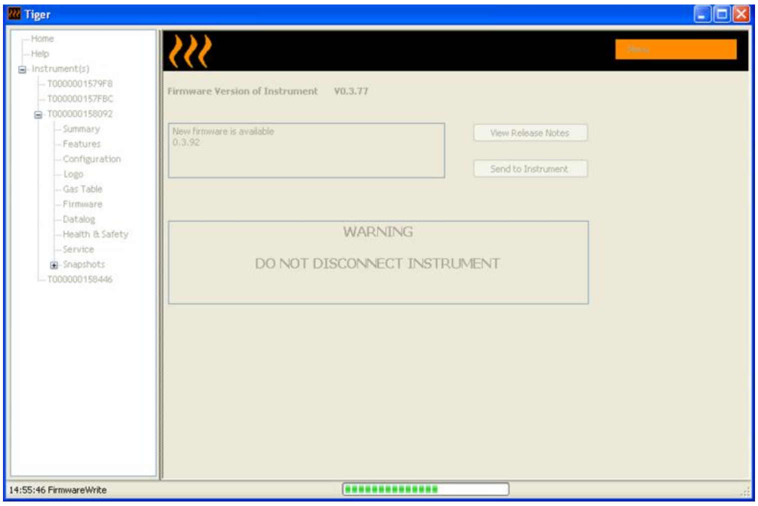
A 'WARNING' message will appear. If you are happy
To continue confirm with 'Yes'.

WARNING: Ensure instrument is NOT disconnected during firmware upgrade."

Do you want to proceed?

TIGER PC Software (continued)

IMPORTANT: Do not attempt to operate your TIGER during the update process.
The firmware on your TIGER will be updated and the new version will be shown on the Firmware screen.



Firmware Version of Instrument V0.3.77

New firmware is available
0.3.92

WARNING

DO NOT DISCONNECT INSTRUMENT

14:55:46 FirmwareWrite

A bar at the bottom of the screen will indicate the progress of the update.

IMPORTANT: Do not disconnect the Tiger at this point. Please follow the next part before disconnecting the Tiger.

After the PC Software has completed sending the upgrade to the Tiger the instrument will then have to finish the upgrade process. The Tiger will flash the two torch LED's and the screen on the Tiger will remain blank for approximately 30 Seconds.
A bar will then appear and travel across the screen. A message will be displayed as follows, 'verifying file system'. The Firmware is now installed on to the instrument and will start up automatically.

TIGER PC Software (continued)

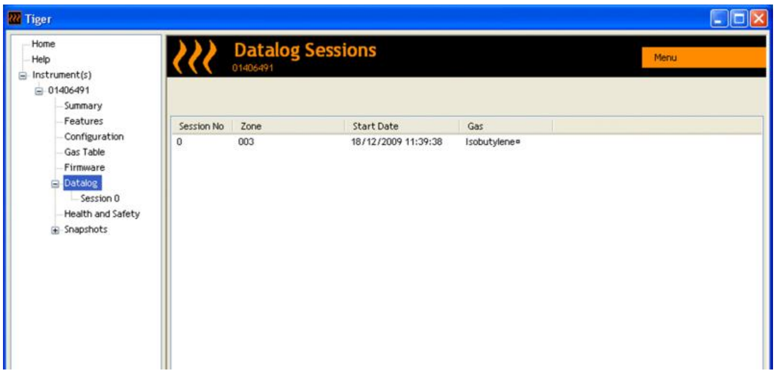
Downloading data logged readings

Connect your TIGER to your PC as described previously. Any fresh data-logged readings will be downloaded as the software 'reads' your TIGER.

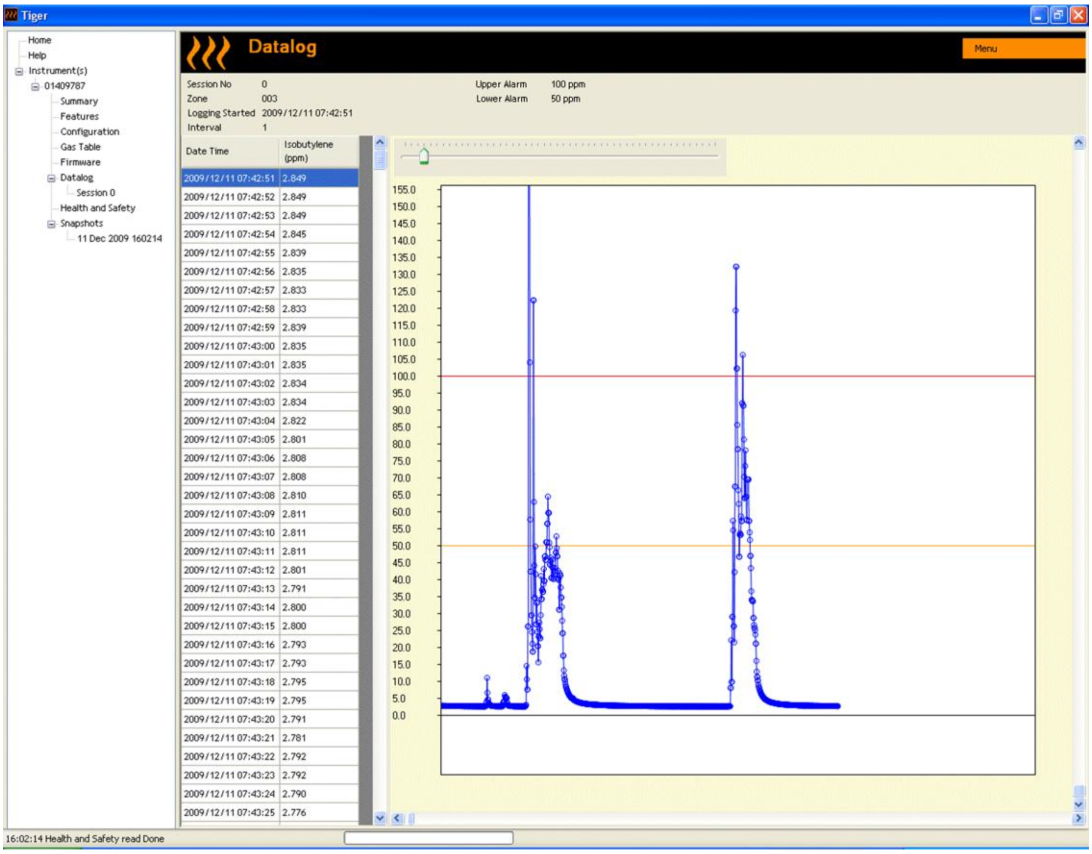
Go to the datalog screen and a list of the datalog sessions is presented.

Expand the datalog folder and select the session of interest.

Details of the data collected during that session are presented in numerical and graphical form.



Session No	Zone	Start Date	Gas
0	003	18/12/2009 11:39:38	Isobutylene



Session No 0
Zone 003
Logging Started 2009/12/11 07:42:51
Interval 1
Upper Alarm 100 ppm
Lower Alarm 50 ppm

Date Time	Isobutylene (ppm)
2009/12/11 07:42:51	2.849
2009/12/11 07:42:52	2.849
2009/12/11 07:42:53	2.849
2009/12/11 07:42:54	2.845
2009/12/11 07:42:55	2.839
2009/12/11 07:42:56	2.835
2009/12/11 07:42:57	2.833
2009/12/11 07:42:58	2.833
2009/12/11 07:42:59	2.839
2009/12/11 07:43:00	2.835
2009/12/11 07:43:01	2.835
2009/12/11 07:43:02	2.834
2009/12/11 07:43:03	2.834
2009/12/11 07:43:04	2.822
2009/12/11 07:43:05	2.801
2009/12/11 07:43:06	2.808
2009/12/11 07:43:07	2.808
2009/12/11 07:43:08	2.810
2009/12/11 07:43:09	2.811
2009/12/11 07:43:10	2.811
2009/12/11 07:43:11	2.811
2009/12/11 07:43:12	2.801
2009/12/11 07:43:13	2.791
2009/12/11 07:43:14	2.800
2009/12/11 07:43:15	2.800
2009/12/11 07:43:16	2.793
2009/12/11 07:43:17	2.793
2009/12/11 07:43:18	2.795
2009/12/11 07:43:19	2.795
2009/12/11 07:43:20	2.791
2009/12/11 07:43:21	2.781
2009/12/11 07:43:22	2.792
2009/12/11 07:43:23	2.792
2009/12/11 07:43:24	2.790
2009/12/11 07:43:25	2.776

16:02:14 Health and Safety read Done

Use the menu function at the top right hand corner of the window to print, export or delete the data.

WARNING: The delete function deletes all logged data from your TIGER. Ensure all valuable data is exported to your PC before selecting 'Delete'.

TIGER PC Software (continued)

The Health & Safety Screen

This screen displays the latest Health & Safety readings held on your TIGER. Click 'Menu' then 'Export' to save this data to a file on your computer. The next readings will overwrite the data on your TIGER.

Recording Started: 10 December 2009 06:05:12
Gas: Isobutylene
STEL Alarm: 0 ppm
TWA Alarm: 0 ppm
Battery: 100%
Last Average time: 10 December 2009 06:05:15
STEL value: 0.003 ppm
TWA value: 0 ppm

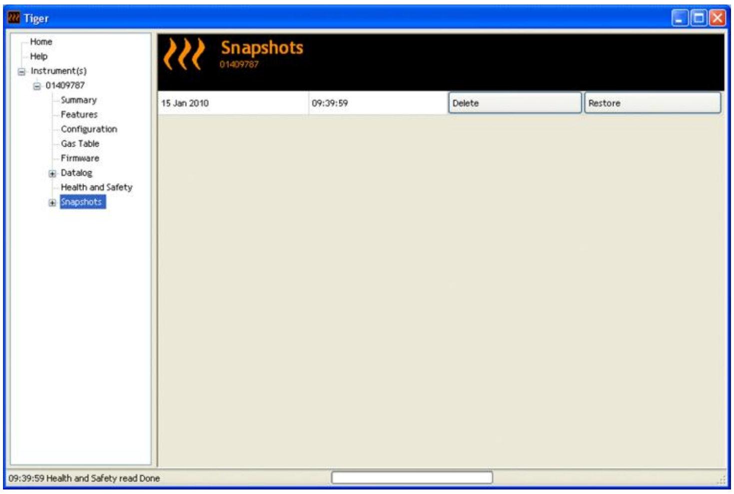
09:39:59 Health and Safety read Done

Snapshots

A snapshot records the settings and calibration data on your Tiger at any particular point in time. The Snapshots screen displays a list of all those stored on your PC.

Click 'Delete' to remove a selected snapshot.

To restore the stored settings to your TIGER, first ensure that your instrument is fully booted and connected to your PC as detailed previously. Ensure that your instrument is in normal Survey mode, is not in an alarm condition and that no datalogging or Health & Safety readings are being collected. Click 'Restore' against the relevant snapshot. ***Be aware that this process will replace all setup and calibration files.*** On the restore screen click 'Yes'. When complete, click 'Close' and restart your TIGER. Your TIGER will now be restored to the settings and calibration data stored at the time of that snapshot.



15 Jan 2010 09:39:59

09:39:59 Health and Safety read Done

The snapshot menu also allows review of stored data when an instrument is not attached.
Expand the menu until the latest or relevant snapshot is displayed. Double-click on the snapshot and all the data stored in that snapshot can be accessed

TIGER PC Software (continued)

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Governing Law

The laws of the United Kingdom govern this Agreement.

Batteries

WARNINGS

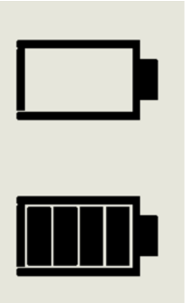
BATTERY CHARGING:	Charge PhoCheck Tiger and its Lithium ion battery packs in a Non Hazardous environment only.
BATTERY REPLACEMENT:	Never replace primary Alkaline battery cells while in a potentially explosive or hazardous location. Use only Duracell Procell Alkaline batteries MN1500.
BATTERY CONNECTION:	The PhoCheck Tigers Lithium ion and Alkaline battery packs have been specially designed to allow connection to the PhoCheck Tiger Instrument while in potentially hazardous atmospheres. The PhoCheck Tiger instruments ingress protection rating is reduced to IP 20 when its battery pack is removed so avoid changing batteries in dusty or wet environments.

Two battery packs are available for use with the tiger instrument. A lithium ion rechargeable pack and non-rechargeable pack, (that may be fitted with 3 AA Alkaline batteries). The rechargeable pack is recommended for normal operation with the Non-rechargeable pack available when power is not available and the use of the instrument is needed. The rechargeable pack is normally fitted as standard to the instrument when shipped.

Recharging batteries

Ensure the PhoCheck Tiger is charged for at least 7 hours before using it for the first time. To ensure optimum charging the TIGER should be switched off during charging. If left on, the TIGER will take longer to charge, but should not suffer any damage. The TIGER should be charged in a non hazardous environment only.

To charge your TIGER, first connect the charging cradle to the mains, and switch on. A red light will indicate that the charger is ready. Place the TIGER in the charging cradle such that the contacts on the TIGER are aligned with those in the cradle. (There is no need to remove the black rubber Boot from the TIGER during charging.) During charging, the charger will display an orange light. A green light indicates that charging is complete.



Discharged

Fully Charged

The battery icon on the TIGER will display the level of charge.

NOTE: 1. Only use the charger supplied with your TIGER to charge your instrument.
2. Ion Science recommends keeping your PhoCheck TIGER on charge at all times when not in use, as batteries can lose power over time.

Batteries (continued)

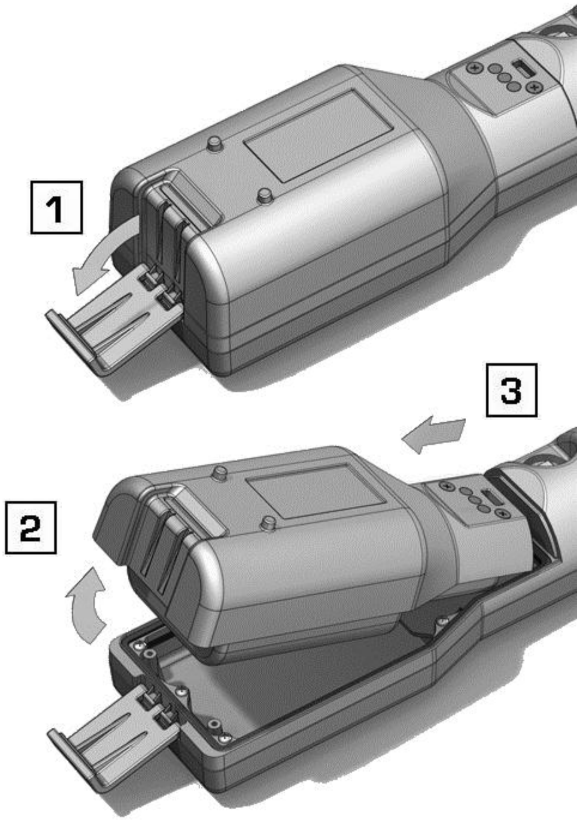
Replacement / exchange of battery packs

To replace the battery pack, proceed as follows:

a. Ensure TIGER is switched Off;

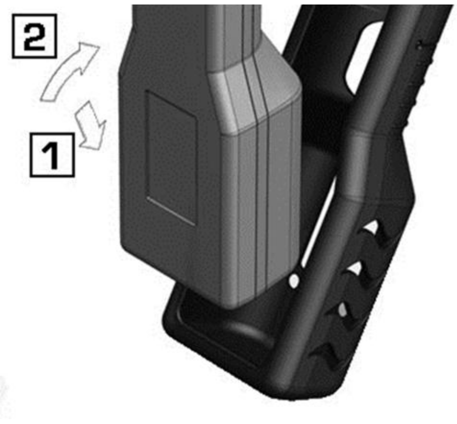
b. Remove the black rubber Boot from your TIGER (this is most easily achieved by starting at the front end of the instrument (step 4 below));

c. Release the clip at the rear end of the instrument and lift the battery pack away from the body of the instrument, coincidently sliding it slightly backwards;



d. Reverse the procedure to install the replacement pack, ensuring that the Boot is a snug fit around the front of the instrument and the lights are not obscured;

e. Charge TIGER for seven hours before use.



Batteries (continued)

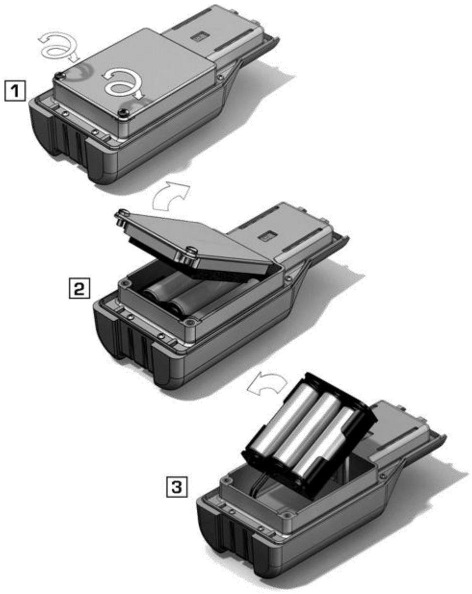
Replacement of Non-rechargeable batteries in battery pack

WARNING

BATTERY REPLACEMENT:	Never replace primary Alkaline battery cells while in a potentially explosive or hazardous location. Use only Duracell Procell Alkaline batteries MN1500.

a. Ensure TIGER is switched Off.

b. Remove the pack as in (b) and (c) above;



c. Remove the screws retaining the battery cover and lift it off. This reveals a set of 3 x AA cells contained in a removable battery holder;

d. Remove the battery holder;

e. Replace the exhausted batteries; Use Duracell PROCELL Alkaline batteries MN1500

f. Check all batteries have the correct polarity before replacing the holder;

g. Replace the pack as described above.

WARNING: Fitting batteries or connecting the clip with the wrong polarity may result in damage to the instrument!

WARNING: Non-rechargeable batteries **MUST NOT** be replaced in the field. Batteries should be loaded into the battery clip in a safe environment only. Only the assembled battery pack may be changed in the field.

NOTE: When loading batteries check for correct battery polarity before connecting them.

Diagnostics

Basic faults or diagnostics are presented as symbols. Should a fault occur most can be corrected by pressing ENTER or ESC to clear the fault message. All fault conditions cause the TIGER to alarm.

Pump failure

Pump blocked or pump failure

The flow of gas through the instrument has fallen below 100 cc/minute. Check the probe and filter for signs of blockage. Water or dirt in the probe, a bent probe, dirty filter on the inlet or blockage of the exhaust (finger over hole on the back?) can all cause low flow. If the blockage can be removed, press Escape to clear the alarm. If the fault persists send the instrument to your distributor for service.

Battery dead

Battery low or battery failure

The Tiger will shut down when the battery level falls below 2%. Recharge the battery as instructed in the 'Batteries' section of this manual ensuring that all connections are sound and the indicator lights on the charger are in order. If the battery fails to charge, fit another battery pack if available. If using alkaline batteries, replace them. If the fault persists send the instrument and charger to your distributor for service.

Lamp out

Lamp failure

The PID lamp has failed to strike (illuminate); this may occur at switch on or during use. Switch the TIGER off and replace the lamp. See the 'Maintenance' section .

Memory full

Memory cannot receive more data

The data log memory is full. This will only happen if the Log Full box is set to 'alarm' on the TIGER PC configuration screen. Press the Escape key to continue, but the TIGER will no longer continue to log data. Select 'recycle' in TIGER PC and the TIGER will overwrite the oldest data and no alarm will be raised.

System error

! os 212

Total system failure

The instrument's firmware is corrupted. In the unlikely event of this message appearing, contact Ion Science or your nearest authorised service centre.

Maintenance

Calibration

Ion Science recommends an annual service and calibration for users who require a traceable calibration. During this service the lamp and detector are brought back to factory specifications and new Factory Calibration data is stored.

Due to the linear output of the Ion Science PID detector, a two-point calibration is often adequate. TIGER scales its linear output across a ZERO level (clean air reference) and the SPAN 1 user defined gas concentration. For more exacting requirements, TIGER offers a three-point calibration with a higher SPAN 2 gas concentration.

TIGER offers the options of Factory calibration or Custom calibration. 'Factory calibration' is set by Ion Science during instrument manufacture or on re-calibration. 'Custom calibration' can be set by the instrument user.

For ***Factory Calibration*** contact Ion Science Ltd. or your distributor.
'Factory' calibration offers a safe set of three-point calibration data. This should be used if the custom calibration fails and will keep the unit working until a good custom calibration is completed.

For ***Custom Calibration***, first set up the parameters in TIGER PC - see the 'Tiger PC Software' section of the manual.
TIGER allows you to custom calibrate using any gas from the Gas Table at any concentration from 10ppm. You will need a cylinder of the selected gas at each of the chosen concentrations. Each cylinder should be regulated for a flow rate above 250ml/min.

Have the cylinder(s) of gas, regulator(s) and the zero carbon filter (included in the Calibration Kit for your TIGER) on hand before starting the procedure. Alternatively a known clean air supply may be used as the 'zero' gas. Please ensure you are familiar with the entire calibration procedure before attempting to calibrate your TIGER.

Note: The calibration of your TIGER must be carried out in a clean air environment. Ensure all parts of the calibration kit are available and ready for use.
Never calibrate the zero with the span gas connected

Press the Options soft key on your TIGER to access the adjustable features.

Then use the UP or DOWN key to select calibration. Press ENTER to confirm selection.

Select Custom Calibration and press Enter to confirm.

On confirming the selection, the user is presented with a 15 second count down. ZERO
Remove both caps from the carbon filter and then fit onto the probe of your TIGER. Press ENTER to start the 'zero' countdown. At the end of the count down a tick '✓' will appear, indicating that the Zero has been accepted. Disconnect the carbon canister and replace the cap ends. The useful life of the carbon canister will be shortened if the canister is open to atmosphere for prolonged periods.

Maintenance (continued)

Press ENTER again and the gas and concentration for Span 1 (previously set up in TIGER PC) are displayed along with a 15 second count-down. SPAN 1 Attach the 'Span 1' gas using the calibration adaptor supplied in the accessory box (see 'Accessories') and press ENTER to start the Span 1 countdown. At the end of the count down a tick '✓' will appear, indicating that the Span 1 has been accepted. For two-point calibration, press ENTER and the calibration is complete.

For three-point calibration, press ENTER to display the gas and concentration for Span 2 (previously set up in TIGER PC) along with a 15 second count-down. SPAN 2 Attach the 'Span 2' gas and press ENTER to start the Span 2 countdown. At the end of the count down a tick '✓' will appear, indicating that the Span 2 has been accepted.
Press ENTER again and the calibration is complete.

Probes

Should the probe become cantaminated or damaged, replacement probes may be obtained from your distributor or from Ion Science Ltd. Please note that a small 'O ring' at the base of the probe ensures the probe is sealed, this can bee seen in the transparent filter housing when the probe is removed.

The probe can be removed for cleaning or replacement by unscrewing it from the transparent filter housing.

Refit the probe using fingers only, avoid using tools as this may damage the filter housing. To ensure the assembly is sealed, place a finger over the probe to block the flow while the instrument is running. A flow alarm should occur if sealed correctly.

Filter

The filter should be changed after every 100 hours of use.
This frequency should be increased for dusty or moisture laden environments or whenever the filter appears 'dirty' when viewed through the transparent upper surface of the Filter Clamp. Filter changing should be conducted in a suitably clean environment, with clean hands and equipment to avoid contamination of the new filter.

To change the filter, unscrew the Filter Housing Cap (item 1 of the 'Front End Filter Assembly' under the 'Maintenance' section), lift off the Filter Clamp and O-ring and lift the filter from the TIGER Body'. Carefully place a new filter into the TIGER Body. ***(Under no circumstances should a filter be used once it has been removed.)*** Replace the Filter Clamp, ensuring the locating lugs are correctly positioned in the cut-outs in the Tiger Body and that the O-ring is correctly seated. Replace the Filter Housing Cap. Do not over-tighten.

Maintenance (continued)

PID Sensor/Lamp replacement and cleaning

When using your TIGER in conditions of high ambient humidity, the PID may show unexpected readings appearing to increase. This occurs due to dust or other small particles within the detector becoming hydrated with humidity. This causes these particles to conduct a signal between the electrodes. The problem can be resolved by the user in the field using the procedure below and a can of computer duster air.

In normal use the lamp should be cleaned after every 100 hours of use (based on 30 ppm for 100 hours). Reduce this if TIGER is used in heavily gas contaminated environments. Please note that some esters, amines and halogenated compounds may accelerate window fouling; in these cases cleaning may be required after every 20 hours of use. Cleaning frequency will also depend upon alarm levels set and prevailing environmental conditions.

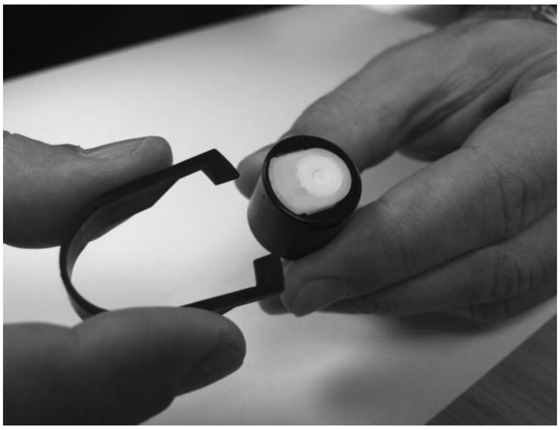
CAUTION!
The TIGER is a sensitive detector. Internal components must be handled with clean hands and clean tools. The TIGER lamp is fragile. Handle with great care. Never touch the window and do not drop!!

To remove the Mini PID sensor for cleaning or lamp replacement, first ensure that the TIGER is turned off and that you are in a clean environment such that the sensor parts will not be contaminated by dust, oil or grease. Remove the sensor cover (see image on right). The centre screw may be turned with a small coin or a suitable flat bladed screwdriver.

Ensure that the sensor seal (9), on the inside of the sensor cover is not disturbed.

Carefully lift the Mini PID Sensor (A6) from the TIGER body, ensuring that the two Inlet/Outlet Seals (10) remain in place in the TIGER body.

Using the special tool provided, locate its ‘prongs’ in the slots in the side of the Sensor body. Using the forefinger to restrain the sensor, (the internal parts are spring-loaded and careless disassembly will leave you hunting for the spring!) squeeze the tool to release the lamp housing.



The lamp may now be removed.

To replace the lamp or install a new one, reverse the procedure, ensuring the seals are all in place. When replacing the sensor cover ensure that the markers are aligned correctly and that the cover is a snug fit.

The instrument MUST be re-calibrated after fitting a replacement or cleaned lamp.

WARNING! NEVER REFIT A DAMAGED LAMP!

Maintenance (continued)

Lamp Cleaning

The TIGER PID relies on an ultraviolet light source ionising VOC gases as they pass across the lamp window. This process may result in a very fine layer of contamination appearing on the detector window that must be removed on a regular basis.

CAUTION!
The TIGER is a sensitive detector. Internal components must be handled with clean hands and clean tools. The TIGER lamp is fragile. Handle with great care!

First ensure that the TIGER is turned off and that you are in a clean environment such that the sensor parts will not be contaminated by dust, oil or grease.

Remove the lamp as detailed above.

Inspection of the lamp may reveal a layer of contamination on the detection window that presents itself as a 'blue hue.' To check for confirmation, hold the lamp in front of a light source and look across the window surface. Clean the window using the cleaning kit supplied.

USE of PID lamp cleaning kit A-31063

The container of cleaning compound contains Aluminium Oxide as a very fine power (CAS Number 1344-28-1).
A full material safety data sheet MSDS is available on request from Ion science ltd. The key issues are listed below:
Always replace the lid after using the cleaning compound.

Hazard identification:
- *May cause irritation of respiratory tract and eyes.*

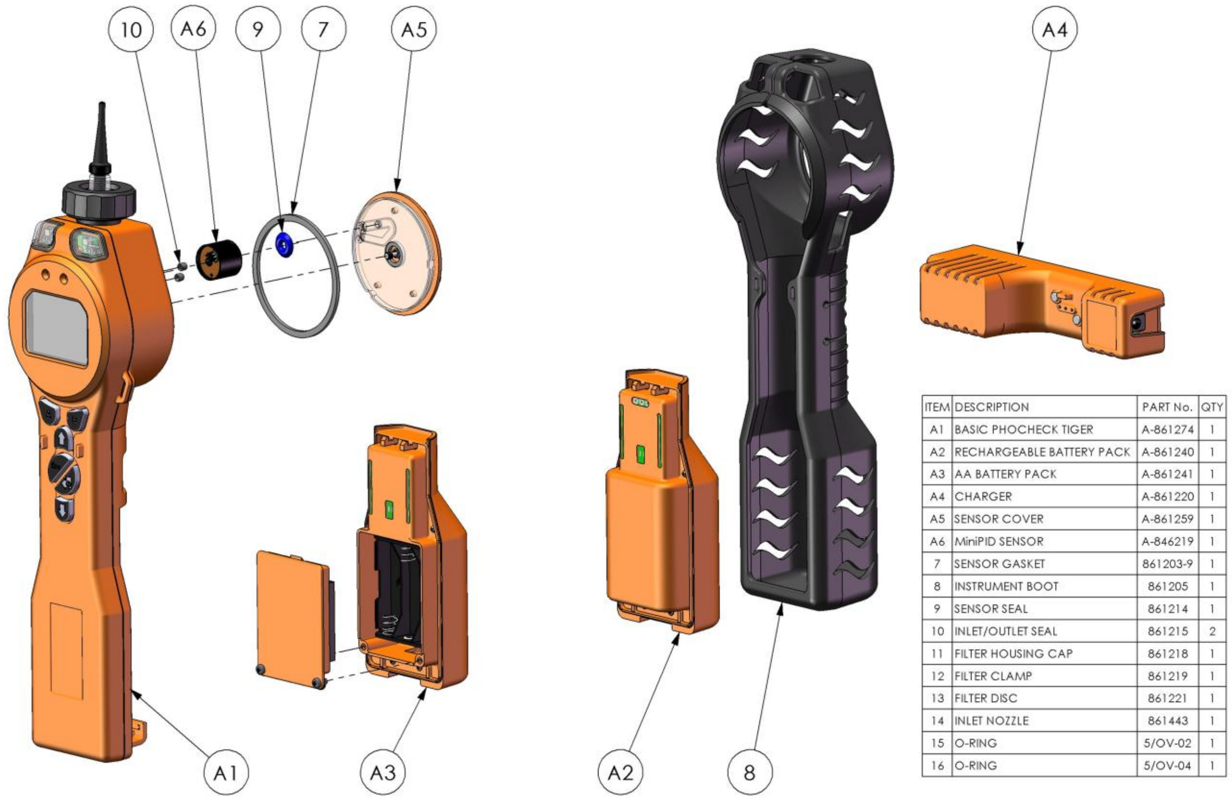
Handling:
- *Do not breathe vapour/dust. Avoid contact with skin, eyes and clothing;*
- *Wear suitable protective clothing;*
- *Follow industrial hygiene practices: Wash face and hands thoroughly with soap and water after use and before eating, drinking, smoking or applying cosmetics;*
- *The Compound has a TVL(TWA) of 10 mg/m*^{3}*.*

Storage:
- *Keep container closed to prevent water adsorption and contamination.*

To clean the lamp:
1. Open the vial of Aluminium Oxide polishing compound. With a clean cotton bud collect a small amount of compound;
2. Use this cotton bud to polish the PID lamp window. Use a circular action applying light pressure to clean the lamp window. Never touch the lamp window with fingers;
3. Continue polishing until an audible "squeaking" is made by the cotton bud with compound moving over the window surface (usually within fifteen seconds);
4. Remove the residual powder with short blast of air from the can of air duster;
5. The instrument MUST now be re-calibrated.

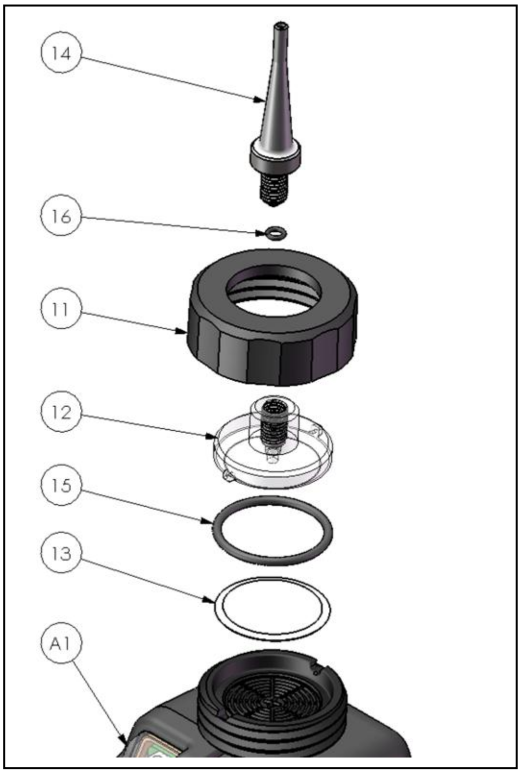
TIGER Parts

TIGER Main Assembly



ITEM	DESCRIPTION	PART No.	QTY
A1	BASIC PHOCHECK TIGER	A-861274	1
A2	RECHARGEABLE BATTERY PACK	A-861240	1
A3	AA BATTERY PACK	A-861241	1
A4	CHARGER	A-861220	1
A5	SENSOR COVER	A-861259	1
A6	MiniPID SENSOR	A-846219	1
7	SENSOR GASKET	861203-9	1
8	INSTRUMENT BOOT	861205	1
9	SENSOR SEAL	861214	1
10	INLET/OUTLET SEAL	861215	2
11	FILTER HOUSING CAP	861218	1
12	FILTER CLAMP	861219	1
13	FILTER DISC	861221	1
14	INLET NOZZLE	861443	1
15	O-RING	5/OV-02	1
16	O-RING	5/OV-04	1

Front End Filter Assembly



Accessories

Ion Science has developed an exclusive range of high quality accessories to compliment the PhoCheck TIGER. Please see a selection of these below:

Part Number	**Accessory Description**
1/jawu-01	2.1mm DC jack - cigar lighter plug Car Charger Lead
846216	Removal tool Min PID stack
861205	Protective, Removable rubber boot
861230	USB Cable - Angled B Connector
861413	5m Extension Hose
861414	10m Extension Hose
861415	Diluter
A-31063	PID lamp cleaning kit
A-830206	Decontamination Bag (10 Off)
A-861269	Explorer Case - Phocheck Tiger
A-861272	Accessory Kit - Rechargeable Battery
A-861273	Accessory Kit - Alkaline Battery
A-861400	Drager Tube Holder Assembly
A-861406	Flexible Probe Assembly
A-861416	Charging/Calibration Dock
A-861418	Calibration Kit
LA4TM600	MiniPID Lamp Krypton 10.6eV ppm
LA4TB600	MiniPID Lamp Krypton 10.6eV ppb
LA4SM700	MiniPID Lamp (Argon) 11.7eV

Contact Ion Science or your local Distributor for more information.

Accessories Content

	A-861267	Phocheck Tiger Accessory Box
	846216	Removal Tool Min PID Stack
	A-31057	Carbon Filter Assembly (Sm Blue)
	861221	PTFE Filter Disc
	861235	Lanyard
	A-31063	PID Lamp Cleaning Kit

Accessories Content

	861476	Calibration Adaptor
	861214	Sensor seal

Instrument Warranty and Service

Warranty

Standard Warranty can be extended to up to 5 years on the PhoCheck TIGER when registering your instrument via our website: www.ionscience.com/instrument-registration To receive your Extended Warranty, you need to register within one month of purchase (Terms and Conditions apply).

To register your PhoCheck TIGER instrument, simply fill in the online form. You will need to enter your instrument serial (IRN) number to hand. To find this, switch on your instrument. Using your soft keys, go into the 'info' menu and scroll down until you find the IRN number.

You will then receive a confirmation email that your Extended Warranty Period has been activated and processed.

Full details, along with a copy of our Warranty Statement can be found by visiting: www.ionscience.com/instrument-registration

Service

Ion Science Ltd also offers a number of service options for your PhoCheck TIGER that allows you to choose the instrument cover to best suits your requirements.

At Ion Science we recommend that all of our gas detection instruments be returned for service and factory calibration once every 12 months.

Contact Ion Science or your local distributor for service options in your area.

Find your local distributor by visiting: www.ionscience.com

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Web: www.ism-d.de

Technical Specifications

Response time	T90 < 2 second	
Detectable Range	1 ppb – 10,000 ppm & ppb to 20,000ppm for Specific Gases	
Resolution	+/- 1 ppb	
Accuracy	+/- 5% displayed reading +/- one digit	
Linearity	+/- 5% displayed reading +/- one digit	
Battery	Lithium ion	24 hours
	Alkaline (Duracell Procell MN1500)	8.5 hours
Data log	Including date / time	120,000
Alarm visual	Flashing Red & Amber LED	
Alarm audible	95 dBA @ 30 cm	
Flow Rate	≥ 220 ml/min in Ambient conditions	
Temperature	Operating	-20 to 60 °C (- 4 to 140 °F)
	Storage	-25 to 60 °C (-13 to 140 °F)
	Certified to	-15 to 45 °C (- 5 to 140 °F)
Dimensions	Instrument	340 x 90 x 60 mm
Weight	Instrument	0.720 kg (1.6 lb)
Materials	Instrument	Anti-static PC/ABS (Polycarbonate/ Acrylonitrile Butadiene Styrene)
	Rubber Boot	Anti-static TPE (Thermoplastic Polyolefin Elastomeric)

Manual Log

Manual version	Amendment	Issue Date	Instrument Firmware	PC Software
1.0	First issue	15/01/2010	V 0.3.40	V 1.0.0.18
1.4	Updated filter replacement instructions on page 34.	9/4/2010	V 0.3.49	V 1.0.0.26
1.5	Addition of ATEX information and new probe graphics	11/05/2010	V0.0.57	V 1.0.0.30
1.6	Addition of IECEx number on page 4	17/06/2010	V0.0.63	V 1.0.0.31
1.7	Instrument Warranty Information added to page 41 Accessory images added to page 39-40 Images added on pages 33 and 34	21/07/10	V0.0.63	V 1.0.0.31
1.8	Pg 38 – Part Numbers LA4SB600 & LA4SM600 have been deleted and replaced with LA4TM600, LA4TB600 & LA4SM700	30/09/10	V0.0.63	V 1.0.0.31
1.9	Page 21 – New screen shot of PC software. New tick box added for 'Sleep during PC connect' mode. Page 33 – carbon filter adaptor added in instructions. Page 33 – Note added, 'Never calibrate the zero with the span gas connected'	10/10/10	V0.0.74	V 1.0.0.31
2.0	Page 41 – Accessory added, Sensor seal .	12/11/10	V0.0.74	V 1.0.0.33
2.1	Page 37 – Part number 5/OV-02 changed from 5/OV-04	13/01/11	V.0.0.77	V 1.0.0.39
2.3	Battery Charging & Proper use added. Page 3 Field replacement of alkaline battery pack note added. Page 8 Information screens updated to include features screen. Page 16 Firmware upgrade screen updated. Page 25 Battery Charging note added. Page 30 Two battery packs note added. Page 30 11.7eV lamp information and spec added to page 22 Page 4 &7 updated to correct Quality Management System. Page 7 Responsibility for use updated and Legal Notice added	25/02/11 03/03/11	V.0.0.85	V 1.0.0.42

Manual Log (continued)

2.4	Front cover, Issue updated to V2.4 Servicing warnings and Intrinsically safe note added to warnings section on page 3 Page 12, Softkey note added Page 15, Stealth mode added Page 19 & 20, PC Software upgrade Updated Page 23, Lock Softkeys mote added Page 26 & 27, Tiger Firmware upgrades updated	29/03/11	V0.3.93	V1.0.0.45
2.5	Lamp information added on page 25 Page 37, Reference to Carbon Filter Adaptor deleted as this is not used. Page 44, A-861229, Carbon Filter Adaptor deleted.	07/06/11	V0.3.93	V1.0.0.45
2.6	Page 24 Zeroing information added Page 46 Battery specifications updated	15/03/12	V0.3.93	V1.0.0.45

Landtec GEM™ 2000

The GEM™ 2000 is designed for analyzing LFG composition and calculating flow. The GEM™ 2000 combines the capabilities of the now discontinued GA-90 for monitoring gas migration probes and the GEM™ 500 for monitoring gas extraction systems. The GEM™ 2000 is certified intrinsically safe and offers improved speed and accuracy.

FEATURES

- **Diverse Field Applications** – Monitors migration control systems, gas extraction systems, flares, migration probes, and more.
- **Gas Extraction Monitor Mode** – Provides automatic sampling and analysis of gas composition % by volume CH_4, CO_2, O_2 and balance gas, % LEL CH_4, temperature (with optional probe), static pressure, differential pressure, and barometric pressure. Calculates gas flow rates (SCFM) as well as BTU content.
- **Landfill Gas Analyzer Mode** – Provides automatic sampling and analysis of gas composition % by volume CH_4, CO_2, O_2 and % balance gas, % LEL CH_4, temperature (with optional probe), barometric pressure and relative pressure. Can be used for data logging, with user programmed intervals.
- **Easy to Read Display** – Extra large backlit LCD shows up to five gases, atmospheric and gas vacuum pressure, temperature, ID code – all at the same time.
- **Quick Analysis** – Completes sampling and displays gas analysis and flow results in less than one minute.
- **Infrared Gas Analyzer** – Provides accurate measurements of methane (CH_4), and carbon dioxide (CO_2).
- **Gas Temperature** – Read when using optional temperature probe or can be entered manually.
- **Durable Oxygen Sensor** – Provided by the galvanic cell principle, not influenced by other gases (i.e. CH_4, CO_2, CO, SO_2 or H_2S).
- **User Friendly On-Screen Menu** – In each mode the user performs most operations in just two screens.
- **PC Data Downloading** – Provided by RS232 interface with DataField CS software (Release 3.0 or later).
- **Data Storage/Retrieval** – Stores prior measurements taken for each monitoring point, 900 monitoring points total.
- **Date/Time Stamp** – Recorded for all stored data.
- **Prior Data Recall** – Allows user to view prior data for each monitoring point.
- **Methane Analysis** – Displayed as either % CH_4 by volume or LEL CH_4 (Landfill Gas Analyzer Mode only).
- **Durable Construction** – Built of strong, durable plastic material suitable for harsh landfill environments.
- **All Weather Use** – Designed to operate in extremes from 32°F to 104°F. Sealed, weather-tight case.
- **Built-in Adjustable Alarms** – Allows user to set alarm limits for CH_4 and O_2.
- **Rechargeable Batteries** – Internal, rechargeable nickel metal hydride batteries are standard.
- **Operating Time** – Approximately 8 hours with normal pump usage (approximately 10 hours without pump running).
- **Fast Recharge Time** – Approximately 3 hours from complete discharge.
- **Battery Check** – Battery life is continuously displayed.
- **Monitoring Point ID Codes** – Provides alphanumeric identification of monitoring points for data storage and recall.
- **ID Comments** – Allows user to answer up to 3 questions with a list of 9 potential answers each.
- **Imperial vs. SI Units** – Can display measurements in Imperial (USA) or SI (metric) units.
- **Interfaces to DataField Management Software** – Which provides statistical analysis and reporting of LFG data.

SPECIFICATIONS

SENSOR

	Range	**Resolution**
Methane – CH4	0-70%	0.1%
Carbon Dioxide – CO_2	0-40%	0.1%
Oxygen – O_2	0-25%	0.1%
Pressures		
(diff.)	0-10" W.C.	0.001" W.C.
(static)	0-100" W.C.	0.1" W.C.

Pump Flow Rate – 500 cc/min at nominal flow, 250 cc/min at 80" W.C.

Vacuum – up to 80" W.C.

UL Certified to Class 1, Zone 1, AEx ib d iia T4

TYPICAL ACCURACY

Concentration	**% CH_4 by Volume**	**% CO_2 by Volume**	**% O_2 by Volume**
5% (Lel, CH_4)	±0.3%	±0.3%	±1.0%
Full Scale	±3.0% (70%)	±3.0% (40%)	±1.0% (25%)

GEM™2000
GEM™2000 Plus

GAS ANALYZER & EXTRACTION MONITOR

OPERATION MANUAL

For further information contact:

LANDTEC
850 S. Via Lata, Suite 112
Colton, CA 92324
Telephone: (800) 821-0496 or (909) 783-3636
Fax: (909) 825-0591
www.CES-LANDTEC.com

LANDTEC Release Date: August 2, 2005

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1 Introduction

LANDTEC is the premier manufacturer of products, instruments and software for landfill gas extraction and for regulatory monitoring compliance. LANDTEC has provided the landfill industry with a technologically innovative family of products for more than a decade. These products are the result of field-proven experience in design, operation and maintenance of landfills for environmental compliance.

The GEM™2000 and GEM™2000 Plus, designed by LANDTEC, are specifically for use on landfills to monitor landfill gas (LFG) extraction systems, flares and migration control systems. Both instruments sample and analyze the Methane, Carbon Dioxide and Oxygen content of LFG. The GEM™2000 Plus also samples and analyzes Carbon Monoxide and Hydrogen Sulfide. The readings are displayed and can be stored in the instrument or downloaded to a personal computer for reporting, analyzing and archiving.

The GEM™2000 / GEM™2000 Plus instrument is frequently shipped in an optional protective hard case with a foam interior that offers additional protection, transportation convenience and component hardware storage. When properly sealed, the hard case is watertight. The hard case is equipped with a pressure relief valve (located under the handle on the case) that is normally kept closed. If there is a change in elevation, the hard case may not open until turning the pressure relief valve equalizes internal pressure. When shipping a GEM™2000 / GEM™2000 Plus back to LANDTEC for calibration or service, always ship it in the original packaging to protect unit from damage.

Carefully unpack the contents of the GEM™2000 / GEM™2000 Plus, inspect and inventory them. The following items should be contained in your package:

- The GEM™2000 / GEM™2000 Plus instrument
- GEM™2000 / GEM™2000 Plus Operation Manual
- Registration/Warranty Card
- Soft carrying case with replaceable protective window and carrying strap
- Clear ¼" vinyl sampling hose assembly (5 ft.) with external water trap filter assembly
- Blue ¼" vinyl pressure sampling hose (5 ft.)
- Spare internal particulate filter element
- Polypropylene male connector (hose barb) connects to blue vinyl hose
- Spare external water trap filter element
- 100-240 volt battery charger
- DataField CS software on CD-ROM
- RS-232 serial cable for computer/printer data downloading
- Temperature probe (optional)
- Hard carrying case (optional)

Complete the Registration/Warranty Card and return it to LANDTEC. The model and serial numbers are located on the back of the GEM™2000 / GEM™2000 Plus instrument.

Immediately notify shipping company if the GEM™2000 / GEM™2000 Plus **unit or accessories are damaged due to shipping.** Contact LANDTEC immediately if any items are missing.

For questions regarding instrument operation and procedures, please contact LANDTEC at:

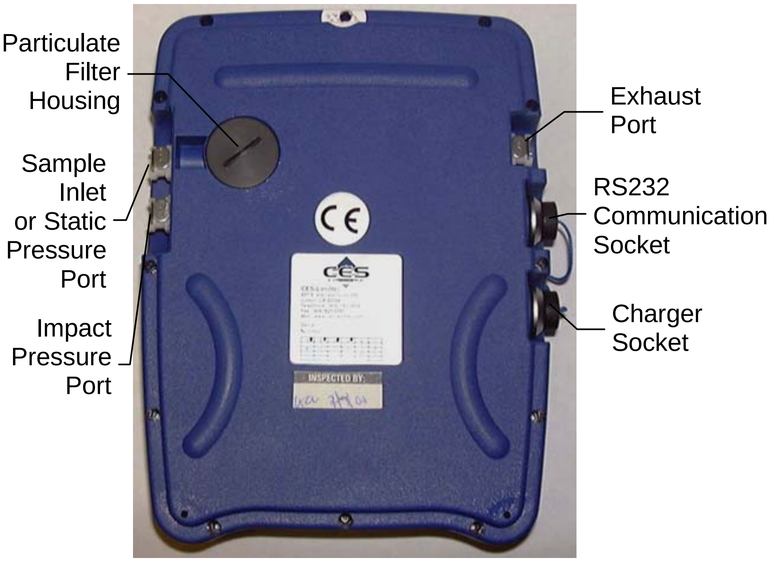
Customer Service or Technical Support Factory Service Spare Parts and Calibration Gas DataField Software Support	(800) 821-0496

2 General Operational Features

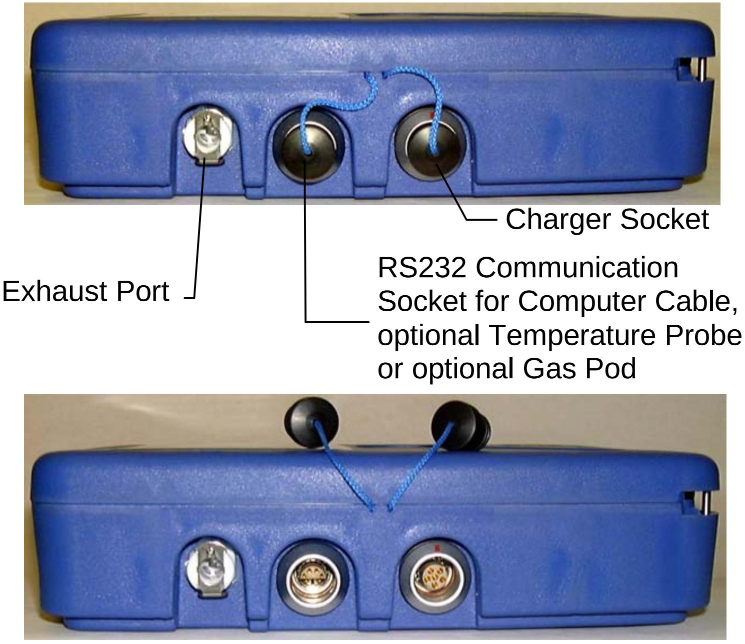
2.1 Physical Characteristics of the GEM™2000 / GEM™2000 Plus

Front View

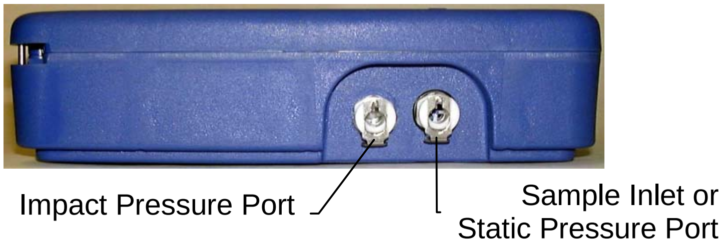
Back View



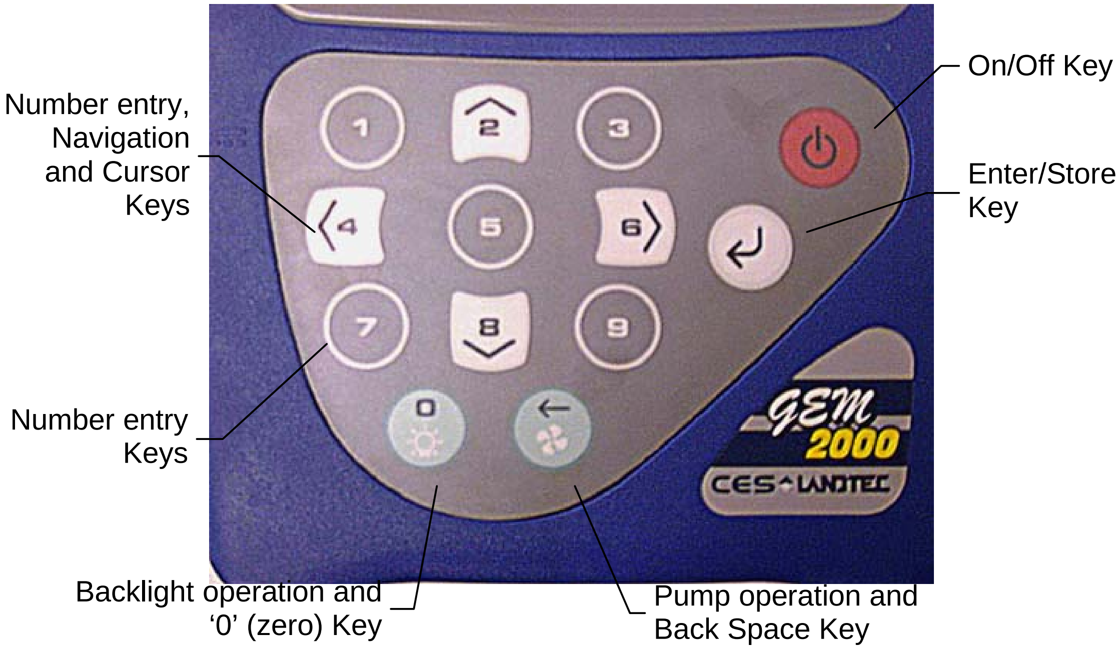
Left Side View



Right Side View



Keypad



Whenever a key is pressed the unit will emit a short ‘beep’ as an acknowledgement. This function cannot be turned off.

2.2 Turning the Instrument On/Off

When switching the instrument on, a long beep will sound, followed by the LANDTEC logo being displayed and the self-test will commence.

When switching the instrument off, the On/Off button must be held down for approximately 15 seconds, at which point a clean air purge will be carried out. If for any reason the instrument ‘locks-up’ and will not switch off, press and hold the On/Off button for 15 seconds. This will force the instrument to switch off.

2.3 Warm-up Self Test

When switched on, the instrument will perform a predetermined self-test sequence taking approximately 20 seconds, during this time many of the instrument’s functions are tested, including:

- General operation
- Pump function
- Gas flow measurement
- Calibration
- Backlight function
- Solenoid function

During the self-test, the following information is also displayed:

- Calibration due date.
- Software version.
- Lifetime guarantee covered (or not).
- Date format.
- Serial Number.
- Operating language.

Upon self-test completion, the GEM™2000 / GEM™2000 Plus should automatically enter the read gas levels screen.

2.4 Warning and Error Display

During the self-test, if any operational parameters are out of specification or the pre-programmed recommended calibration/service date has passed errors or warnings may be displayed. Only three errors/warnings can be displayed at any time. To ascertain if more errors occurred, use the '∧' and '∨' key to scroll up/down the list.

2.4.1 WARNING Displayed

All warnings displayed will be prefixed by the word '**WARNING**' followed by a relevant description. Two types of warnings may be displayed.

1. General warnings that may not have an effect on the instrument's function and those where the self-test has detected a function that is outside the usual programmed operating criteria (e.g. Battery charge low, memory nearly full, etc.).
2. Specific warnings of operational parameters that can affect the performance of the instrument (e.g. O_2 Cell out of calibration, CH_4 out of calibration, CO_2 out of calibration, etc.).

The most likely reason for the errors is either an incorrect user calibration, or sensor failure. If an incorrect user calibration has caused the warning, it should be correctable by way of returning the instrument to factory settings, zeroing or carrying out a user calibration as necessary for the relevant function.

2.4.2 ERROR Displayed

All errors displayed will be prefixed by the word '**ERROR**' followed by a number and description. The errors detected by the self-test are usually caused by a user calibration being out of specification or possibly memory corruption. This will have an effect on the functionality of the instrument and should be corrected before use (e.g. 01 - User cal data, CH_4 reading or channel out of specification, 02 - User cal data, CO_2 reading out of specification).

If any other Warnings or Errors are displayed, contact LANDTEC for further information.
LANDTEC is the ONLY authorized service center for the GEM™2000 / GEM™2000 Plus instruments in the Americas.

2.5 Storage

Do not keep the instrument in the trunk of a car or shed because it may be exposed to temperature extremes.

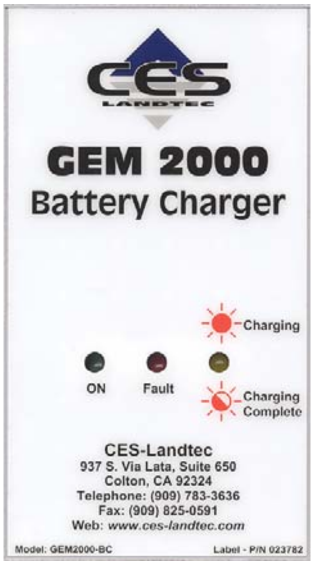
When not in use, instruments should be kept in a clean, dry and warm environment such as an office.

The instrument batteries should be discharged and fully charged at least once every four weeks regardless of indicated charge state. The discharge function may be carried out with the use of the Data Logging Function in GA mode of operation.

2.6 Battery/Charging

The Battery Charger IS NOT covered by the unit UL certification. Therefore, when connected to the Battery Charger, the instrument IS NOT intrinsically safe and should not be used in confined spaces.

The battery used in the GEM™2000 / GEM™2000 Plus is a Nickel Metal Hydride manufactured as an encapsulated pack from six individual cells. This type of battery is not so susceptible to "memory effects" as Nickel Cadmium batteries, although it is not recommended that the unit be given short-term charges. When the flashing LED indicates "Charging Complete", disconnect the charger.



The battery charger indicates when the unit is charging, charged or if there is a fault. A full charge should take approximately 2 hours. Charge the batteries until the 'Charging Complete' indicator is flashing.

2.7 Read Gas Levels Screen (GA mode of operation)

The read gas levels screen is also considered the normal operation screen and all operations are carried out from this starting point. The following information is displayed in various boxed sections at this time:

- Current programmed time and date.
- Current selected ID code.
- Pump status.
- Pump run time.
- Three main constituent gases – CH_4, CO_2, O_2 (in %).
- Two minor gases – CO & H_2S (GEM™2000 Plus only)
- Balance gas.
- Last read time/date (if previous data is in memory), the benefits of this are, 1 – it is easily noted if a reading has been taken/stored, 2 – the current and previous readings can be easily compared.
- External Gas Pod “Not Fitted” (displays pod type when attached).
- Peak CH_4 reading (in %) (GA mode only).
- LEL CH_4 (GA mode only).
- Current barometric pressure reading.
- Current relative pressure reading (GA mode only).
- Gas Pod or Temperature Probe reading (if connected).
- Battery Charge graph (5 segment, flashes at 20% remaining).
- Memory Usage graph (5 segment, flashes at 5% remaining).

Other options:

① Menu	Allows access to all instrument user functions.
③ Next ID	Allows the next ID to be selected (if data available).
⑦Previous Reading	Allows the previous reading of the selected ID to be viewed (if data available).
↵ Store Reading	Stores the current displayed reading. (GA mode only)

2.8 Optional Gas Pods

Optional gas pods are available for use with the GEM™2000 / GEM™2000 Plus. These pods are available in seven different gases with nine different PPM ranges. Connection to the instrument is made via the data port and exhaust port. The detected PPM level is displayed in the upper right area of the gas read screen and is saved in the same manner as the other gas readings.

Gas Type	**Range (PPM)**	**Resolution (PPM)**
H_2S	0-50	0.1
	0-200	1.0
CO	0-1000	1.0
SO_2	0-20	0.1
	0-100	1.0
NO_2	0-20	0.1
CL_2	0-20	0.1
H_2	0-1000	1.0
HCN	0-100	1.0

Gas pods are intended for use as an inexpensive detection means and not for regulatory reporting purposes. If the GEM™2000, fitted with a Gas Pod, indicates the presence of the selected gas, further testing should be performed with regulatory approved instrumentation. LANDTEC recommends that field calibration be performed using the relevant gas and concentration, prior to sampling with a gas pod.

2.9 Cold Start

THIS FUNCTION SHOULD BE USED ONLY AS A LAST RESORT.
(For Gas Calibration Error Messages, confirm that Factory Setting and User Calibration is done).

A Cold Start should only be carried out to correct an instrument if no other course of action has proved successful. This function **WILL ERASE** the instrument memory entirely. After a cold start is performed the user will need to reset the instrument to factory settings, perform a field calibration and reset the internal time/date to the default settings. Please note that the time/date may only be updated through DataField software. It cannot be updated manually.

To carry out a cold start, turn the instrument on, during the self-test press and continue to hold the '↵' key until the self-test has been completed. Upon completion of the self-test, a pass code entry screen will be displayed. At this point the '↵' key may be released. Enter the code **12345** and press '↵' to confirm.

After the pass-code entry has been accepted, the instrument serial number will be displayed along with the hours of operation and two options:

1 - Cold Start
0 - Continue

ONLY select option '**1'** if a Cold Start is to be carried out. Press key '**1**' to confirm this operation. The cold start menu will be displayed again, press key '**0**' to continue with normal operation.

3 General Operations Menu

The following features and functions are selectable from the main menu via key ‘① **Menu**’ from the read gas levels screen. Various options are available to the user including:

3.1 Zero Transducers

This function allows the user to zero the pressure transducer(s). Upon selection, the current pressure reading is displayed. The operation will be carried out when the ‘↵’ is pressed.

3.2 Update Site Data

Allows the user to answer questions (pre-defined in DataField software) relating to the site (e.g. name of operator, weather conditions, etc.). Site Questions are different from Site Comments.

This is covered in detail in Section 6 of this manual.

3.3 Data Logging (GA mode only)

Enables the user to leave the Instrument unattended to take samples at a pre-determined time. The reading interval and pump run time may be edited prior to commencing the logging cycle. The ID code may ONLY be set in DataField communication software.

Once the logging function is activated, the instrument will carry out a 30 second ‘Warm-up’ countdown (displayed bottom right) and begin the first sample. After each sample, the unit will shut down (sleep) to conserve power if the time between the pump ending and the next sample is greater than 30 seconds.

The instrument is reactivated (awakened) during a logging cycle, the company logo will be displayed for a few seconds and the read gas levels screen will be displayed. This will initiate a 30 second countdown to the next sample being taken unless the operator stops the logging function.

If for any reason during a logging cycle the inlet port were to become blocked the Instrument will sense this as a flow fail during the ‘pump on’ time and will automatically retry until a reading can be obtained. Therefore, position the sample hoses carefully to ensure no blockage due to water/moisture can occur.

3.4 Print Data

Allows ALL the data currently stored to be printed. This may ONLY be carried out with an appropriate RS232 cable (included with new instruments & available from LANDTEC) and a printer with a serial port connection.

3.5 Adjust Contrast

The GEM™2000 automatically adjusts the screen contrast according to the ambient temperature to maintain normal viewing.

The contrast can be manually adjusted by using the ‘<’ and ‘>’ cursor keys. The manual contrast setting is stored when the instrument is switched off.

3.6 Field Calibration

Whenever carrying out a user calibration function it is important to ensure the correct value is entered. Additionally, in the case of a zeroing function, ensure only ambient air is used and no connection is made to a probe or wellhead fitting. The calibration cylinders sold by LANDTEC have a volume of 17 liters. The regulator, sold by same, is set to 0.5 liters per minute and 15 psig maximum. A normal field calibration usually requires the gas to be running for about two minutes.

Upon selecting this option, the Field Calibration screen is displayed. A brief description of the user span calibration procedure and the current reading (row '**R**') and user span calibration gas values (row '**S**') are displayed.
The span gas values may be changed via the '③ **Edit Target Concentrations**' option. Once this option has been selected, **all** the gas values will require entry. Each entry is to be confirmed by pressing the '↵' key.

3.6.1 Zero Channels

Selected from the '**Field Calibration**' - '**↵-Calibration Menu**' allows the relevant reading to be zeroed. When selected, a list of the available options will be displayed, this usually includes CH_4, and O_2, also the Gas Pod (if fitted).

Supply a zero gas mixture to the instrument for the gas to be zeroed. Ensure the reading for the selected gas has settled to its lowest value before selecting the zero function. When the required option is selected, the user zero function will be carried out automatically. The operation will be carried out when the '↵' key is pressed.

3.6.2 Span Channels

Spanning Channels should be carried out prior to use or when the ambient operating temperature changes greater than +/- 20 degrees. Selected from the '**Field Calibration**' - '**↵-Calibration Menu**', allows the relevant reading to be span calibrated (in accordance with the calibration value entered). When selected, a list of the available options will be displayed, which includes CH_4, CO_2, O_2, (CO & H_2S for the Plus) and Gas Pod (if fitted).

When the required option is selected from the list, the span calibration function will be carried out automatically. When carrying out this procedure, ensure the span calibration procedure (as outlined below) is followed:

1. Apply the relevant known certified gas concentration through the inlet port of the Instrument.
2. Wait until the current gas reading has stabilized.
3. Select the required calibration option via the '**↵-Calibration Menu**'.

3.6.3 Factory Settings

This will clear any user zero and span calibration data. It will also restore the pre-programmed factory settings for **ALL** channels – CH_4, CO_2, O_2 (CO & H_2S for the Plus) or Gas Pod (if fitted) and pressure transducers.

3.6.4 Last Field Cal

Displays the date the last field calibration was carried out (zero or span).

3.7 Mode of Operation

Allows changing instrument between GA mode and GEM mode of operation.

4 Taking Probe Readings (GA Mode)

LANDTEC classifies non-extraction wells as Probes when **NOT** connected to an active vacuum extraction system. Probes, (commonly known as migration probes), may be placed on the perimeter of the landfill to test for gas migration or may be placed next to a building or road to test for the presence of Methane. The GEM™2000 / GEM™2000 Plus instrument may be configured as a Gas Analyzer (GA mode) for sampling probes. To access this function from the gas read screen press '①' for menu and scroll down to **Mode of Operation**, press the '↵' key and highlight **Landfill Gas Analyzer**, pressing the '↵' key again will select GA mode of operation.

4.1 Preliminary Checks

Prior to going to the test site, it is good practice to ensure:

- All necessary ID codes and readings have been uploaded via DataField software.
- The time and date are correct.
- The water trap has a clean and dry filter fitted.
- The inlet-port particulate filter is clean and dry.
- A supply of spare filters is available in case of accidental water blockage or contamination.
- The battery has a good charge (minimum 25% charge, even if only a few readings are required).
- The memory has sufficient space available.
- The CH_4, CO_2, and O_2 readings have been auto-zeroed, without gas concentration present.
- Check the span calibration with a known concentration calibration gas.

Travel to the site with the analyzer in the vehicle's interior - not in the trunk or truck bed, where it may be subjected to extremes of temperature and possible shock damage. Do not place the analyzer against anything hot (e.g. gas extraction pipe, car body or in an unattended car during the summer). This may cause erroneous readings.

When moving around a site, protect the instrument from strong direct sunlight, heavy rain or wind-chill. Strong direct sunlight can raise the temperature of the instrument beyond its operating range. If this occurs, the LCD display will appear almost black and the contrast setting cannot alter the contrast.

Always use the water trap! If the water trap becomes flooded, change the filter immediately and ensure all hoses are clear before re-use.

4.2 Update Site Data

Prior to taking the readings at a particular site, the Site Data should be updated (if programmed). This is accessed via the General Menu '① **Update Site Data**'. This function removes the need for the site conditions to be recorded manually.

A series of up to five questions can be pre-programmed with the use of DataField and answered at this time. The answers to these questions are stored and appended to each reading stored thereafter, until the site data is updated for another site.

4.3 Taking Readings – With ID

For this function to be used it is essential that the relevant ID and if required, previous readings are uploaded to the Instrument. An ID **cannot** be entered from the Instrument.

1. When the read gas levels screen is displayed, option **'③ Next ID'** should be selected. A list of stored IDs is displayed for selection via the '∧' and '∨' cursor keys, the 'next' ID on the list is automatically highlighted. To confirm selection, press the '↵' key. The display may be toggled to display any relevant ID information such as a description of the probe location, work to be carried out, etc.

2. A reminder is displayed to disconnect sample hoses, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via DataField (default is 30 seconds). Once the '↵' key is pressed, purge will begin and the Read Gas Levels screen will be displayed upon completion. The purge may be aborted by pressing the '①**EXIT**' key.
3. The ID number selected and the pump runtime is displayed in the upper left corner of the read gas levels display.
4. At this point, connect the sample hose (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' into place. Then connect the sample hose to the probe sample port. **Do not connect the sample hose to the probe port before connecting to the instrument as this will cause any pressure in the probe to dissipate and a proper pressure reading will not be taken.**
5. As soon as the connection is made, the relative/static pressure reading will be displayed. No sample is taken from the probe at this time. Once the reading stabilizes and the pump starts, the relative/static pressure reading is stored. The relative/static reading will remain displayed as the pressure last taken.
6. The pump will run for the pre-programmed time and a countdown timer will be displayed. The pump may be stopped or started at anytime by way of the '✇' (pump) key. The reading may be stored at anytime with the use of the '↵' key. When the pump automatically stops this should be used as a prompt to store the reading.
7. Upon storing the reading, any pre-programmed questions will be displayed for response. This may require a numeric, alphanumeric selectable comment, or exclusive comment answer. A maximum of eight selectable and exclusive comments may be entered.
8. Disconnect the sample hose from the probe and proceed to Step 1 for the next probe.

For each reading, the following information will be stored:

- ID code.
- Current time/date.
- Site data (if entered).
- All gas readings and balance (CH_4, CO_2, O_2 (, CO and H_2S for the Plus)).
- LEL CH_4.
- Barometric Pressure.
- Relative Pressure.
- Questions/comments.
- Temperature (if temperature probe is connected).
- Gas Pod (if connected).

When the instrument is switched off, a clean air purge is automatically started for a pre-determined period. This may be aborted with the use of the '↵' key, although it is not recommended.

A tone will sound and a flashing bell will be displayed next to the appropriate gas reading value if a preset alarm condition has been exceeded.

4.4 Taking Readings – Without ID

1. From the ID list press **'⑤ Select No ID'** or, if ID information has not been uploaded to the instrument, an ID list will not be available. In either case, the ID will be displayed and stored as '**- - - - - - - -**'.
9. A reminder is displayed to disconnect sample hoses, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via DataField (default is 30 seconds). Once '↵' is pressed, purge will begin and the Read Gas Levels screen will be displayed upon completion. The purge may be aborted by pressing the '①**EXIT**' key.
2. At this point, connect the sample hose (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' in to place.

3. Now connect the sample hose to the probe sample port. **Do not connect the sample hose to the probe port before connecting to the instrument as this will cause any pressure in the probe to dissipate and a proper pressure reading will not be taken.**
4. The pump may be started or stopped at anytime by way of the '⊛' (pump) key and a 'time-on' timer will be displayed. The pump should always be stopped using the '↵' key, before storing a reading.
5. Upon storing the reading, a virtual keyboard will be displayed for any alphanumeric comments to be entered.
6. Disconnect the sample hose from the probe and proceed from step 1 for the next probe.

Except for the ID code information, which will be stored as '**- - - - - - - -**', and probe questions, for each reading the information stored will be the same as that for a reading with an ID.

A tone will sound and a flashing bell will be displayed next to the appropriate gas reading value if a preset alarm condition has been exceeded.

4.5 Temperature Probe Reading

The GEM™2000 / GEM™2000 Plus has the facility to automatically display and record the probe temperature via an optional temperature probe (TP-2000). When a temperature probe is fitted to the RS232 Communication Socket, the temperature will be displayed in the read gas levels screen and recorded with all other data. The temperature probe is part of the GEM™2000 UL certification and is therefore certified for use under the same conditions as the instrument.

4.6 Cross-Gas Effects

4.6.1 Methane, Carbon Dioxide and Oxygen

The Methane reading is filtered to an infrared absorption frequency of 3.41μm (nominal), the frequency specific to hydrocarbon bonds. Instruments are calibrated using certified Methane mixtures and will give correct readings provided there are no other hydrocarbon gasses present within the sample (e.g. ethane, propane, butane, etc.). If there are other hydrocarbons present, the Methane reading will be higher (never lower) than the actual Methane concentration being monitored.

The extent to which the Methane reading is affected depends upon the concentration of the Methane in the sample and the concentration of the other hydrocarbons. The effect is non-linear and difficult to predict.

The Carbon Dioxide reading is filtered to an infrared absorption frequency of 4.29μm (nominal), the frequency specific to Carbon Dioxide. Therefore, any other gases usually found on landfill sites will not affect the Carbon Dioxide reading.

The Oxygen sensor is a newly developed galvanic cell type and suffers virtually no influence from CO_2, CO, H_2S, NO_2, SO_2 or H_2, unlike many other types of Oxygen cell.

The infrared sensors will not be "poisoned" by other hydrocarbons. Normal operation will resume as soon as the gas sample has been purged.

Note - there has been one reported incident of a high reading due to the presence of Carbon Disulfide, which has a similar absorption frequency to Carbon Dioxide.

4.6.2 H_2S, CO and other Optional Gas Pods

The Gas Pods used to measure H_2S and CO do suffer from cross-gas effects. Such effects are not accurately specified. However, the following table may be useful as a guide. This table represents how many ppm would be read by a Gas Pod if 100ppm of the interfering gas was applied, (with no other cross-contaminates being present in the sample).

Cell	**CO**	**H_2S**	**SO_2**	**NO_2**	**CL_2**	**H_2**	**CH_4**	**CO_2**
CO	100	<3	0	<-20	0	<40	0	0
H_2S	<0.5	100	~20	~-20		~0.1	0	0

NOTE: All readings are given in parts per million (ppm). The life of an electrochemical cell is determined by exposure to gasses, typical life being one to two years. It is recommended that Gas Pods be field calibrated at regular intervals.

NOTE: Cross-gas effects can be mitigated by employing a filter for the gas not being tested. The GEM™2000 Plus has a built-in H_2S filter to protect the CO sensor.

4.7 Memory

The instrument's memory is volatile. It is maintained by a battery back-up system, which will maintain the memory while the battery is being changed.

The memory is not to be used as a permanent storage medium and any data should be transferred to a more permanent storage medium as soon as possible. An Instrument should never be stored for prolonged periods with valuable data in its memory.

Although unlikely, sudden shocks, high levels of electromagnetic interference or static discharge may cause memory corruption or loss. If this occurs, the instrument should be Cold Started and the calibration reset to factory settings before further use. **Cold starting will erase all data in the instrument including resetting the time and date to the default value**.

4.8 RF Interference

The gas sensors, especially the Methane sensor, are sensitive to RF interference.

Any device that transmits radio waves can cause your gas readings to fluctuate. Cell phones are the most common cause of the problem. You should never use your cell phone while you are taking gas readings.

5 Taking Extraction Well Readings (GEM Mode)

LANDTEC classifies gas-producing penetrations on landfills as wells when used with vacuum extraction systems and flow determining devices such as the Accu-Flo wellheads, orifice plates or pitot tubes. The GEM™2000 / GEM™2000 Plus may be configured as a Gas Extraction Monitor (GEM mode) for the purpose of sampling wells and obtaining flow measurements. To access this function from the gas read screen press '①' and scroll down to **Mode of Operation**, press the '↵' key and highlight **Gas Extraction Monitor**, pressing the '↵' key again will select GEM mode of operation.

5.1 Preliminary Checks

Prior to going on site, it is good practice to ensure:

- All necessary ID codes and readings have been uploaded via DataField software.
- The time and date are correct.
- The water trap has a clean and dry filter fitted.
- The inlet-port particulate filter is clean and dry.
- A supply of spare filters is available in case of accidental water blockage or contamination.
- The battery has a good charge (minimum 25% charge, even if only a few readings are required).
- The memory has sufficient space available.
- The CH_4, CO_2 and O_2 readings have been auto-zeroed without gas concentration present.
- Check the span calibration with a known concentration calibration gas.

Travel to the site with the analyzer in the vehicle's interior - not in the trunk or truck bed, where it may be subjected to extremes of temperature and possible shock damage. Do not place the analyzer against anything hot (e.g. gas extraction pipe, car body or in an unattended car during the summer). This may cause erroneous readings.

When moving around a site, protect the instrument from strong direct sunlight, heavy rain or wind-chill. Strong direct sunlight can raise the temperature of the instrument beyond its operating range. If this occurs, the LCD display will appear almost black and the contrast setting cannot alter the contrast.

Always use the water trap! If the water trap becomes flooded, change the filter immediately and ensure all hoses are clear before re-use.

5.2 Update Site Data

Prior to taking the readings at a particular site, the Site Data should be updated (if programmed). This is accessed via the General Menu '①'. This function removes the need for the site conditions to be recorded manually. A series of up to five questions can be pre-programmed with the use of DataField and answered at this time. The answers to these questions are stored and appended to each reading stored thereafter, until the site data is updated for another site.

5.3 Taking Gas and Flow Readings (GEM Mode)

The GEM mode of operation is designed to allow for gas flow (SCFM) and energy measurements (BTU) to be calculated at the wellhead. This function requires the use of an ID that has been uploaded from DataField software with the type of flow device defined. **Gas flow and BTU will not be calculated if this action has not been performed.**

1. When the gas read screen is displayed select **'③ Next ID'**. A list of stored IDs will be displayed for selection via the '∧' and '∨' cursor keys, the 'next' ID is automatically highlighted, to confirm the selection press the '↵' key. The screen may be toggled to display any relevant ID information such as a description of the well location, work to be carried out, etc.

2. A reminder is displayed to disconnect sample hoses, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via DataField (default is 30 seconds). Once the '↵' key is pressed, purge will begin and the Read Gas Levels screen will be displayed upon completion. The purge may be aborted by pressing the '①**EXIT**' key.
3. Connect the sample hoses (with water trap filter) to the wellhead ensuring the gas sample hose and impact pressure hose are properly oriented. Insert the temperature probe if used.
4. Press the '✇' key to start the sample pump; a countdown timer will be displayed in the upper left area of the display. The pump may be stopped and restarted and any time by pressing the '✇' key. The pump run time is set in DataField software. Allow the gas readings to stabilize and press '⑤**Measure Flow**' key, this will store the gas level readings and display the '**PRESSURE READINGS**' screen. Note; a flashing bell will be displayed next to the appropriate gas and a beeping tone will be heard, if a preset alarm condition has been exceeded.
5. The '**PRESSURE READINGS**' screen will prompt the user to disconnect the sample hoses and allow the pressure to stabilize. Once the pressure has stabilized press '↵ **Zero Transducers**'. Press '①' to continue. **Note**; if Accu-Flo wellheads are used this zero function may be performed prior to connecting the sample hoses to the well head by selecting **'① MENU**' and highlighting '**ZERO TRANSDUCERS**'. This eliminates the need to disconnect and re-connect the sample hoses on the same wellhead.
6. If a temperature probe is not connected, the user is prompted to manually input the gas temperature, press the '↵' key when entry is finished.
7. The gas flow and energy screen is now displayed showing all the gas level readings taken in the gas read screen as well as the level of gas flow (SCFM) and power (BTU). In addition, Adjusted, Current and Previous (if downloaded) readings are displayed so modifications may be made to the well if required.
8. Pressing '↵ **STORE**' will save the readings to memory. Then, the comments screen (if comments were loaded) will display and allow you to answer questions or select comments about the condition of the well. A total of seven comments and one exclusive comment may be stored with each ID.
9. Press '③ **NEXT ID**' and proceed to the next wellhead. An automatic purge will be performed at this time to ensure the sample has been exhausted from the instrument.

For each reading, the following information will be stored:

- ID code.
- Current time/date.
- Site data (if entered).
- All gas readings and balance gas (CH_4, CO_2, O_2 (CO & H_2S for the Plus)).
- Barometric Pressure.
- Temperature.
- Gas Pod (if connected).
- Gas flow (SCFM) and Power (BTU).
- Comments and exclusive comment.

When the Instrument is switched off, a clean air purge is automatically started for a pre-determined global period. This may be aborted by pressing the '↵' key, although we do not recommend this action.

6 DataField CS Software

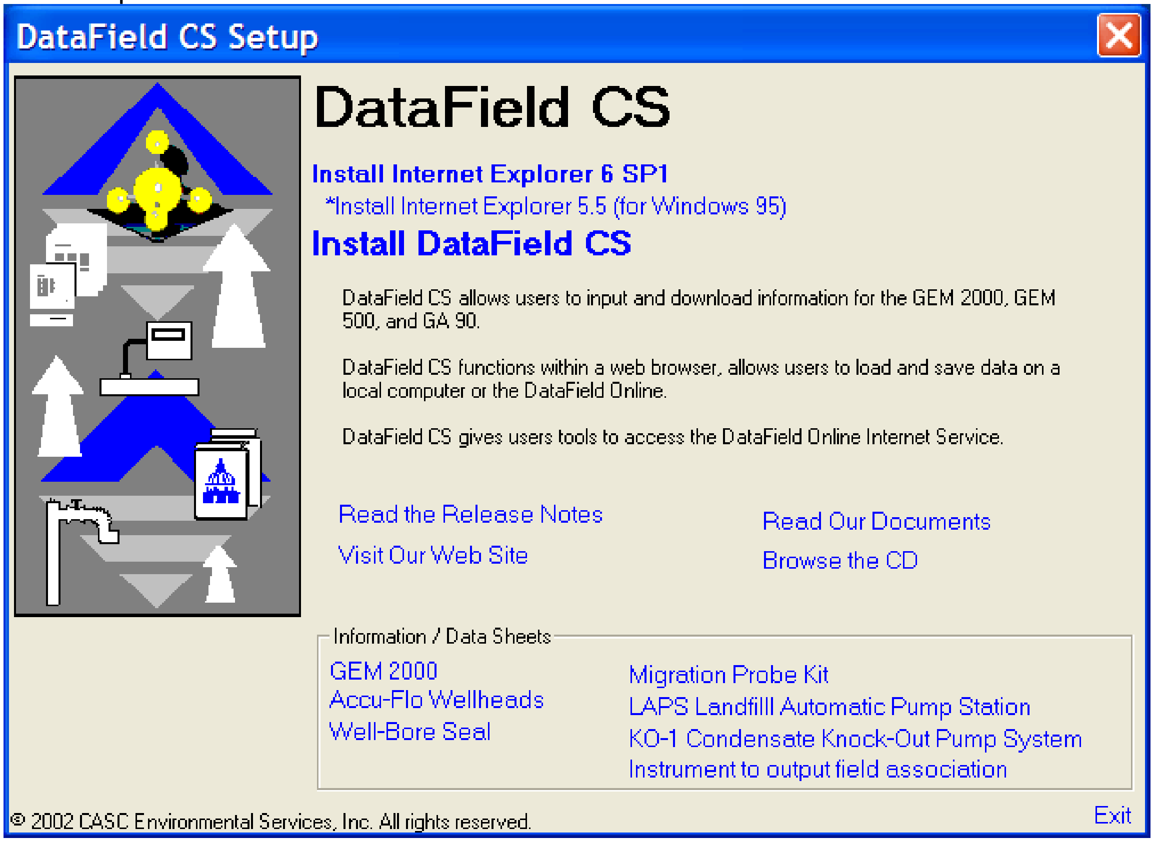
DataField CS is an integrated software program designed to communicate with the GEM™2000, Plus, GEM™2000, GEM™500 and GA-90 instruments. The software will create files used for storing gas read data, ID data, comments and instrument configuration data. The files created are significantly different from the files created with GEM_COMM or GA_COMM software and are not compatible with these versions of software.

DataField CS is browser based (Java enabled) and will operate on Windows 98/ME/NT/2000/XP operating systems. Recommended hardware requirements are:

- Pentium III 500 MHz microprocessor or equal.
- 64 MB RAM.
- 120 MB of free hard disk space.
- CDROM drive.
- Mouse or pointer system.
- Standard keyboard.
- Installed printer.

6.1 Installing DataField CS

Be sure your computer is turned on and all software programs have been properly closed. Place the program disk in the CD ROM drive and close the tray. DataField CS will self start and display the DataField CS set-up screen.*



DataField CS allows users to input and download information for the GEM 2000, GEM 500, and GA 90.

DataField CS functions within a web browser, allows users to load and save data on a local computer or the DataField Online.

DataField CS gives users tools to access the DataField Online Internet Service.

Install the Internet Explorer 6 SP1 by clicking on the corresponding link in the DataField CS set-up screen. If you are using Windows 95, install the Internet Explorer 5.5. Follow the onscreen instructions until the Internet Explorer is installed successfully.

Reboot the computer after the installation of the Internet Explorer is completed.

Re-insert CD Rom to start autorun again.

Install the DataField CS by clicking on the corresponding link in the DataField CS set-up screen. Follow the onscreen instructions.*

Other useful links on the DataField CS set-up screen:

Read the DataField CS Overview link will open a presentation with an overview of DataField CS.

Read the Release Notes link has information on the system requirements, application compatibility and other important issues.
Visit Our Web Site link will open the LANDTEC web site.
Read Our Documents link will open a new window with manuals and user guides for GEM Instruments, as well as several viewers and 3rd party tools that can be downloaded.
Browse the CD link will open a file browser.
Information / Data Sheets set of links provides information on various Landfill instruments.

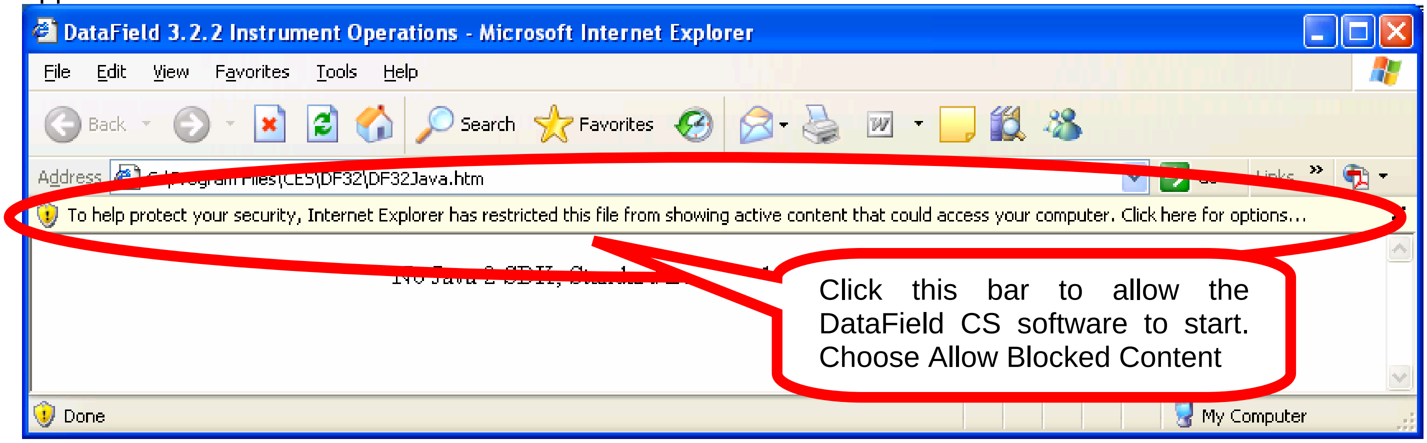
* If the DataField CS set-up screen hasn't appeared, open a file browser (ex. right-click on the Start button on your desktop and choose open) and navigate to your CD-ROM drive. Double-click on the **Autorun.exe**.

6.2 Establishing Communications

Connect the RS-232 download cable to an open COM port on your computer. Connect the other end of the RS-232 download cable to the GEM™2000 / GEM™2000 Plus data port. DataField CS has the ability to automatically scan the different COM ports on your computer to find where the instrument is connected.

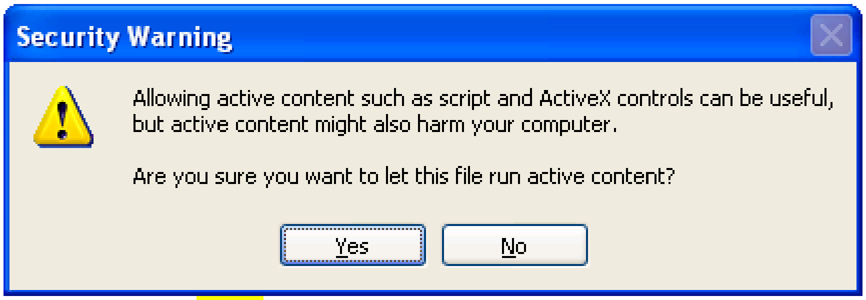
Turn the instrument on, wait for the self-test function to finish. The Gas Readings screen will display, if not, then turn off the GEM and re-start the instrument. The GEM™2000 / GEM™2000 Plus must be in the Gas Reading screen in order to establish communications.

Once the instrument is in the proper communications mode, click on the Start menu then All Programs menu. Scroll to DataField and then DataField CS to initialize the software. The following screen may appear



To help protect your security, Internet Explorer has restricted this file from showing active content that could access your computer. Click here for options...

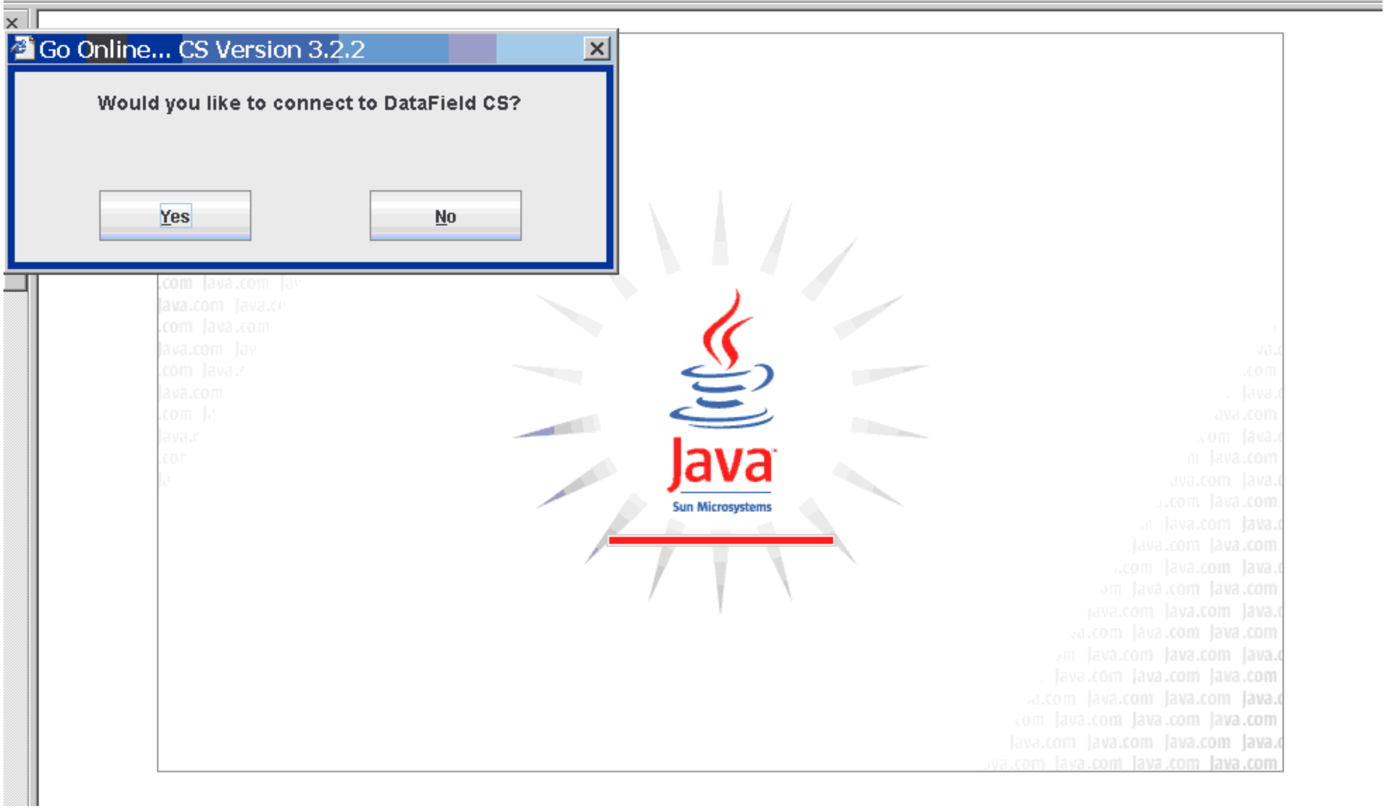
Click this bar to allow the DataField CS software to start. Choose Allow Blocked Content



Allowing active content such as script and ActiveX controls can be useful, but active content might also harm your computer.

Are you sure you want to let this file run active content?

Answer yes to allow the Active Content to load.

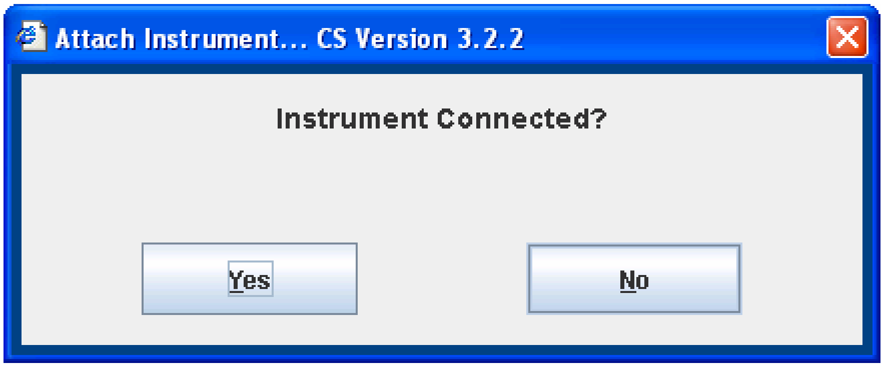


Would you like to connect to DataField CS?

This the Java screen and it part of the DF program.
The DataField CS here in the pop up window is the internet service from CES LANDTEC.

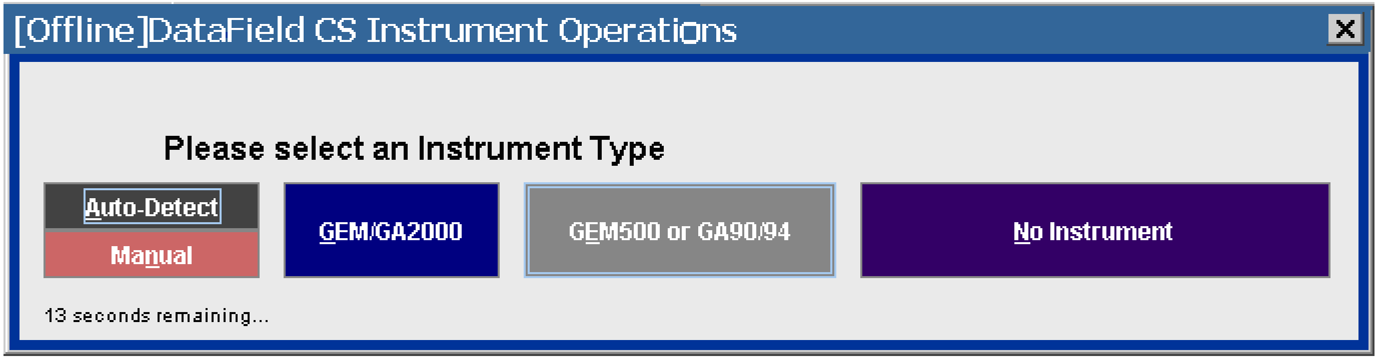
Would you like to connect to DataField CS?

Click Yes to connect DataField CS to the online EnviroComp Report Service or No to run it offline.



Instrument Connected?

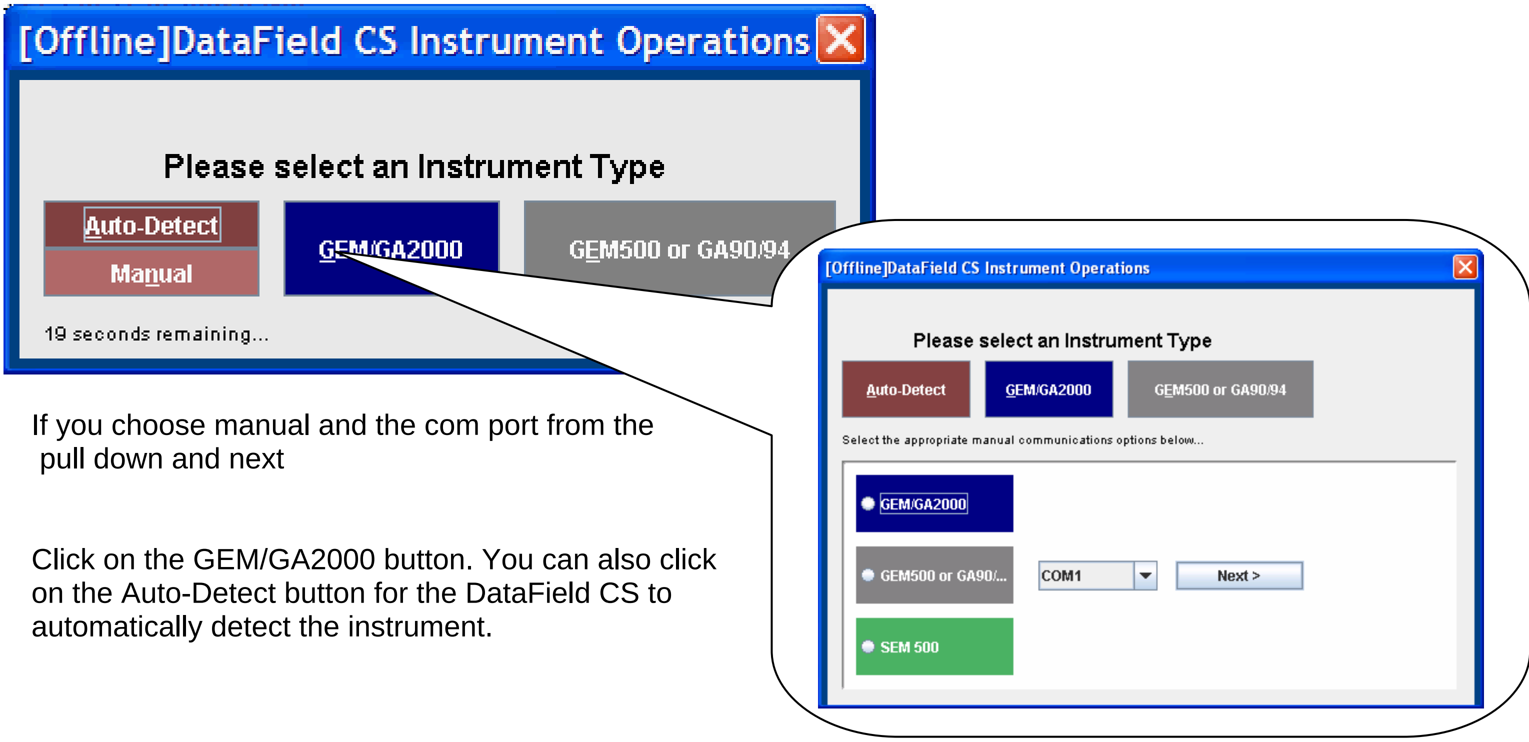
Select Yes If your Instrument is connected with the RS-232 Cable



Please select an Instrument Type

13 seconds remaining...

Please select an Instrument type. Click on Gem 2000
OR



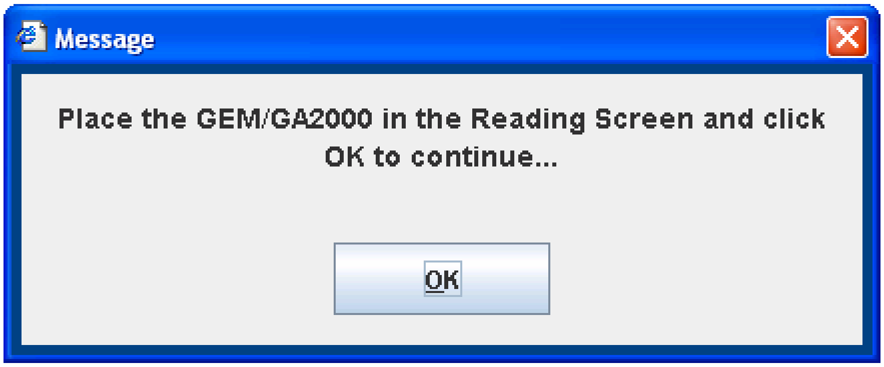
Please select an Instrument Type

19 seconds remaining...

Select the appropriate manual communications options below...

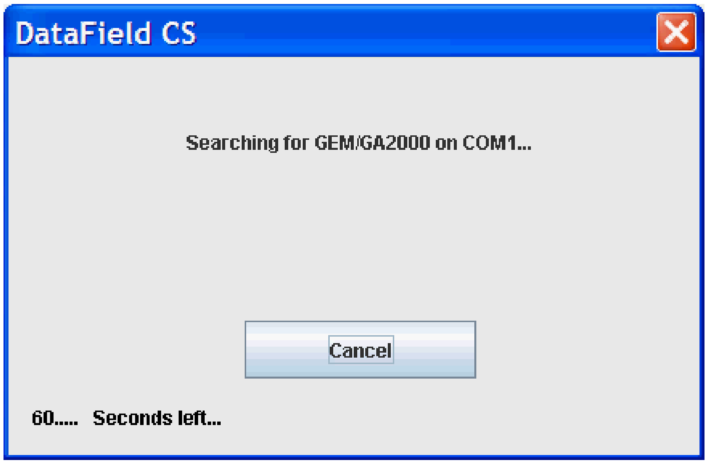
If you choose manual and the com port from the pull down and next

Click on the GEM/GA2000 button. You can also click on the Auto-Detect button for the DataField CS to automatically detect the instrument.



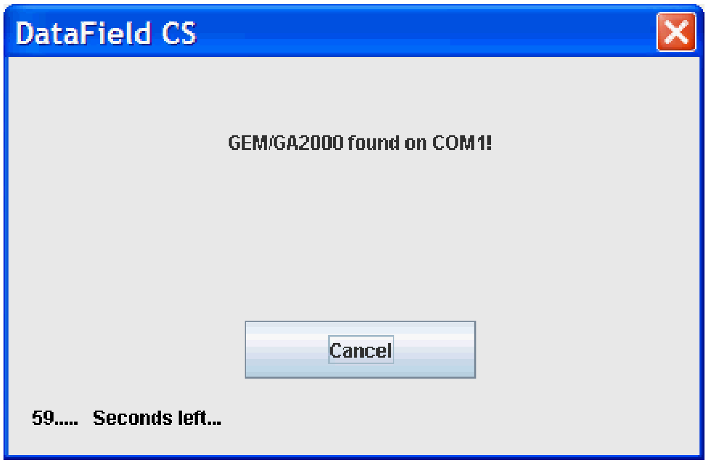
Place the GEM/GA2000 in the Reading Screen and click OK to continue...

Click OK and DataField CS will automatically search for the instrument. This may take a few minutes. When the instrument is found and the communication is established, the software will display a box that indicates what type of instrument was found. If the software does not find the instrument, it will display a box that indicates that no instrument was found.



Searching for GEM/GA2000 on COM1...

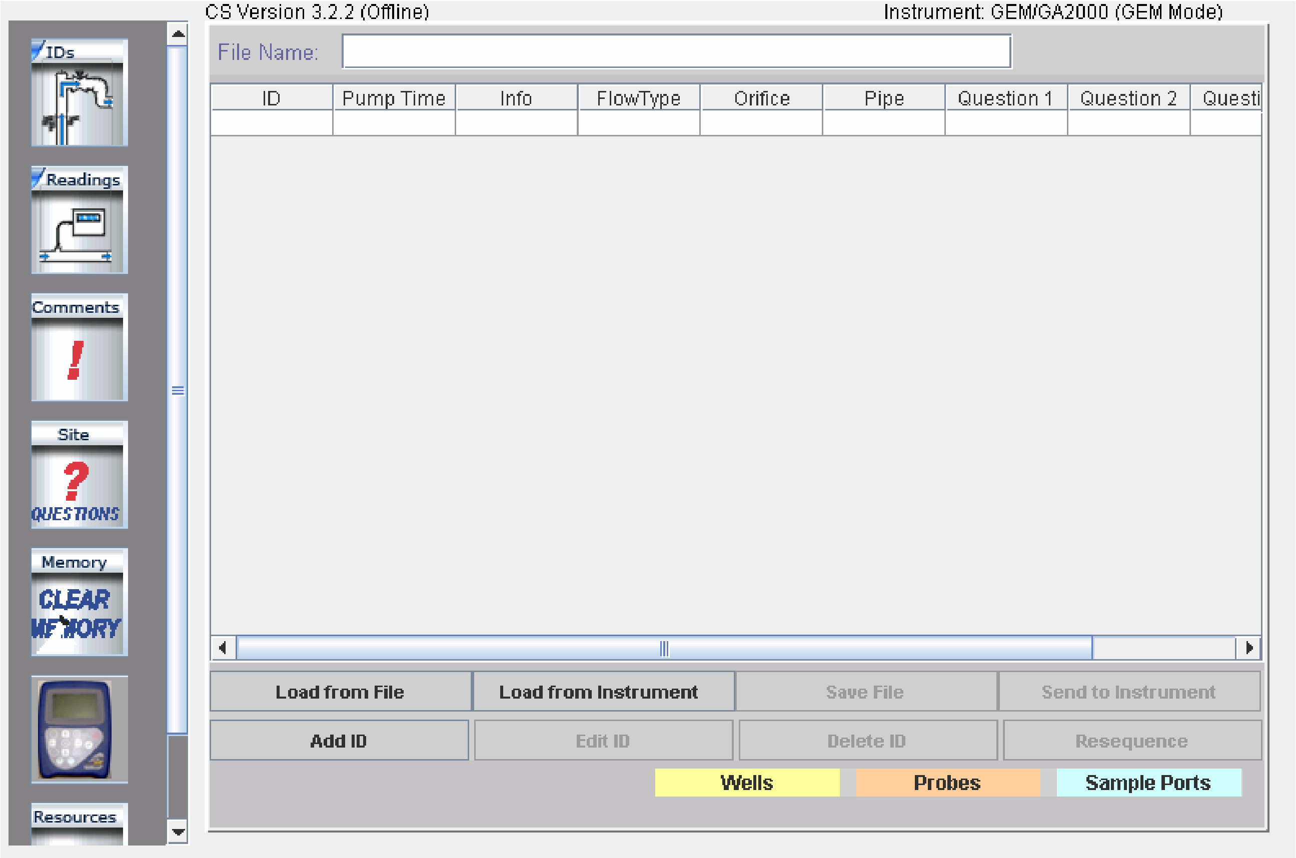
60..... Seconds left...



GEM/GA2000 found on COM1!

59..... Seconds left...

6.3 *Main Screen*



CS Version 3.2.2 (Offline)

Instrument: GEM/GA2000 (GEM Mode)

Once DataField CS establishes the communication with the instrument, the main software screen will appear.

Seven main categories (buttons) are listed down the left side of the screen: ID Functions, Readings, Comments, Site Questions, Clear Memory, Instrument Settings and Resource Links. Clicking on any one of the buttons will take the user to that functionality of the application.

6.4 *Close the program*

Clicking on the **Close** button in the top right corner of the screen will exit the program. This will close all files and exit the program.

6.5 *Communications*

It is not possible to change instruments and establish communications without re-starting the software.

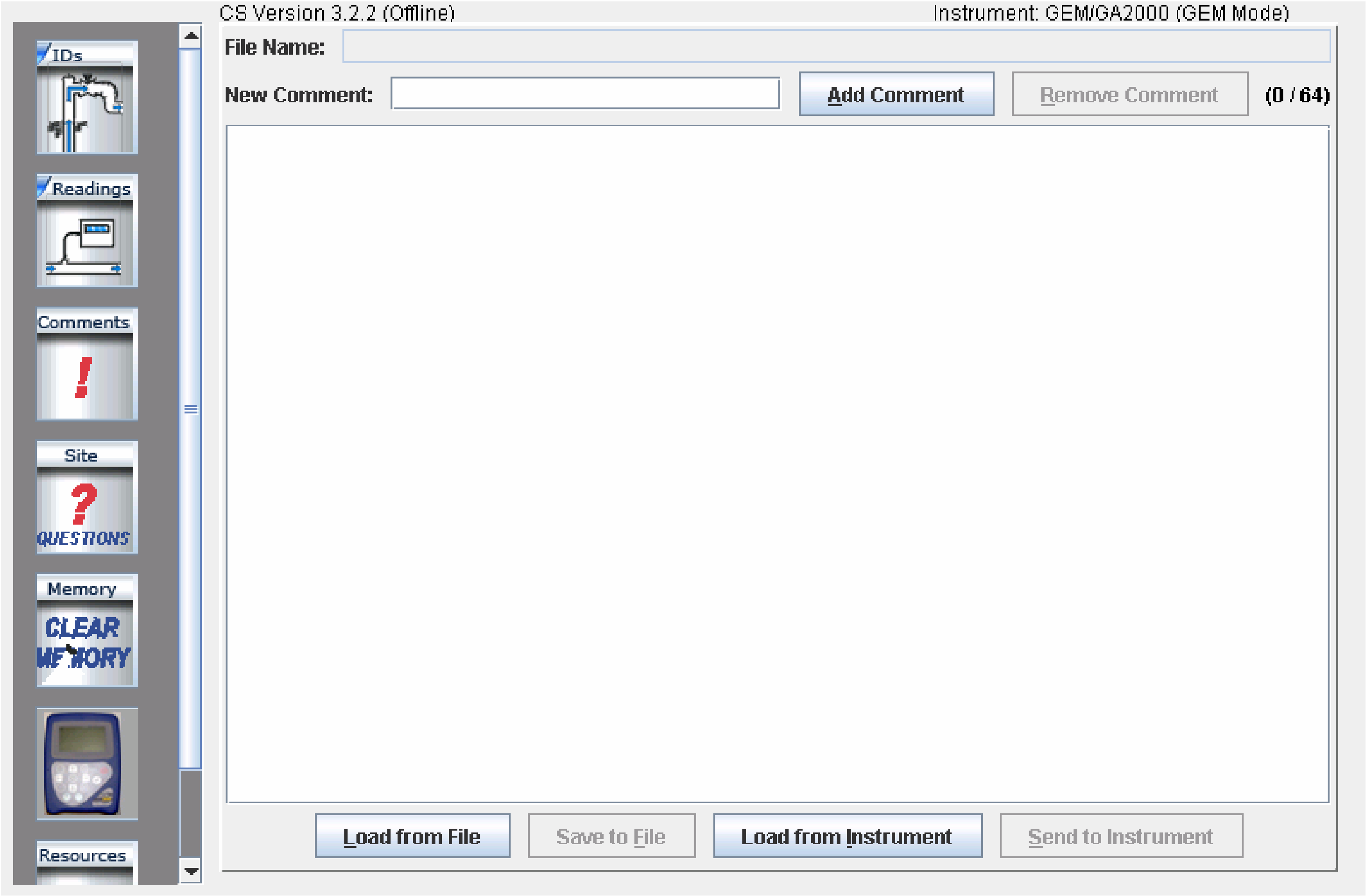
6.6 Functions

Each button has a specific function as listed below:

1. **Comments** – Allows entry of comments that may be selected for the IDs. A total of seven comments and one exclusive comment may be selected for each ID.
2. **IDs** – Used for adding new IDs, editing IDs or deleting IDs and entry of ID parameters such as pump run time, flow device, comments and questions for the ID.
3. **Readings** – Allows downloading and viewing data from instrument and uploading of previous data to the instrument.
4. **Site Questions** – DataField CS supports a total of five site questions that are answered by the technician and saved to the ID data.
5. **Clear Memory** – Allows the deletion if selective IDs, readings, comments, site questions or all memory loaded in instrument memory.
6. **Resource Links** – Allows the user to directly access information via the www.

6.6.1 Comments

DataField CS allows up to 64 comments to be created for upload to the GEM™2000. Each comment may be up to 36 characters in length and may be alphanumeric or any character on the computer keyboard. **Select Comment** or **Exclusive Comment** must be turned on for comments to be selected for that ID. See section 6.6.2. Click on the **Comments** button to open the following screen.


CS Version 3.2.2 (Offline)

Instrument: GEM/GA2000 (GEM Mode)

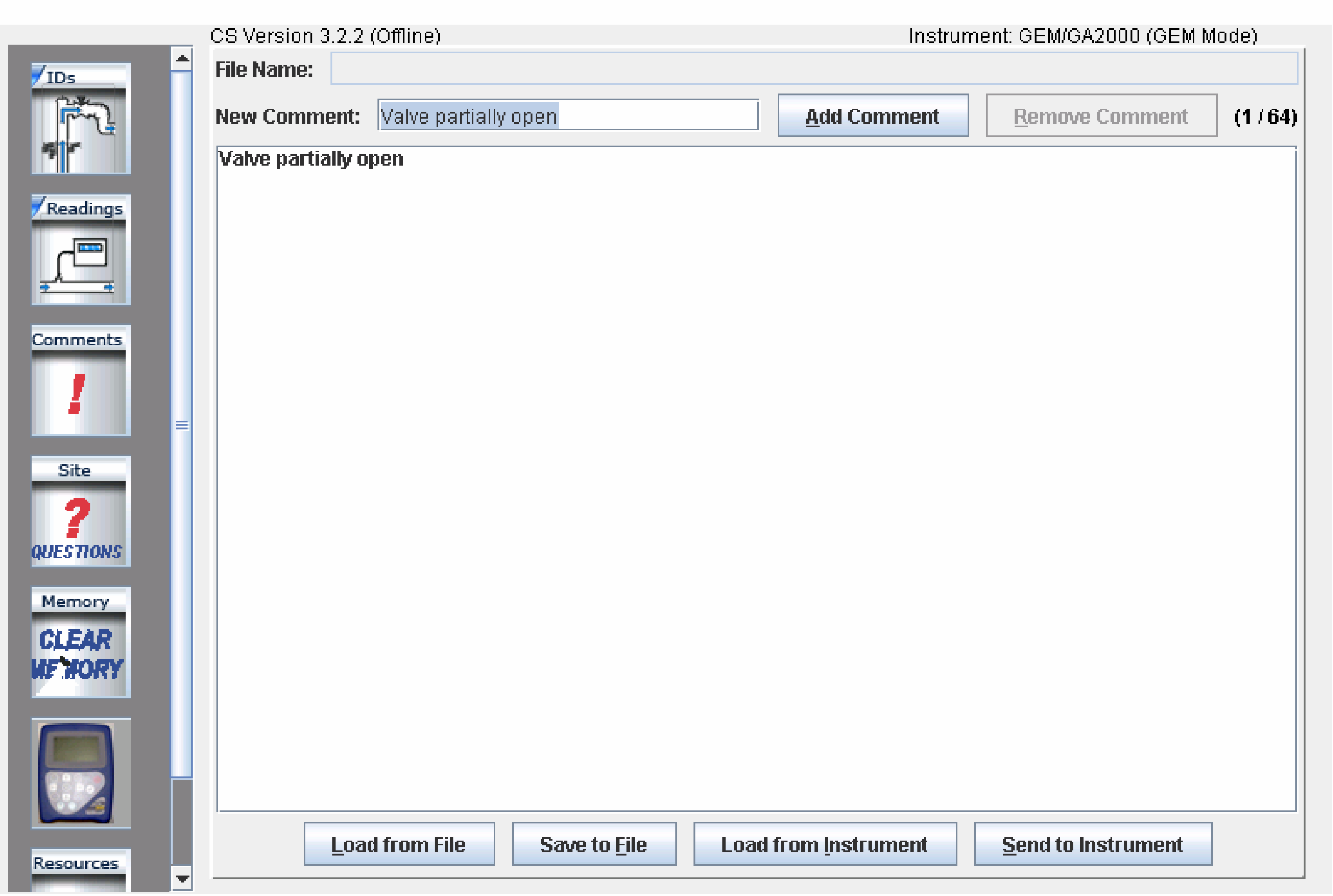
File Name:

New Comment:

(0 / 64)

Enter the comment on the comment line and press **Enter** to continue entering comments until all the desired comments have been entered. Click on **Save File** to save the data to disk and then click on **Send to Instrument** to save the comments in the instrument. To delete a comment, click on the comment to highlight the comment and press the **Delete** key on the computer keyboard to remove the highlighted comment. It is always suggested to save the comment file because of the potential size and time required to recreate the comments. Once created, the comment file may be modified and saved under a different file name at any time.

Note: Comments must be created and sent to the instrument through the software. They can not be hand input into the instrument in the field.



CS Version 3.2.2 (Offline)

Instrument: GEM/GA2000 (GEM Mode)

File Name:

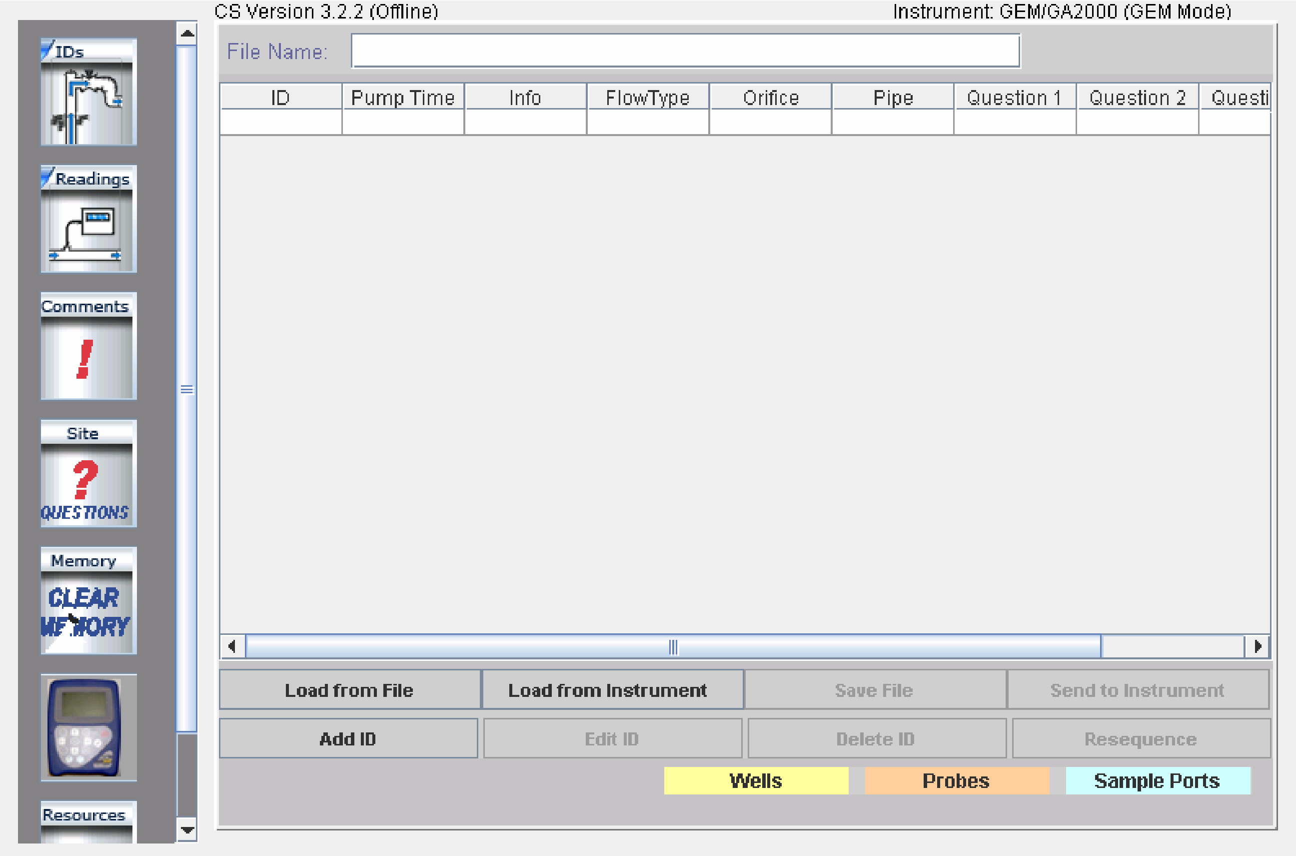
New Comment: Valve partially open

(1 / 64)

Valve partially open

6.6.2 Entering IDs

From the opening screen select the **ID** button. The following screen will open:



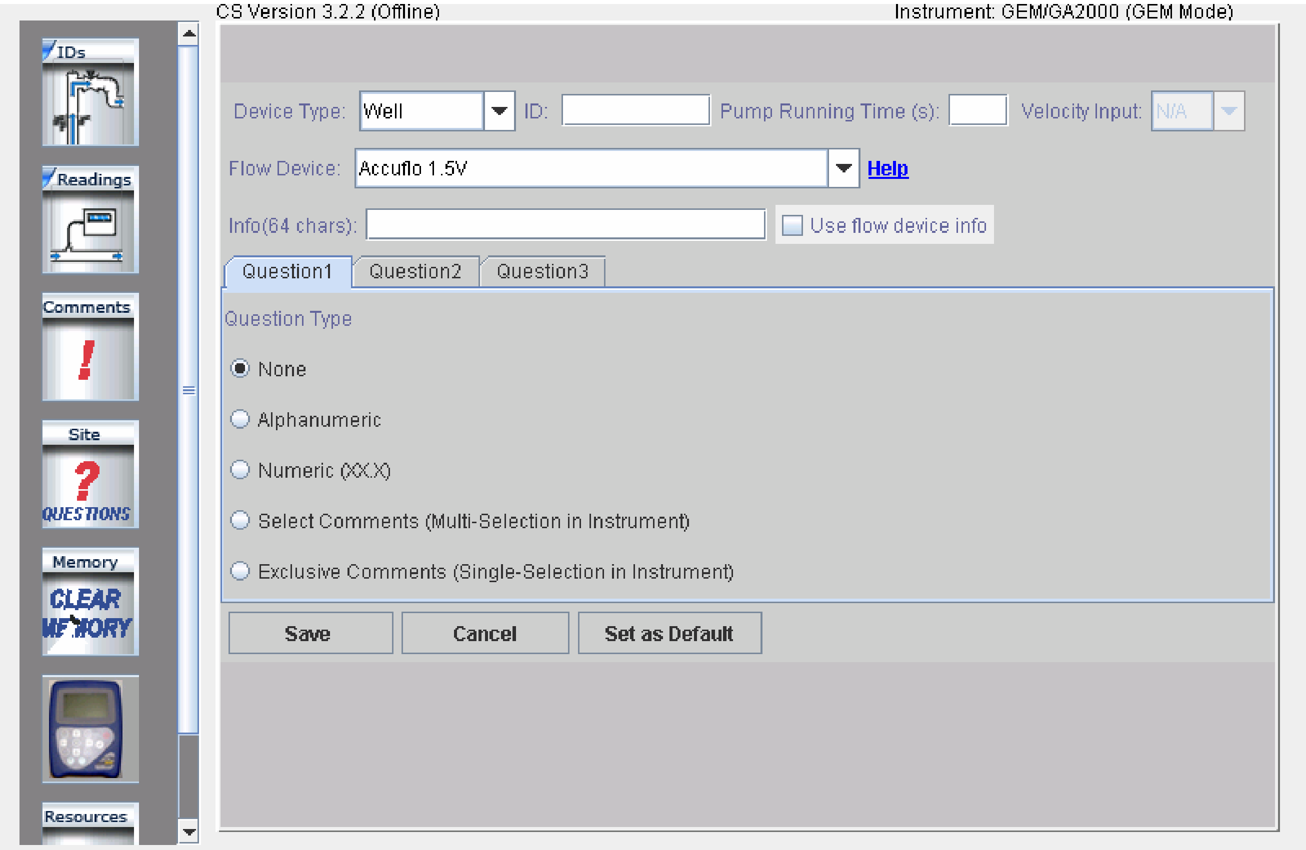
Selecting the **Save File** button will allow you to enter the name for the file you wish to save. The naming of files follows the extended naming convention for Windows (255 characters maximum, all characters allowed except \ / : * ? " < > |).

Selecting the **Load from File** button will allow a previously created file to be loaded from the computer disk drive.

Selecting the **Load from Instrument** button will allow previously loaded IDs in the instrument to be downloaded for modification such as increasing the pump run time or adding additional comments to a specific ID. CAUTION: Loading IDs from an instrument can be a dangerous practice and is not recommended if using DF online service. The possibility exists of introducing into a project IDs from another project. When the IDs are downloaded from the instrument and stored online all IDs that are present in the instrument will be stored to the current project IRRESPECTIVE of if the IDs belong to the project.

Add ID button is used for the creation of a new ID or multiple IDs that may be sent to the instrument or saved to a new file for later use.

To enter a new ID or create a new ID set, click on the **Add ID** button and the following screen will open:



CS Version 3.2.2 (Offline)

Instrument: GEM/GA2000 (GEM Mode)

Device Type: Well

ID:

Pump Running Time (s):

Velocity Input: N/A

Flow Device: Accuflo 1.5V

Info(64 chars):

☐ Use flow device info

Question Type

● None

○ Alphanumeric

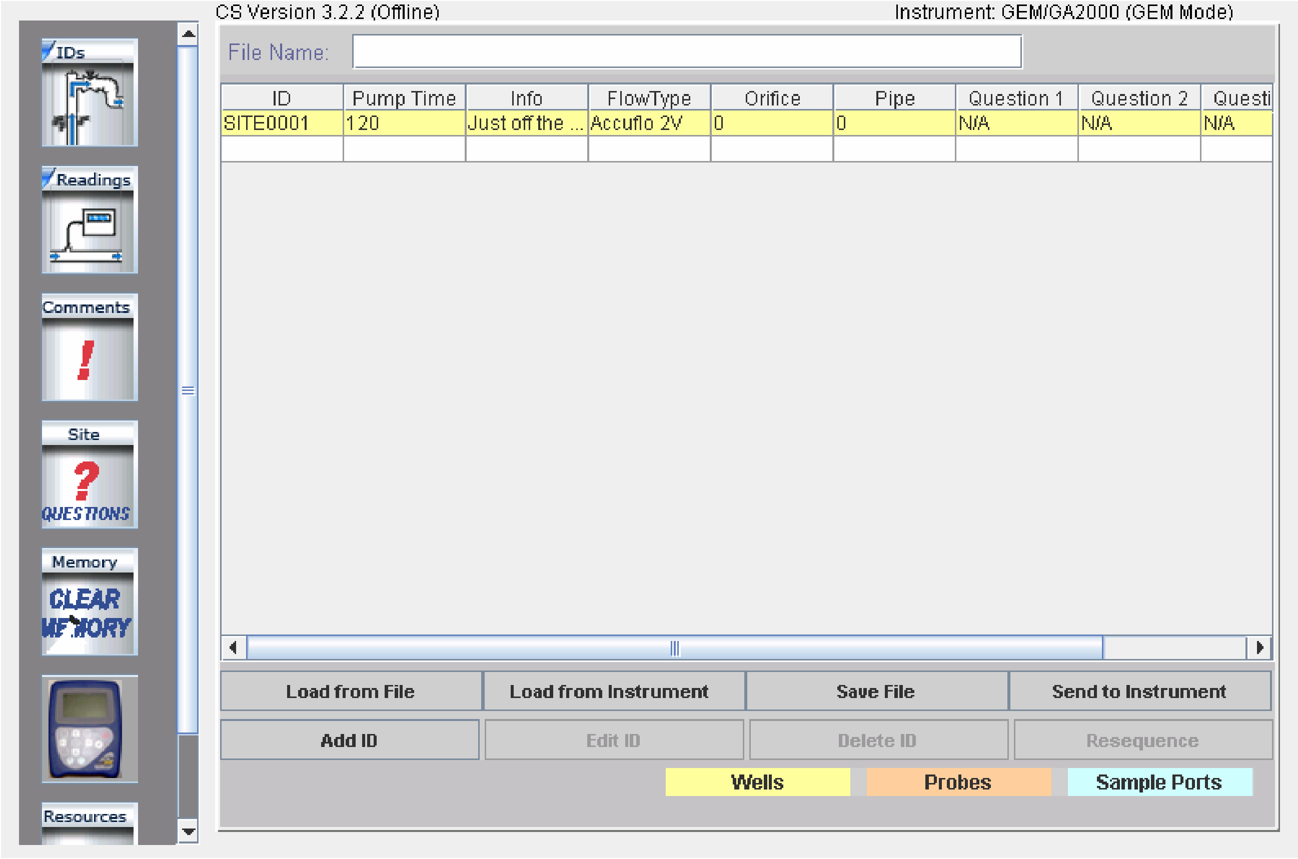
○ Numeric (XX.X)

○ Select Comments (Multi-Selection in Instrument)

○ Exclusive Comments (Single-Selection in Instrument)

Enter the Well ID in any combination of alpha or numeric characters for a maximum of eight characters. **All eight characters must be used**. Enter the pump run time in seconds (maximum of 999 seconds); pump run time must be entered in order for the pump to be turned on for gas sampling. Enter information about the well, such as its location, previous problems, etc or leave blank. Enter the type of flow device used with the well (Accu-Flo wellhead, Pitot tube, or orifice plate); user input may also be selected. If Pitot tube or orifice plate is selected, the **inside** pipe diameter and **orifice diameter** must be entered. If the pump run time and the flow device are going to be the same for multiple wells, click on **Set as Default** to lock these two values. Three questions may be asked about the well for reply by the technician at the time a sample is taken. These can take the form of alphanumeric, numeric, selected comments or exclusive comments. If none is selected then no questions will be asked for this ID. Note: **If Select Comments or Exclusive Comments is selected, Comments must be created and sent to the instrument.** See section 6.6.1.

Click on **Save** to add this ID to the editor screen seen below. If additional IDs need to be entered, simply click on **Add ID** and enter the data as before.



CS Version 3.2.2 (Offline) Instrument: GEM/GA2000 (GEM Mode)

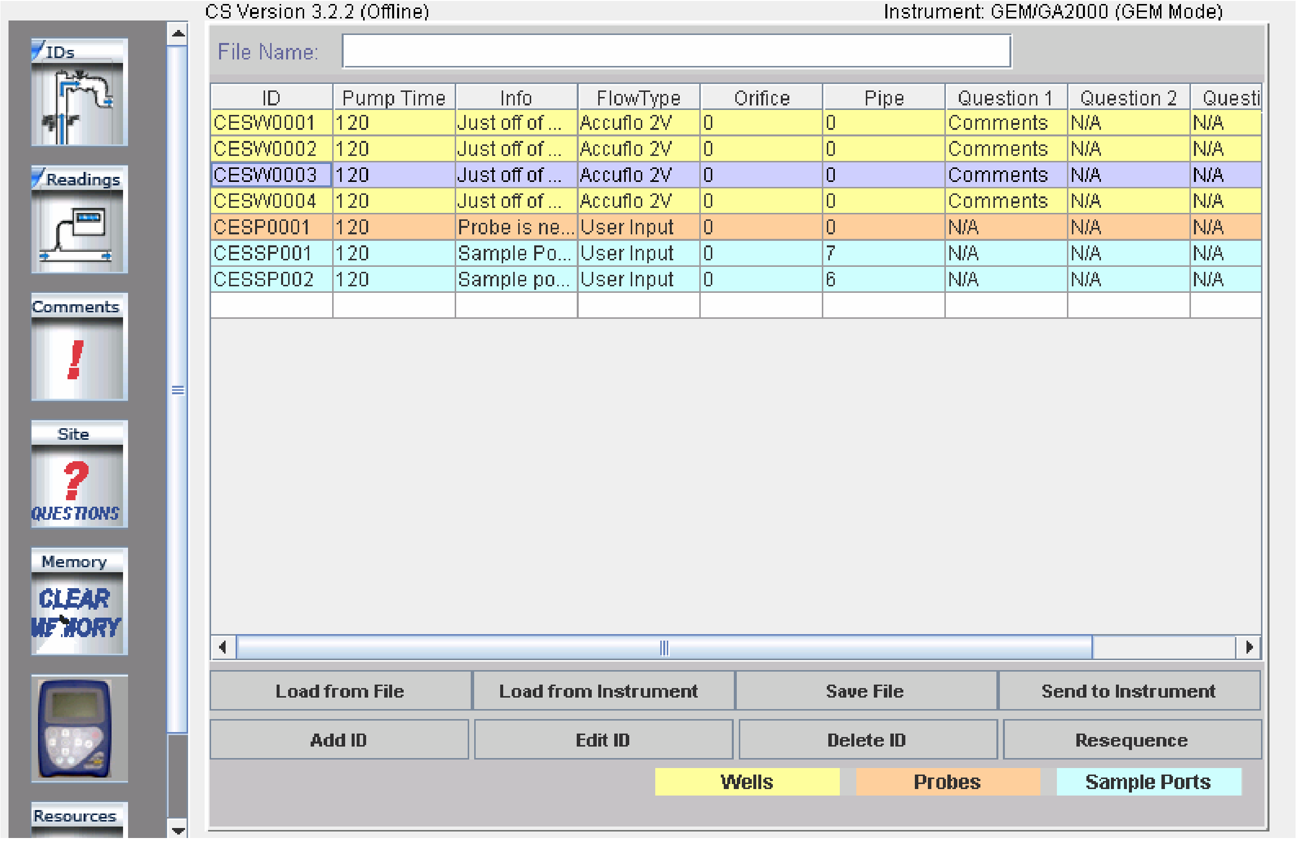
File Name:

ID	Pump Time	Info	FlowType	Orifice	Pipe	Question 1	Question 2	Questi
SITE0001	120	Just off the ...	Accuflo 2V	0	0	N/A	N/A	N/A

Once all the IDs have been entered, click **Save File** button to save the ID data to a file or **Send to Instrument** button if data is to be uploaded to an instrument for field sampling.

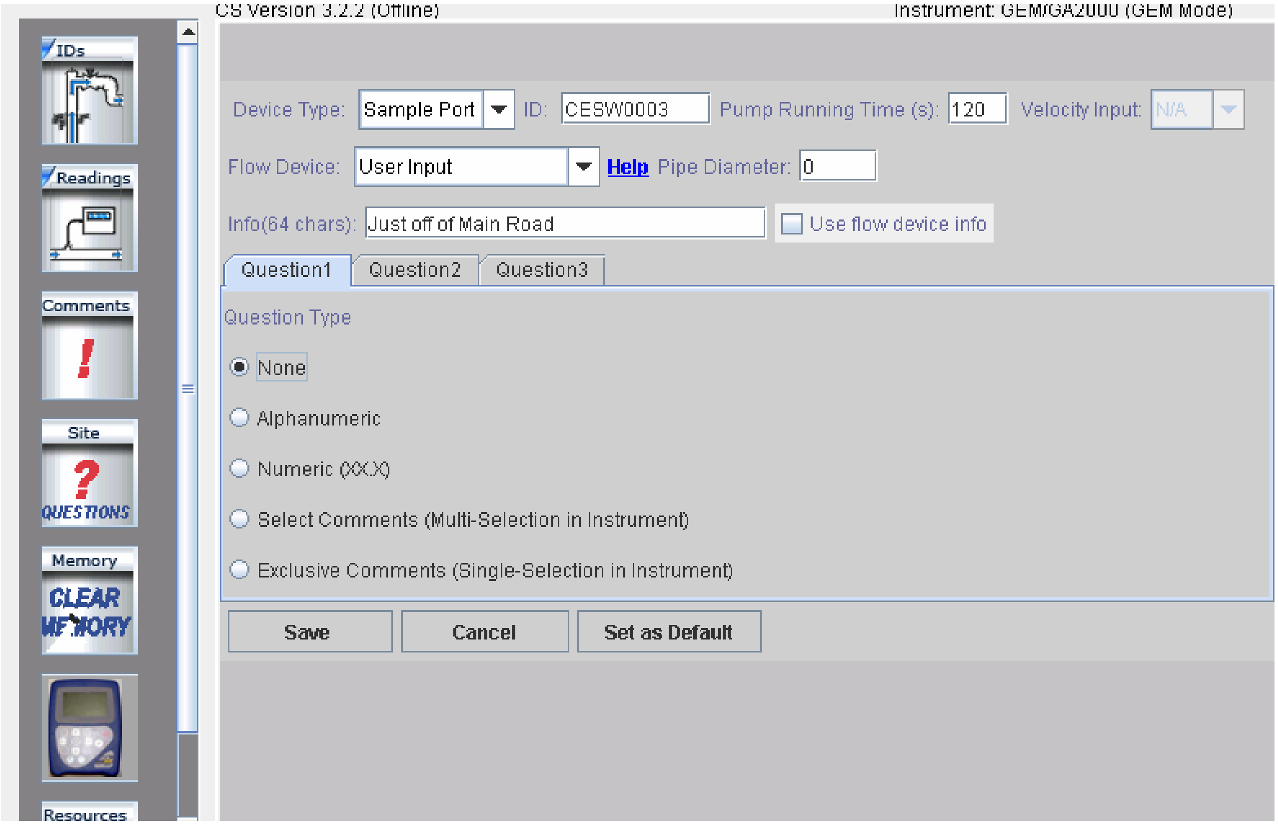
6.6.3 Editing IDs

IDs may be edited in a similar manner to entering a new ID. Click on the **ID** button. Click on the **Load from File** button if the IDs to be edited are in a saved file on disk or click on **Load from Instrument** if the IDs to be edited reside in the instrument. Once the IDs have been opened, the **ID Editor** screen will appear as shown below.



ID	Pump Time	Info	FlowType	Orifice	Pipe	Question 1	Question 2	Questi
CESW0001	120	Just off of ...	Accuflo 2V	0	0	Comments	N/A	N/A
CESW0002	120	Just off of ...	Accuflo 2V	0	0	Comments	N/A	N/A
CESW0003	120	Just off of ...	Accuflo 2V	0	0	Comments	N/A	N/A
CESW0004	120	Just off of ...	Accuflo 2V	0	0	Comments	N/A	N/A
CESP0001	120	Probe is ne...	User Input	0	0	N/A	N/A	N/A
CESSP001	120	Sample Po...	User Input	0	7	N/A	N/A	N/A
CESSP002	120	Sample po...	User Input	0	6	N/A	N/A	N/A

To select an ID for editing, click on the ID to highlight the ID, and then click on the **Edit ID** button. The Edit ID screen will open and allow information for the selected ID to be changed. When finished with the changes, click on **Save** to save the edited ID to the ID list.



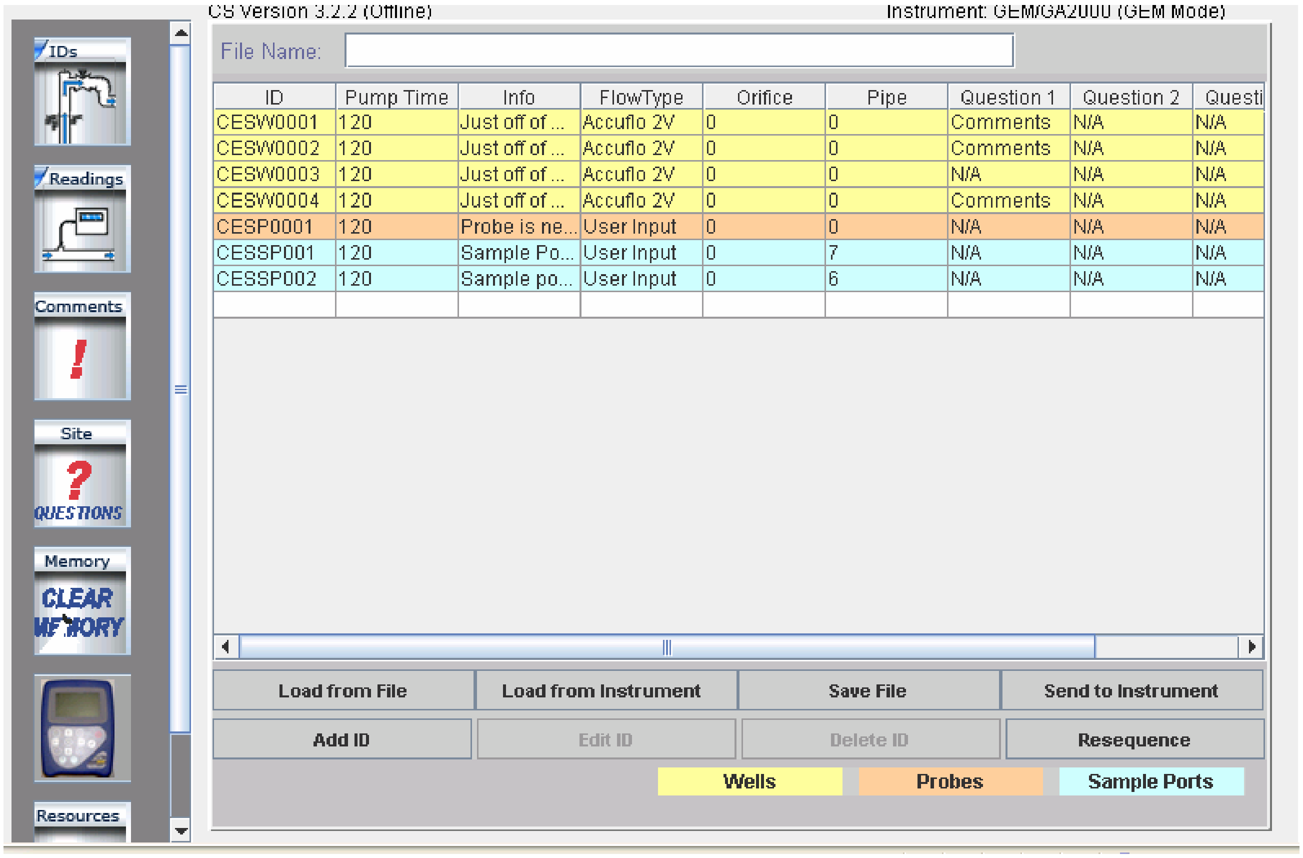
CS Version 3.2.2 (Offline)
Instrument: GEM/GA2000 (GEM Mode)

Device Type: Sample Port
ID: CESW0003
Pump Running Time (s): 120
Velocity Input: N/A
Flow Device: User Input
Pipe Diameter: 0
Info(64 chars): Just off of Main Road
☐ Use flow device info

Question Type
● None
○ Alphanumeric
○ Numeric (XX.X)
○ Select Comments (Multi-Selection in Instrument)
○ Exclusive Comments (Single-Selection in Instrument)

When editing is completed, click on **Save** to return to the previous screen. Click on **Save File** to save the edited data to disk or click on **Send to Instrument** to append the IDs to the IDs in the instrument.
Note: IDs are only appended to the unit. It is strongly recommended to erase/clear IDs from unit prior to sending new IDs to the unit. One obvious exception is in the case of loading IDs for multiple sites in an instrument.

\



ID	Pump Time	Info	FlowType	Orifice	Pipe	Question 1	Question 2	Questi
CESW0001	120	Just off of ...	Accuflo 2V	0	0	Comments	N/A	N/A
CESW0002	120	Just off of ...	Accuflo 2V	0	0	Comments	N/A	N/A
CESW0003	120	Just off of ...	Accuflo 2V	0	0	N/A	N/A	N/A
CESW0004	120	Just off of ...	Accuflo 2V	0	0	Comments	N/A	N/A
CESP0001	120	Probe is ne...	User Input	0	0	N/A	N/A	N/A
CESSP001	120	Sample Po...	User Input	0	7	N/A	N/A	N/A
CESSP002	120	Sample po...	User Input	0	6	N/A	N/A	N/A

6.6.4 Delete IDs

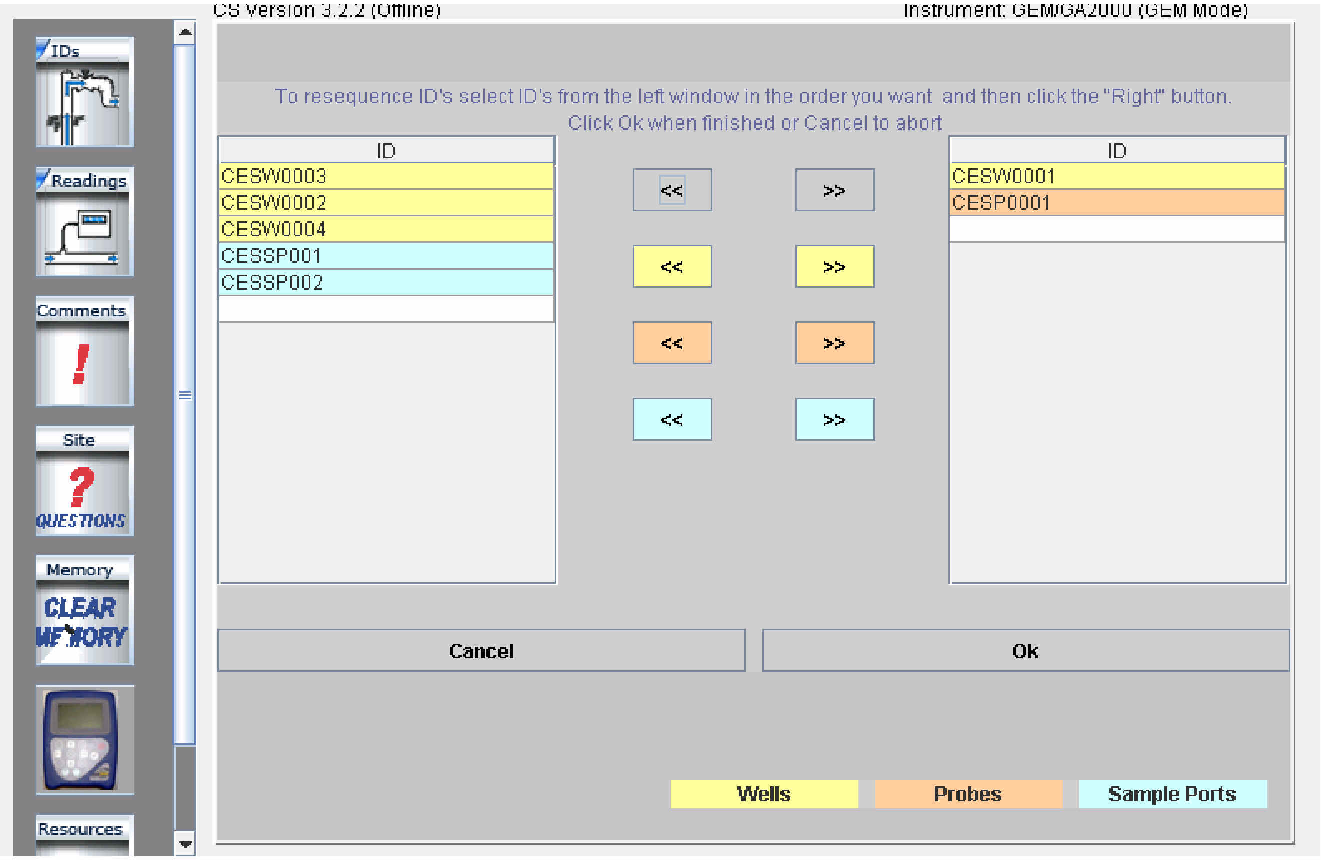
Select an ID to delete and click on it to highlight it. Click on the **Delete ID** button. A prompt will appear to verify the action. Clicking **Yes** will delete the ID. To select multiple IDs use **Ctrl** and **Shift** buttons on your keyboard. When deleting multiple IDs after clicking on the **Delete ID** button a prompt will appear: “Would you like to verify each deletion?” Clicking **No** will delete all the selected IDs. Clicking **Yes** will prompt on the deletion of each ID in the selection. In this case the deletion of some IDs in the selection can be cancelled.

Click on **Save File** to save the updated file to disk or click on **Send to Instrument** to update the instrument for field sampling.

Note: We suggest clearing the ID information from the instrument prior to uploading the revised ID list. Otherwise the new ID list will be appended to the existing list. Clearing IDs in the instrument will clear IDs in the both GEM & GA modes of operation.

6.6.5 Re-sequencing

With DataField CS it is possible to change the order of the IDs in a file to put them in the same order as they are sampled in the field. This is called **Re-sequencing**. To re-sequence an ID data set, click on the **ID** button to open the ID editor. Load the ID data set from a file or download the data set from the instrument. Click on the **Re-sequence** button to open the screen shown below.



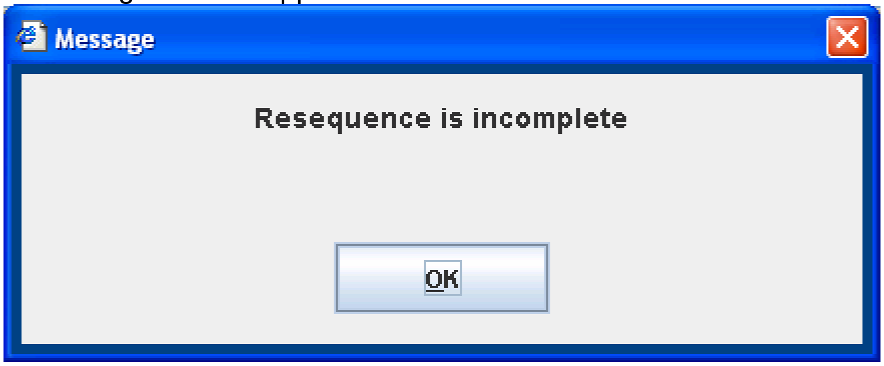
To resequence ID's select ID's from the left window in the order you want and then click the "Right" button.
Click Ok when finished or Cancel to abort

ID
CESW0003
CESW0002
CESW0004
CESSP001
CESSP002

ID
CESW0001
CESP0001

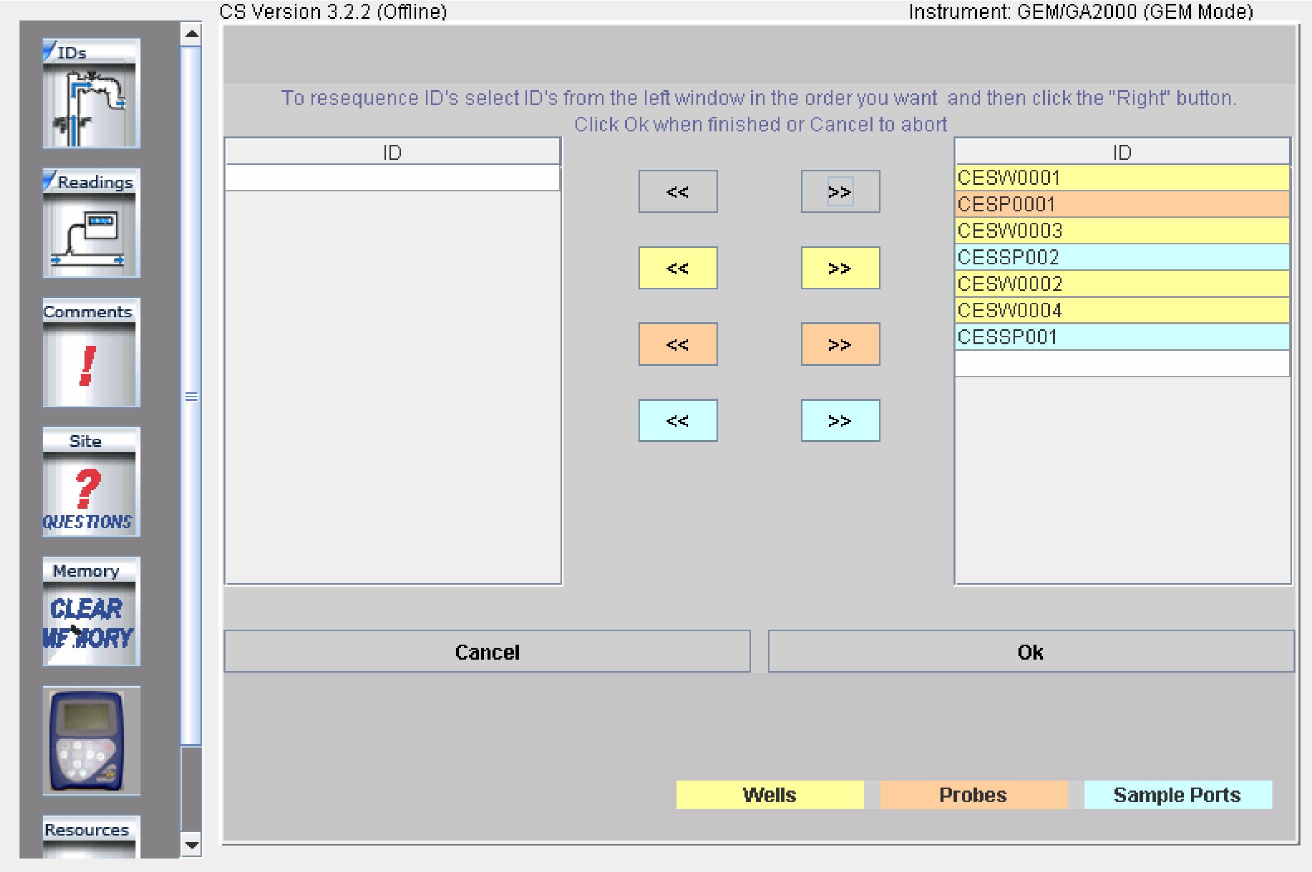
Select the ID from the left side window and click on the **Right** button to move ID to the right window to create the new sequence order. Repeat this process moving all IDs to the right side in the desired order.

If you click OK before all ID's are moved to the right hand side of the screen, you'll get a message indicating that the sequence is Incomplete.
A message box will appear.



Resequence is incomplete

Once all of the ID's are in the right hand window, Click OK



CS Version 3.2.2 (Offline)

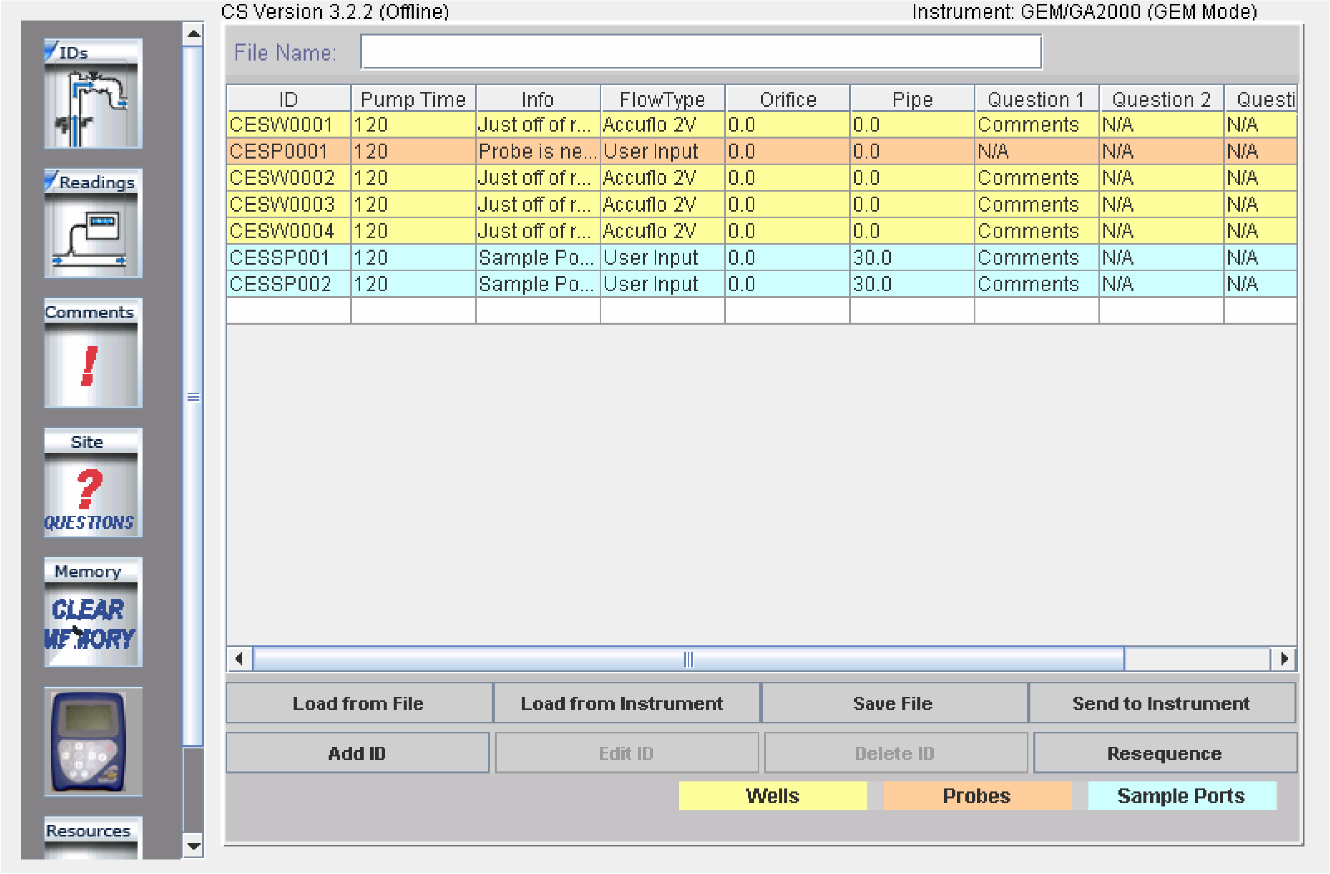
Instrument: GEM/GA2000 (GEM Mode)

To resequence ID's select ID's from the left window in the order you want and then click the "Right" button.
Click Ok when finished or Cancel to abort

ID
CESW0001
CESP0001
CESW0003
CESSP002
CESW0002
CESW0004
CESSP001

I

Clicking OK, returns you to the well ID screen and you'll see the ID's in your new sequence.



CS Version 3.2.2 (Offline)

Instrument: GEM/GA2000 (GEM Mode)

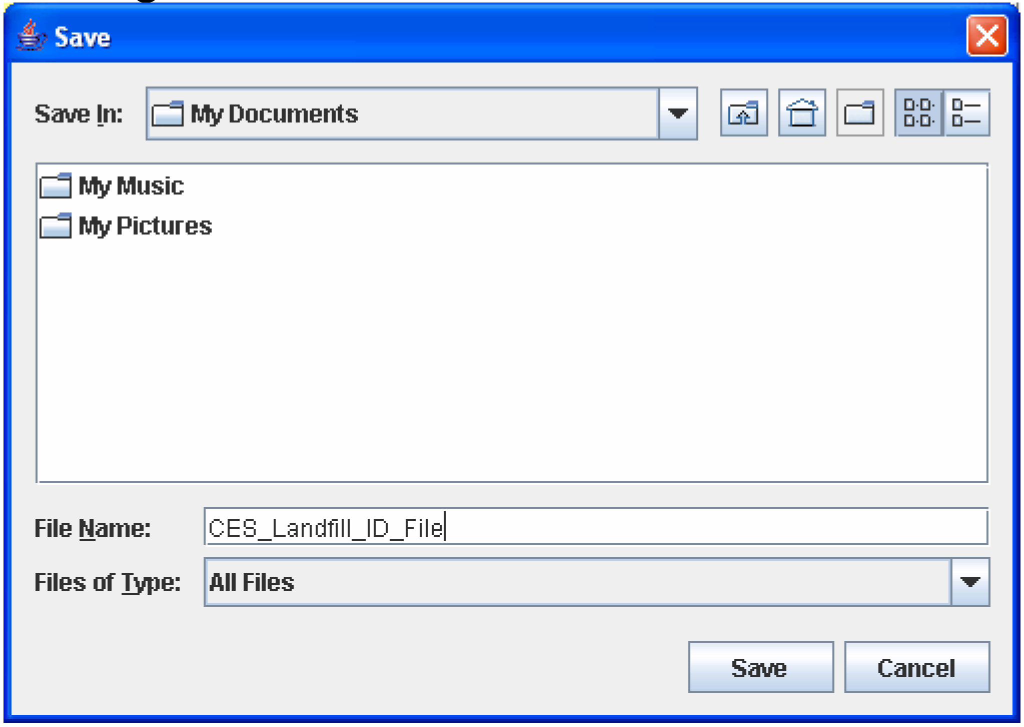
File Name:

ID	Pump Time	Info	FlowType	Orifice	Pipe	Question 1	Question 2	Questi
CESW0001	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESP0001	120	Probe is ne...	User Input	0.0	0.0	N/A	N/A	N/A
CESW0002	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESW0003	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESW0004	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESSP001	120	Sample Po...	User Input	0.0	30.0	Comments	N/A	N/A
CESSP002	120	Sample Po...	User Input	0.0	30.0	Comments	N/A	N/A

Wells Probes Sample Ports

Click on the **Save File** button to save the new data set to a file on disk or click on **Send to Instrument** to upload the new data to the instrument.

Saving the ID File to disk:



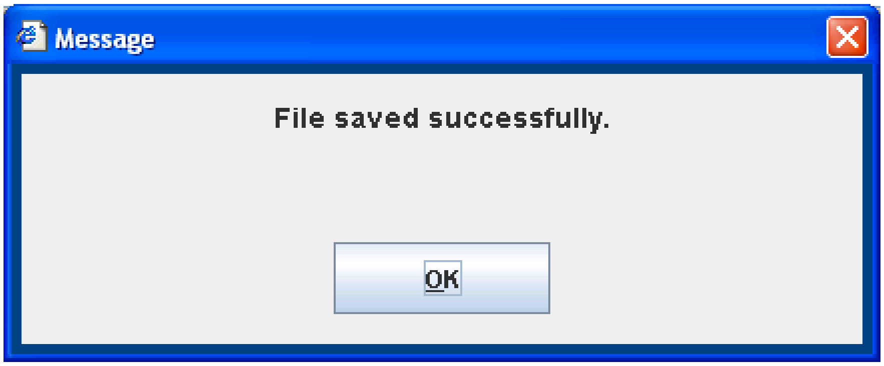
Save In: My Documents

My Music
My Pictures

File Name: CES_Landfill_ID_File

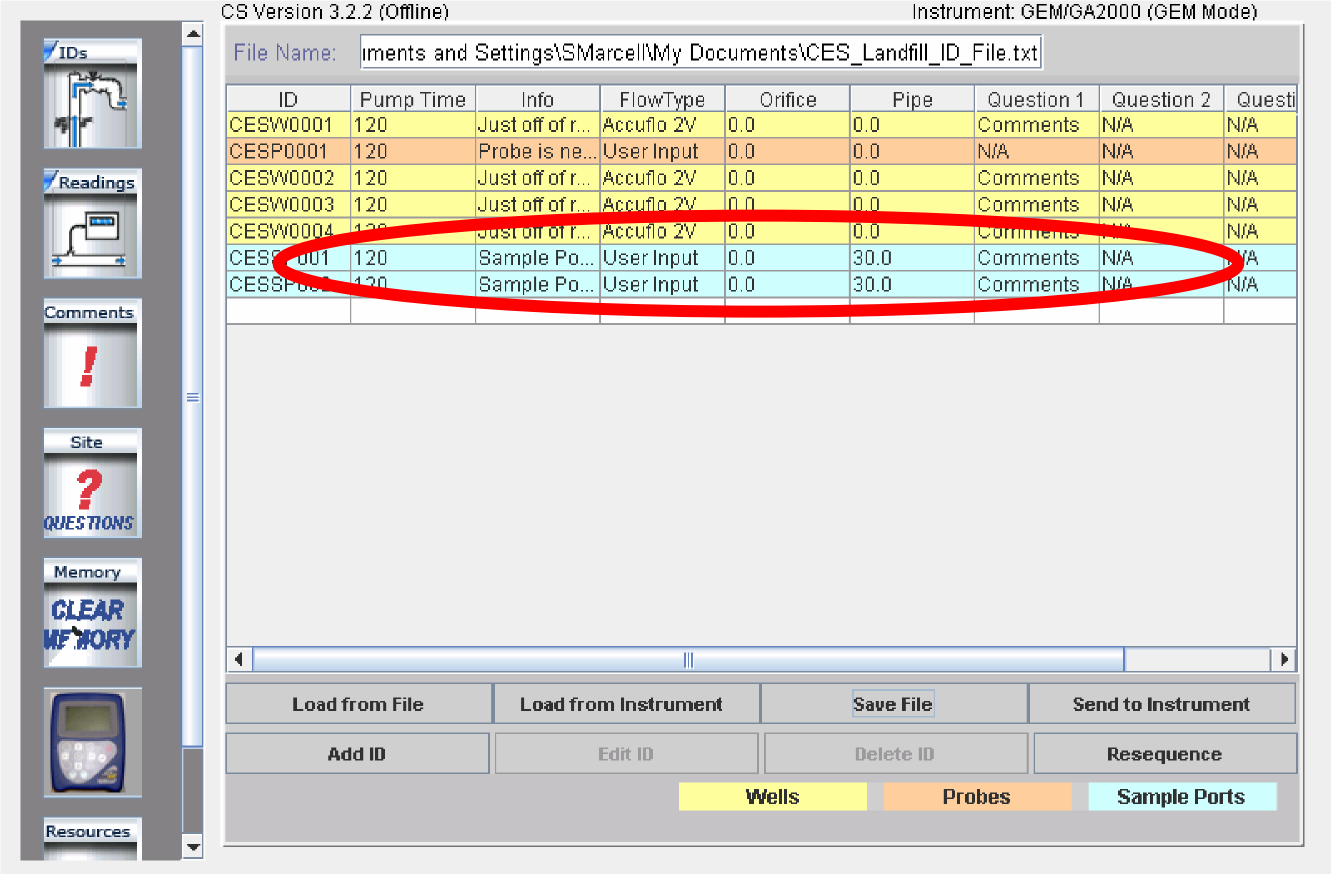
Files of Type: All Files

Enter in a name for the file and then click on the Save Button.



File saved successfully.

Once Saved, the main ID screen will now show the name of your ID file.



CS Version 3.2.2 (Offline)

Instrument: GEM/GA2000 (GEM Mode)

File Name: ıments and Settings\SMarcell\My Documents\CES_Landfill_ID_File.txt

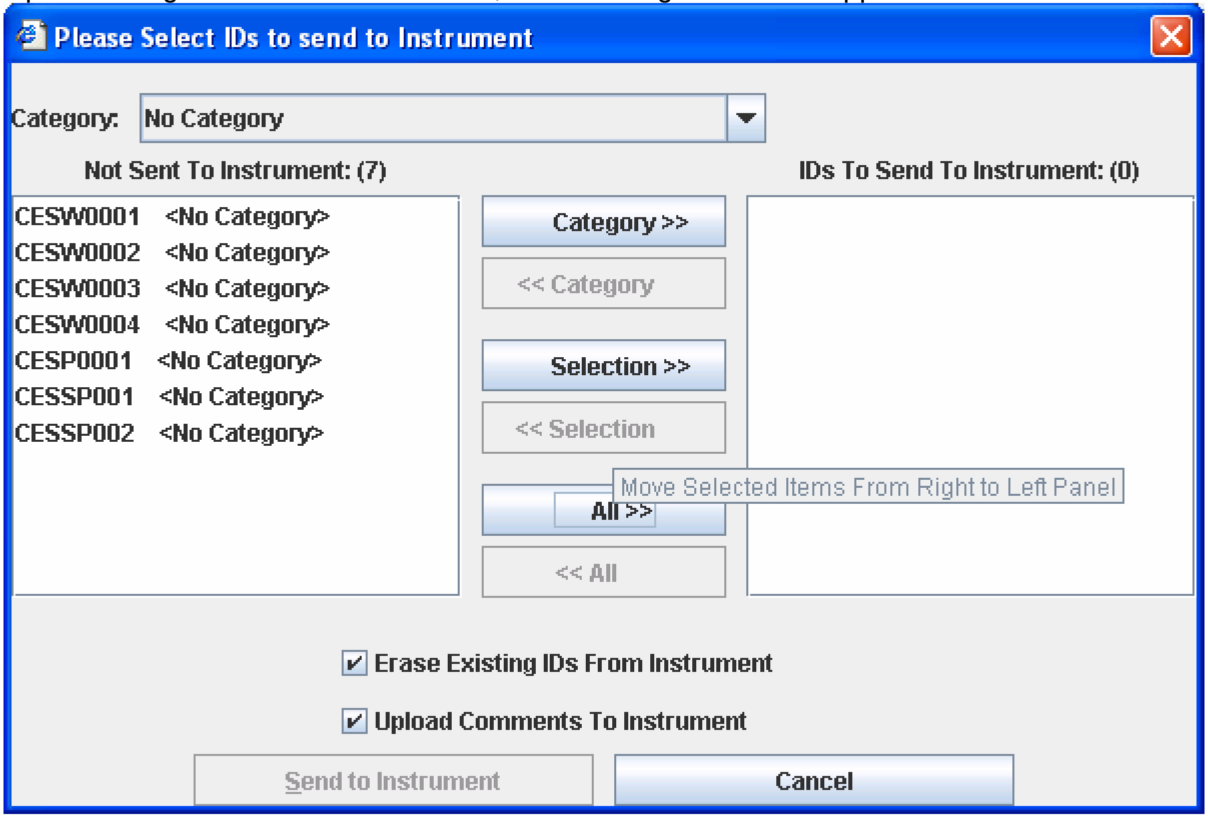
ID	Pump Time	Info	FlowType	Orifice	Pipe	Question 1	Question 2	Questi
CESW0001	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESP0001	120	Probe is ne...	User Input	0.0	0.0	N/A	N/A	N/A
CESW0002	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESW0003	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	N/A	N/A
CESW0004	120	Just off of r...	Accuflo 2V	0.0	0.0	Comments	[illegible]	N/A
CES[illegible]001	120	Sample Po...	User Input	0.0	30.0	Comments	N/A	N/A
CESSP[illegible]	120	Sample Po...	User Input	0.0	30.0	Comments	N/A	N/A

Wells | Probes | Sample Ports

Note: It is suggested to clear ID information from the instrument prior to uploading the re-sequenced ID list. Otherwise the new ID list will be appended to the existing list. Clearing IDs in the instrument will clear IDs in the both GEM & GA modes of operation.

Sending ID’s to the Instrument

Upon clicking Send ID’s to Instrument, the following screen will appear.



Category: No Category

Not Sent To Instrument: (7)

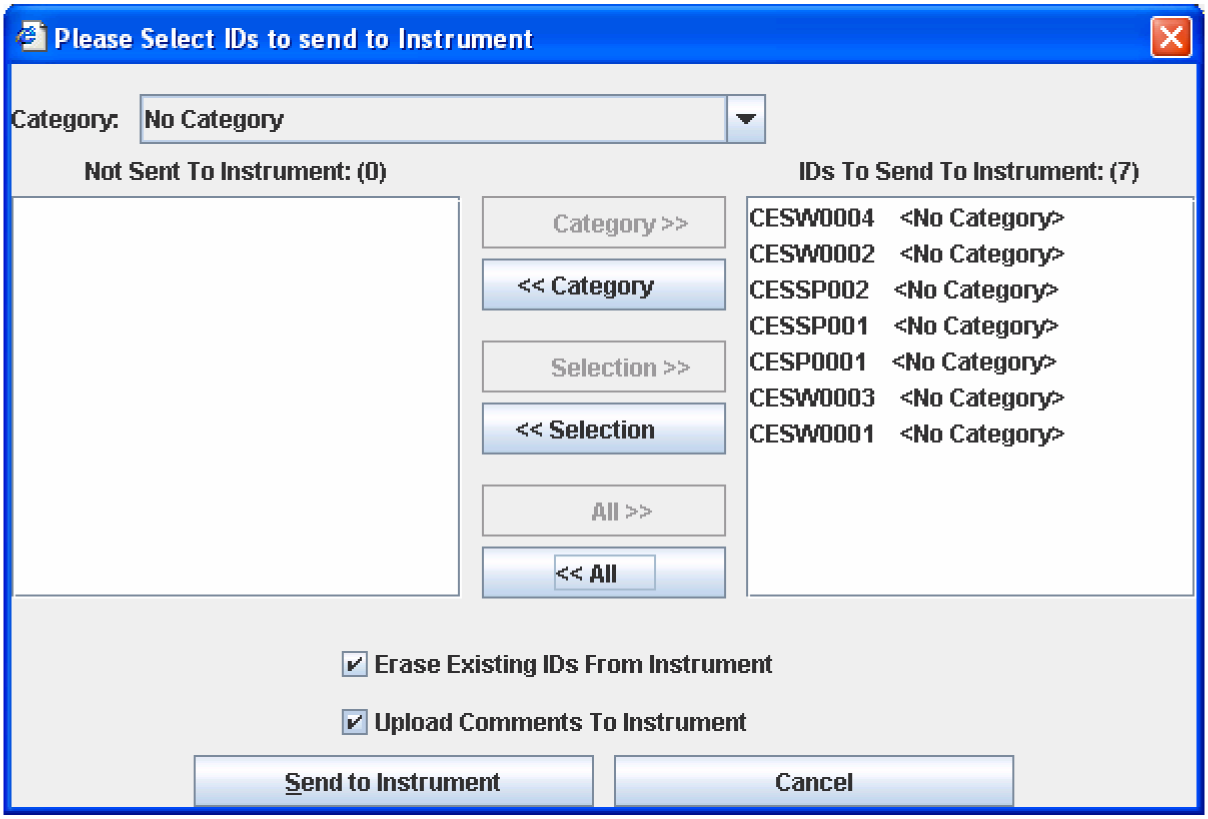
CESW0001	<No Category>
CESW0002	<No Category>
CESW0003	<No Category>
CESW0004	<No Category>
CESP0001	<No Category>
CESSP001	<No Category>
CESSP002	<No Category>

IDs To Send To Instrument: (0)

☑ Erase Existing IDs From Instrument

☑ Upload Comments To Instrument

You can choose ID’s on the left side and send them to the right side one at a time by clicking on **Selection>>** or the ID’s can all be sent by clicking on the **All>>** button.



Please Select IDs to send to Instrument

Category: No Category

Not Sent To Instrument: (0)

IDs To Send To Instrument: (7)

CESW0004	<No Category>
CESW0002	<No Category>
CESSP002	<No Category>
CESSP001	<No Category>
CESP0001	<No Category>
CESW0003	<No Category>
CESW0001	<No Category>

☑ Erase Existing IDs From Instrument

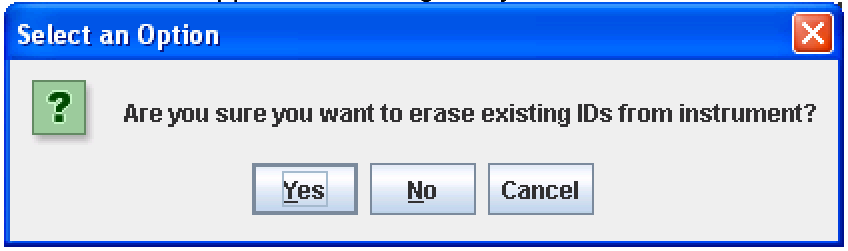
☑ Upload Comments To Instrument

Once the ID’s have been selected, they appear in the right hand window. Once all desired ID’s are in the right hand window they will need to be sent to the instrument.

Two options exist:

- Erase Existing ID’s will erase the existing ID’s from the instrument if any ID’s are present in the instrument.
- Upload Comments to the Instrument.

Once the options are selected, click on the **Send to Instrument** button. If you selected the Erase Existing ID’s, a box will appear confirming that you want to erase the ID’s that are in the instrument.

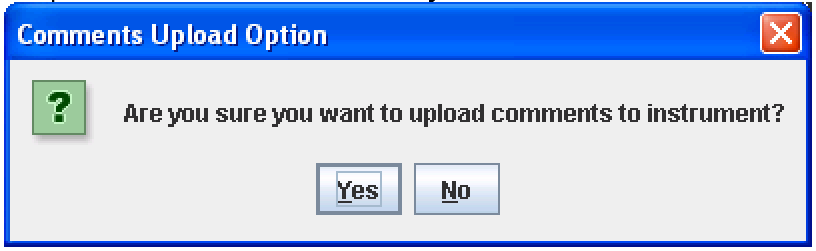


Select an Option

Are you sure you want to erase existing IDs from instrument?

Answer Yes if you wish to erase the ID’s.

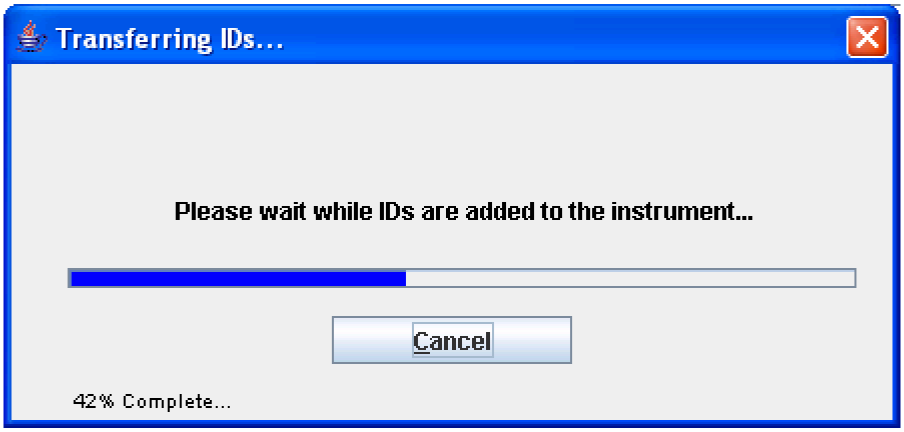
If Upload comments is checked, you’ll need to click on Yes when the comments upload appears.



Comments Upload Option

Are you sure you want to upload comments to instrument?

A progress bar will appear during the upload process.



Please wait while IDs are added to the instrument...

42% Complete...

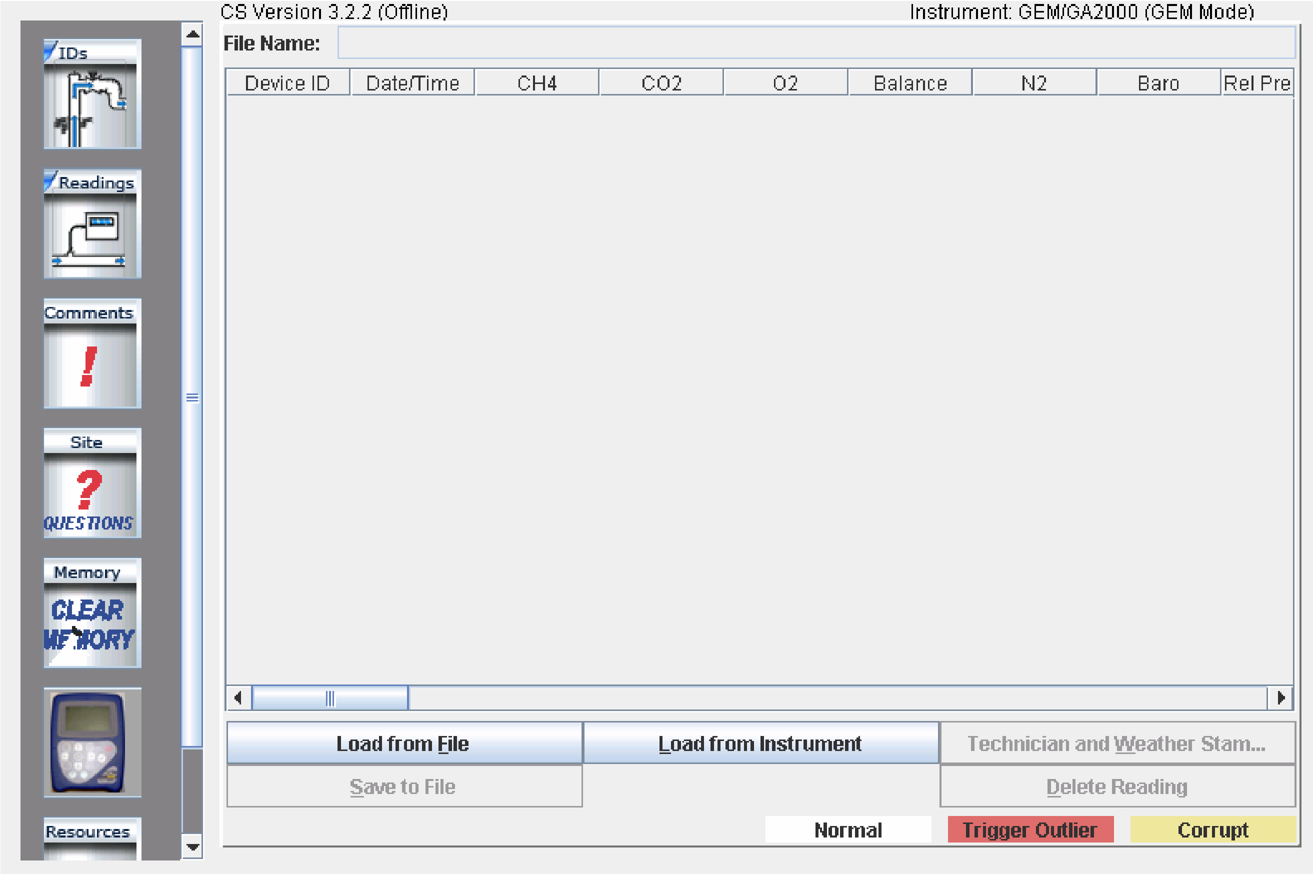
Once complete, a message will appear indicating the upload status.

ID's uploaded successfully.

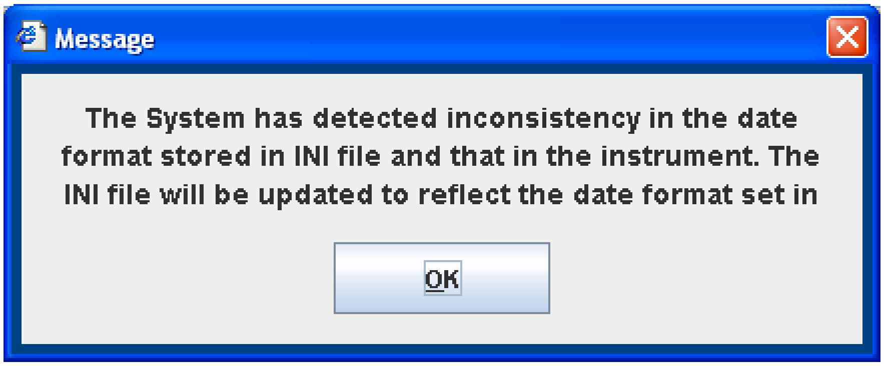
Click OK to continue.

6.6.6 Readings

The Readings screen provides the capability to download, upload, view, save data to a file and delete individual or multiple readings from a data set. Click on the **Readings** button to open the screen shown below.

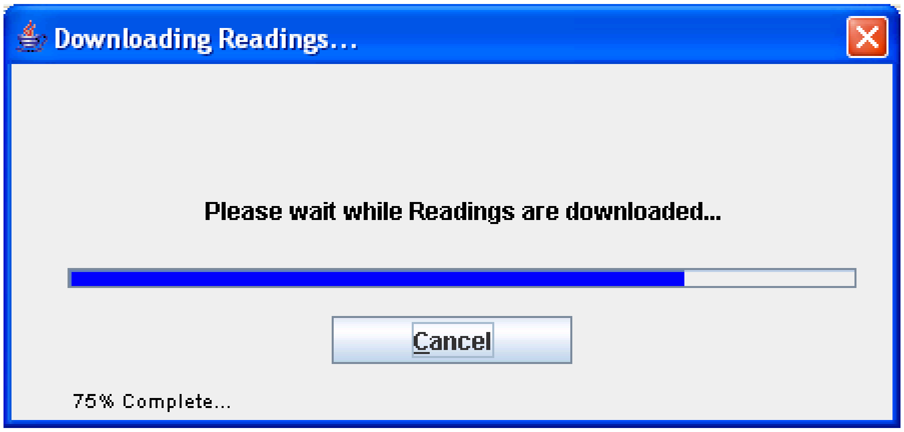


Click on the load from instrument button. The first time you click on this button you'll get a message as follows:



The System has detected inconsistency in the date format stored in INI file and that in the instrument. The INI file will be updated to reflect the date format set in

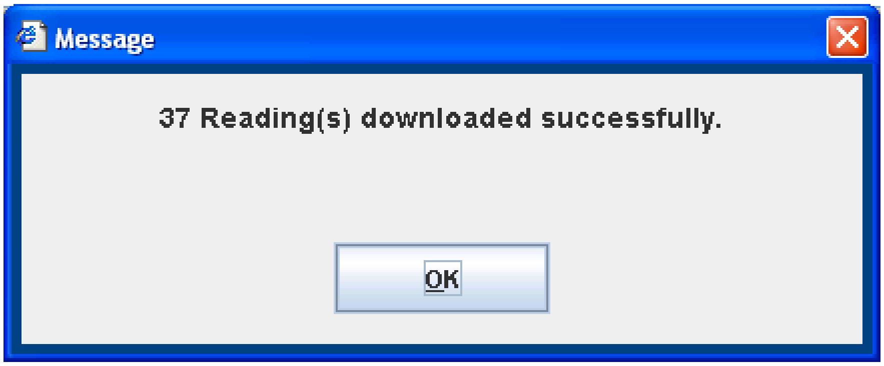
Click OK to update the INI file settings to match your instrument.



Please wait while Readings are downloaded...

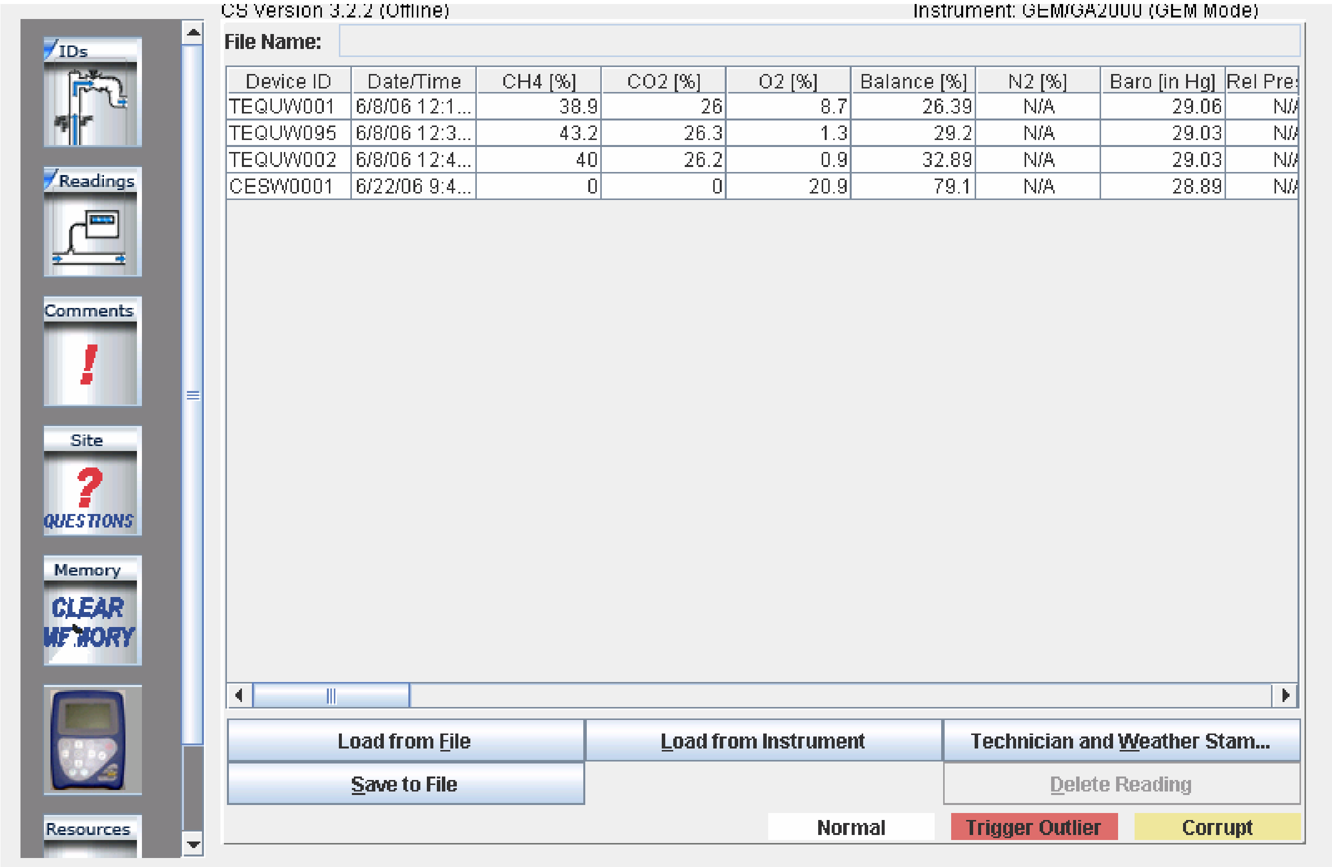
75% Complete...

Readings will be downloaded from your instrument and a message box will appear indicating the number of readings downloaded.



37 Reading(s) downloaded successfully.

Click on **Load from File** to open a file folder of saved data on the disk drive or click on **Load from Instrument** to download data from the instrument. Either action will open the following screen. All readings should be downloaded on a daily basis. While the instrument can hold readings for an extended period of time, it is recommended to download them to a non-volatile memory device (e.g. hard drive, CD, etc.).



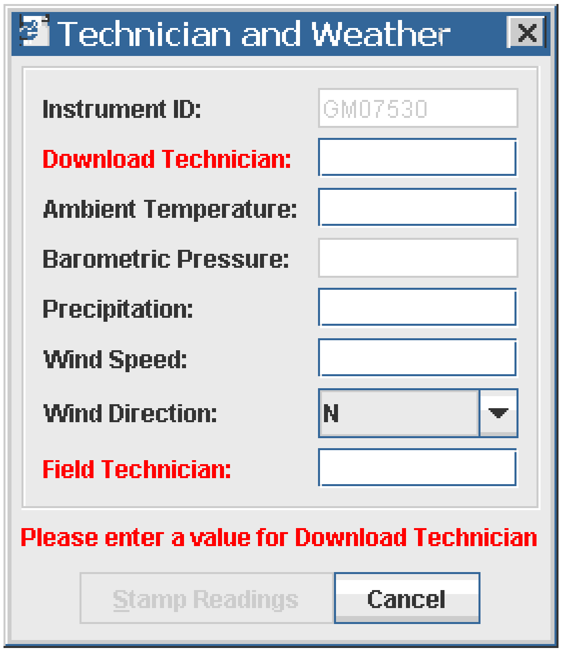
Device ID	Date/Time	CH4 [%]	CO2 [%]	O2 [%]	Balance [%]	N2 [%]	Baro [in Hg]	Rel Pre
TEQUW001	6/8/06 12:1...	38.9	26	8.7	26.39	N/A	29.06	N/
TEQUW095	6/8/06 12:3...	43.2	26.3	1.3	29.2	N/A	29.03	N/
TEQUW002	6/8/06 12:4...	40	26.2	0.9	32.89	N/A	29.03	N/
CESW0001	6/22/06 9:4...	0	0	20.9	79.1	N/A	28.89	N/

Once the file has been opened or data downloaded from the instrument, the readings can be either **stored online** (only with the online version) or **saved to a file** (only with the offline version). When the instrument is in the GA Mode the readings can also be **sent to the instrument**. **Send to Instrument** button will be disabled when the instrument is in the GEM Mode. The screenshot above shows the online version with the instrument in the GEM mode.

6.6.7 Delete Readings

Highlight the row you wish to delete. Click **Delete Readings**.
[message] “are you sure you want to delete” Click **Yes**. This will remove the reading in the highlighted row.

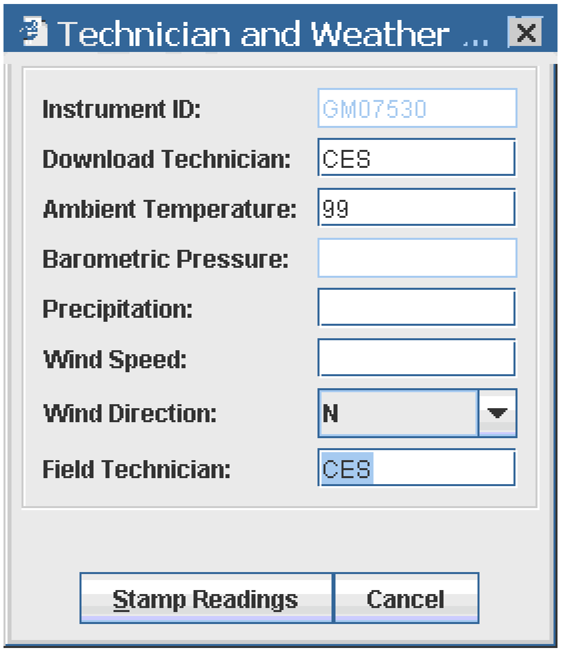
After verifying your readings Click on **Save File** button if you wish to save the file for future use.
This will bring up a screen for TECHNICIAN AND WEATHER STAMPING



Technician and Weather

Instrument ID: GM07530
Download Technician:
Ambient Temperature:
Barometric Pressure:
Precipitation:
Wind Speed:
Wind Direction: N
Field Technician:

Please enter a value for Download Technician

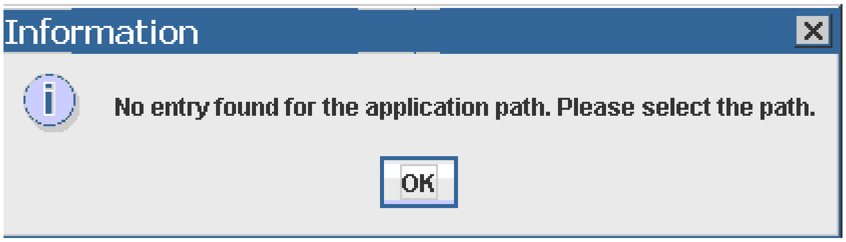


Technician and Weather ...

Instrument ID: GM07530
Download Technician: CES
Ambient Temperature: 99
Barometric Pressure:
Precipitation:
Wind Speed:
Wind Direction: N
Field Technician: CES

THE Instrument ID will already be entered. Enter the Technician initials Next enter applicable information [all entries must be numbers except Technician initials]. Click **Stamp Readings** at the bottom

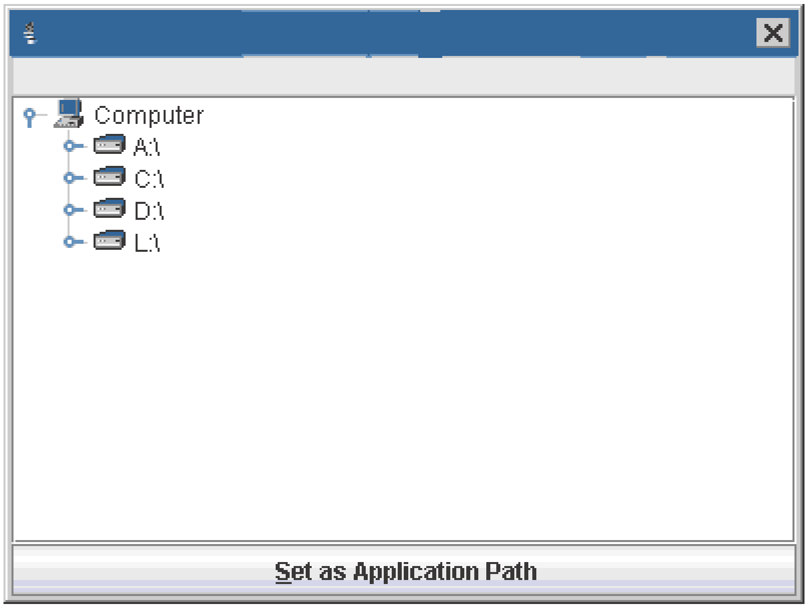
If this is the first time you are saving a readings file you will see this message
We suggest the path C:\Program Files\CES\DF32



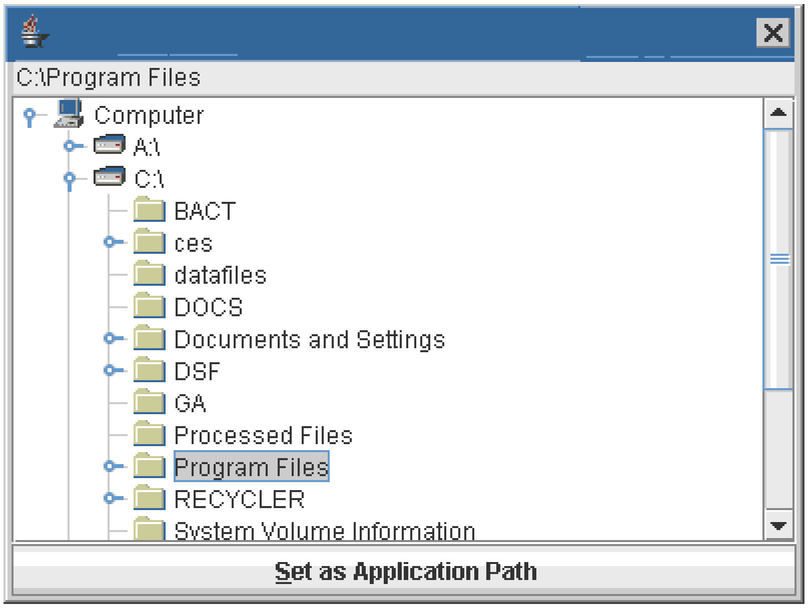
Information

No entry found for the application path. Please select the path.

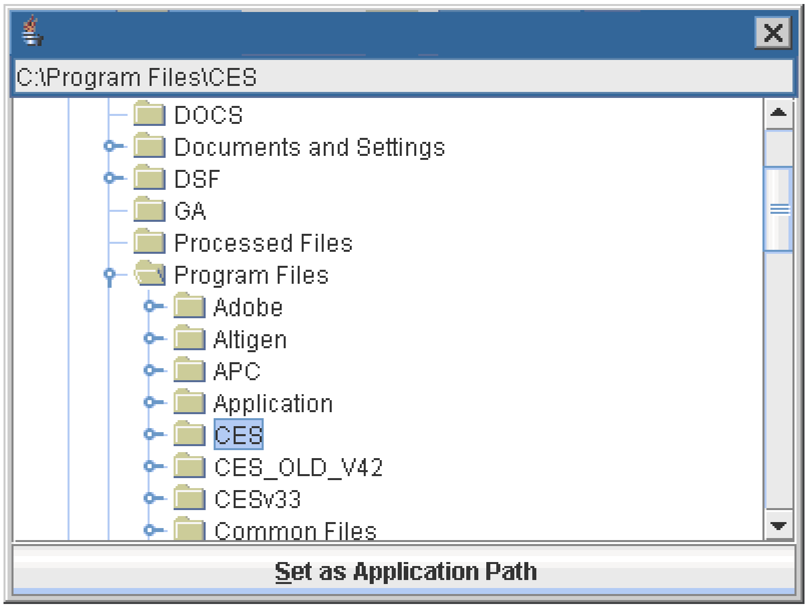
Click OK



Select C double click

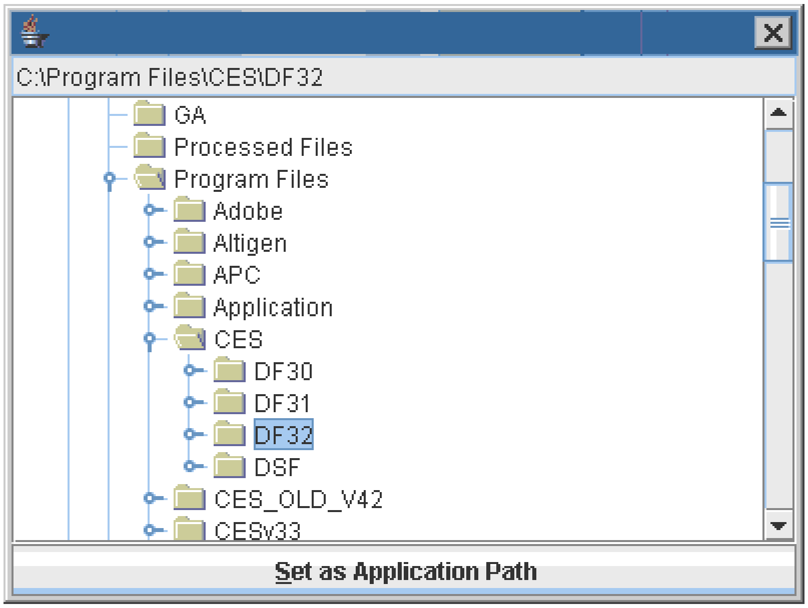


Select Program Files



C:\Program Files\CES

Select CES

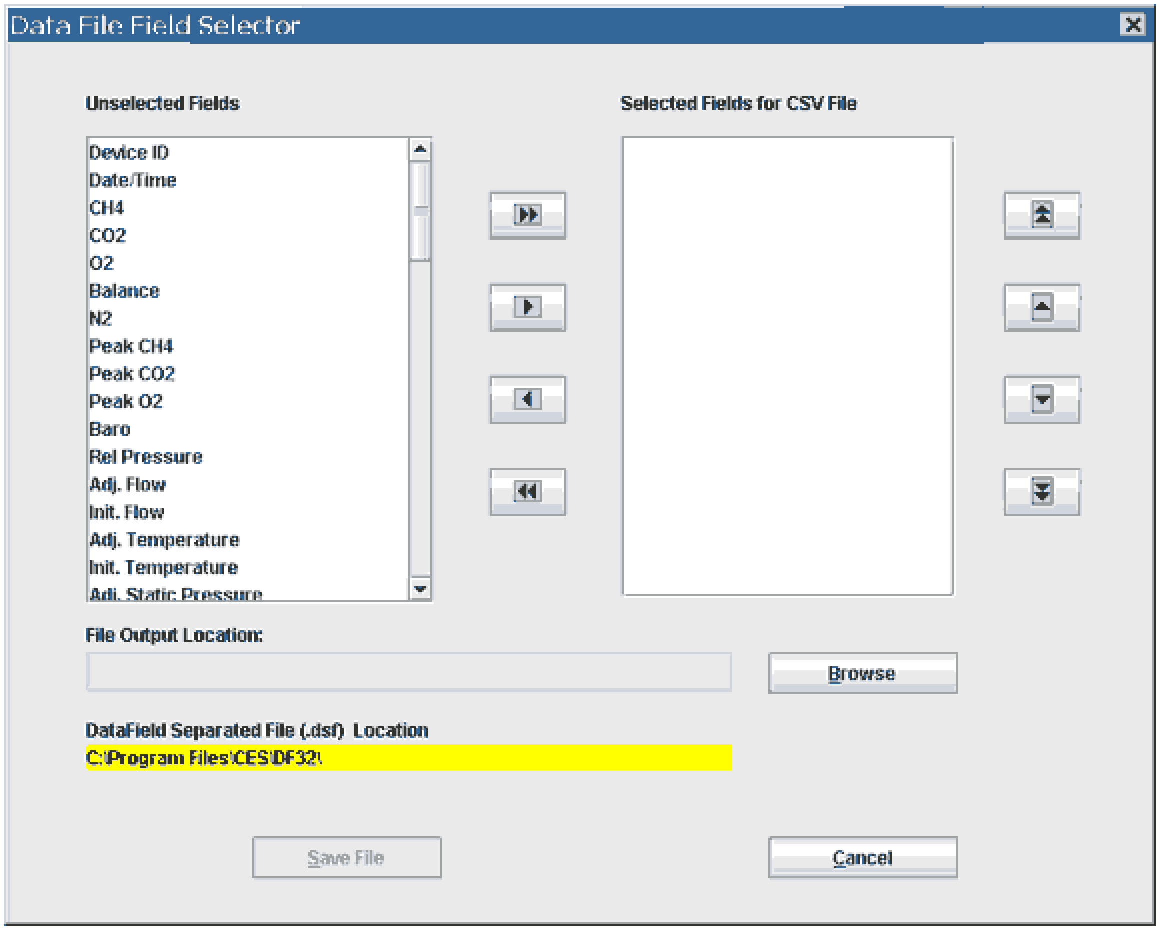


C:\Program Files\CES\DF32

Select DF32

Click on Set as Application Path

Now you will go to the screen where you select only the headings you want



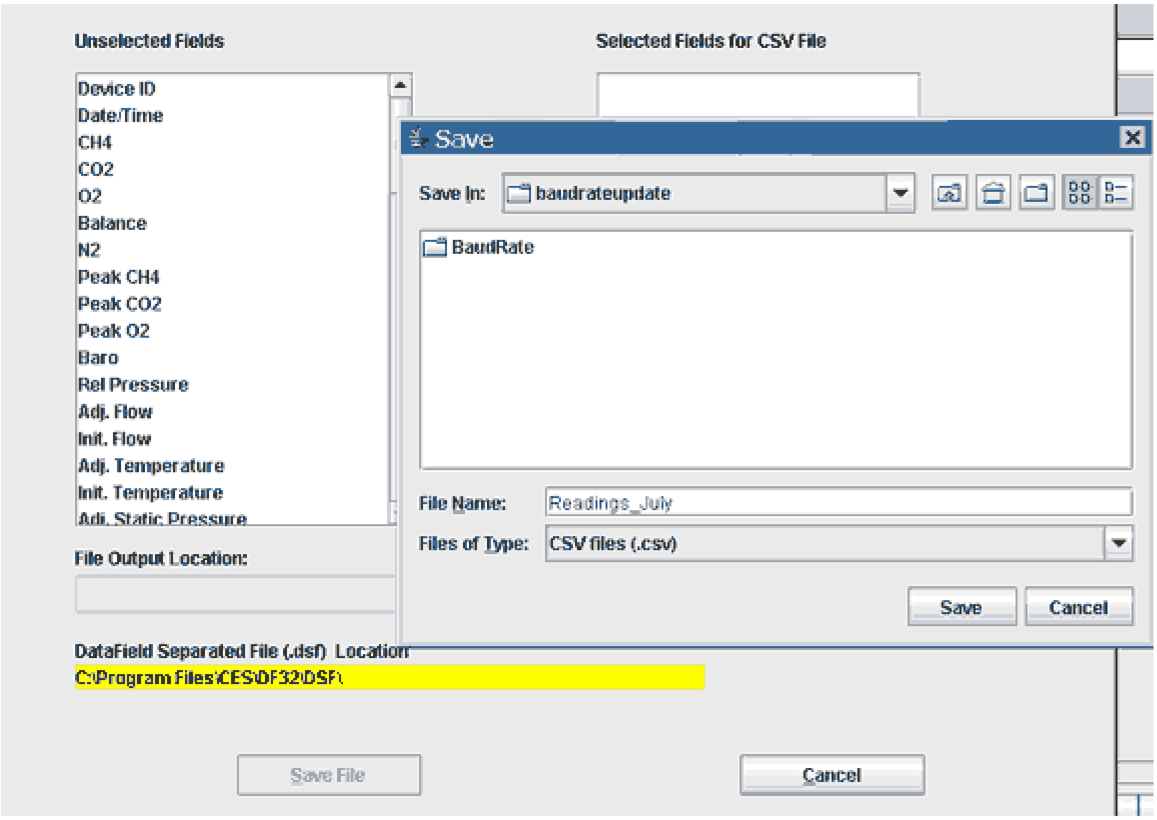
You will see the path set in the dsf location address

You only set this path one time after setting this when you Click **Save to File**. This will open a new window.

The raw data file will be saved as a dsf file, for which you have set the path the first time you save after that the dsf path will be in the highlighted box so all your dsf files will be saved to this location this is the raw data file that will load back to the readings page when you use load from file, we suggest the path be C:\PROGRAM FILES\CES\DF32 from the pull downs.

For your report sheet choose the headings you wish to use on the field selector page move headings to the right hand side then they may be move up or down in order by highlighting and using the up and down arrows on the left.

After all headings have been selected and order has been completed click **browse** ,as with the ID function this will open a new window (this will save the location of the csv file that opens in excel). Choose the location and folder enter the name you wish to save the file with, **then click save file button**, but you have **only saved the location**. You will be returned to the field selector page at the bottom of the page **click on the save file** The program will prompt you with the file saved click OK [The csv and dsf file are now both saved



Save In: baudrateupdate

File Name: Readings_July

Files of Type: CSV files (.csv)

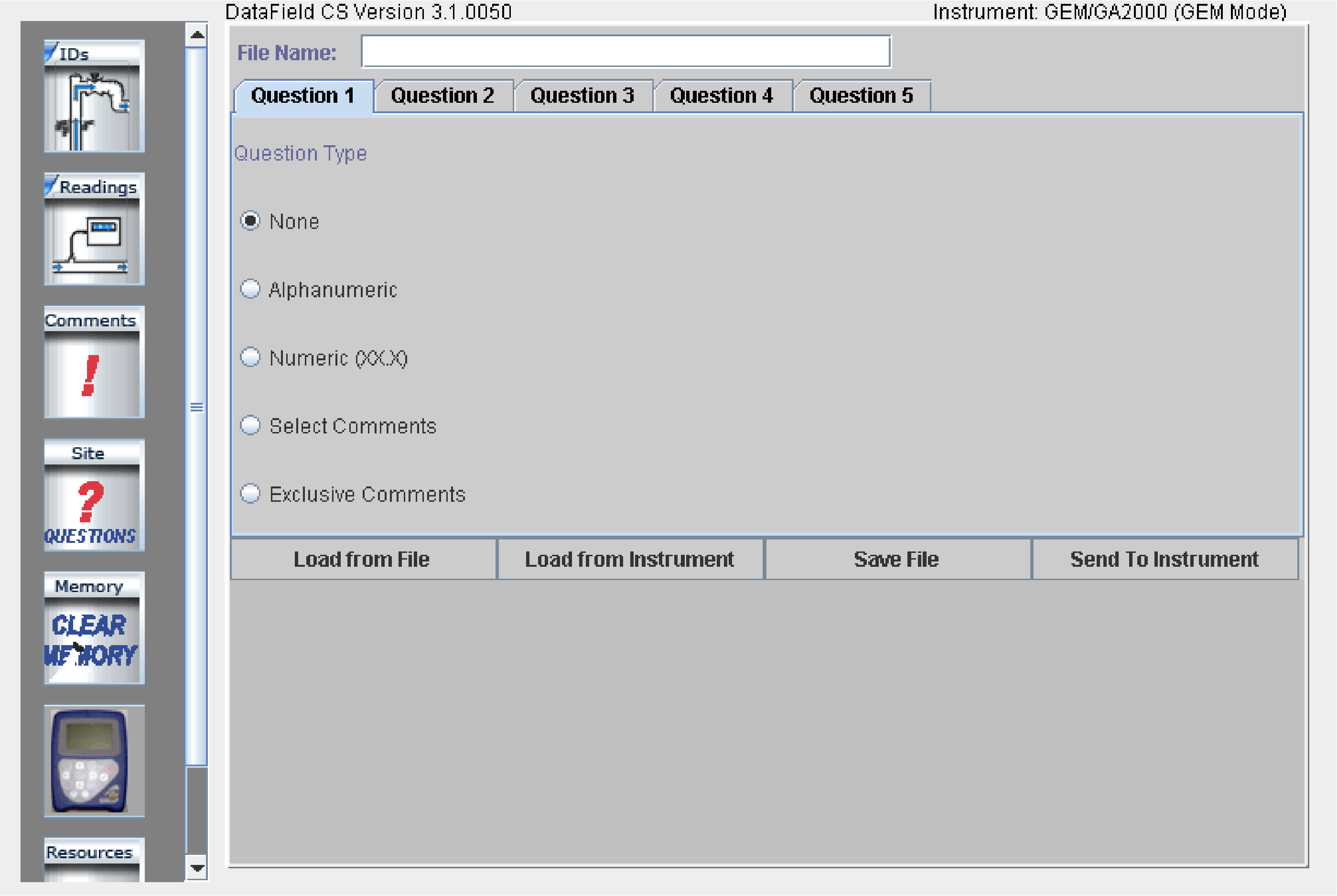
DataField Separated File (.dsf) Location
C:\Program Files\CES\DF32\DSF\

Note: If you load from file and you must be sure and load the dsf original file.
The dsf files will all be save at the location you have set the path for


Files saved successfully.

6.6.8 Site Questions

DataField CS supports up to five site questions. Site questions are answered only when **Update Site Data** is selected from the GEM menu screen and appended to all IDs taken thereafter until Update Site Data is selected again. This is a useful feature if conditions change in various locations on the landfill site or for selected wells/probes. Site questions can be either alphanumeric, numeric, select comment (the technician selects the comment from a list of ten answers) or exclusive comments (the technician may select only **ONE** exclusive question from a list of 10 answers). From the opening screen, click on the **Site Questions** button to open the following screen.


DataField CS Version 3.1.0050

Instrument: GEM/GA2000 (GEM Mode)

File Name:

Question Type

● None

○ Alphanumeric

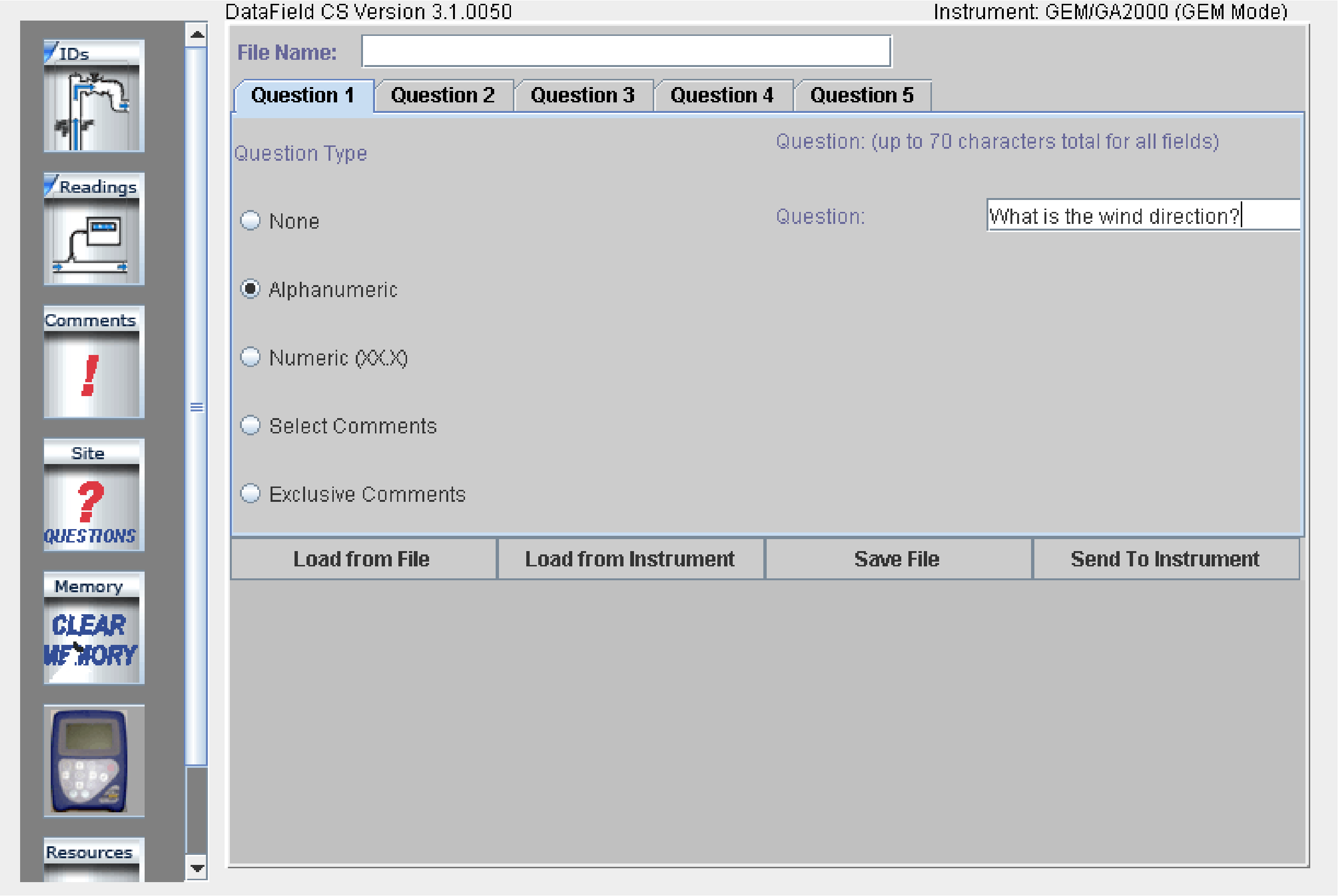
○ Numeric (XX.X)

○ Select Comments

○ Exclusive Comments

Note: Site questions must be created and sent to the instrument by the software prior to going into the field. They can not be hand inputted into the instrument in the field.

Click on the open spot, to the left of the alphanumeric category in **Question Type** to define Question 1 and type in the question.



DataField CS Version 3.1.0050

Instrument: GEM/GA2000 (GEM Mode)

File Name:

Question: (up to 70 characters total for all fields)

Question Type

○ None

● Alphanumeric

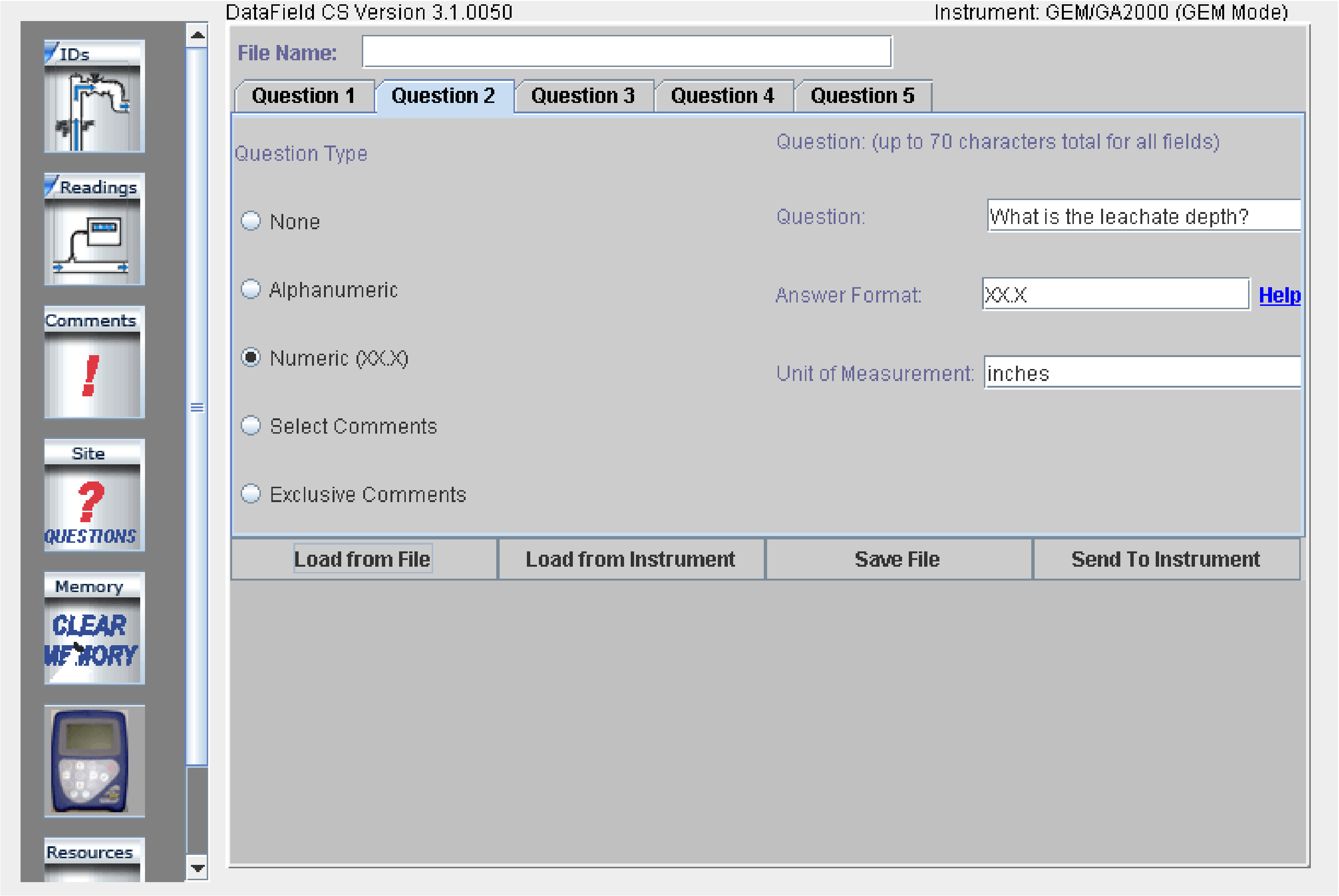
○ Numeric (XX.X)

○ Select Comments

○ Exclusive Comments

Question: What is the wind direction?

Click on Question 2 and then select Numeric as the Question Type. Note that Answer Format and Unit of Measurement fields appear for this type of question. Answer format refers to the number of digits and decimal places required for the answer. Unit of Measurement refers to inches, feet, yards, etc. for the answer. In this example, XX.X could be equal to 20.5 inches as per the question 'What is the leachate depth in tank?'



File Name:

Question Type

○ None

○ Alphanumeric

● Numeric (XX.X)

○ Select Comments

○ Exclusive Comments

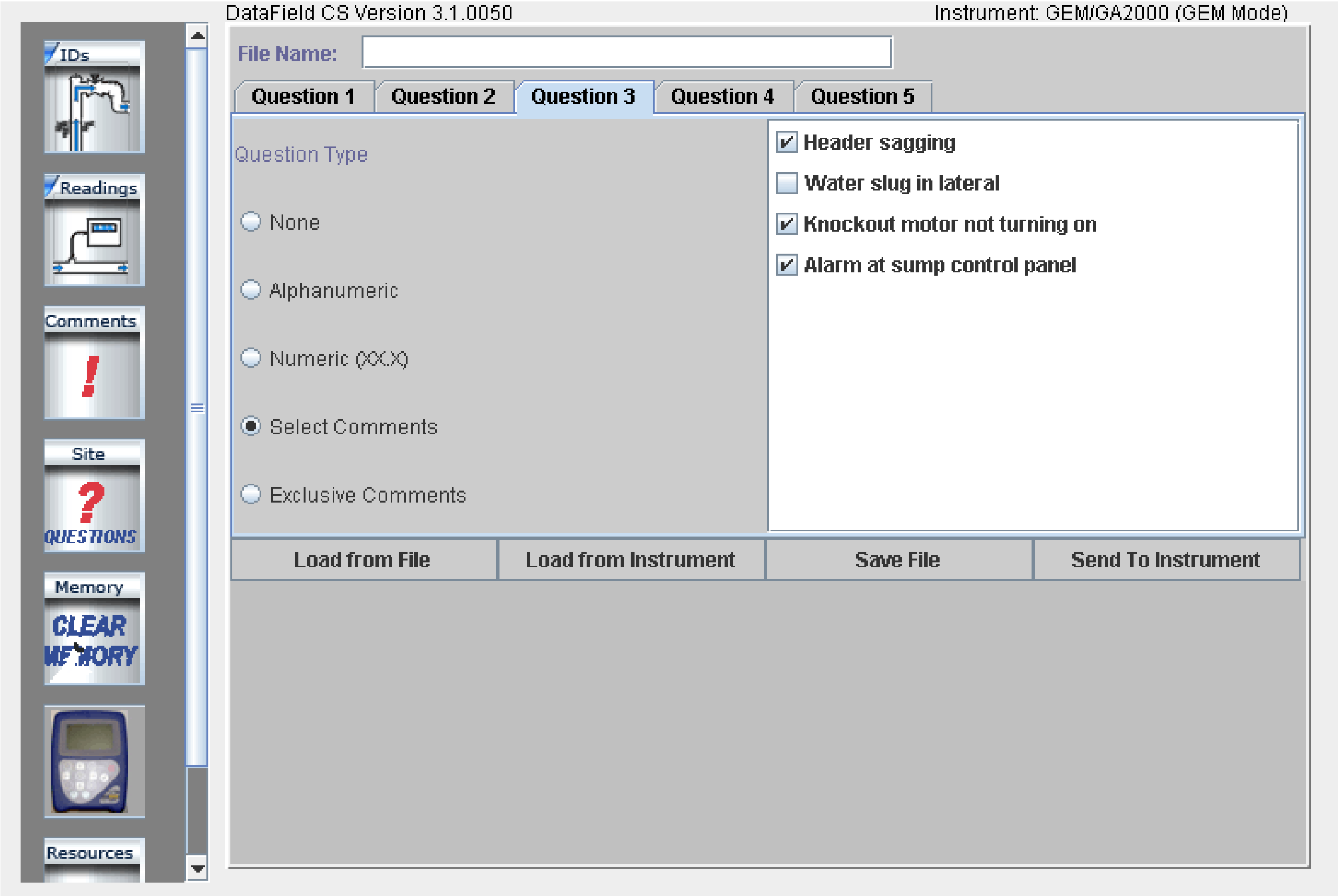
Question: (up to 70 characters total for all fields)

Question: What is the leachate depth?

Answer Format: XX.X

Unit of Measurement: inches

Comments may also be used as a site question; however, comments must be downloaded from an instrument that already has comments loaded in it. Connect the GEM™2000 / GEM™2000 Plus and be sure it is in the read gas screen. Click on Select Comments and the list of comments from the instrument will open in the window for selection. Ten comments may be selected from the list to become **Site Questions**. Click on the box to the left of the comment to select it. The operator may choose any or all of the ten comments when **Update Site Data** is selected on the instrument.



File Name:

Question Type

○ None

○ Alphanumeric

○ Numeric (XX.X)

● Select Comments

○ Exclusive Comments

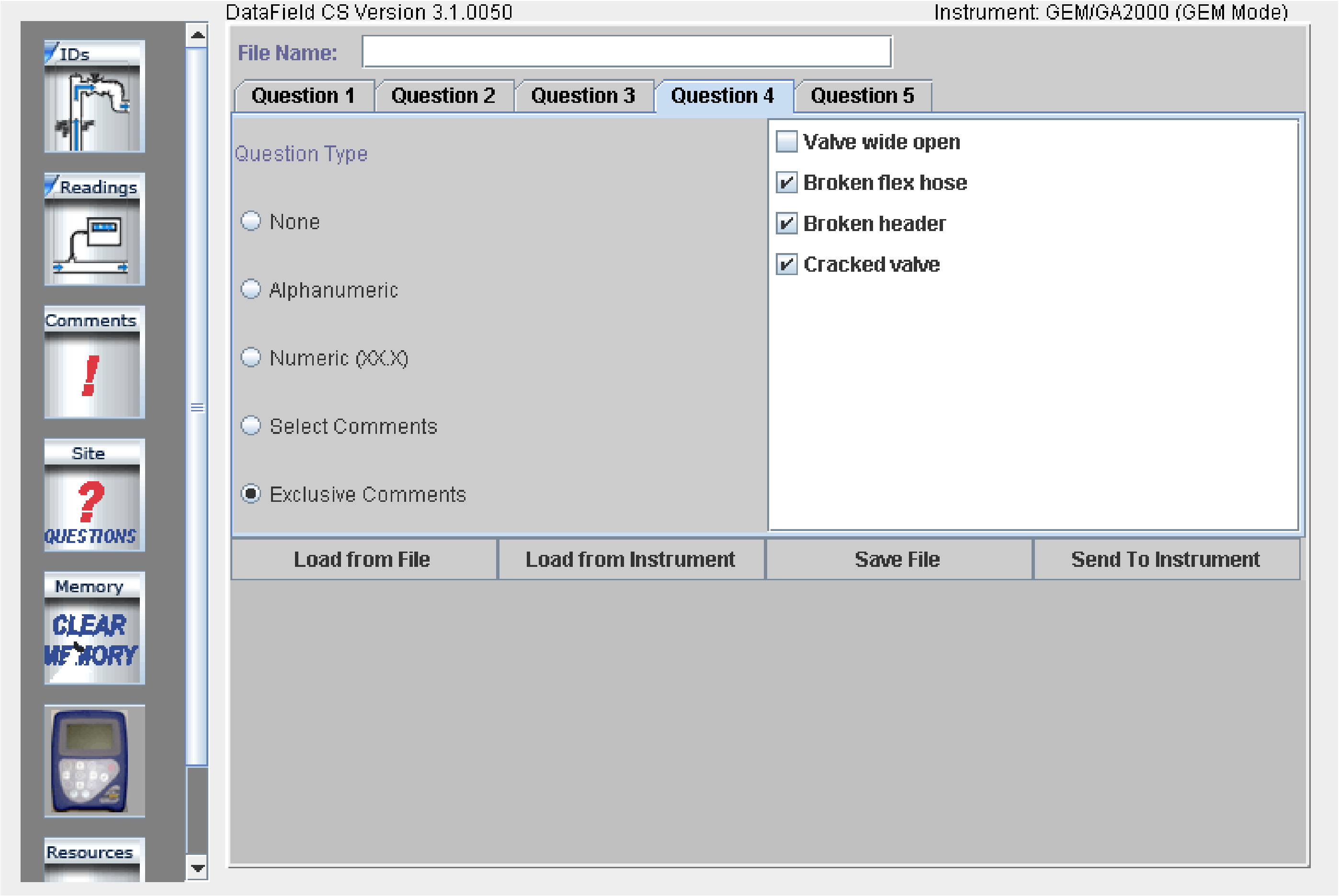
☑ Header sagging

☐ Water slug in lateral

☑ Knockout motor not turning on

☑ Alarm at sump control panel

Exclusive comments are treated in a similar manner as select comments in that they also must be downloaded from the instrument. Ten exclusive comments may be selected, however only **ONE** may be chosen by the operator to become an **Exclusive Comment.**



DataField CS Version 3.1.0050

Instrument: GEM/GA2000 (GEM Mode)

File Name:

Question 4

Question Type

○ None

○ Alphanumeric

○ Numeric (XX.X)

○ Select Comments

● Exclusive Comments

☐ Valve wide open

☑ Broken flex hose

☑ Broken header

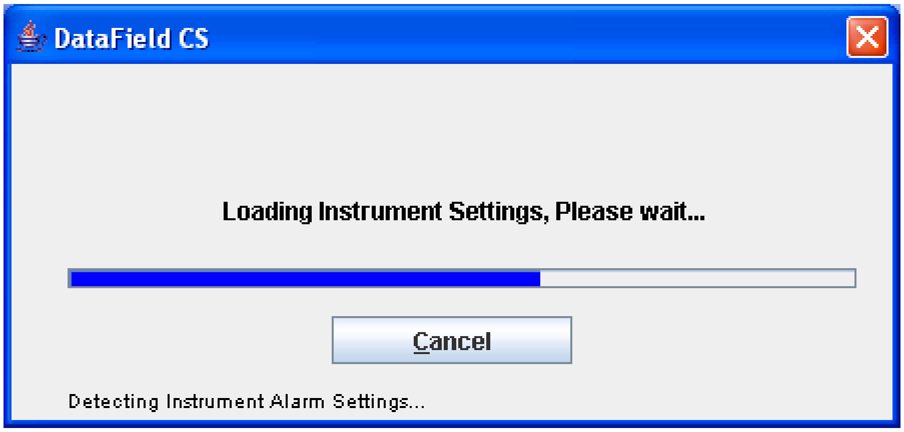
☑ Cracked valve

When all the desired questions have been entered, click on **Save File** to retain the information for later use and then click on **Send to Instrument** to update site data in the instrument.

6.7 Settings

Clicking on the **Settings** button on the main screen will display the **Instrument Settings.** The Instrument settings provide the capability to set or change optional controls in the instrument, such as time/date, data logging (GA mode only), purge times, etc.

Clicking on the Instrument Icon to access the Instrument settings will take a few moments to download all of the instrument.

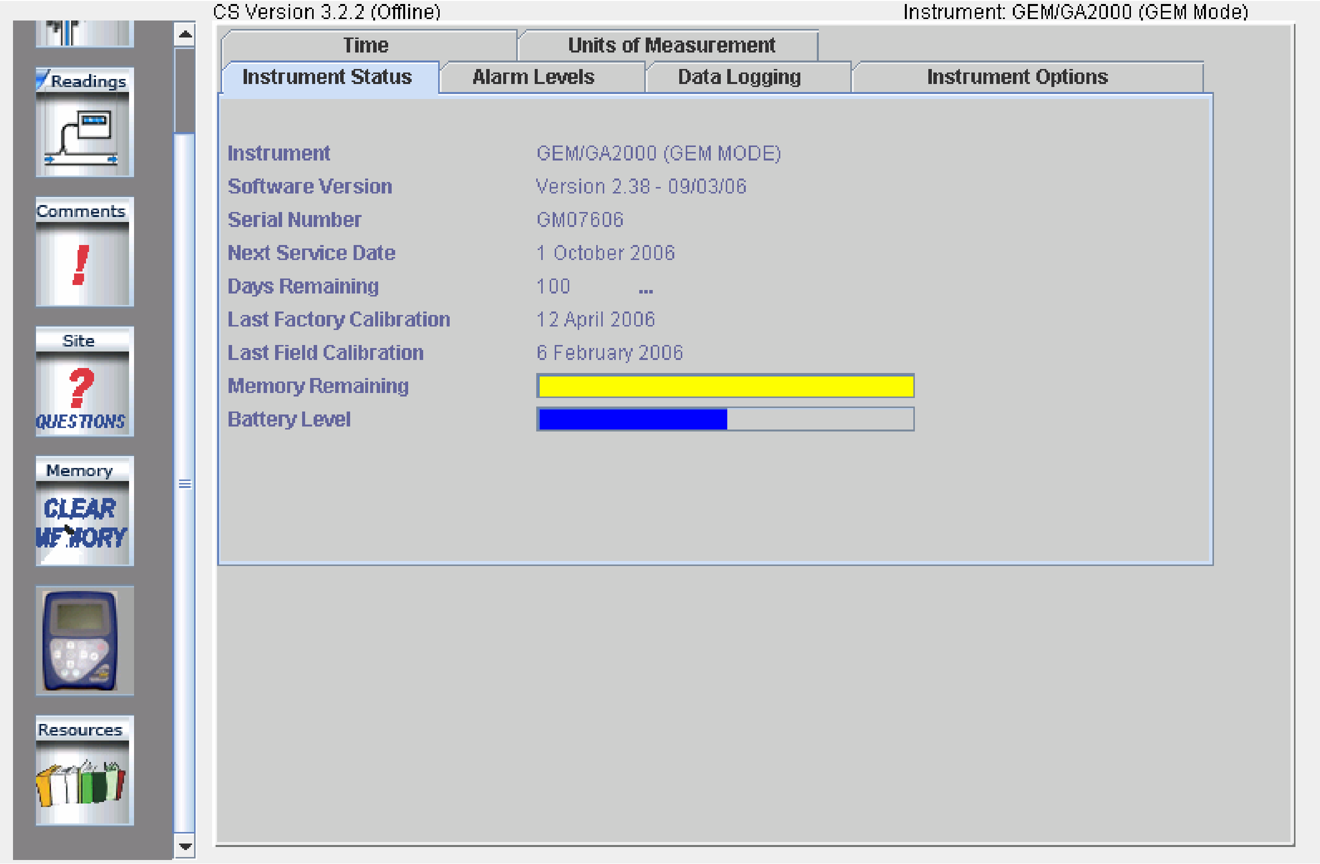


Loading Instrument Settings, Please wait...

Detecting Instrument Alarm Settings...

6.7.1 Instrument Settings

Set the instrument for RS-232 communications and click on the **Settings** button and the following screen will open. The software will establish communications and download the current instrument settings.

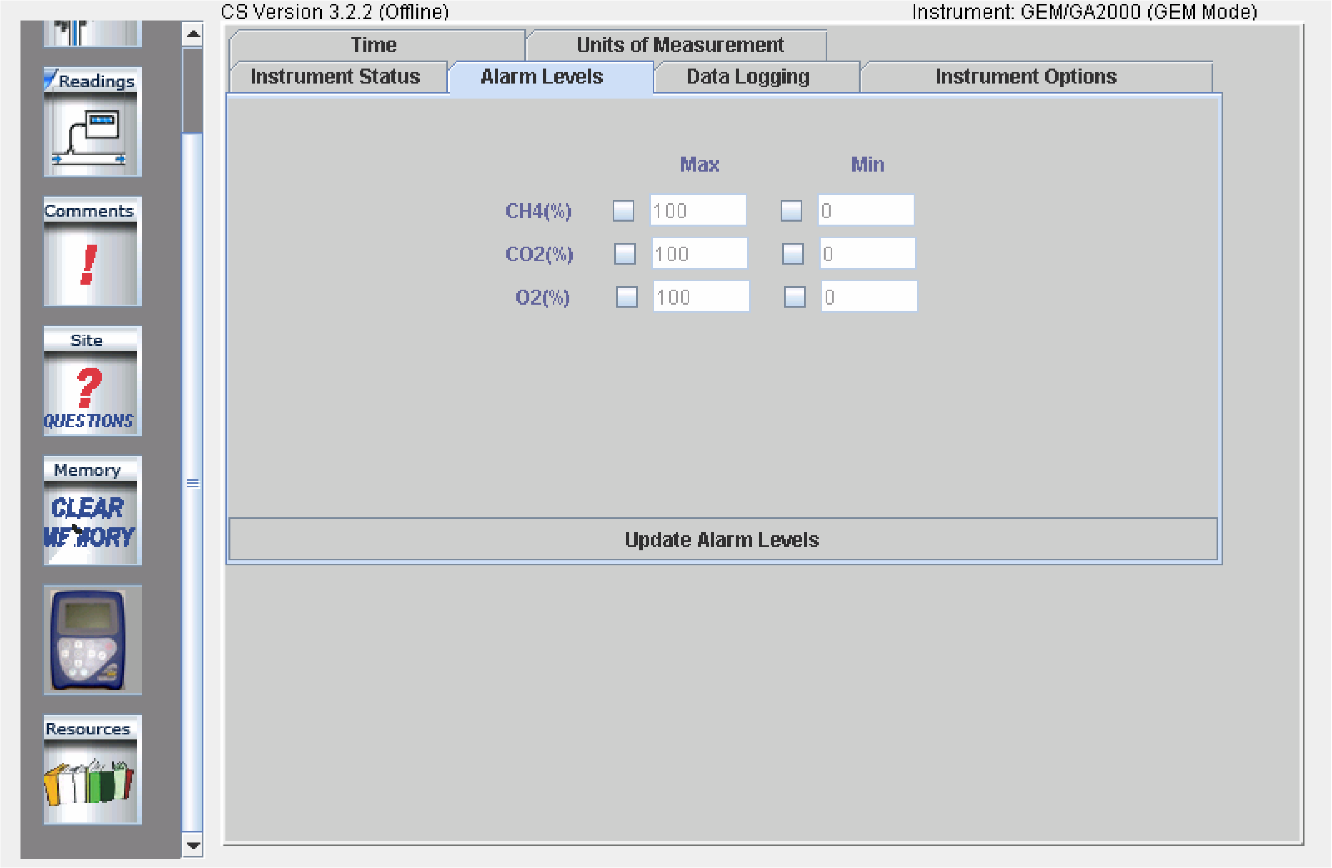


Instrument GEM/GA2000 (GEM MODE)
Software Version Version 2.38 - 09/03/06
Serial Number GM07606
Next Service Date 1 October 2006
Days Remaining 100
Last Factory Calibration 12 April 2006
Last Field Calibration 6 February 2006
Memory Remaining
Battery Level

Once the current settings have been obtained, the following screen will open.

There are six different “Menu Cards” under instrument settings. Each card provides different information or instrument settings that may be changed to update the operation of the GEM™2000 / GEM™2000 Plus. The instrument status card will always be shown first, providing calibration and maintenance information in addition to instrument serial number and software version number.

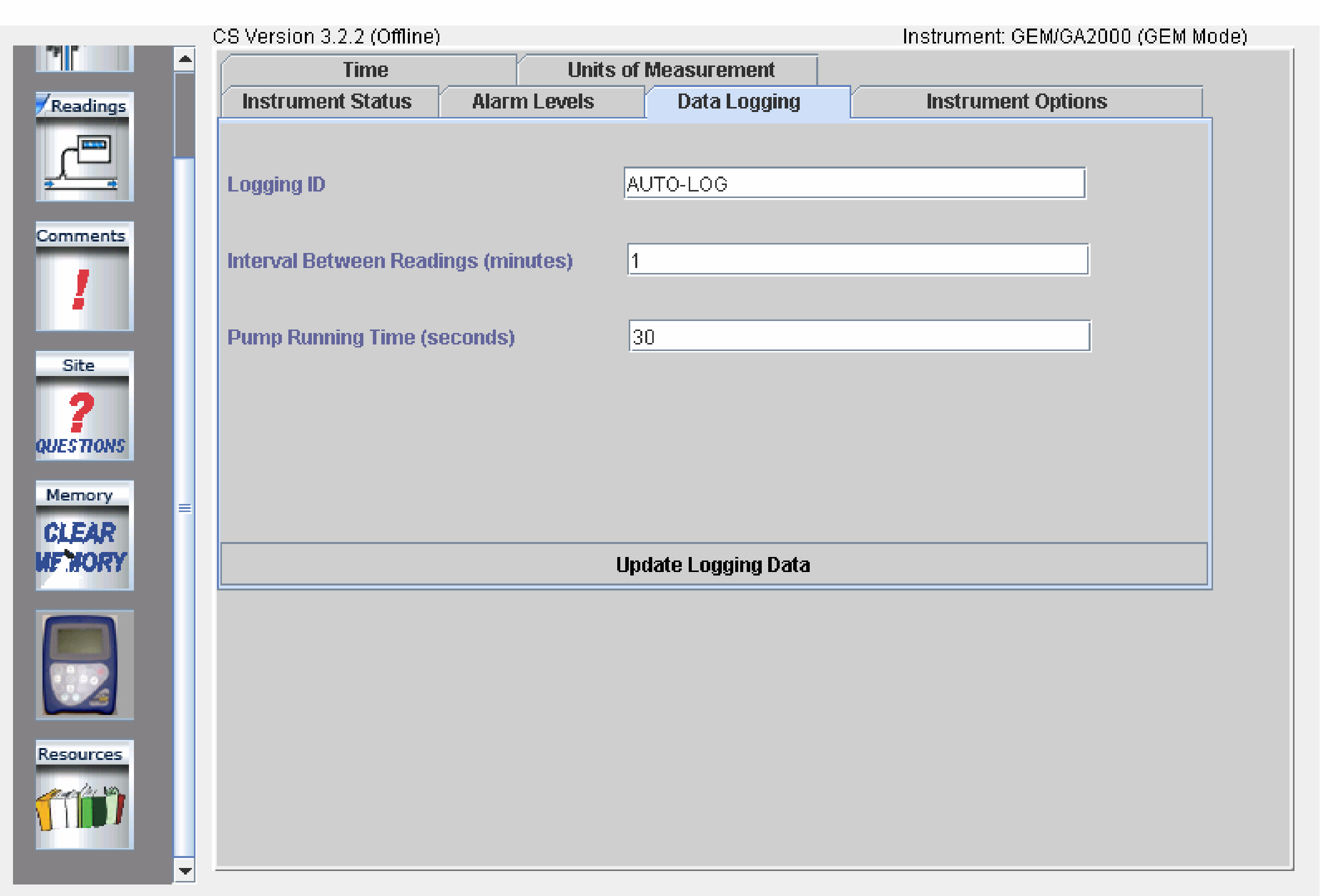
Click on the card tab for **Alarm Levels** to open the alarm levels screen. Both a maximum alarm and a minimum alarm may be set. Note these are global settings and will be the same for all IDs entered in the instrument. Turn off the alarm by clicking off the check mark next to the gas. Click on **Update Alarm Levels** to send the new settings to the instrument.



CS Version 3.2.2 (Offline)
Instrument: GEM/GA2000 (GEM Mode)

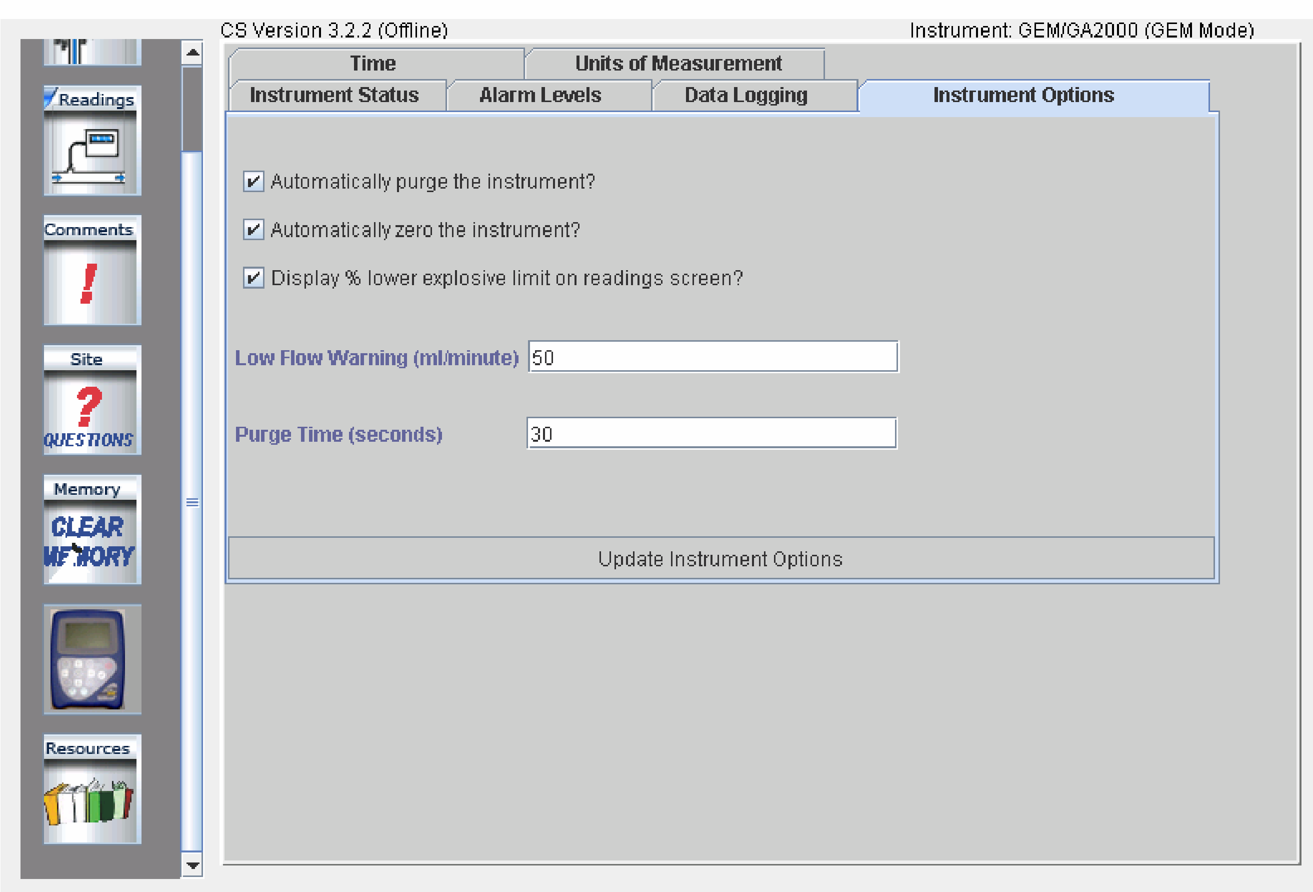
		Max		Min
CH4(%)	☐	100	☐	0
CO2(%)	☐	100	☐	0
O2(%)	☐	100	☐	0

Click on the **Data Logging** card tab to open the data-logging screen. In this screen enter the Logging ID; this may be any alphanumeric combination of eight characters. Enter the interval between readings in minutes and pump run time in seconds. Click on **Update Logging Data** to send to instrument. Only one logging ID may be loaded to the instrument.



Logging ID: AUTO-LOG
Interval Between Readings (minutes): 1
Pump Running Time (seconds): 30

Click on the **Instrument Options** card tab to open the instrument options screen. The settings in this screen affect different global functions of the instrument. Check the corresponding boxes in order to do the following: automatically purge the instrument during a shut down, automatically zero the instrument, display the percent lower explosive limit on readings screen. **Unchecking the last feature will disable % LEL display in both GA and GEM modes of operation**. The **Low Flow Warning** setting controls the point at which the pump is shut off due to low flow conditions. The default setting for this feature is 50 milliliters per minute but may be set to a lower number or even to zero, if sampling on high vacuum systems. The default value for the **Purge Time** is 30 seconds and may be reset to any length required. Turning off this feature is not recommended. Click on the **Update Instrument Options** button to send the new settings to the instrument.



☑ Automatically purge the instrument?

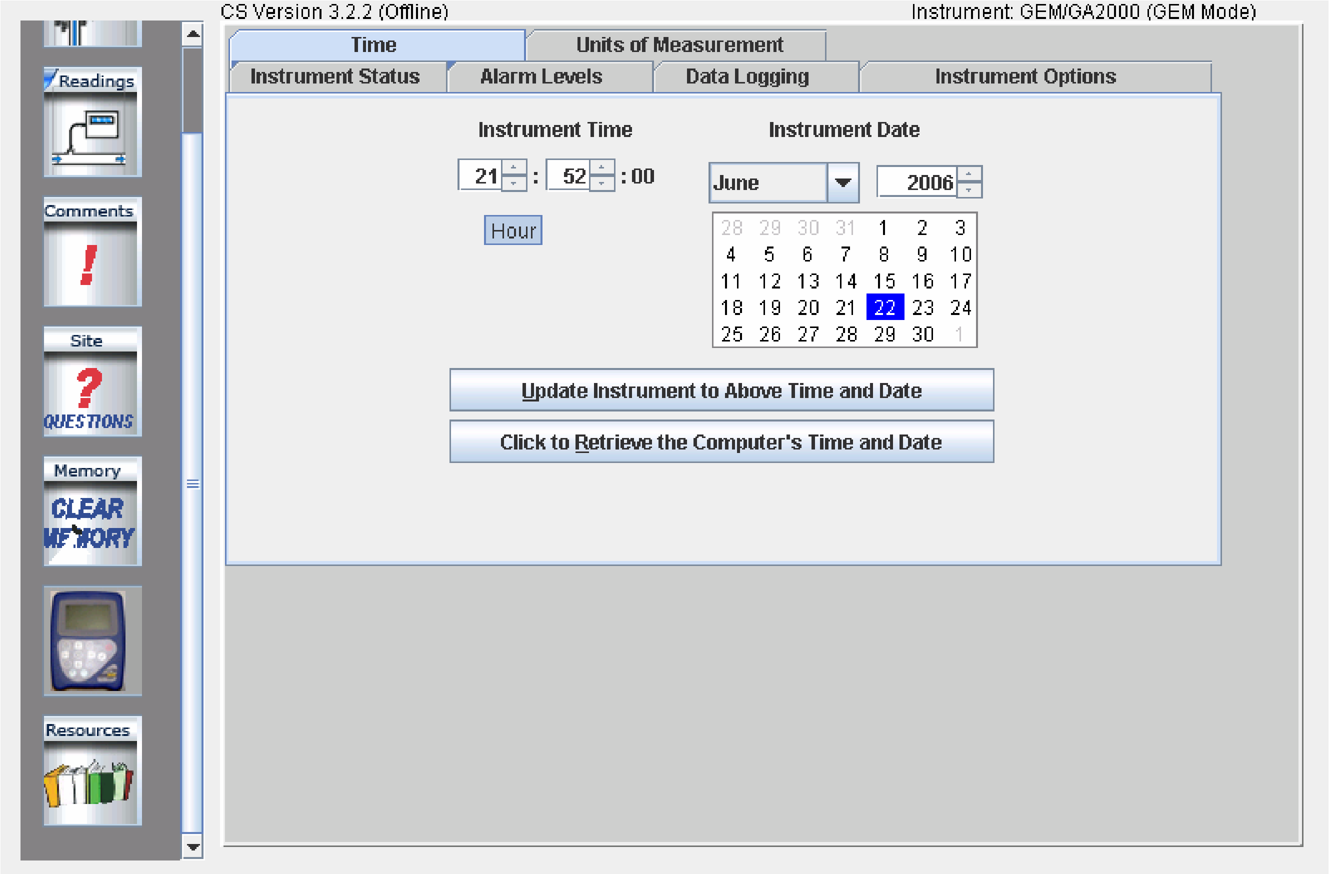
☑ Automatically zero the instrument?

☑ Display % lower explosive limit on readings screen?

Low Flow Warning (ml/minute) 50

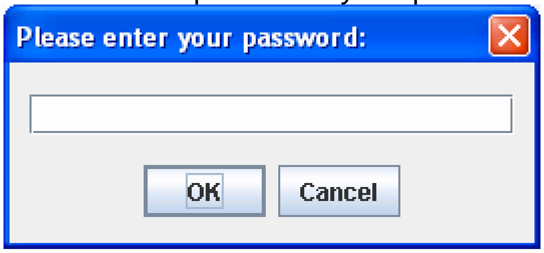
Purge Time (seconds) 30

Click on the Time card tab to open the time and date setting screen. Time and date may be set to the computer time and date settings by clicking on the **Click to Retrieve the Computer's Time and Date** button. Manual setting of the time and date may be accomplished by clicking on the **Update Instrument Time to Above Time and Date**. Any time updates must be done through the software. The instrument time can not be manually updated in the field.

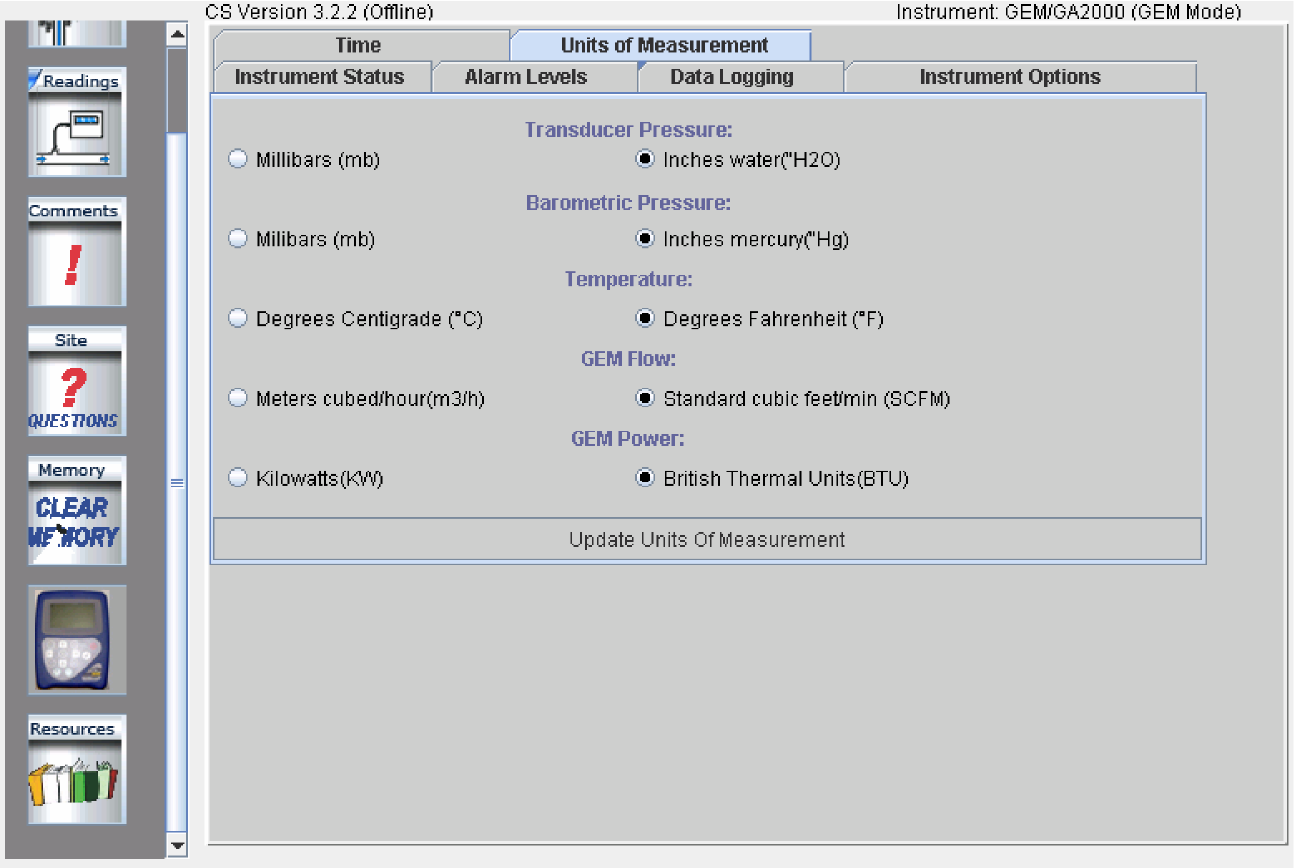


Units of Measurement screen allows the units to be changed.

This screen is protected by the password.



If you need to change the units of measurement, please contact our technical support team.



CS Version 3.2.2 (Offline)

Instrument: GEM/GA2000 (GEM Mode)

Transducer Pressure:
○ Millibars (mb) ● Inches water("H2O)

Barometric Pressure:
○ Milibars (mb) ● Inches mercury("Hg)

Temperature:
○ Degrees Centigrade (°C) ● Degrees Fahrenheit (°F)

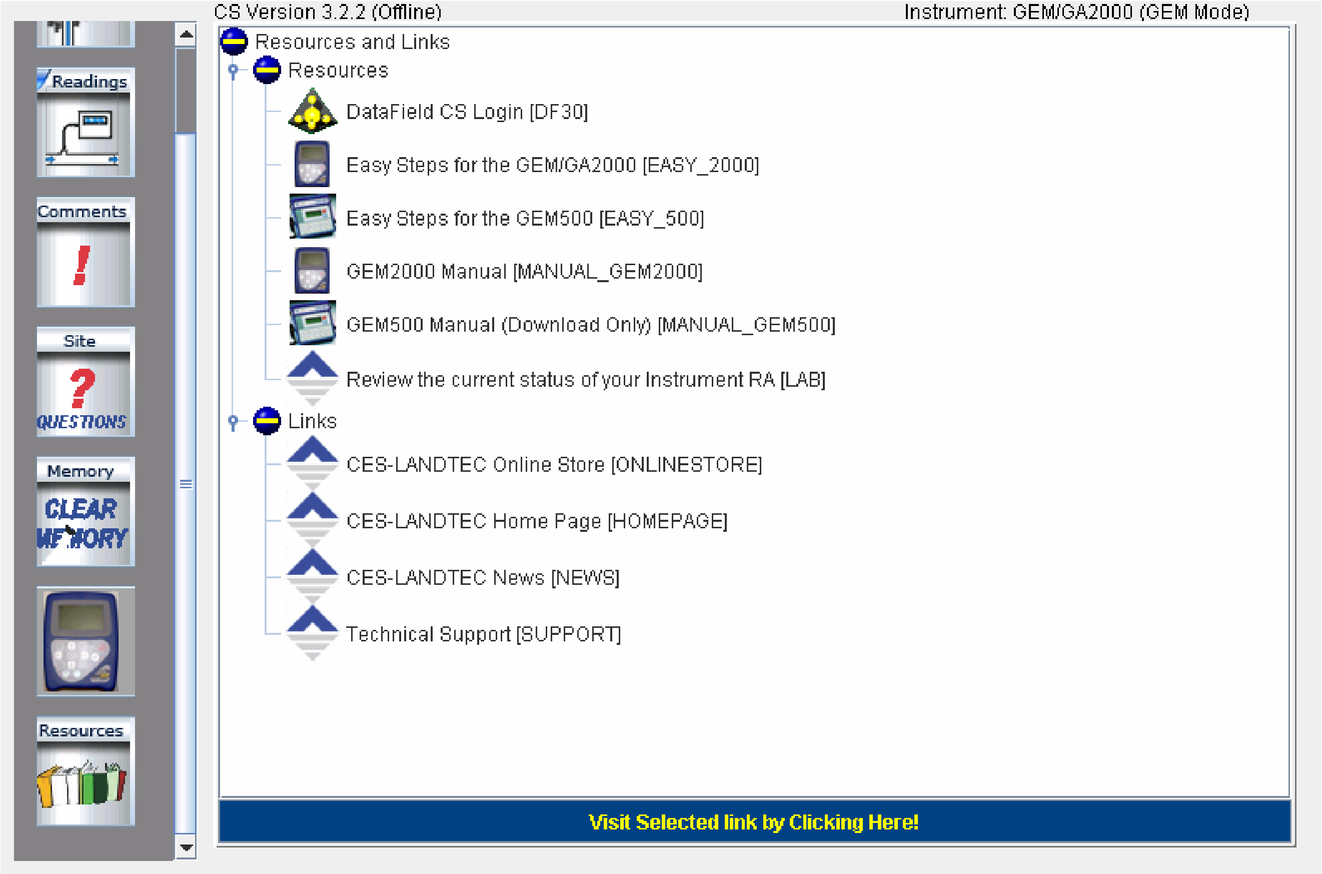
GEM Flow:
○ Meters cubed/hour(m3/h) ● Standard cubic feet/min (SCFM)

GEM Power:
○ Kilowatts(KW) ● British Thermal Units(BTU)

Note: EXTREME CAUTION should be taken if changing the Units of Measurement. All data from the instrument should be downloaded and stored in both, the GEM and the GA modes before updating the Units of Measurement. Updating Units of Measurement will erase readings from the instrument. The instrument should be turned off and restarted once the units of measurement have been updated.

Resource Links

Clicking on the **Resource Links** button on the main screen will display the **Resources and Links** screen.



CS Version 3.2.2 (Offline)

Instrument: GEM/GA2000 (GEM Mode)

- Resources and Links
  - Resources
    - DataField CS Login [DF30]
    - Easy Steps for the GEM/GA2000 [EASY_2000]
    - Easy Steps for the GEM500 [EASY_500]
    - GEM2000 Manual [MANUAL_GEM2000]
    - GEM500 Manual (Download Only) [MANUAL_GEM500]
    - Review the current status of your Instrument RA [LAB]
  - Links
    - CES-LANDTEC Online Store [ONLINESTORE]
    - CES-LANDTEC Home Page [HOMEPAGE]
    - CES-LANDTEC News [NEWS]
    - Technical Support [SUPPORT]

Visit Selected link by Clicking Here!

By clicking on the supplied link the user is taken directly to the www and the information listed.

7 Field Operations

7.1 Landfill Gas Generation

A brief overview of the theory of landfill gas generation and Methane recovery follows. Initially, when decomposable refuse is placed into a solid waste landfill, the refuse is entrained with air from the surrounding atmosphere. Through a natural process of bacterial decomposition, the Oxygen from the air is consumed and an anaerobic (Oxygen free) environment is created within the landfill. This anaerobic environment is one of several conditions necessary for the formation of Methane-CH_4.

If Oxygen is reintroduced into the landfill, those areas are returned to an aerobic (Oxygen present) state and the Methane-producing bacteria population is destroyed. A period of time must pass before the productive capacity is returned to normal. Since there is some Methane of a given quality within the landfill void space, a decline in Methane quality is only gradually apparent depending upon the size of the landfill.

Carbon Dioxide is also produced under either an aerobic or anaerobic condition. Under static conditions, the landfill gas will be composed of roughly half Methane and half Carbon Dioxide with a little Nitrogen.

As air is introduced into the landfill, the Oxygen is initially converted to Carbon Dioxide and residual Nitrogen remains. Measurement of residual Nitrogen is usually a good indicator of the anaerobic state of the landfill; however, it cannot be directly measured. It can, however, be assumed and estimated using a subtraction basis as the balance gas. Hence, the measurement of Carbon Dioxide is an intermediary step. Because Carbon Dioxide levels may fluctuate depending on the changing concentrations of the other constituent gases, Carbon Dioxide levels are not evaluated directly but are considered in light of other data.

In evaluation of residual Nitrogen, allowances must be made if there has been any air leakage into the gas collection system or if there has been serious over pull. If enough air is drawn into the landfill, not all Oxygen is converted into Carbon Dioxide and the Oxygen is apparent in the sample. It is ideal to perform routine analysis of individual wells, as well as an overall well field composite sample, by a gas chromatography. This is not always practical at every landfill.

Under some conditions there may be a small amount of hydrogen in the LFG, (about 1 percent, usually much less). This may affect field monitoring response factors, but otherwise it can be ignored.

7.2 Subsurface Fires

If very large quantities of air are introduced into the landfill, either through natural occurrence or overly aggressive operation of the LFG system, a partly unsupported subsurface combustion of the buried refuse may be initiated. Subsurface fire situations are difficult to control or extinguish once started, present health and safety hazards, and can be quite costly. Therefore, prevention by good operation of the collection system and maintenance of the landfill cover is the best course of action. The presence of Carbon Monoxide, Carbon Dioxide, and Hydrogen Sulfide are indicators of poorly supported combustion within the landfill.

7.3 Techniques for Controlling Landfill Gas

There are many techniques for controlling landfill gas extraction. These techniques represent tools, which are used together to control landfill gas. The Accu-Flo wellhead is designed to work with all of these techniques. Below is a discussion of the individual techniques, how to use them, and their limitations. Reliance on only a few of the techniques discussed can lead to misinterpretation of field data and improper operation of the well field. Later the best use of these techniques to optimize landfill gas control will be discussed.

7.3.1 Controlling by Wellhead Valve Position

Unless the valve handle is calibrated for a given flow rate, this method is unreliable. The position of the valve handle alone does not provide sufficient information about the well to control it. It is useful to note the relative position of the valve, and essential to know which valves are fully open or fully closed.

7.3.2 Controlling by Wellhead Vacuum

This technique relies on the relationship of well pressure/vacuum to flow for a given well. Reliance upon this method, however, can be misleading. This is because the square root relationship between flow and pressure is difficult to affect while performing day-to-day well field adjustments. As decomposition, moisture, and other conditions change, this method shows itself to be inadequate and imprecise.

7.3.3 Controlling by Gas Composition

This method determines Methane, Nitrogen (balance gas) and other gas composition parameters at wellheads and at recovery facilities using portable field instruments and, sometimes, analytical laboratory equipment. Complete knowledge of gas composition (i.e., major fixed gases: Methane, Carbon Dioxide, Oxygen and Nitrogen) is desirable. It is also necessary to check other gas parameters, such as Carbon Monoxide, to fully evaluate the condition of the well field. Reliance on this information can lead to improper operation of the well field. Indications of excessive extraction often do not show up right away. This method often leads to a cycle of damage to the Methane producing bacteria population and then to over-correction. This cycling of the well and producing area of the landfill is not a good practice. It leads to further misinterpretation of the condition of the well field and has a disruptive effect on the operation of the well field. The use of analytical laboratory instrumentation such as a gas chromatograph is a valuable supplementary tool to verify gas composition. This normally requires collection of samples at the wellhead and analysis at some fixed location where the equipment is located. The drawbacks of this method as a primary means of obtaining information for well field adjustment are the time expended, cost, and probably most important, responsiveness to the needs of the well field for timely adjustment. The laboratory equipment required is also very costly. Some analysis is recommended for verification of field readings from time to time. It is recommended a monthly sample of the composite gas be taken at the inlet to the flare or gas recovery facility.

7.3.4 Controlling by Flow Rate

This is a more exacting technique for determining and adjusting gas flow at individual wells. It requires using a fixed or portable flow measurement device at each wellhead to obtain the data needed to calculate volumetric (or mass) flow rates. It is normally convenient to use cubic feet per minute or per day, as a standard unit of measure for volumetric flow. It is important to distinguish between the volumetric quantity of landfill gas and the volumetric quantity of Methane extracted from each well and the landfill in total. The two variables are somewhat independent of each other and it is the total quantity of Methane extracted we are interested in. It is possible for the total quantity of landfill gas extracted to increase while the total quantity of Methane extracted decreases. To monitor this, the quantity of Methane extracted (LFG flow x percent Methane) or the quantity of BTUs recovered per hour (LFG flow x percent Methane x BTUs per cubic foot of Methane x 60 minutes per hour) can be calculated. It is conventional to measure BTUs per hour as a unit of time. There are approximately 1012 BTUs of heat per cubic foot of pure Methane (like natural gas), although this figure varies a little among reference texts.

Measuring flow is an essential part of monitoring and adjusting a well field. The well should be adjusted until the amount of Methane recovered is maximized for the long term. A greater amount of Methane or energy can usually be recovered over the short term; however, this ultimately leads to diminishing returns. This is seen in stages as increased CO_2 and gas temperature and later as increased Oxygen from well over-pull. In time, the Methane will also decline. This is the result of a portion of the landfill, usually at the surface, being driven aerobic. In this portion of the landfill, the Methane-producing bacteria will have been destroyed (due to the presence of Oxygen). With the Methane-producing capacity of the landfill reduced, the pore space in the area no longer producing may become filled with landfill gas equilibrating (moving in) from an unaffected producing area. This leaves the impression that more gas can be recovered from this area, and may lead to the operator opening the well or increasing flow.

7.4 Well field Monitoring

The frequency of LFG well field monitoring varies depending upon field requirements and conditions. Normal monitoring frequency for a complete field monitoring session with full field readings (suggested normal and abbreviated field readings list follows) will vary from typically once a month to once a week. Well field monitoring should not normally be extended beyond one month. The importance of regular, timely monitoring cannot be overemphasized.

7.5 Typical Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Carbon Dioxide (CO_2)
- Balance Gas (primarily Nitrogen N_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM™2000 or magnehelic) or other device(anemometer/velometer)
- Velocity head (P or PT) (from GEM™2000 or pitot tube and magnehelic)
- Wellhead gas flow (from GEM™2000, or pitot tube & magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Calculation of each well’s LFG and Methane flow and sum total
- Observations/comments

Additionally, Carbon Monoxide (CO) or Hydrogen Sulfide (H_2S) readings may be taken if problems are suspected. Supplementary monitoring once to several times a week may be performed using an abbreviated form of field readings.

7.6 Abbreviated Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM™2000 or magnehelic)
- Velocity head (P or Pt) (from GEM™2000 or pitot tube and magnehelic)
- Wellhead gas flow (from GEM™2000, or pitot tube and magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Observations/comments

Line vacuums and gas quality may be taken at key points along the main gas collection header and at subordinate branches. This helps to identify locations of poor performance, excessive pressure drop, or leakage. Perform systematic monitoring of the well field, taking and logging measurements at each wellhead and major branch junction in the collection system.

During monitoring, examine landfill and gas collection system for maintenance issues. Record needed maintenance or unusual conditions. Examples of unusual occurrences or conditions are unusual settlement, signs of subsurface fires, cracks and fissures, liquid ponding, condensate/leachate weeping from side slopes, surface emissions and hot spots, and liquid surging and blockage in the gas collection system. Field readings should be kept in a chronological log and submitted to management on a timely basis.

7.7 Well field Adjustment Criteria

There are several criteria used in well field adjustment. The primary criterion is Methane quality. Methane quality is an indicator of the healthy anaerobic state of the landfill and thus proper operation of the LFG collection system. However, a decline in the healthy productive state of the landfill is usually not immediately apparent from Methane quality. Due to this, several criteria must be considered at once.

Conditions within the landfill favor Methane production. Following are well field adjustment criteria and typical conditions for consideration:

- Methane quality (ranging from 26 percent upwards)
- pH
- Temperature
- General overall quality
- Moisture conditions
- Waste stream characteristics
- Placement chronology
- Insulation characteristics
- Oxygen quality (ranging below 1 percent, preferably less then ½ percent)
- Landfill cover porosity and depth in the proximity of the well
- Landfill construction factors including:
- Type of fill
- Size and shape of refuse mass
- Depth of fill

- Compaction
- Leachate control methods
- Seasonal, climatic, geographical, and recent weather, or other considerations, including seasonally arid or wet conditions, precipitation, drainage, groundwater
- Surrounding topography and geologic conditions
- Proximity of the well to side slopes (within 150 to 200 feet and less may require conservative operation of the well)
- Nitrogen (typically 8 to 12 percent and less)
- Temperature (between ambient and about 130 °F)
- LFG and Methane flow from the wellhead
- Design of the gas collection system
- Landfill perimeter gas migration and surface emission control, or energy recovery objectives
- Diurnal fluctuation (day to night) of atmospheric pressure

7.8 Establishing Target Flows

The goal is to establish a target flow which will likely produce the best possible Methane quality and minimum Oxygen levels while maximizing the recovery of landfill gas. Typically, small adjustments are made in flow to achieve and maintain quality objectives. The well must not be allowed to over pull. High well temperatures, (130° to 140°F and greater), are an indication of aerobic activity and, thus, well over-pull. These effects may not be immediately apparent.

Well adjustment should be made in as small an increment as possible, preferably an increment of ten percent of the existing flow or less. There may be obvious conditions when this is not appropriate, such as when first opening up a well or when serious over-pull is recognized. Every effort should be made to make adjustments and operations as smooth as possible. Dramatic adjustments, or operating while switching between a high flow mode and a well shutoff mode, should be avoided.

7.9 Well field Optimization

Every effort should be made to continuously locate and correct or eliminate conditions (e.g., gas condensate, surging and blockage, settlement, etc.), which inhibit efficient operation of the gas collection system. This allows well monitoring and adjustment to be significantly more effective.

7.10 Migration Control—Dealing with Poor Methane Quality

If Methane and Oxygen quality objectives cannot be maintained at a given well, such as a perimeter migration control well, then an attempt should be made to stabilize the well as closely as is practical, avoiding significant or rapid down trending of Methane or up trending of Oxygen.

It is not uncommon for perimeter migration control wells to be operated at less than 40 percent Methane or greater than one-percent Oxygen. It should be recognized that these wells are likely in a zone where some aerobic action is being induced, and that there is some risk of introducing or enhancing the spread of a subsurface fire. Sometimes a judicious compromise is necessary to achieve critical migration control objectives or because existing conditions do not allow otherwise. Such situations should be monitored closely.

7.11 Well field Adjustment—Purpose and Objectives

The objective of well field adjustment is to achieve a steady state of operation of the gas collection system by stabilizing the rate and quality of extracted LFG in order to achieve one or several goals. Typical reasons for recovery of LFG and close control of the well field are:

- Achieve and maintain effective subsurface gas migration control.
- Achieve and maintain effective surface gas emissions control.
- Assist with proper operation of control and recovery equipment.
- Avoid well “over-pull” and maintain of a healthy anaerobic state within the landfill.
- Optimize LFG recovery for energy recovery purposes.
- Control nuisance landfill gas odors.
- Prevent or control subsurface LFG fires.
- Protect structures on and near the landfill.
- Meet environmental and regulatory compliance requirements.

Well field adjustment is partly subjective and can be confusing because it involves judgment calls based on simultaneous evaluation of several variables, as well a general knowledge of site specific field conditions and historical trends. Well field evaluation and adjustment consist of a collection of techniques, which may be used, in combination, to achieve a steady state of well field operation.

8 Troubleshooting

Problem	Corrective Action/Reason
Unit does not turn on or operation is erratic	Battery charge is too low-recharge batteries. Unit is too hot - cool down unit and try again. Contact Factory Service.
"Flow Fail" is displayed and an audible alarm is heard	The inlet is blocked. Remove blockage and retry. The particulate filter or water trap filter needs replacing.
Readings taken are not what was expected	Unit may be out of calibration. Calibrate unit with known gas concentration. Water trap or particulate filters are clogged. Replace filter(s).
Readings swing up or down wildly as they are being taken.	Cell phones and other sources of RF interference can affect Methane readings. Don't use your cell phone while taking readings.
Unit displays***** or >>>>>	These symbols are substituted when the measured reading is out of range of the instruments capabilities in some fields or when a value needs to be entered manually such as temperature.
Oxygen reading is high on all wells	Check that the water trap housing is screwed on tight. Check or replace O-rings on the water trap and instrument inlet. Check the wellhead inset for cracks, replace O-ring on insert. Field calibrate Oxygen channel.
Unit will not download readings or an error occurs while downloading.	Verify that the communications software is the right version for the instrument being used. Check that the proper serial port is selected in the software. Contact Factory Service.
Methane and Carbon Dioxide readings drift	Perform a field calibration and check well again. Verify cal gas is flowing when regulator is turned on. Verify all connections are tight and filters are not clogged. Contact Factory Service.
Oxygen readings drift	Perform a field calibration - zero and span. Contact Factory Service.
Black screen displayed when unit turned On	Charge unit over night and try again. Unit too hot - cool down and try again. Try adjusting contrast level. Contact Factory Service.
Nothing happens when the Gas Pod is installed	Remove and re-seat the Gas Pod. Contact Factory Service.
Temperature does not update when temperature probe is installed	Check the probe fitting is fully seated. Check the probe plug is screwed together tightly. Contact Factory Service.

9 Technical Specifications

9.1 Physical

Weight	4.4 lbs.
Size	L 2.48” x W 7.48’’ x D 9.92”.
Case material	Anti-static ABS.
Keys	Membrane panel.
Display	Liquid Crystal Display 40 x 16 characters. Fiber optic woven backlight for low light conditions.
Filters	User replaceable integral fiber filter at inlet port and external PTFE water trap filter.

9.2 General

Certifications	UL Certified to Class 1, Zone 1, AEx Ib d IIa T4
Temperature measurement	With optional probe 14°F to 167°F.
Temperature accuracy	±0.4ºF (± probe accuracy).
Visual and audible alarm	User selectable CO_2, CH_4 and O_2 Min/Max levels via DataField CS software.
Communications	RS232 protocol via download lead with variable baud rate.
Relative pressure	±250 mbar from calibration pressure

9.3 Power supply

Battery type	Rechargeable Nickel Metal Hydride battery pack containing six 4AH cells. **Not user replaceable**. Lithium Manganese battery for data retention.
Battery life	Typical use 10 hours from fully charged condition.
Battery charger	Separate intelligent 2A battery charger powered from AC voltage supply (110-230V).
Charge time	Approximately 2 hours from complete discharge.
Alternative power	Can be powered externally for fixed-in-place applications only. Contact LANDTEC for further information.
Battery lifetime	Up to 1,000 charge/discharge cycles.

9.4 Gas Ranges

Detection principle	CO_2 and CH_4 by dual wavelength infrared cell with reference channel. O_2 by internal electrochemical cell.
Oxygen cell lifetime	Approximately 18 months in air.
Typical Accuracy 0 - Full Scale	**Gas** / **0-5% volume** / **5-15% volume** / **15%-FS** **CH_4** ±0.3% ±1% ±3% (100%) **CO_2** ±0.3% ±1% ±3% (60%) **O_2** ±1% ±1% ±1% (21%)
Response time, T90	CH_4 ≤20 seconds CO_2 ≤20 seconds O_2 ≤20 seconds
Range	CH_4 0-70% to specification, 0-100% reading. CO_2 0-40% to specification, 0-100% reading. O_2 0-25%

9.5 Pump

Typical flow	300 cc/min.
Flow fail point	50 cc/min approximately.
Flow with 200 mbar vacuum	250 cc/min approximately.
Vacuum	70 inches H_20.

9.6 Operating Conditions

Operating temp range	32°F to 104°F.
Relative humidity	0-95% non-condensing.
Atmospheric pressure range	700-1200 mbar. Displayed in Inches of Mercury (5.9 – 35.4“Hg). Not corrected for sea level.
Atmospheric pressure accuracy	±5 mbar approximately.
Case seal	IP65.

9.7 Optional Gas Pods

	Gas	0-Full Scale
Typical Accuracy (Subject to User calibration).	CO	±10% FS
	H_2S	±10% FS
	SO_2	±10% FS
	NO_2	±10% FS
	CL_2	±10% FS
	H_2	±10% FS
	HCN	±10% FS
Response time, T90	CO	≤60 seconds
	H_2S	≤60 seconds
	SO_2	≤60 seconds
	NO_2	≤60 seconds
	CL_2	≤60 seconds
	H_2	≤60 seconds
	HCN	≤60 seconds
Range	CO	0-500ppm
	H_2S	0-50 or 0-200ppm
	SO_2	0-20 or 0-100ppm
	NO_2	0-20ppm
	CL_2	0-20ppm
	H_2	0-1000ppm
	HCN	0-100ppm

APPENDIX C

Laboratory SOPs

Canisters
and
Tedlar Bags

Air Toxics LTD.
Laboratory Services Since 1989

Guide to Air Sampling & Analysis

Always Air, Always Accurate

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Section 1.0 Introduction

Air Toxics Ltd. presents this guide as a resource for individuals engaged in 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 equipment and media used. 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 sufficiently address the multitude of field conditions. Note that this guide is intended for projects involving whole air sampling of volatile organic compounds (VOCs) in canisters and Tedlar® bags. Air Toxics Ltd. provides the "Guide to Sorbent-Based Sampling - Volatiles and Semi-Volatiles" for other types of sampling.

1.1 Whole Air Sampling of VOCs

This guide focuses on collecting a sample in the most common air sampling containers, Summa canisters and Tedlar® bags. The sample may be collected in the container either passively (i.e., by evacuating the canister prior to sampling) or actively (i.e., using a pump). The sample is referred to as a "whole air sample" and the compounds remain in the gas matrix (e.g., ambient air) inside the container.

1.2 Choosing Between Canisters and Tedlar® Bags

Table 1.2 compares the features of canisters and Tedlar® bags. Canisters have superior inertness, hold time to analysis and ruggedness. They also do not require a sampling pump. Tedlar® bags can be purchased inexpensively in bulk, carried to a sampling site in a briefcase, filled in seconds and shipped easily to the laboratory for analysis. Call Client Services at 800-985-5955 if you have questions regarding the appropriate sampling media.

Table 1.2 Comparison of Canisters to Tedlar® Bags

	Canisters	Tedlar® Bags
Common Volumes	1 and 6 L	1, 3, and 5 L
Type of Sampling	Passive (vacuum)	Active (pump required)
Sample Handling	Room temperature	Room temperature
Media Hold Time	Up to 30 days recommended	Indefinite
Hold Time to Analysis	Up to 30 days	Up to 3 days
Surface Inertness	Excellent	Fair
Cleanliness	10% or 100% certified to ppbv/pptv levels	Some VOCs present at 0.5 to 45 ppbv
Sampling Application	Ambient/indoor air, soil/landfill gas, stationary source	Ambient air (fixed gases only), soil/landfill gas, stationary source
Rule of Thumb	"ppbv device"	"ppmv device"
Advantages	Inertness, hold time, ruggedness, no pump	Purchase/shipping cost, availability, convenience

Section 2. Canisters and Associated Media

This section provides a description of air sampling canisters, practical considerations for sampling, and step-by-step sampling instructions. Tables provide detailed information on many operational factors that ultimately influence the quality of the data obtained from a canister sample.

2.1 Introduction to Canisters

The canister is prepared for sampling by evacuating the contents to a vacuum of approximately 29.9 inches of Mercury (in. Hg). Opening the stainless steel bellows valve allows the air sample to enter the canister. When the target volume of sample is collected, the valve is closed and the canister is returned to the laboratory. Canisters range in volume from less than 1 liter (L) to greater than 6 L. At Air Toxics Ltd., 6 L canisters are used for ambient air samples and for taking integrated samples. One liter canisters are generally used for taking high concentration (i.e., greater than 5 ppbv) grab samples, although exceptions to these guidelines are common.

2.1.1 Summa Canister

A Summa canister is a stainless steel container that has had the internal surfaces specially passivated using a “Summa” process. This process combines an electropolishing step with a chemical deactivation step to produce a surface that is nearly chemically inert. A Summa surface has the appearance of a mirror: bright, shiny and smooth. The degree of chemical inertness of a whole air sample container is crucial to minimizing reactions with the sample and maximizing recovery of target compounds from the container.

2.1.2 Canister Cleaning

Air Toxics Ltd. provides two types of canister cleaning certification, 10% and 100%, depending upon the requirements of the project. The 10% certification process is appropriate for routine ambient air applications and high concentration applications such as soil vapor and landfill gas monitoring. The 10% certification process begins by cleaning canisters using a combination of dilution, heat and high vacuum. Canisters are certified for approximately 60 VOCs using GC/MS. As part of our quality control plan we perform a 10% process certification which requires that target compound concentrations be below 0.2 ppbv using GC/MS analysis. Alternatively, the 100% certification (i.e., individual certification) process is appropriate for ambient and indoor air applications driven by risk assessment or litigation requiring pptv (parts per trillion by volume) sensitivity. Similar to the 10% certification, the 100% certification also begins with the canister cleaning process. The difference with the 100% certification is that canisters are individually certified for a client-specific list of target compounds using GC/MS. When the 100% certified canisters are shipped the analytical documentation demonstrating that they are free of the target compounds down to the project reporting limits is emailed to the client. When sampling with certified media it is important to note that all media is certified as a train and must be sampled as such (i.e., a particular flow controller goes with a particular canister and is labeled as such).

Specify whether your project requires
10% or 100% canister cleaning certification

2.1.3 Canister Hold Time

Media Hold Time : Canister sampling differs considerably from collecting a water sample in a VOA vial or a soil sample in an amber jar in that the container (valued at over $500) is cleaned and reused. Air Toxics Ltd. requires that our canisters be returned within 14 days of receipt to effectively manage our inventory. Once a canister is cleaned, certified and evacuated we recommend the canister be used for sample collection within 30 days. Over time, low-level (pptv) concentrations of typical VOCs may off-gas from the canister surface resulting in potential artifacts in the sample results.

Sample Hold Time: Although 30 days is the most commonly cited hold time for a canister sample, the hold time is compound-specific. For example, compounds such as chloroform, benzene, and vinyl chloride are stable in a canister for at least 30 days. In fact, EPA Method TO-15 states, “Fortunately, under conditions of normal usage for sampling ambient air, most VOCs may be recovered from canisters near their original concentrations for after storage times of up to thirty days”. However, some VOCs such as bis(chloromethyl)ether degrade quickly and demonstrate low recovery even after 7 days. The standard VOC list reported by Air Toxics is stable up to 30 days after sample collection. Some projects require a more rigorous 14-day hold time.

2.2 Associated Canister Hardware

Associated hardware used with the canister includes the valve, brass cap, particulate filter and vacuum gauge.

2.2.1 Valve

An industry standard, 1/4 in. stainless steel bellows valve (manufactured by Swagelok or Parker Instruments) is mounted at the top of the canister. The valve allows a vacuum to be maintained in the canister prior to sampling and seals off the canister once the sample has been collected. No more than a half turn by hand is required to open the valve. Do not over-tighten the valve after sampling or it may become damaged. A damaged valve can leak, possibly compromising the sample. Some canisters have a metal cage near the top to protect the valve.

2.2.2 Brass Cap

Each canister comes with a brass cap (i.e., Swagelok 1/4 in. plug) secured to the inlet of the valve assembly. The cap serves two purposes: first, it ensures that there is no loss of vacuum due to a leaky valve or a valve that is accidentally opened during handling; second, it prevents dust and other particulate matter from fouling the valve. The cap is removed prior to sampling and replaced following sample collection.

Always replace the brass cap following canister sampling.

7 Micron

2 Micron

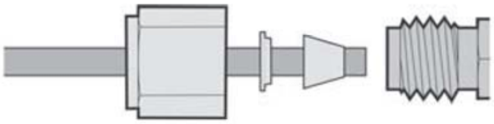
2.2.3 Particulate Filter

Particulate filters should always be used when sampling with a canister. Separate filters are provided to clients taking a grab sample and filters are built into the flow controllers for clients taking integrated samples. Air Toxics Ltd. provides either a 2 micron filter or a 7 micron filter. These devices filter particulate matter greater than 2 and 7 microns in diameter respectively. The shorter 2 micron filter is a fritted stainless steel disk that has been pressed into a conventional Swagelok adapter and is disposed of after each use. This device has a relatively high pressure drop across the fritted disk and restricts the flow into the canister. The 2 micron filter is standard for clients taking integrated samples. The longer 7 micron filter is cleaned in a similar manner as the stainless steel canisters after each single use, and does not significantly restrict the flow rate into the canister. The 7 micron filter is primarily used with grab samples. **Both the 2 and 7 micron filters are not calibrated devices and therefore the flow rates can and do vary for each filter.**

Always use the particulate filter for canister sampling.

2.2.4 Fittings

All fittings on the sampling hardware are 1/4 in. Swagelok; a 9/16 in. wrench is used to assemble the hardware. Compression fittings should be used for all connections; never use tube in tube connections. It is critical to avoid leaks in the sampling train. Leaks of ambient air through fittings between pieces of the sampling train (e.g., tubing to particulate filter) will dilute the sample and cause the canister to fill at a faster rate than desired. Air Toxics can provide the necessary fittings and ferrules if requested.



2.2.5 Vacuum Gauge

A vacuum gauge is used to measure the initial vacuum of the canister before sampling, and the final vacuum upon completion. A gauge can also be used to monitor the fill rate of the canister when collecting an integrated sample. Air Toxics Ltd. provides 2 types of gauges. For grab sampling, a test gauge checks initial and final vacuums only and is not to be sampled through. For integrated sampling a gauge is built into the flow controller and may be used for monitoring initial and final vacuums, as well as monitoring the fill rate of the canister. Both gauges are not calibrated and are considered to be equally rough gauges, which also means they can provide you with differing numbers for the same canister. In special cases a pressure/vacuum gauge can be provided upon request. Air Toxics Ltd.'s gauges are provided only to obtain a relative measure of "change." Individuals with work plans that outline specific gauge reading requirements are strongly encouraged to purchase and maintain their own gauges.

The gauges that Air Toxics Ltd. provides are for rough estimates only. If the project plan requires a certain level of gauge accuracy the use of a calibrated gauge is highly recommended.

Table 2.2.3 Approximate Fill Times for Canisters

CANISTER VOLUME	7 micron filter	2 micron filter
6 L	16 sec	3 min
1 L	3 sec	30 sec

Section 3.0 Sampling with Canisters

There are two basic modes of canister sampling: grab and integrated. A grab sample is taken over a short interval (i.e., 1-5 minutes) while an integrated sample is taken over an extended period (e.g., 0.5-24 hours). In both modes the canister vacuum is used to draw the sample into the canister.

3.1 Considerations for Grab Sampling With Canisters

The following are some considerations for collecting a grab sample in a canister.

- **Verify Initial Vacuum of the Canister**: Prior to shipment, each canister is checked for mechanical integrity. However, it is still important to check the vacuum of the canister prior to use. Air Toxics recommends doing this before going to the field if possible. The initial vacuum of the canister should be greater than 25 in. Hg. If the canister vacuum is less than 25 in. Hg, do not use it. Call Client Services at 800-985-5955 and arrange for a replacement canister. If sampling at altitude there are special considerations for gauge readings and sampling (see Section 5.2). The procedure to verify the initial vacuum of a canister is simple but unforgiving:

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove the brass cap
3. Attach gauge
4. Attach brass cap to side of gauge tee fitting, if one is not already there, to ensure a closed train
5. Open and close valve quickly (a few seconds)
6. Read vacuum on the gauge
7. Record gauge reading on "Initial Vacuum" column of chain-of-custody
8. Verify the canister valve is closed and remove gauge
9. Replace the brass cap

3.1.1 Step-By-Step Procedures for Canister Grab Sampling

These procedures are for a typical ambient air sampling application; actual field conditions and procedures may vary.

Before you get to the field:

1. Verify contents of the shipped package (e.g., chain-of-custody, canister, particulate filter, and gauge – if requested)
2. Verify the gauge is working properly
3. Verify the initial vacuum of canister

When ready to sample:

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove brass cap
3. Attach particulate filter to canister
4. Open valve 1/2 turn (6 L canister normally takes about 16 sec to fill)
5. Close valve by hand tightening knob clockwise
6. Verify and record final vacuum of canister (repeat steps used to verify initial vacuum)
7. Replace brass cap
8. Fill out canister sample tag (make sure the sample ID and date of collection recorded on the sample tag matches what is recorded on the COC exactly)
9. Return canister in box provided (unreturned canister charge of $500 each)
10. Return sample media in packaging provided (unreturned equipment charges: $45 per particulate filter; $45 per gauge)
11. Fill out chain-of-custody and relinquish samples properly (it is important to note the canister serial numbers on the chain-of-custody)
12. Place chain-of-custody in box and retain pink copy
13. Tape box shut and affix custody seal at each opening (if applicable)
14. Ship accordingly to meet method holding times

- **Leave Residual Vacuum**: A grab sample can be collected either by allowing the canister to reach ambient conditions or by leaving some residual vacuum (e.g., 5 in. Hg) in the canister. In either case, the final vacuum should be noted in the "Final Vacuum" column on the chain-of-custody. This will enable the laboratory to compare the final vacuum with the receipt vacuum (i.e., the vacuum measured upon arrival at the laboratory).

3.2 Integrated Sampling with Canisters and Flow Controllers

An air sample collected over more than a few minutes is referred to as an integrated sample and can provide information on compound concentrations in air averaged or composited over time. An 8- or 10-hour integrated sample can be used to determine indoor air quality in the workplace. Similarly, a 24-hour integrated sample may be an economical and practical approach to determine residential exposure to indoor or outdoor air sources. The most common hardware configurations used to take an integrated sample are illustrated above.

Flow controllers are devices that regulate the flow of air during sampling into an evacuated canister. Also known as flow restrictors, these devices enable a sampler to achieve a desired flow rate and thus, a sampling interval. Air Toxics Ltd. provides two general types of flow controllers: mass flow controllers and critical orifice devices. Both devices are driven by differential pressure between ambient conditions and the vacuum in the canister.

3.2.1 Mass Flow Controller

A mass flow controller employs a diaphragm that actively compensates to maintain a constant mass flow rate. As the differential pressure decreases, the flow rate tends to decrease and the diaphragm responds by opening up to allow more air to pass through. Mass flow controllers can provide integrated samples with intervals ranging from hours to days. Air Toxics Ltd. provides a fixed mass flow controller that is calibrated at the laboratory for 24-hour sampling. Adjustable mass flow controllers have a knob that can be adjusted in the field to provide integrated samples with intervals ranging from 1 to 24 hours. The rugged conditions of field sampling are not usually compatible with adjustable mass flow controllers and Air Toxics Ltd. has designed a more reliable flow controller based on a critical orifice design.

3.2.2 Critical Orifice Device

Air Toxics Ltd. designed a critical orifice flow controller to provide time-weighted samples with intervals from 0.5 to 12 hours into a 6 L canister and 4 min. to 2 hrs. in a 1 L canister. The device restricts air flow by forcing the sample to enter a capillary column of minute radius. This device is passive compared to an actively compensating diaphragm and the flow rate decreases as the driving force (differential pressure) decreases. For sampling intervals from 0.5 to 12 hours, however, the flow rate is time weighted. The main advantages of the Air Toxics Ltd. flow controllers are improved ruggedness and cleanliness. With no moving or adjustable parts, the Air Toxics Ltd. design is unlikely to lose its flow setting. In addition, a vacuum gauge is built into the device to monitor sampling progress.

3.2.3 Sampling Interval and Flow Controller Setting

When you request canisters and flow controllers from Air Toxics Ltd., you will be asked for the sampling interval, and the flow controllers will be pre-set prior to shipment according to the table below. The flow controller is set to collect a 5 L sample over the sampling interval. Final canister vacuum is targeted at 5 in. Hg. The flow rate is set at standard atmospheric conditions (approximately sea level). If the air sample is from a process (pressurized or under vacuum) or is collected at elevation, the canister will fill faster or slower depending on sample conditions. If you specify the source at project set-up, we can set the flow controller accordingly. See Section 5.2 for a discussion of collecting a sample at elevation. The 24-hr flow controllers should not be used for process or source samples.

Table 3.2.3 Flow Rates for Selected Sampling Intervals (mL/min)

Sampling Interval (hrs)	**4 min.**	**0.5**	**1**	**2**	**4**	**8**	**12**	**24**
6 L Canister	**na**	**167**	**83.3**	**41.7**	**20.8**	**11.5**	**7.6**	**3.8**
1 L Canister	**166.7**	**26.6**	**13.3**	**6.7**	**-**	**-**	**-**	**-**

Note: Target fill volumes for 6 L and 1 L canisters are 5,000 mL and 800 mL, respectively.

$$\text{Flow Rate(mL/min)} = \frac{\text{Target Fill Volume (mL)}}{\text{Sampling Interval (min)}}$$

3.2.4 Final Canister Vacuum and Flow Controller Performance

Ideally, the final vacuum of a 6 L canister should be between 5-10 in. Hg or greater. As long as the differential pressure is greater than 4 in. Hg ambient pressure, then the flow through the device will remain approximately constant as the canister fills. If there is insufficient differential pressure, the flow through the controller will decrease as the canister pressure approaches ambient. Because of the normal fluctuations in the flow rate (due to changes in ambient temperature, pressure and diaphragm instabilities) during sampling, the final vacuum will range between 2 and 10 in. Hg.

- **If the residual canister vacuum is greater than 5 in. Hg** (i.e., more vacuum), less than 5 L of sample was collected. When the canister is pressurized to 5 psig prior to analysis, sample dilution will be greater than normal. This will result in elevated reporting limits.
- **If the residual canister vacuum is less than 5 in. Hg** (i.e., less vacuum), the initial flow rate was high or there was a leak in the connection. Once the vacuum decreases below 5 in.Hg, the flow rate begins to drop significantly. This scenario indicates that the sample is skewed in favor of the first portion of the sampling interval.
- **If the final vacuum is near ambient** (i.e., less than 1 in. Hg), there is inadequate differential pressure to drive the flow controller. The sampler cannot be certain the desired sampling interval was achieved before the canister arrived at ambient conditions. Although the actual sampling interval is uncertain, the canister still contains a sample from the site.

Table 3.2.4 Relationship Between Final Canister Vacuum, VolumeSampled, and Dilution Factor (6 L Canister)

Final Vacuum (in. Hg)	**0**	**2.5**	**5**	**7.5**	**10**	**12.5**	**15**	**17.5**	**20**
Volume Sampled (L)	**6**	**5.5**	**5.4**	**5**	**4**	**3.5**	**3**	**2.5**	**2**
Dilution Factor*	**1.34**	**1.46**	**1.61**	**1.79**	**2.01**	**2.30**	**2.68**	**3.22**	**4.02**

*** Canister pressurized to 5 psig for analysis**

$$\text{Final Reporting Limit} = \text{Method Reporting Limit} \times \underset{\text{(Canister Pressurization)}}{\text{Dilution Factor}} \times \underset{\text{(Sample Concentration)}}{\text{Dilution Factor}}$$

$$\underset{\text{(Canister Pressurization)}}{\text{Dilution Factor}} = \frac{\text{Pressurization for Analysis}}{\text{Receipt Vacuum}} = \frac{14.7\ \text{psig} + \text{Press. for Analysis (psig)}}{14.7\ \text{psig}\left[1 - \dfrac{\text{Rec. Vac (in Hg)}}{29.9\ \text{in. Hg}}\right]}$$

3.2.5 Considerations for Integrated Sampling with Canisters

Collecting an integrated air sample is more involved than collecting a grab sample. Sampling considerations include verifying that the sampling train is properly configured, monitoring the integrated sampling progress, and avoiding contamination.

- **Avoid Leaks in the Sampling Train:** See Section 3.1 for instructions on how to securely assemble sampling hardware. A leak in any one of these connections means that some air will be pulled in through the leak and not through the flow controller. A final pressure reading near ambient is one indication that there may have been a leak.
- **Verify Initial Vacuum of Canister:** See Section 3.1 for instructions on verifying initial canister vacuum. If you are using an Air Toxics Ltd. critical orifice flow controller, note that you can use the built-in gauge.
- **Monitor Integrated Sampling Progress:** It's a good idea to monitor the progress of the integrated sampling during the sampling interval. The volume of air sampled is a linear function of the canister vacuum. For example, halfway (4 hours) into an 8-hour sampling interval, the canister should be half filled (2.5 L) and the gauge should read approximately 17 in. Hg. More vacuum than 17 in. Hg indicates that the canister is filling too slowly; less than 17 in. Hg and the canister is filling too quickly. If the canister is filling too slowly, a valid sample can still be collected (see Section 3.2.4). If the canister is filling too quickly because of a leak or incorrect flow controller setting, corrective action can be taken. Ensuring all connections are tight may eliminate a leak. It is possible to take an intermittent sample.
- **Avoid Contamination:** Flow controllers should be cleaned between uses. This is done by returning them to the laboratory.
- **Caution Against Sampling in Extreme Temperatures:** There can be some flow rate drift if the temperature of the controllers is allowed to vary significantly.

3.2.6 Step-by-Step Procedures for Integrated Sampling

These procedures are for a typical ambient air sampling application; actual field conditions and procedures may vary.

Before you get to the field:

1. Verify contents of the shipped package (e.g., chain-of-custody, canister, particulate filter and flow controller)
2. Verify the gauge is working properly
3. Verify the initial vacuum of the canister

When ready to sample:

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove brass cap from canister
3. Attach flow controller to canister
4. Place the brass cap at the end of the flow controller creating an air tight train, and quickly open and close the canister valve in order to check for leaks. If the needle on the gauge drops, your train is not airtight. In this case, try refitting your connections and/or tightening them until the needle holds steady
5. Once the sample train is airtight remove the brass cap from the flow controller and open the canister valve, 1/2 turn
6. Monitor integrated sampling progress periodically
7. Verify and record final vacuum of canister (simply read built-in gauge)
8. Close valve by hand tightening knob clockwise
9. Replace brass cap
10. Fill out canister sample tag (make sure the sample ID and date of collection recorded on the sample tag matches what is recorded on the COC exactly)
11. Return canisters in boxes provided (unreturned canister replacement charge of $500 each)
12. Return sample media in packaging provided (unreturned equipment charges: $45 per particulate filter; $50-500 per flow controller)
13. Fill out chain-of-custody and relinquish samples properly (it is important to note the canister serial numbers on the chain-of-custody)
14. Place chain-of-custody in box and retain pink copy
15. Tape box shut and affix custody seal at each opening (if applicable)
16. Ship accordingly to meet method holding times

Important Information for Canister Sampling

@ DO NOT use canister to collect explosive substances, radiological or biological agents, corrosives, extremely toxic substances or other hazardous materials. It is illegal to ship such substances and you will be liable for damages.

@ ALWAYS use a filter when sampling. NEVER allow liquids (including water) or corrosive vapors to enter canister.

@ DO NOT attach labels to the surface of the canister or write on the canister; you will be liable for cleaning charges.

@ DO NOT over tighten the valve and remember to replace the brass cap.

@ IF the canister is returned in unsatisfactory condition, you will be liable for damages.

For assistance call Client Services at 800-985-5955.

Section 4. Sampling with Tedlar® Bags

This section provides a description of Tedlar® bags, practical considerations for sampling, and step-by-step instructions for collecting a grab sample. A photograph illustrates the correct way to assemble the various sampling components.

4.1 Introduction to Tedlar® Bags

The Tedlar® bag is best suited for projects involving analysis of compounds in the ppmv range. However, Tedlar® bags may be used for other applications such as ambient air monitoring for atmospheric/ fixed gases.
They can be used to collect sulfur compounds, but only if the fittings are non-metallic (e.g., polypropylene, Teflon®, or Nylon).
A Tedlar® bag is made of two plies of Tedlar® film sealed together at the edges, and features a valve that allows for filling. Sample collection requires a pressurized sampling port, a low flow rate pump or a lung sampler. The bag expands as the sample enters. Air Toxics Ltd. maintains Tedlar® bags in 1, 3 and 5 L volumes.

4.1.1 Tedlar® Film

Tedlar® is a trade name for a polyvinyl fluoride film developed by DuPont Corporation in the 1960's. This patented fluoropolymer has been used in a wide variety of applications including protective surfacing for signs, exterior wall panels and aircraft interiors. Tedlar® film is tough yet flexible and retains its impressive mechanical properties over a wide range of temperatures (from well below freezing to over 200°F). Tedlar® exhibits low permeability to gases, good chemical inertness, good weathering resistance and low off-gassing.

4.1.2 How "Active" is the Surface of a Tedlar® Bag?

The surface of a Tedlar® bag is a work in progress. The surface of a new bag is essentially free of VOCs at the single digit ppbv level. Compounds detected from analyzing new Tedlar® bags include methylene chloride, toluene, acetone, ethanol and 2-propanol. Note that 2-propanol has been detected in some new bags up to 45 ppbv. Once the Tedlar® bag is used, however, the surface has been exposed to moisture and possible

VOCs. It may irreversibly adsorb many VOCs at the low ppbv level. A series of purges with certified gas may not remove the VOCs from the surface. $10 for a new bag is a small price to pay for peace of mind.

Never reuse a Tedlar® bag when sampling for ppbv level compounds.

4.1.3 Hold Time for a Tedlar® Bag

The media hold time for a Tedlar® bag is indefinite if stored out of sunlight in a cool, dry location. Tedlar® bags may be used to collect samples containing common solvents, hydrocarbons, chlorinated solvents, sulfur compounds and many other classes of compounds. The sample hold time to analysis varies for different classes of compounds:

- **24 hours:** Sulfur compounds (e.g., hydrogen sulfide and methyl mercaptan) and chemically active compounds (e.g., 1,3-butadiene)
- **72 hours:** Chlorinated solvents, aromatic compounds and atmospheric/fixed gases (oxygen, nitrogen, carbon dioxide)

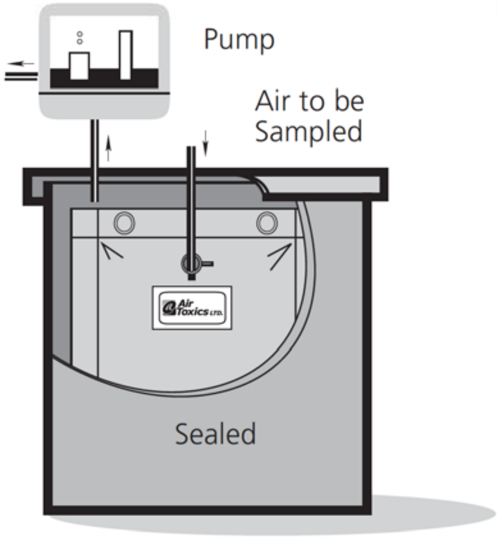
4.2 Tedlar® Bag Sampling

Using a Tedlar® bag to collect an air sample normally involves “active” sampling, unlike an evacuated canister that can be filled “passively” by simply opening the valve. There are two methods commonly used to fill a Tedlar® bag: a pump or a lung sampler.

- **Sampling with a Pump:** The most common method for filling a Tedlar® bag is to use a small pump with low flow rates (50-200 mL/min) and tubing to fill the bag.
  Air Toxics Ltd. does not provide pumps.

- **Sampling with a Lung Sampler:** A “lung sampler” may be used to fill a Tedlar® bag. Although a little more complicated than simply using a pump, the main advantage to using a lung sampler to fill a Tedlar® bag is that it avoids potential pump contamination.

A Tedlar® bag with attached tubing is placed in a small airtight chamber with the tubing protruding from the chamber. The sealed chamber is then evacuated via a pump, causing the bag to expand and draw the sample into the bag through the protruding tube. The sample air never touches the wetted surfaces of the pump. Air Toxics Ltd. does not provide lung samplers.



4.2.1 Considerations for Tedlar® Bag Sampling

Some considerations for collecting a Tedlar® bag sample:

- **Fill the Tedlar® bag no more than 2/3 full:** Allow for possible expansion due to an increase in temperature or decrease in atmospheric pressure (e.g., the cargo hold of a plane)
- **Keep the Tedlar® bag out of sunlight:** Tedlar® film is transparent to ultraviolet light (although opaque versions are available) and the sample should be kept out of sunlight to avoid any photochemical reactions
- **Protect the Tedlar® bag:** Store and ship the Tedlar® bag samples in a protective box at room temperature. An ice chest may be used, but DO NOT CHILL
- **Fill out the Tedlar® bag label:** It is much easier to write the sample information on the label before the Tedlar® bag is inflated
- **Provide a second Tedlar® bag:** Consider filling two bags per location in the rare occasion that a defective bag deflates before analysis. The “hold” sample does not need to be documented on the Chain-of-Custody and should have an identical sample ID to the original sample indicating that it is the “hold” sample
- **Avoid Contamination:** Care should be taken to avoid contamination introduced by the pump or tubing. Begin sampling at locations with the lowest compound concentrations (e.g., sample the SVE effluent before the influent). Decontaminate the pump between uses by purging with certified air for an extended period; better yet, use a lung sampler. Use the shortest length possible of Teflon® tubing or other inert tubing. DO NOT REUSE TUBING. If long lengths of tubing are used, consider purging the tubing with several volumes worth before sampling. If you are concerned about sampling for trace compounds, you shouldn’t be using a Tedlar® bag (see Section 1.2)
- **Don’t Sample Dangerous Compounds in a Tedlar® Bag:** Do not ship any explosive substances, radiological or biological agents, corrosives or extremely hazardous materials to Air Toxics Ltd. Tedlar® bag rupture during transit to the laboratory is possible and the sampler assumes full liability

4.2.2 Step-by-Step Procedures for Tedlar® Bag Sampling (Pump)

Note: These procedures are for a typical stationary source (e.g., SVE system) sampling application; actual field conditions and procedures may vary. See additional sampling considerations in Section 5.3 for sampling soil gas or landfill gas.

Before you get to the field:

1. Verify contents of the shipped package (e.g., chain-of-custody, Tedlar® bag, and tubing/fittings – if requested)
2. Verify pump cleanliness and operation (Air Toxics Ltd. does not provide pumps)

When ready to sample:

3. Purge sample port
4. Attach new Teflon® tubing from sample port or probe to low flow rate pump
5. Purge tubing
6. Fill out Tedlar® bag sample tag
7. Attach additional new Teflon® tubing from the pump outlet to the Tedlar® bag valve
8. Open Tedlar® bag valve
9. Collect sample (FILL NO MORE THAN 2/3 FULL)
10. Close Tedlar® bag valve by hand tightening valve clockwise
11. Return Tedlar® bag in boxes provided (DO NOT CHILL)
12. Fill out chain-of-custody and relinquish samples properly.
13. Place chain-of-custody in box and retain pink copy
14. Tape box shut and affix custody seal as both openings (if applicable)
15. Ship priority overnight to meet method holding times.

Section 5. Special Sampling Considerations

This section provides considerations for special sampling configurations that a sampler may collect in the field such as field duplicates or an ambient blank. This section also provides considerations for sampling at altitude, as well as soil gas and landfill gas sampling.

5.1 Special Sampling Configurations

Special sampling configurations include a field duplicate, field split, field blank, ambient blank, and a trip blank. Call Client Services at 800-985-5955 if your project involves any of these special sampling configurations.

5.1.1 Field Duplicate

A field duplicate is a second sample collected in the field simultaneously with the primary sample at one sampling location. The results of the duplicate sample may be compared (e.g., calculate relative percent difference) with the primary sample to provide information on consistency and reproducibility of field sampling procedures. Due to the nature of the gas phase, duplicate samples should be collected from a common inlet. The configuration for collecting a field duplicate includes stainless steel or Teflon® tubing connected to a Swagelok "T". If integrated samples are being collected and the sample duration is to be maintained, the sample train should be assembled as follows: each canister should have a flow controller attached, then the duplicate sampling T should be attached to the flow controllers. If the collection flow rate from the sample port is to be maintained then the duplicate sampling T should be connected to the canisters; then the flow controller is connected to the inlet of the sampling T.

5.1.2 Field Blank

A field blank is a sample collected in the field from a certified air source. Analysis of the field blank can provide information on the decontamination procedures used in the field. Clean stainless steel or Teflon® tubing and a certified regulator should be used. It is imperative that individually certified canisters (the sample canister and the source canister/cylinder, if applicable) be used to collect a field blank.

5.1.3 Ambient Blank

An ambient blank is an ambient air sample collected in the field. It is usually used in conjunction with soil gas or stationary source (e.g., SVE system) sampling. Analysis of the ambient blank can provide information on the ambient levels of site contaminants. It is recommended that an individually certified canister be used to collect an ambient blank.

5.1.4 Trip Blank

When sampling for contaminants in water, the laboratory prepares a trip blank by filling a VOA vial with clean, de-ionized water. The trip blank is sent to the field in a cooler with new sample vials. After sampling, the filled sample vials are placed back in the cooler next to the trip blank and returned to the laboratory. Analysis of the trip blank provides information on decontamination and sample handling procedures in the field as well as the cleanliness of the cooler and packaging.

When sampling for compounds in air, a trip blank provides little, if any, of the information above. A trip blank canister can be individually certified, evacuated, and sent to the field in a box with the sample canisters. Since the valve is closed and the brass cap tightened, it is questionable if the trip blank canister contents are ever "exposed" to sampling conditions. **Air Toxics Ltd. does not recommend analyzing a trip blank for air sampling.**

5.2 Considerations for Sampling at Altitude

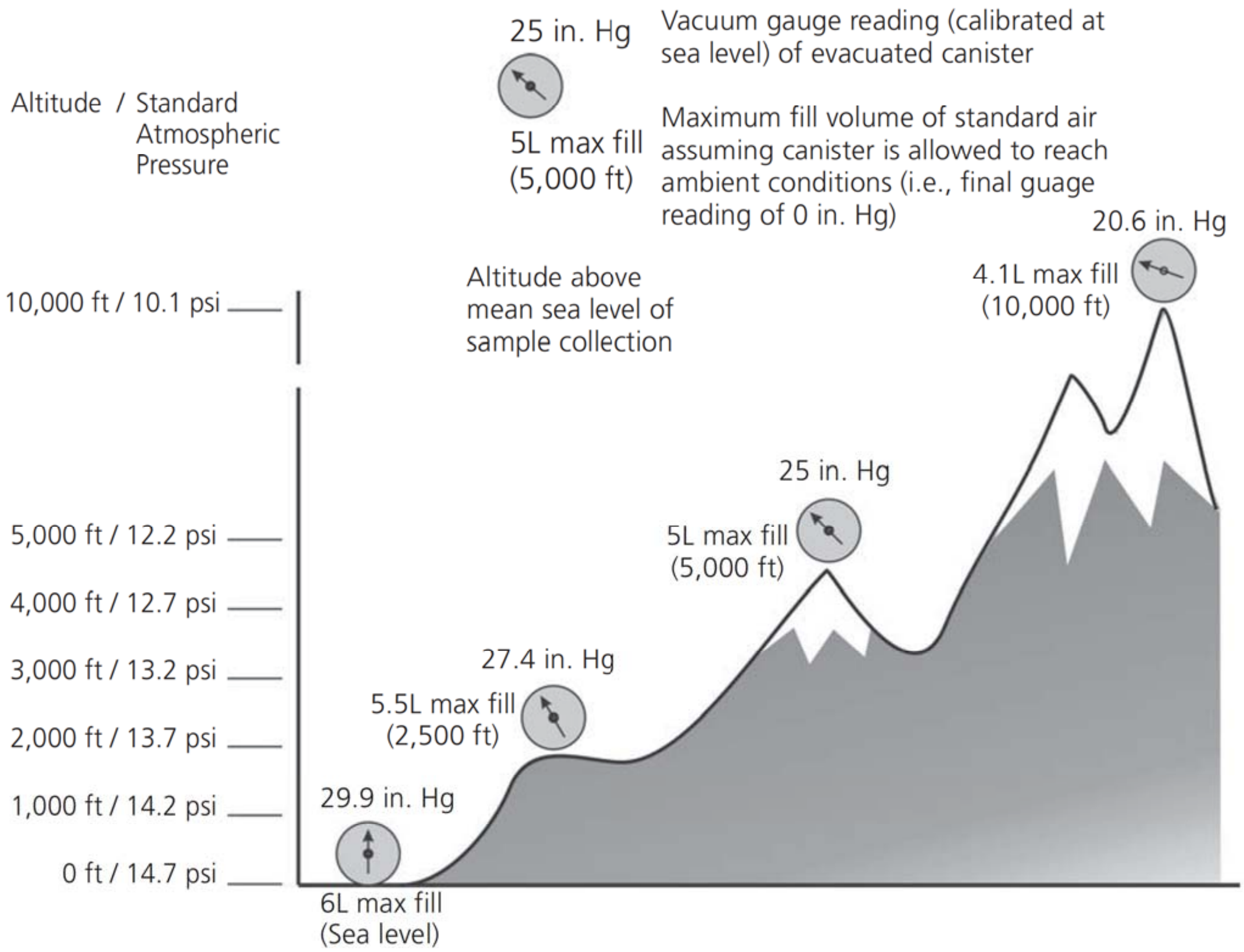
Sampling at altitudes significantly above sea level is similar to sampling a stationary source under vacuum, in that target fill volumes may be difficult to achieve. The figure below illustrates the relationship between increasing altitude and decreasing atmospheric pressure. Ambient conditions in Denver at 5,000 ft altitude are quite different from ambient conditions at sea level. Canister sampling is driven by the differential pressure between ambient conditions and the vacuum in the canister.

There is less atmospheric pressure in Denver and 5 L is the maximum fill volume of standard air assuming the canister is allowed to reach ambient conditions (i.e., final gauge reading of 0 in. Hg). Theoretically, if you sample high enough (e.g., in space), no sample would enter the canister because there is no pressure difference between the evacuated canister and ambient conditions. To fill a canister to 6 L in Denver, you would need to use an air pump.

Sampling at altitude also affects gauge readings. The gauges supplied by Air Toxics Ltd. (see Section 2.2.4) measure canister vacuum relative to atmospheric pressure and are calibrated at approximately sea level. Before sampling at altitude, the gauges should be equilibrated (see Section 3.1). But even after equilibrating the gauge, verifying the initial vacuum of a canister at altitude is misleading. In Denver at 5,000 ft, expect the gauge to read 25, not 29.9 in. Hg. You do not have a bad canister (i.e., leaking or not evacuated properly). The canister is ready for sampling and the gauge is working properly.

Rule of Thumb: For every 1,000 ft of elevation, the gauge will be off by 1 in. Hg and the fill volume will be reduced by 1/5 L.

If you have questions about sampling at altitude, please call Client Services at 800-985-5955.



5.3 Considerations for Soil Gas / Landfill Gas Sampling

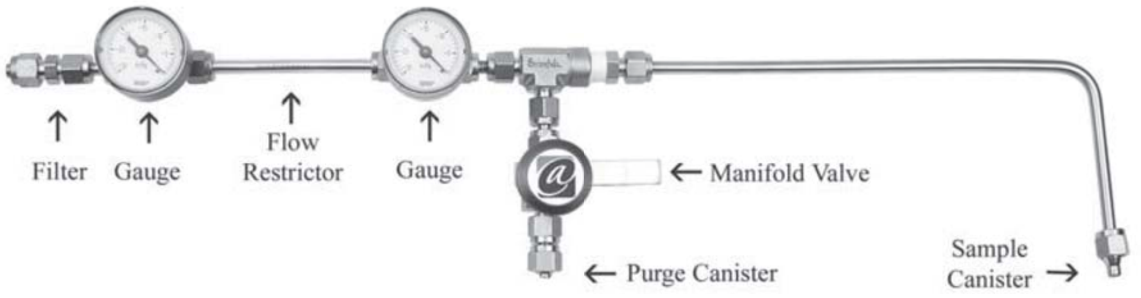
There are some additional sampling considerations for collecting grab samples (canister or Tedlar® bag) from a soil boring, landfill boring, SVE system or landfill gas (LFG) collection system. The general challenge with these samples arises from the need to employ long lengths of tubing to direct the soil gas, landfill gas or process air to the canister or Tedlar® bag. Tubing introduces the potential for contamination and diluting the sample.

5.3.1 Collecting Soil Gas Samples with Sampling Manifolds

Air Toxics provides soil gas sampling manifolds in order to facilitate meeting the numerous quality control guidelines for collecting soil gas data. Two of the most critical aspects of soil gas sampling are purging the lines and preventing leaks. The manifold setup allows for automatic leak-checking of the canister sample train without the application of a leak check compound to the canister fittings. When the purge can is opened and closed, it creates a vacuum within the canister lines and fittings. If this vacuum is maintained, the train is considered leak-free. Because there is only one connection – the probe tubing to sample train – the chance for leaks is greatly reduced.

The manifold's in line gauge system used with a purge canister enables the sampler to determine the appropriate purge volume. Typically, purge volumes of 3 to 5 times the volume of the train tubing are used, and once the purge volume is calculated the lines can be purged by opening the purge canister valve and monitoring the decrease in vacuum. This decrease in vacuum is proportional to the volume purged through the lines. There is a suggested flow rate of between 100 and 200 milliliters per minute, a step thought to prevent ambient air intrusion as a result of taking the sample too quickly. Our manifold has a "built-in" flow restrictor; a frit of stainless steel tubing between the two gauges that is calibrated to 167 milliliters per minute.

The first gauge, located prior to the flow restrictor, is a vacuum gauge that informs the sampler if sufficient vapor is being collected from the soil or if the substrate is too compacted. Because this is not a flow meter but a measure of pressure/vacuum, the gauge should read at zero if there is sufficient flow from the soil. If the gauge begins to read a vacuum, then the flow is being restricted. The second gauge, in line after the flow controller and prior to the purge canister, is a vacuum gauge that indicates to the sampler whether or not the canister is filling properly at the expected rate. This setup enables the sampler to evaluate the lithologic conditions at the site and determine if a valid soil gas sample is being taken. Finally, when duplicate samples are required, the manifold can be used as a duplicate sampling "T" by simply replacing the purge canister with another sample canister.



5.3.2 Step-by-Step Procedures for Soil Gas Sampling Using Sampling Manifolds

These procedures are for a typical soil gas sampling application; actual field conditions and procedures may vary.

Before you get to the field:

1. Verify contents of the shipped package (e.g., chain-of-custody, canister, particulate filter and flow controller)
2. Verify the gauge is working properly
3. Verify the initial vacuum of canister

When ready to sample:

Leak Check Test

1. Confirm that canister valves are closed (knob should already be tightened clockwise)
2. Remove brass caps from both the sample canister and the purge canister (unless using certified media there is no difference between the two)
3. Attach manifold to canisters
4. Confirm that there is a brass cap secured at the inlet of the manifold creating an air tight train, make sure the manifold valve above the purge canister is open, and quickly open and close the purge canister valve in order to check for leaks. If the needle on the gauge drops, your train is not airtight. In this case, try refitting your connections and/or tightening them until the needle holds steady

Purging

5. Once the sample train is airtight remove the brass cap from the manifold inlet, connect the tubing from the sample port using a compression fitting and open the purge canister valve, 1/2 turn
6. Monitor integrated sampling progress periodically. *Please note, because the purge canister is inline after the flow restrictor the line will not purge faster than at a rate of 167mls/min
7. Once the desired purge volume is met close both the manifold valve and the purge canister valve by hand tightening the knobs clockwise
8. If sampling at multiple locations, the purge canister can be disconnected from the manifold and used to begin purging the next sample location without compromising the sample train

Sampling

9. The line is now ready to be sampled. Open the sample canister valve and monitor sampling progress periodically.
10. When the sampling is complete close the valve and replace the brass cap on the canister; record final vacuum of canister (simply read built-in gauge)
11. Fill out canister sample tag (make sure the sample ID and date of collection recorded on the sample tag matches what is recorded on the COC exactly)
12. Return canisters in boxes provided (Unreturned canister replacement charge of $500 each)
13. Return sample media in packaging provided (Unreturned equipment charges: $45 per particulate filter; $50-500 per flow controller)
14. Fill out chain-of-custody and relinquish samples properly (it is important to note the canister serial numbers on the chain-of-custody)
15. Place chain-of-custody in box and retain pink copy
16. Ship accordingly to meet method holding times

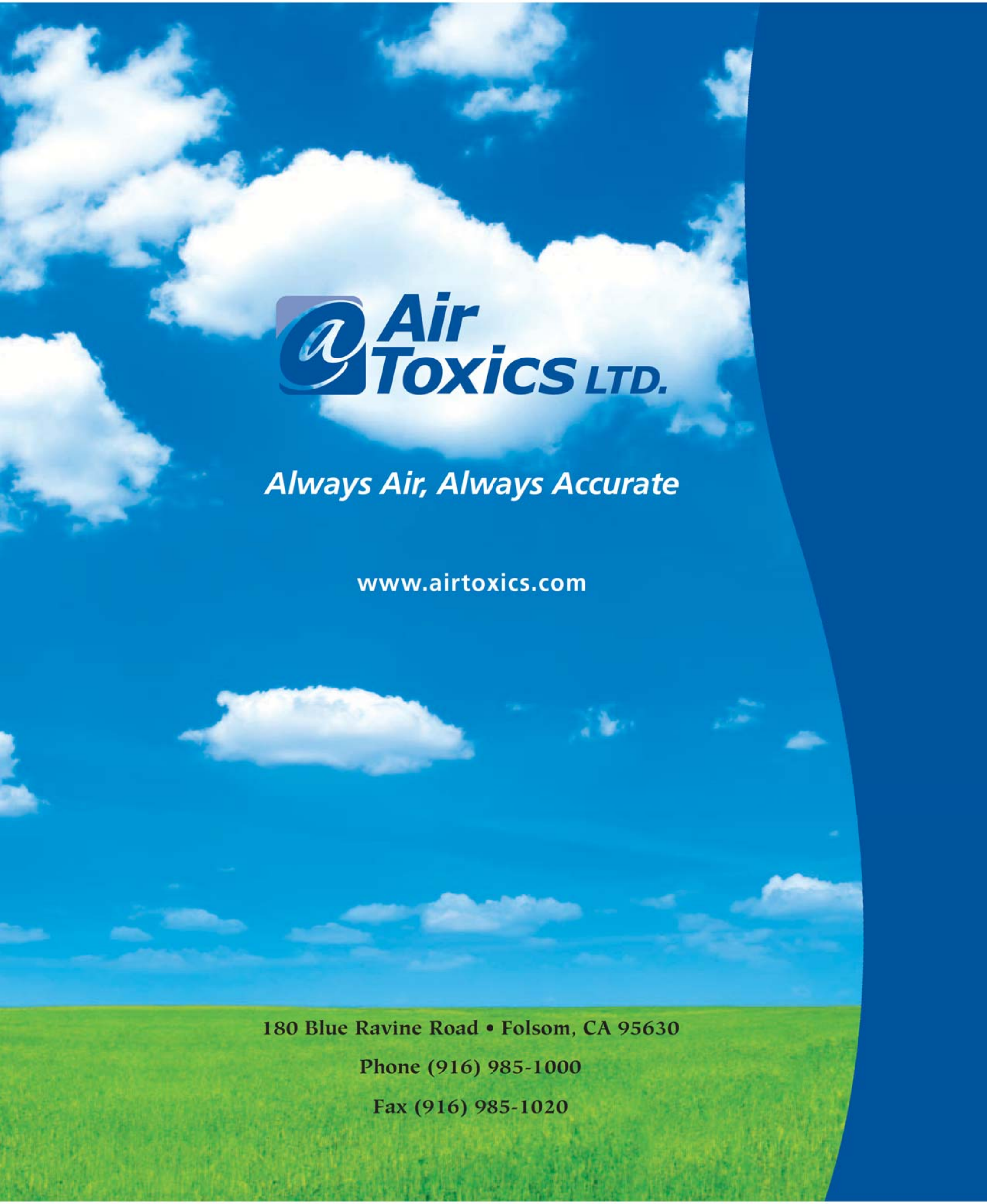
5.3.3 Special Considerations for Soil Gas and Landfill Gas Sampling

- **Use inert tubing**. Teflon® tubing is recommended. Tubing with an outer diameter of 1/4 in. works best with the fittings on the particulate filter.
- **Do not reuse tubing**. $2 per foot for new tubing is a small price to pay for peace of mind.
- **Purge tubing adequately**. A long length of tubing has significant volume of "dead air" inside.

  Without purging, this air will enter the canister and dilute the sample. Consider using a handheld PID/FID to confirm that you have purged the tubing and are drawing sample air through the tubing.
- **Avoid leaks in the sampling train**. Leaks of ambient air through fittings between pieces of the sampling train (e.g., tubing to particulate filter) will dilute the sample. Always use compression fittings for all connections; never use tube in tube connections.
- **Don't sample water**. If moisture is visible in the sample tubing, the soil gas sample may be compromised. Soil gas probes should be at an appropriate depth to avoid reaching the water table. Additionally, subsurface vapor should not be collected immediately after measurable precipitation.
- **Purge the sample port**. A sample port on an SVE system or LFG collection system can accumulate solids or liquids depending upon the location of the port in the process and the orientation of the port. An influent sample port located upstream of a filter or moisture knock-out can be laden with particulates or saturated with water vapor. Heavy particulate matter can clog the particulate filter and foul the canister

valve. It is important to prevent liquids from entering the canister. A sample port oriented downward may have liquid standing in the valve. Purge the sample port adequately before connecting the sampling train.

- **Consider the effects of sampling a process under vacuum or pressure**. When collecting a grab sample from a stationary source such as an SVE system or LFG collection system, some sample ports may be under vacuum or pressure relative to ambient conditions. When the sample port is under vacuum, such as the header pipe from the extraction well network, it may be difficult to fill the canister with the desired volume of sample. A vacuum pump may be used to collect a canister grab sample from a sample port under considerable vacuum. See the related discussion on sampling at altitude in Section 5.2. When the sample port is under pressure, such as the effluent stack downstream of the blower and treatment system, you may inadvertently pressurize the canister. Only a DOT-approved sample cylinder should be used to transport pressurized air samples. Under no circumstances should an Air Toxics Ltd. canister be pressurized more than 5 psig for a 6 L canister and 15 psig for a 1 L canister. Bleed off excess pressure by opening the valve temporarily while monitoring the canister with a pressure gauge.



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Phone (916) 985-1000
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EUROFINS AIR TOXICS LIMITED TO-15 OPEN SCAN ANALYTES AND REPORTING LIMITS

Compound	Rpt. Limit (µg/m³)	Compound	Rpt. Limit (µg/m³)
1,1,1-Trichloroethane	2.7	Chlorobenzene	2.3
1,1-Dichloroethane	2	Chloroethane	5.3
1,1-Dichloroethene	2	Chloroform	2.4
1,2-Dibromoethane (EDB)	3.8	Chloromethane	10
1,2-Dichlorobenzene	3	cis-1,2-Dichloroethene	2
1,2-Dichloroethane	2	cis-1,3-Dichloropropene	2.3
1,2-Dichloropropane	2.3	Cumene	2.4
1,1,2-Trichloroethane	2.7	Cyclohexane	1.7
1,2,4-Trichlorobenzene	15	Dibromochloromethane	4.2
1,2,4-Trimethylbenzene	2.4	Ethanol	3.8
1,3-Butadiene	1.1	Ethyl Benzene	2.2
1,3-Dichlorobenzene	3	Freon 11	2.8
1,3,5-Trimethylbenzene	2.4	Freon 113	3.8
1,4-Dichlorobenzene	3	Freon 114	3.5
1,4-Dioxane	7.2	Freon 12	2.5
1,1,2,2-Tetrachloroethane	3.4	Heptane	2
2-Butanone (Methyl Ethyl Ketone)	5.9	Hexachlorobutadiene	21
2-Hexanone	8.2	Hexane	1.8
2-Propanol	4.9	m,p-Xylene	2.2
4-Ethyltoluene	2.4	Methyl tert-butyl ether	1.8
4-Methyl-2-pentanone	2	Methylene Chloride	17
2,2,4-Trimethylpentane	2.3	Naphthalene	10.5(1)
3-Chloropropene	6.3	o-Xylene	2.2
Acetone	12	Propylbenzene	2.4
alpha-Chlorotoluene	2.6	Styrene	2.1
Benzene	1.6	Tetrachloroethene	3.4
Bromodichloromethane	3.4	Tetrahydrofuran	1.5
Bromoform	5.2	Toluene	1.9
Bromomethane	19	trans-1,2-Dichloroethene	2
Carbon Disulfide	6.2	trans-1,3-Dichloropropene	2.3
Carbon Tetrachloride	3.1	Trichloroethene	2.7
Notes:		Vinyl Chloride	1.3

* Data provided by Air Toxics Limited/Eurofins (Folsom, CA).

EUROFINS AIR TOXICS LIMITED TO-15 Hi/Lo METHOD REPORTING LIMITS (SIM)

Compound	Rpt. Limit (µg/m³)	Compound	Rpt. Limit (µg/m³)
1,1,1-Trichloroethane	1.10E-01	Chloroethane	2.70E-01
1,1-Dichloroethane	8.20E-02	Chloroform	5.00E-01
1,1-Dichloroethene	4.00E-02	Chloromethane	2.10E-01
1,2-Dibromoethane (EDB)	7.80E-01	cis-1,2-Dichloroethene	8.00E-02
1,2-Dichlorobenzene	6.10E-01	cis-1,3-Dichloropropene	4.60E-01
1,2-Dichloroethane	8.20E-02	Cumene	5.00E-01
1,2-Dichloropropane	4.70E-01	Cyclohexane	3.50E-01
1,1,2-Trichloroethane	1.10E-01	Dibromochloromethane	8.60E-01
1,2,4-Trichlorobenzene	3.80E+00	Ethanol	9.60E-01
1,2,4-Trimethylbenzene	5.00E-01	Ethyl Benzene	8.80E-02
1,3-Butadiene	2.20E-01	Freon 11	5.70E-01
1,3-Dichlorobenzene	6.10E-01	Freon 113	7.80E-01
1,3,5-Trimethylbenzene	5.00E-01	Freon 114	7.10E-01
1,4-Dichlorobenzene	6.10E-01	Freon 12	5.00E-01
1,4-Dioxane	3.70E-01	Heptane	4.20E-01
1,1,2,2-Tetrachloroethane	1.40E-01	Hexachlorobutadiene	5.40E-00
2-Butanone (Methyl Ethyl Ketone)	3.00E-01	Hexane	3.60E-01
2-Hexanone	2.10E+00	m,p-Xylene	1.80E-01
2-Propanol	1.20E+00	Methyl tert-butyl ether	3.70E-01
4-Ethyltoluene	5.00E-01	Methylene Chloride	7.10E-01
4-Methyl-2-pentanone	4.20E-01	Naphthalene	2.62E-01
Acetone	1.20E+00	o-Xylene	8.80E-02
alpha-Chlorotoluene	5.30E-01	Propylbenzene	5.00E-01
Benzene	1.60E-01	Styrene	4.30E-01
Bromodichloromethane	6.80E-01	Tetrachloroethene	1.40E-01
Bromoform	1.00E+00	Tetrahydrofuran	1.50E+00
Bromomethane	3.90E-01	Toluene	7.60E-02
Carbon Disulfide	1.60E+00	trans-1,2-Dichloroethene	4.00E-01
Carbon Tetrachloride	6.40E-01	trans-1,3-Dichloropropene	4.60E-01
Chlorobenzene	4.70E-01	Trichloroethene	1.10E-01
Notes:		Vinyl Chloride	2.60E-02

* Data provided by Eurofins Air Toxics Limited (Folsom, CA)

APPENDIX D
Quality Assurance Project Plan

QAPP Worksheet #1 - Title and Approval Page

QUALITY ASSURANCE PROJECT PLAN FOR THE VAPOR INTRUSION WORK PLAN

August 2017

FLINT GROUP PIGMENTS HUNTINGTON FACILITY
HUNTINGTON, WEST VIRGINIA

Prepared for:
BASF – We Create Chemistry
100 Park Drive
Florham Park, New Jersey 07932

Prepared by:
Geosyntec Consultants, Inc.
1 Penn Center West Drive
Penn Center West One, Suite 402
Pittsburgh, Pennsylvania 15276

Prepared under:
PO #4935985437

Review Signature:	Vernon Burrows BASF	Date
Approval Signature:	USEPA – Region 3	Date

EXECUTIVE SUMMARY

This *Quality Assurance Project Plan (QAPP) for the Vapor Intrusion (VI) Investigation Work Plan (Work Plan)* has been prepared to support the VI activities for the Flint Group Pigments Huntington Facility (the Facility) located at 2401 5th Avenue, Huntington, West Virginia. This QAPP has been prepared by Geosyntec Consultants, Inc. (Geosyntec) for the BASF Corporation (BASF) in accordance with BASF Purchase Order (PO) #4935985437.

The Facility is being investigated through the Resource Conservation and Recovery Act (RCRA) Facility Lead Corrective Action Program, under enforcement of the United States Environmental Protection Agency (USEPA) Region 3. This QAPP is an addendum to the Work Plan, which is to be used in tandem with the existing RCRA Facility Investigation (RFI) Work Plan, Phase II RFI Work Plan, RFI Completion Work Plan, and site-specific QAPP (last revision October 2015). The Work Plan presents the proposed scope of work for VI sampling activities at the on- and off-site commercial/industrial buildings and residential locations downgradient of the Facility. Initial VI sampling activities at off-site residential locations will involve: outdoor and indoor air sampling as well as crawlspace sampling (or sub-slab vapor sampling if basements are encountered). Initial sampling activities at on-site commercial/industrial buildings will involve: outdoor and indoor air sampling, sub-slab vapor sampling, and differential pressure monitoring. Following the results of the initial sampling and decision matrix presented in the Work Plan, follow-on sampling may be conducted.

This QAPP presents the planned field and laboratory analytical activities associated with the VI investigation activities that are described in the Work Plan. All field and laboratory personnel engaged in sampling and analysis during the course of the project will review this QAPP and have a copy available during sampling and analysis activities. This QAPP includes project quality objectives (PQOs), field sampling procedures, quality assurance/quality control (QA/QC) requirements, and data gathering methods that will be used during the project. This QAPP is generally prepared in accordance with the requirements of the U.S. Environmental Protection Agency (EPA) *Guidance for Quality Assurance Project Plans*, EPA QA/G-5 (EPA, 2002) and *Uniform Federal Policy for Quality Assurance Project Plans* (UFP-QAPP; U.S. Department of Defense [DoD], 2005).

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VI Work Plan Appendix C Eurofins Air Toxics Sampling SOPs
VI Work Plan Appendix E Health and Safety Plan

ABBREVIATIONS AND ACRONYMS

CCV	continuing calibration verification
COC	chain of custody/compounds of concern
CSM	conceptual site model
CV	calibration verification
DFTPP	decafluorotriphenylphosphine
DL	detection limit
DoD	Department of Defense, United States
DQI	data quality indicator
DQO	data quality objective
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency, United States
GC/MS	gas chromatograph/mass spectrometer
Geosyntec	Geosyntec Consultants, Inc.
HV	heating and ventilation
HVAC	heating, ventilation, and air conditioning
ICAL	initial calibration
ICV	initial calibration verification
ID	identification
IS	internal standard
L	liter
LCS	laboratory control sample
LD	laboratory duplicate
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
µg/L	microgram per liter
µg/m^3	microgram per cubic meter
N/A	not applicable or not available
NELAC	National Environmental Laboratory Accreditation Conference
No.	number
OSHA	Occupational Safety and Health Administration
%	percent
%R	percent recovery
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCE	tetrachloroethene
PID	photoionization detector
PQO	project quality objective
QA	quality assurance
QAO	quality assurance officer
QAPP	quality assurance project plan
QC	quality control

ABBREVIATIONS AND ACRONYMS (Continued)

RPD	relative percent difference
RSD	relative standard deviation
SOP	standard operating procedure
TCE	trichloroethene
U.S.	United States
UFP	uniform federal policy
VC	vinyl chloride
VI	vapor intrusion
VOC	volatile organic compound
VP	Vapor Pin®

QAPP Worksheet #2 - QAPP Identifying Information

Site Name/Number: Flint Group Pigments Huntington Facility, Huntington, West Virginia
Contract Number: PO# 4935985437
Contract Title: BASF Huntington Vapor Intrusion Investigation

1. This QAPP incorporates some of the requirements of the *Uniform Federal Policy for Quality Assurance Plans* (DoD, 2005) and EPA *Guidance for Quality Assurance Project* Plans, EPA QA/G-5 (EPA, 2002).
2. Regulatory program: Resource Conservation and Recovery Act (RCRA) under Environmental Protection Agency (EPA) Region 3.
3. This QAPP is **Project Specific**.
4. List dates of scoping sessions that were held:

Scoping Session	Date
BASF Huntington VI Project Scoping Meeting	March 10, 2017

5. List dates and titles of any QAPP documents written for previous site work that are relevant to the current investigation

Title	Date
RFI Field Sampling Plan and Quality Assurance Project Plan, October 2015 Revision (ELMSS, 2015)	October 2015

6. List organizational partners (stakeholders) and connection with lead organization:

Organization Partners / Stakeholders	Role
Environmental Protection Agency (EPA)	EPA is a regulatory partner.

7. Lead organization: BASF Corporation (BASF)
8. If any required QAPP elements or required information are not applicable to the project or are provided elsewhere, then note the omitted QAPP elements and provide an explanation for their exclusion below:

No Special Personnel Training is required for this project (WS#8).

Quality Assurance Managements Reports are not part of this scope of work (WS#33).

QAPP Worksheet #2 - QAPP Identifying Information (Continued)

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information
A. Project Management		
Documentation		
1	Title and Approval Page	Page 1
2	Table of Contents QAPP Identifying Information	Page 7
3	Distribution List	Page 10
4	Project Personnel Sign-Off Sheet	Page 11
Project Organization		
5	Project Organizational Chart	Page 12
6	Communication Pathways	Page 13
7	Personnel Responsibilities and Qualifications Table	Page 15
8	Special Personnel Training Requirements Table	Page 17
Project Planning/ Problem Definition		
9	Project Planning Session Documentation (including Data Needs tables) Project Scoping Session Participants Sheet	Page 18
10	Problem Definition, Site History, and Background. Site Maps (historical and present)	Page 19
11	Site-Specific Project Quality Objectives	Page 24
12	Measurement Performance Criteria Table	Page 26
13	Sources of Secondary Data and Information Secondary Data Criteria and Limitations Table	Page 27
14	Summary of Project Tasks	Page 28
15	Reference Limits and Evaluation Table	Page 29
16	Project Schedule/Timeline Table	Page 33
B. Measurement Data Acquisition		
Sampling Tasks		
17	Sampling Design and Rationale	Page 34
18	Sampling Locations and Methods/ SOP Requirements Table Sample Location Map(s)	Page 35
19	Analytical Methods/SOP Requirements Table	Page 36
20	Field Quality Control Sample Summary Table	Page 37
21	Project Sampling SOP References Table Sampling SOPs	Page 38
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	Page 39
Analytical Tasks		
23	Analytical SOPs	Page 40

QAPP Worksheet #2 - QAPP Identifying Information (Continued)

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information
	Analytical SOP References Table	
24	Analytical Instrument Calibration Table	Page 41
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	Page 44
Sample Collection		
26	Sample Handling System, Documentation Collection, Tracking, Archiving and Disposal Sample Handling Flow Diagram	Page 45
27	Sample Custody Requirements, Procedures/SOPs Sample Container Identification Example Chain-of-Custody Form and Seal	Page 46
Quality Control Samples		
28	QC Samples Table Screening/Confirmatory Analysis Decision Tree	Page 49
Data Management Tasks		
29	Project Documents and Records Table	Page 50
30	Analytical Services Table Analytical and Data Management SOPs	Page 51
C. Assessment Oversight		
31	Planned Project Assessments Table Audit Checklists	Page 52
32	Assessment Findings and Corrective Action Responses Table	Page 53
33	QA Management Reports Table	Page 54
D. Data Review		
34	Verification (Step I) Process Table	Page 55
35	Validation (Step II) Process Table	Page 56
36	Validation (Step II) Summary Table	Page 58
37	Usability Assessment	Page 59

Notes:

QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
SOP	standard operating procedure
UFP	uniform federal policy

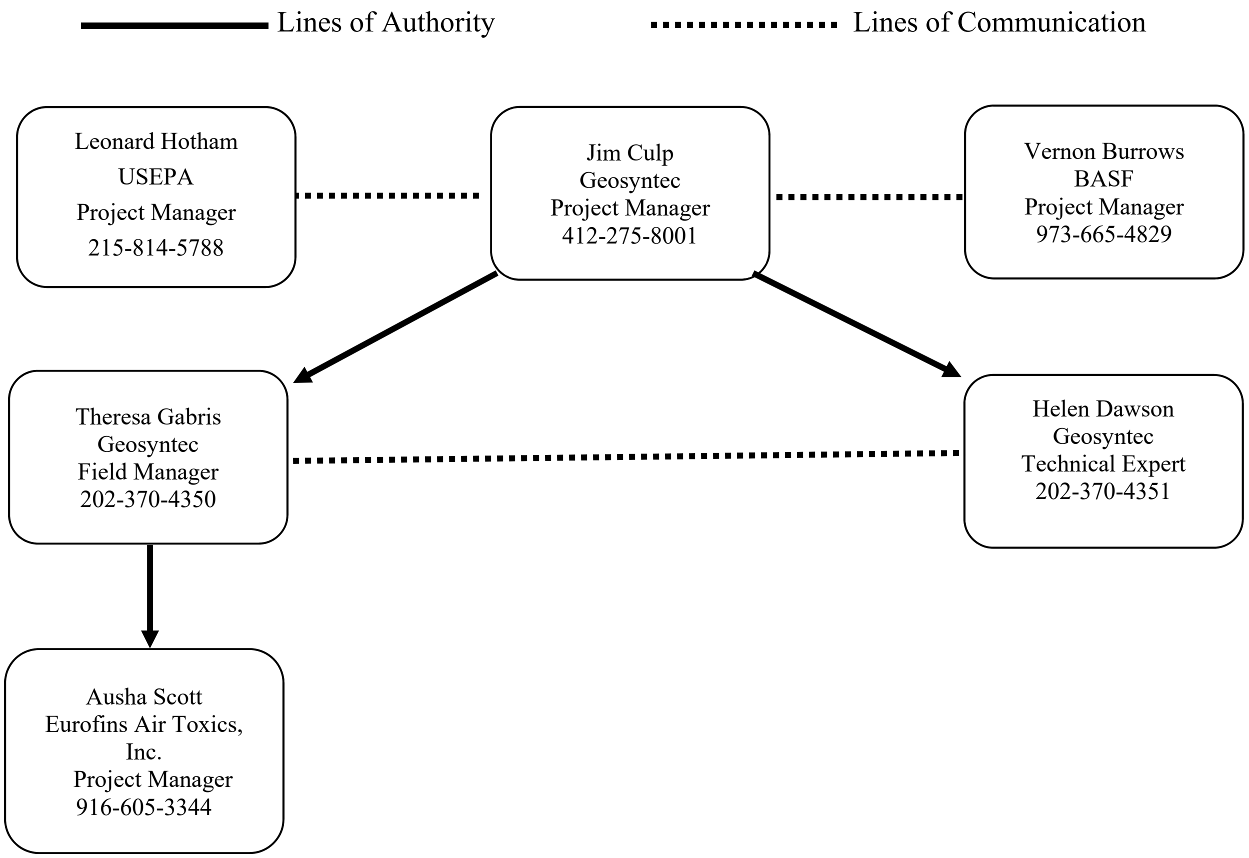
QAPP Worksheet #3 - Distribution List

Name of QAPP Recipients	Title/Role	Organization	Telephone Number (Optional)	E-mail Address or Mailing Address
Vernon Burrows	Project Manager	BASF	973-665-4829	vernon.burrows@basf.com
Jim Culp	Project Manager	Geosyntec	412-275-8001	jculp@geosyntec.com
Helen Dawson	Technical Expert	Geosyntec	202-370-4351	hdawson@geosyntec.com
Theresa Gabris	Field Manager	Geosyntec	202-370-4351	tgabris@geosyntec.com
Leonard Hotham	Project Manager	USEPA – Region 3	215-814-5788	hotham.leonard@epa.gov
Ausha Scott	Analytical Laboratory Project Manager – Air	Eurofins Air Toxics, Inc.	916-605-3344	aushascott@eurofinsUS.com

QAPP Worksheet #4 - Project Personnel Sign-Off Sheet

Name	Organization/Title/Role	Telephone Number (optional)	Signature/E-mail Receipt	QAPP Worksheet Reviewed	Date QAPP Read
Vernon Burrows	BASF/Project Manager	9736654829			
Jim Culp	Geosyntec/Project Manager	412-275-8001			
Helen Dawson	Geosyntec/Technical Expert	202-370-4351			
Theresa Gabris	Geosyntec/Field Manager	202-370-4351			
Leonard Hotham	USEPA/Project Manager	215-814-5788			
Ausha Scott	Eurofins Air Toxics, Inc./ Project Manager	916-605-3344			

QAPP Worksheet #5 – Project Organizational Chart



Note:

EPA	Environmental Protection Agency

QAPP Worksheet #6 - Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure
Project Management	EPA Project Manager	Leonard Hotham	215-814-5788	EPA Project Manager will review and approve this QAPP and any amendments to the original QAPP.
	BASF Project Manager	Vernon Burrows	973-665-4829	BASF Project Manager will manage the contract and review deliverables.
	Geosyntec Project Manager	Jim Culp	412-275-8001	Geosyntec Project Manager will manage the contract, deliverables, and field and project personnel.
	Geosyntec Technical Expert	Helen Dawson	202-370-4351	Technical Expert will be in contact with field and project personnel, and provide advice and direction as needed.
Coordination and communication of fieldwork activities related to sampling	Geosyntec Field Manager	Theresa Gabris	202-370-4351	Field Team Leader will communicate relevant field information to the Geosyntec Project Manager and Laboratory Project Manager.
Coordination of laboratory for field activities and data validation	Eurofins Air Toxics, Inc. Project Manager	Ausha Scott	202-370-4351	Laboratory Project Manager will provide all necessary sample containers and appropriate shipping materials (such as coolers and bubble wrap) to be delivered on-site before field sampling begins and throughout the project.
Submittal of samples to the laboratory	Geosyntec Sampling Personnel	TBD	TBD	Sampling personnel will package and ship samples in accordance with this QAPP.
Daily COC reports and shipping documentation	Geosyntec Sampling Personnel	TBD	TBD	COCs and shipping documentation will be submitted via fax or e-mail to the Geosyntec Field Manager at the end of each day that samples are collected.
Reporting laboratory data quality issues	Eurofins Air Toxics, Inc. Project Manager	Ausha Scott	202-370-4351	All QA/QC issues will be reported by the Laboratory Project Manager to the Geosyntec Project Manager and Field Manager in writing within 2 business days.

QAPP Worksheet #6 - Communication Pathways (Continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure
Analytical corrective actions (CAs)	Eurofins Air Toxics, Inc. Project Manager	Ausha Scott	202-370-4351	The Lab Project Manager will immediately notify the Geosyntec Project Manager in writing of any analytical procedures that were not performed in accordance with this QAPP. The Lab Project Manager, in coordination with the Geosyntec, will complete documentation of the non-conformance and CAs to be taken. The Lab Project Manager will verify that the CAs have been implemented.
QAPP addenda	Geosyntec Project Manager	Jim Culp	412-275-8001	Any changes to the QAPP will require the Geosyntec Project Manager to prepare an addendum that will be approved by the BASF Project Manager and EPA Project Manager before any field activities begin.

Notes:

CA	corrective action
COC	chain-of-custody
QA	quality assurance
QC	quality control
QAPP	quality assurance project plan

QAPP Worksheet #7 - Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Vernon Burrows	Project Manager	BASF	Performing project management for BASF. Ensuring that the project scope of work requirements are fulfilled. Providing formal technical direction to the project team, as needed. Acting as lead interface with agencies.
Leonard Hotham	Project Manager	USEPA	Reviewing and approving the QAPP, QAPP Addenda, and Work Plan. Providing EPA oversight of the QA Program.
Jim Culp	Project Manager	Geosyntec	Coordinating work activities of subcontractors and ensuring that all personnel adhere to the administrative and technical requirements of the project. Monitoring and reporting the progress of work and ensuring that the project deliverables are completed on time and within project budget. Monitoring the budget and schedule and notifying the BASF Project Manager of any changes that may require administrative actions. Ensuring adherence to the quality requirements of the contract, project scope of work, and the QC Plans. Ensuring that all work meets the requirements of the technical specifications and complies with applicable codes and regulations. Serving as the primary contact between BASF and EPA for actions and information related to the work and including appropriate technical personnel in the decision-making.
Helen Dawson	Technical Expert	Geosyntec	Evaluating and selecting a qualified subcontract laboratory. Supporting projects as the technical lead for chemical data collection and analysis.
Theresa Gabris	Field Manager	Geosyntec	Ensuring that all fieldwork is conducted in accordance with the Work Plan, QAPP, and QAPP Addenda. Ensuring that sampling personnel have documented training on sampling procedures for specific project requirements. Providing direction to field staff and subcontractors. Reporting field information to the Geosyntec Project Manager and Lab Project Manager.

QAPP Worksheet #7 - Personnel Responsibilities Table (Continued)

Name	Title/Role	Organizational Affiliation	Responsibilities
Julia Klens-Caprio	Data Quality Manager	Geosyntec	Validating all analytical data. Preparing data validation reports. Communicating any data quality issues with the Laboratory Project Manager, Geosyntec Project Manager, and Geosyntec Technical Expert.
Ausha Scott	Analytical Laboratory Project Managers	Eurofins Air Toxics, Inc.	Maintaining and documenting log-in records, internal COC records, and provide sample analysis progress. Submitting accurate and complete analytical data packages within the required turn-around-times. Immediately communicating with the Geosyntec Project Manager and Field Manager any nonconformance that may impact data quality.

Notes:

EPA	Environmental Protection Agency	QC	quality control
COC	chain-of-custody	QAPP	sampling and analysis plan
QA	quality assurance		

QAPP Worksheet #8 - Special Personnel Training Requirements Table

Project Function	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates
None						

Notes:

No Special Personnel Training is required for this project. Field personnel have been trained in sampling procedures and hold current Occupational Safety and Health Administration (OSHA) 40-hour Hazardous Waste Operations and Emergency Responses Training.

QAPP Worksheet #9 - Project Scoping Session Participants Sheet

Project Name: Vapor Intrusion Investigation Work Plan Project Manager: Jim Culp	Site Name: Flint Group Pigments Huntington Facility Site Location: Huntington, West Virginia

Date of Session: 10 March 2017
Scoping Session Purpose: BASF Huntington VI Project Scoping Meeting

Name	Title	Affiliation	Phone #	E-mail Address
Vernon Burrows	Project Manager	BASF	973-665-4829	vernon.burrows@basf.com
Jim Culp	Project Manager	Geosyntec	412-275-8001	jculp@geosyntec.com
Helen Dawson	Technical Expert	Geosyntec	202-370-4351	hdawson@geosyntec.com
Theresa Gabris	Field Manager	Geosyntec	202-370-4351	tgabris@geosyntec.com
Leonard Hotham	Project Manager	USEPA	215-814-5788	hotham.leonard.epa.gov
Ausha Scott	Project Manager	Eurofins Air Toxics, Inc.	916-605-3344	aushascott@eurofinsUS.com

Note:

EPA	Environmental Protection Agency

Comments/Decisions:	Discussed project scope, conceptual design, planned field implementation, deliverables, and schedule.
Action Item:	Geosyntec/BASF will prepare a draft Work Plan for EPA to review within 1 month of contract award
	Prepare work plan and schedule work.
Consensus Decision:	Indoor/crawl space/penetration pathways and outdoor air sampling using time-integrated and passive sampling techniques (see Work Plan).

QAPP Worksheet #10 - Conceptual Site Model

Location and Background

The Facility location is shown on **Figure 1**. The Facility is an active industrial facility with controlled access in an industrial residential area of Huntington, West Virginia. Residential properties bound the facility to the northeast (25th Street), while industrial/commercial properties bound the facility to the north, south and west. A CSX Transportation Locomotive Shop Yard lies directly south of BASF. The Facility is currently listed as a hazardous waste generator under USEPA ID WVD000068601 and is broken into the following areas of concern (AOCs) (**Figure 2**):

- AOC1 – 25th Street Landfill
- AOC2 – Former Process Sewers
- AOC3 – On-Site Railroad Line
- AOC4 – Former Gasoline Station
- AOC5 – On-Site Wastewater Treatment System
- AOC6 – Aboveground Storage Tanks
- AOC7 – Electrical Transformers
- AOC8 – Former Coal Storage Area
- AOC9 – Site-Wide Groundwater
- AOC10 – North Parking Lot
- AOC11 – Warehousing Area

The Facility is entirely paved with asphalt and concrete, except for the 25th Street Landfill (AOC1, which has a vegetated soil cap) and the Warehousing Area (AOC11, which has a mixture of asphalt, gravel, and grass). AOC9, AOC10, and AOC11 are the primary focus of the VI Investigation.

The Facility was constructed in 1909 and has been actively manufacturing dyestuffs and pigments since 1912. The primary pigment manufactured at the facility is alkali blue; however, a variety of pigments have been produced at the facility throughout its operational history. The facility was operated by the Holland-SUCo Color Company (formerly the Standard Ultramarine Company) from 1912 to 1964. The facility was acquired by Chemetron Corporation in 1964 and then by the Pigments and Dyestuffs Division of BASF Wyandotte Corporation in 1979, which was re-named BASF Corporation in 1986. Since 2004, the facility has operated under the ownership of Flint Group Pigments (owned by XSYS Printing Systems), which was formed by the merger of BASF Printing Systems and ANI Printing Inks following their respective acquisitions by CVC Capital Partners (a private equity firm).

Subsurface Contaminant Vapor Sources

The exceedances of COC VISLs are largely concentrated in the North Parking Lot (AOC10 – northeastern portion of the Facility) and the Aboveground Storage Tank (AST) area (AOC6 – along the southern Facility boundary). BTEX contaminants at AOC6 are likely due to releases from ASTs in AOC6, as BTEX concentrations exceeding regulatory standards have been detected

QAPP Worksheet #10 - Conceptual Site Model (Continued)

in soil as well as groundwater in this area. The source of chlorinated solvents in groundwater at AOC10 is currently unknown.

A summary of all documented spills, releases, and environmental contamination within a one mile radius of the Facility was compiled by property due diligence provider, EDR. EDR searched Federal, State and local regulatory databases relating federal and state-registered cleanup sites, waste storage and disposal, registered ASTs and underground storage tanks (USTs), known releases, and registered automotive shops and dry cleaners. Eleven sites are reported as having leaking storage tanks within a half mile upgradient or side-gradient of the Facility (EDR, 2017). These tanks were largely reported to contain petroleum products including gasoline, diesel, and used oil. These petroleum releases have the potential to contribute to the BTEX concentrations reported in Facility groundwater. No releases of chlorinated solvents were reported within one mile radius of the Facility. One dry cleaner was reported less than 1/8-mile downgradient of the Facility; however it closed in 2010 and did not have reported chlorinated solvent releases.

The Facility VI compounds of concern (COC) list includes all analytes that currently exceed their USEPA groundwater or soil gas (carbon tetrachloride only) VISLs in at least one sampling location. Benzene is also being included as a COC because the method detection limits for benzene in groundwater samples from AOC2 and AOC6 exceeded groundwater VISLs. The groundwater VISL exceedances are shown on **Figure 3** and the COCs are listed below.

- Carbon tetrachloride
- Tetrachloroethene
- Trichloroethene
- Vinyl chloride
- 1,1,2,2-Tetrachloroethane
- Benzene
- Ethylbenzene
- 1,2,4-Trichlorobenzene
- Toluene
- Xylenes

Vapor Intrusion Pathway

Groundwater flow in the vicinity of the Facility is to the north. Thus, the groundwater observed to have elevated COC concentrations in monitoring wells at the northern Facility boundary likely is migrating off-site to the north. VOCs in these groundwater plumes may volatilize and the vapor may migrate through the vadose zone via diffusion through soil pores or larger pathways, such as fractures in rock or sediment, and enter into overlying structures through vapor penetration points in the structure foundations (i.e. cracks or holes). The vapors may also migrate into anthropogenic “preferential pathways” (e.g., utility conduits) and from there directly into structures (bypassing portions of the vadose zone) via improperly sealed utility penetrations in structure foundations or walls.

Current site characterization data indicate the aquifer is generally separated from the overlying structures by an approximately 5- to 20-foot thick layer of silts and clays (Table 2), which may

QAPP Worksheet #10 - Conceptual Site Model (Continued)

significantly attenuate vapor migration. However, this layer was thin or absent from some boreholes in AOC1 (25th Street Landfill) and AOC6, south of the acid tank farm. Boreholes drilled in the North Parking Lot area show that a moist silty to sandy clay is continuously present above the aquifer in this area. This low-conductivity layer is present at varying thicknesses in most boreholes across the Facility and appears to be fairly laterally continuous.

A brief summary of the contaminant fate and transport mechanisms that are relevant for VI are provided below.

Vapor Migration in the Vadose Zone

Concentrations of compounds in soil gas generally decrease as the compounds migrate from near the source through the vadose zone and into indoor air. The transport mechanisms that are important for understanding subsurface vapor transport are diffusion and advection. Near a building, both diffusion and advection may be important; deeper underneath a building, diffusion through soil gas is typically the dominant transport process. Diffusion is caused by the random motion of molecules and occurs along concentration gradients. Contaminants will move from areas of higher concentration to areas of lower concentration, even when there is no movement of a fluid. Since diffusion through water is significantly slower than diffusion through air, the rate of diffusion is related to the soil moisture content. As soil moisture increases, the rate of vapor diffusion decreases. Diffusion from VOCs or groundwater tends to move contaminant vapors upwards toward lower concentrations at the ground surface or the underside of a building while diffusion from residual soil contamination in the vadose zone, if present, can diffuse laterally and vertically in all directions.

Advection in the vadose zone is the bulk movement of soil gas caused by pressure gradients in the subsurface. Advection occurs from areas of higher pressure to areas of lower pressure. The air pressure inside a building can be higher or lower than the soil gas pressure underneath a building and even small differences can cause advection and the flow of vapors into or out of a building. Pressure gradients driving advection can develop from the operation of exhaust fans, heating units, or air conditioners, fluctuations in barometric pressure, the wind load on building walls, the piston action of elevators, or temperature differences between inside and outside air. When air inside a building is heated, either by a heating system or from the sun, hot air will rise and leak through the roof and windows on the upper floor, which will draw in soil gas from lower levels of the building. This is referred to as the “stack effect”. Advection can also be enhanced when gases generated by microbial activity (e.g., methane or carbon dioxide generated from degradation of hydrocarbons) in groundwater are sufficiently high.

Contaminant vapors can migrate further through preferential flow pathways such as the granular fill underneath a building and surrounding utility pipes, or other areas where the porosity of the soil is higher. Conversely, low permeability layers in the vadose zone like silt or clay layers and areas with high moisture levels can impede the upward migration of vapors in the subsurface. The vadose zone underneath the Facility is predominantly sandy and silty clay, which are expected to impede soil gas migration.

Transformation within the Vadose Zone

QAPP Worksheet #10 - Conceptual Site Model (Continued)

Some of the compounds present in the VOCs and groundwater may be susceptible to biodegradation in the vadose zone. The degree to which this would alter the composition of soil gas as it migrates upward depends on the compound biodegradability, soil moisture, oxygen concentration, nutrient availability, and microbial population. Biodegradation tends to be a more significant process when conditions in the vadose zone are aerobic and the compounds are petroleum-based because they are readily biodegradable by common soil microorganisms when there is oxygen present. Highly chlorinated compounds such as tetrachloroethene (PCE) and TCE are not known to biodegrade as primary substrates under aerobic conditions; however, lesser chlorinated compounds such as vinyl chloride (VC), in general, can biodegrade in the vadose zone under aerobic, moist conditions, and bacteria capable of oxidizing VC are thought to be ubiquitous in soil.

Soil Gas Entry into Buildings

Vapors in soil gas can migrate into buildings through floor slab cracks and expansion joints, perimeter cracks between floor slab and walls that allow for expansion and contraction, other gaps in building foundations, floors, and walls such as utility penetrations, sump pits, floor drains, or even concrete that appears to be free of cracks.

Air Exchange and Mixing

Once vapors from soil gas enter into a building, the natural or mechanical ventilation will mix the compounds throughout the air space within the building. Natural ventilation is air flow through open windows, doors, and other openings in the building envelope. Mechanical ventilation is air flow controlled by fans. Heating, ventilation, and air conditioning (HVAC) systems in industrial buildings typically blow air into the building, exhausting a portion of the indoor air and providing a certain amount of fresh outdoor air.

Air flow within a building can be impeded by the presence of doors, walls, and other partitions that separate rooms or building areas. In general, concentrations of compounds from soil gas tend to be higher in rooms with limited ventilation and rooms that are near openings where soil gas can enter the building such as cracks or sumps.

Variability

Pressure differentials between a building and sub-slab soil gas, and the intrusion of vapors into a building, can fluctuate over time due to a number of factors, including:

- Diurnal and seasonal changes in ambient air temperature;
- Ambient air pressure changes;
- Wind direction and speed changes; and
- Mechanical ventilation, HV, or HVAC system operational changes.

These variations can occur over different time scales, within a single day, over several days as the weather changes, or between seasons.

Receptors

Potential receptors include residents of off-site properties as well as on-site and off-site workers in buildings within 100 feet of groundwater samples with VISL exceedances. **Figure 3** shows all

QAPP Worksheet #10 - Conceptual Site Model (Continued)

structures that fall within a 100-foot radius of a well that had reported groundwater contaminant concentrations exceeding USEPA VISLs.

Remedial Actions

No remedial actions have yet been conducted at the Facility. The following summarizes the history of Facility investigation activities to date and the regulatory drivers for the VI investigation:

- BASF entered into the Facility Lead Corrective Action Program in December 1999, in response to USEPA's identification of the Facility as "high priority" under RCRA.
- BASF submitted an initial RFI Work Plan to USEPA in July 2001 and USEPA granted approval to start work in April 2002. The work was completed in 2002.
- Approval for BASF to perform an additional groundwater investigation was granted by USEPA in February 2003. This work was completed in 2003 and 2005.
- The initial RFI and Supplemental Groundwater Monitoring Reports were submitted to USEPA in August 2003 and September 2005, respectively.
- USEPA approved a Phase II RFI Work Plan for further groundwater investigation; the work was performed from 2009 to 2010.
- BASF submitted the RFI Phase II Report to USEPA in May 2010.
- An additional groundwater sampling event was conducted in November 2013.
- ELMSS submitted an RFI Data Gap Work Plan to USEPA in October 2015, which was approved on December 2, 2015. The data gap investigation was conducted between July and September 2016 with the RFI Data Gap Report being submitted by ELMSS in December 2016.
- USEPA issued comments on the RFI Data Gap Report in January 2017 and, therein, required BASF to "take prompt and aggressive action" to address the potential risks to "onsite workers and offsite residents," and develop a plan to address potential VI risks.

QAPP Worksheet #11 - Project Quality Objectives/Systematic Planning Process Statements

Project Quality Objectives (PQOs) define the type, quantity, and quality of data that are needed to answer specific environmental questions and support environmental decisions. PQOs are developed using a systematic planning process described in the Guidance for the Data Quality Objective (DQO) Process (EPA, 2006). The process consists of the following seven iterative steps:

1. State the problem;
2. Identify the goals of the study;
3. Identify information inputs;
4. Define the boundaries of the study;
5. Develop the analytical approach;
6. Specify performance of acceptance criteria; and
7. Develop the plan for obtaining data.

The PQOs are described below.

State the Problem

Data are needed to assess whether there are concentrations of COCs in the shallow soil vapor or sub-slab soil vapor that could pose a risk to occupants of buildings via vapor intrusion.

Identify the Goals of the Study

The goal of the VI assessment program is to identify all structures where the VI-related concentration of site-related COCs could reasonably exceed their respective indoor air risk-based screening levels, and to take appropriate actions to reduce VI-related exposures to those COCs.

The principal study questions for this work are as follows:

1) Is vapor intrusion occurring at onsite and offsite buildings?

2) What are the potential risks to receptors (onsite workers and offsite residents)?

Define the Boundaries of the Study

The investigation will be complete when the nature and extent of potential VI has been fully delineated. While there are no physical boundaries, as detailed in the Decision Matrix of the Work Plan, step-out samples will be collected until all risks from vapor intrusion have been identified.

Develop the Analytical Approach

Risk to human health from VI will be evaluated based on the indoor air, crawl space, sub-slab vapor, and soil vapor samples. Geosyntec will use an iterative assessment approach that initially focuses on off-site areas near the BASF facility and on-site areas with elevated concentrations of COCs in the groundwater. The area of the VI investigation will expand as necessary based on the information collected during the initial and any subsequent phase of the investigation until the program goal has been achieved. The CSM will serve as the framework for integrating site

QAPP Worksheet #11 - Project Quality Objectives/Systematic Planning Process Statements (Continued)

information into a comprehensive portrayal of site conditions and identifying structures that may potentially be adversely impacted by VI. As new information is developed, the CSM will updated to more effectively shape the course of the investigation.

See the Decision Matrix in the Work Plan for a detailed description of the sampling structure.

Specify Performance or Acceptance Criteria

The sampling and analysis program described in this QAPP is designed to ensure that data quality and type are appropriate for the intended use and to reduce the potential for decision errors.

Develop the Plan for Obtaining Data

This sampling plan is further described in Worksheets #14 and #17. Work will be coordinated with the USEPA. Worksheet #18 lists the locations to be sampled, analyses performed, and frequency of sampling.

Target analyte lists are provided in Worksheet #15, analytical method references are provided in Worksheet #23. Worksheet #16 shows the anticipated project schedule.

QAPP Worksheet #12 - Field Quality Control Samples

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
Field Duplicate	VOCs (Air)	1 per 10 project samples	Precision	RPD ≤ 30% when analytes detected in both field duplicate samples ≥ LOQ
Field Blank	VOCs (Air)	1 per sampling event	Presence of contaminants/ accuracy	No analyte greater than (>) LOQ

Notes:

LOQ	limit of quantitation
QC	quality control
%	percent
VOC	volatile organic compound

QAPP Worksheet #13 - Secondary Data Criteria and Limitations Table

Secondary Data	Data Source	Data Generator(s)	How Data Will Be Used	Limitations on Data Use
EDR Radius Report	EDR	Regulatory databases	Data from the EDR Radius Report was used to help identify potential off-site sources of contamination.	The data set for each listed site in the vicinity of the BASF site is incomplete. Several of the Surrounding site s had reported releases but the spilled substance was not reported.

QAPP Worksheet #14 - Summary of Project Tasks

See the VI Work Plan for a detailed description of all project tasks. The vapor intrusion investigation will initially focus on AOC9, AOC10, and AOC11, the off-site area near the North Parking Lot, Phase 1 Area (**Figure 2**), and on three occupied on-site structures (Building 42, Building 66, and Building 92) and one commercial off-site structure (restaurant approximately 100-feet north of monitoring well TMW-7D). These areas are within a 100-foot radius of an existing monitoring point where groundwater concentrations exceed the screening levels that USEPA indicates warrant vapor intrusion investigation (**Figure 3**). The scope of any follow-on activities will be based on the decision framework described above.

The scope of work will include:

- Notification and selection of properties for sampling (residential properties)
    - Prepare and transmit notifications to property owners within the Phase 1 Area of the proposed sampling program
    - Obtain access agreements with property owners that agree to allow sampling
- Building inventory and preferential pathway assessment
    - Conduct a records review of subsurface utility services
    - Perform preliminary building inspections
    - Prepare location-specific work plan for sampling
- Indoor air sampling and analysis (includes residential crawl space sampling) (all properties)
    - Collect samples of indoor air, penetration pathways, and outdoor air
    - Collect quality assurance/quality control (QA/QC) samples
    - Submit samples to certified laboratory for analysis
- Sub-slab vapor sampling and analysis (slab on grade structures and structures with basements)
    - Install sub-slab vapor pins
    - Collect samples of sub-slab vapor and QA/QC samples
    - Submit samples to certified laboratory for analysis
- Differential Pressure Logging (at structures where sub-slab samples are collected)
    - Collect sub-slab pressure differential data from sub-slab vapor pins
- Data evaluation and reporting (all properties)
    - Review analytical results and provide informal data report and recommendations for future sampling to the USEPA
    - Discuss any proposed mitigation measures with the USEPA

QAPP Worksheet #15 - Reference Limits and Evaluation Tables

Matrix: Soil Gas

Analytical Group: VOCs by EPA TO-15 Standard

Analyte (a)	CAS Number	Project Action Limits ($\mu g/m^3$) (b)	Project Action Limits ($\mu g/m^3$) (c)	Laboratory-specific (d)		
		Residential	Industrial	LOQs ($\mu g/m^3$)	LODs ($\mu g/m^3$)	DLs ($\mu g/m^3$)
1,1,2,2-Tetrachloroethane (e)	79-34-5	1.6	7	3.4	1.3	0.76
1,2,4-Trichlorobenzene	120-82-1	70	290	15	4.7	1.1
Benzene	71-43-2	12	52	2.2	0.82	0.22
Carbon tetrachloride	56-23-5	16	68	3.1	1.2	0.47
Ethylbenzene	100-41-4	37	160	2.2	0.82	0.22
Tetrachloroethene	127-18-4	360	1,600	3.4	1.3	0.47
Toluene	108-88-3	70,000	730,000	1.8	0.72	0.37
Trichloroethene	79-01-6	16	100	2.7	1.0	0.84
Vinyl Chloride	75-01-4	5.6	93	1.3	0.48	0.19
Xylenes, Total	1330-20-7	3,500	15,000	2.2	0.82	0.37

Notes:

(a) The analyte list is comprised of compounds that were detected above their groundwater or soil gas vapor intrusion screening levels (VISLs) in at least one sample during the 2016 RFI Data Gap Investigation.

(b) Project Action limits are vapor intrusion screening levels VISLs that are calculated using EPA's VISL Calculator Version 3.5.1 (May 2016 RSLs). Chosen values are the lowest values of the calculated residential cancer/non-cancer screening levels, derived using DTSC's default sub-slab attenuation factors for existing residential buildings.

(b) Project Action limits are VISLs that are calculated using EPA's VISL Calculator Version 3.5.1 (May 2016 RSLs). Chosen values are the lowest values of the calculated commercial cancer/non-cancer screening levels, derived using DTSC's default sub-slab attenuation factors for existing commercial buildings.

(d) Values listed are prior to canister pressurization and will be elevated by a factor dependent on the post-sample vacuum reading.

(e) The laboratory-specific LOQs exceed the residential project action limit for the indicated compound. However, data will be reported to the DLs and values detected between the DL and LOQ will be reported as estimated with a "J" qualifier.

CAS	Chemical Abstract Service
DTSC	Department of Toxic Substances Control

QAPP Worksheet #15 - Reference Limits and Evaluation Tables (Continued)

EPA	Environmental Protection Agency, United States
DL	detection limit
LOD	limit of detection
LOQ	limit of quantitation
VOC	volatile organic compound
$\mu g/m^3$	micrograms per cubic meter

QAPP Worksheet #15 - Reference Limits and Evaluation Tables (Continued)

Matrix: Indoor Air

Analytical Group: VOCs by EPA TO-15 Hi/Lo (SIM)[d]

Analyte (a)	CAS Number	Project Action Limits (µg/m³) (b)	Project Action Limits (µg/m³) (c)	Laboratory-specific (d)		
		Residential	Industrial	LOQs (µg/m³)	LODs (µg/m³)	DLs (µg/m³)
1,1,2,2-Tetrachloroethane [e]	79-34-5	0.048	0.21	0.14	0.04	0.007
1,2,4-Trichlorobenzene [f]	120-82-1	2.1	8.8	3.7	0.59	0.23
Benzene	71-43-2	0.36	1.6	0.05	0.03	0.004
Carbon tetrachloride	56-23-5	0.47	2	0.12	0.04	0.006
Ethylbenzene	100-41-4	1.1	4.9	0.09	0.03	0.009
Tetrachloroethene	127-18-4	11	470	0.13	0.04	0.007
Toluene	108-88-3	5,200	22,000	0.08	0.02	0.004
Trichloroethene	79-01-6	0.48	3	0.11	0.03	0.005
Vinyl Chloride	75-01-4	0.17	2.8	0.03	0.02	0.008
m,p-Xylene	108-38-3	100	440	0.17	0.03	0.009
o-Xylene	95-47-6	100	440	0.09	0.03	0.004

Notes:

(a) The analyte list is comprised of compounds that were detected above their groundwater or soil gas vapor intrusion screening levels (VISLs) in at least one sample during the 2016 RFI Data Gap Investigation.

(b) Project Action limits are vapor intrusion screening levels VISLs that are calculated using EPA's VISL Calculator Version 3.5.1 (May 2016 RSLs). Chosen values are the lowest values of the calculated residential cancer/non-cancer screening levels.

(c) Project Action limits are VISLs that are calculated using EPA's VISL Calculator Version 3.5.1 (May 2016 RSLs). Chosen values are the lowest values of the calculated commercial cancer/non-cancer screening levels.

(d) Values listed are prior to canister pressurization and will be elevated by a factor dependent on the post-sample vacuum reading.

(e) The laboratory-specific LOQs exceed the residential project action limit for the indicated compound. However, data will be reported to the DLs and values detected between the DL and LOQ will be reported as estimated with a "J" qualifier.

(f) 1,2,4-Trichlorobenzene is not available by SIM analysis. This will be analyzed by TO-15 in full scan mode

QAPP Worksheet #15 - Reference Limits and Evaluation Tables (Continued)

CAS	Chemical Abstract Service
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency, United States
DL	detection limit
LOD	limit of detection
LOQ	limit of quantitation
QL	quantitation limit
VOC	volatile organic compound
$\mu g/m^3$	micrograms per cubic meter

QAPP Worksheet #16 - Project Schedule

Activities	Organization	Dates		Deliverable
		Anticipated Date(s) of Initiation	**Anticipated Date of Completion**	
Prepare Draft Work Plan	Geosyntec/BASF /Eurofins Air Toxics, Inc.	March 2017	April 2017	Draft Work Plan
Agency Review and Approval	EPA	April 2017	July 2017	Agency Comments
Final Work Plan	Geosyntec/BASF	July 2017	August 2017	RTCs and Final Work Plan
Notice to Proceed	EPA	Approval Date	Approval Date	Work Plan Approval Letter
Obtain Site-Specific Access Agreements	BASF	Approval Date	Approval Date + 1.5 Months	Site-Specific Access Agreements
Conduct VI Sampling	Geosyntec	Approval Date + 1.5 Months	Approval Date + 3.5 Months	None
Prepare Indoor Air Assessment Summary Reports	Geosyntec	Approval Date + 2.5 Months	Approval Date + 4 Months	Indoor Air Assessment Summary Reports
Prepare Draft VI Report for inclusion in ELMSS' Draft RFI Report	Geosyntec/ ELMSS/BASF	Approval Date + 4 Months	Approval Date + 5.5 Months	Draft RFI Soil, GW, & VI Report
Agency Review of Draft RFI Report	EPA	Approval Date + 5.5 Months	Approval Date + 6.5 Months	Agency Comments
Prepare RTCs for RFI Report	Geosyntec/ ELMSS/BASF	Approval Date + 6.5 Months	Approval Date + 7 Months	RTCs
Agency Approval of RTCs	EPA	Approval Date + 7 Months	Approval Date + 7.5 Months	Approval Letter
Prepare and Submit Final RFI Report	Geosyntec/ ELMSS/BASF	Approval Date + 7.5 Months	Approval Date + 8 Months	Final RFI Report

Notes:

RFI	RCRA Facility Investigation
RTC	response to comments
QAPP	sampling and analysis plan
VI	vapor intrusion

QAPP Worksheet #17 - Sampling Design and Rationale

See the VI Work Plan for a detailed description of the VI sampling locations, protocols, and decision matrices for follow-on sampling.

QAPP Worksheet #18 - Sampling Locations and Methods/SOP Requirements Table

Sampling Location / ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
Residential Structures	Indoor Air	VOC by TO-15	To be determined in site-specific work plan	Worksheet #19, 21
Residential Structures	Outdoor Air	VOC by TO-15	To be determined in site-specific work plan	Worksheet #19, 21
Residential Structures	Crawl Space Air	VOC by TO-15	To be determined in site-specific work plan	Worksheet #19, 21
Commercial Structures	Indoor Air	VOC by TO-15	To be determined in site-specific work plan	Worksheet #19, 21
Commercial Structures	Outdoor Air	VOC by TO-15	To be determined in site-specific work plan	Worksheet #19, 21
Commercial Structures	Sub-slab soil gas	VOC by TO-15	To be determined in site-specific work plan	Worksheet #19, 21
Residential/Commercial Structures, as required	Soil gas	VOC by TO-15	To be determined in site-specific work plan	Worksheet #19, 21

Notes:

ID	identification
QAPP	sampling and analysis plan
SOP	standard operating procedure
VOC	volatile organic compound

QAPP Worksheet #19 - Field Sampling Requirements Table

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference	Containers [a] (number, size, and type)	Sample Volume	Preservation Requirements	Maximum Holding Time [b] (preparation / analysis)
Sub-Slab and Soil Gas	VOCs	EPA TO-15 / TO-14A EATL SOP #6, Revision 37, 3/29/2017	1 1-L Summa canister	1 L	None	30 days (Summa canister)
Indoor and Outdoor Air	VOCs	EPA TO-15 / TO-14A EATL SOP #6, Revision 37, 3/29/2017	1 6-L Summa canister	6 L	None	30 days (Summa canister)

Notes:

[a] Batch-certified Summa canisters will be used for sub-slab and soil gas samples.

[b] Maximum holding time is calculated from the time the sample is collected to the time the sample is analyzed.

EPA	Environmental Protection Agency, United States
L	liter
SOP	standard operating procedures
VOC	volatile organic compound

QAPP Worksheet #20 - Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations[1]	No. of Field Duplicates[2]	No. of Field Blanks[3]	No. of Equip. Blanks	Total No. of Samples to Lab
Sub-Slab Soil Gas	VOCs	9	1	1	N/A	11
Indoor and Outdoor Air	VOCs	40	4	0	N/A	44

Notes:

[1] This is based only on projected initial Phase I sampling: 10 residential properties and 3 commercial/industrial properties. Sample numbers are likely to change based on location-specific work plans and follow-on (step-out) sampling.

[2] For each sampling event, at least 1 field duplicate will be collected for every 10 samples as outlined in Worksheet #12.

[3] For each sampling event, at least 1 field blank will be collected.

N/A	not applicable
No.	number
VOC	volatile organic compound

QAPP Worksheet #21 - Project Sampling SOPs

Detailed Standard Operating Procedures (SOPs) are provided in Appendix B and Appendix C of the VI Work Plan.

QAPP Worksheet #22 - Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action (CA)	Responsible Person	SOP Reference	Comments
PID (PhoCheck Tiger or equivalent)	Maintenance	As needed	Per instrument specifications	In house repair or return to manufacturer or rental vendor	Field Team Leader	Manufacturer’s user manual	Replace batteries as needed
	Calibration	At the start of each sampling event and as needed based on daily calibration check	Per instrument specifications	Recalibrate until within the acceptable range or return to manufacturer or rental vendor	Field Team Leader	Manufacturer’s user manual	
Differential Pressure /Flow Gauge and Recorder (The Energy Conservatory DG-700 or equivalent)	Maintenance	Check if operating properly daily	Per instrument specifications	Return to manufacturer or rental vendor	Field Team Leader	Manufacturer’s user manual	Replace batteries as needed
Portable vacuum lung box	Maintenance	Check if operating properly daily	Pumping at required flow rate to evacuate adequate volume prior to sampling	In house repair or return to manufacturer	Field Team Leader	Manufacturer’s user manual	Replace batteries as needed
Landfill gas meter (GEM 2000 or equivalent)	Calibration	At the start of each sampling event and as needed based on daily calibration check	Per instrument specifications	Recalibrate until within the acceptable range or return to manufacturer or rental vendor	Field Team Leader	Manufacturer’s user manual	Replace batteries as needed
Helium meter, if used for leak check (Dielectric MGD-2002 or equivalent)	Calibration	At the start of each sampling event and as needed based on daily calibration check	Per instrument specifications	Recalibrate until within the acceptable range or return to manufacturer or rental vendor	Field Team Leader	Manufacturer’s user manual	Replace batteries as needed

QAPP Worksheet #23 - Analytical SOP References Table

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
EATL SOP #6	Analysis of Volatile Organic Compounds in Summa^{TM} Polished Canisters: Revision 37, 3/29/2017	Definitive	Air VOCs (Standard/Quad)	GC/MS	Eurofins Air Toxics, Inc., Folsom, CA	N

Notes:

EPA	Environmental Protection Agency, United States
GC/MS	gas chromatograph/mass spectrometer
N/A	not applicable
N	no
SOP	standard operating procedure
VOC	volatile organic compound
Y	yes

QAPP Worksheet #24 - Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Responsible Person	SOP Reference
GC/MS EATL	BFB Tuning Verification	Once every 24-hours or analytical batch	Ion abundance criteria as described in Table 3 of Method TO-15	1) Repeat BFB analysis 2) Retune instrument	Department Supervisor; however, other trained analysts in the team may be responsible	EATL SOP# 6 rev. 37
	ICAL – minimum of five levels	Initially or if continuing calibration no longer meets criteria	% RSD 30 with 2 compounds allowed out to 40% RSD	1) May repeat 1 point (if 5 levels) or 2 points (if 6 levels) 2) Inspect the system for problems and perform required maintenance 3) Repeat ICAL Problem must be corrected. Samples may not be analyzed until there is a valid ICAL.		
	Initial Calibration Verification (ICV)	Following every ICAL	Recoveries for 85% of "Standard" compounds must be 70–130%. No recovery may be < 50% If specified by the client, in-house generated control limits may be used.	Check the system and reanalyze the standard. Re-prepare the standard if necessary to determine the source of error. Re-calibrate the instrument if the primary standard is found to be in error.		
	Continuing Calibration Verification (CCV) for Standard compounds	At the start of each analytical clock after the tune check	70–130%	Compounds exceeding this criterion and associated data will be flagged and narrated with the exception of high bias associated with non-detects. If more than two compounds from the standard list recover outside of 70–130%, corrective action will be taken. If any compound exceeds 60–140%, samples are not analyzed unless data meets project needs. Check the system and reanalyze the standard. Re-prepare the standard if necessary. Re-calibrate the instrument if the criteria cannot be met.		

QAPP Worksheet #24 - Analytical Instrument Calibration Table (Continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Responsible Person	SOP Reference
GC/MS EATL	Internal Standard (IS)	All samples, duplicates, blanks and standards	Retention time (RT) for blanks and samples must be within ±0.33 min of the RT in the CCV and within ±40% of the area counts of the daily CCV internal standards.	**For blanks:** Inspect the system and reanalyze the blank. **For samples:** Re-analyze the sample. If the ISs are within limits in the re-analysis, report the second analysis. If ISs are out-of-limits a second time, dilute the sample until ISs are within acceptance limits and narrate.	Department Supervisor; however, other trained analysts in the team may be responsible	EATL SOP# 6 rev. 37
	Surrogate Standards	All samples, duplicates, blanks and standards	70–130% If specified by the client, in-house generated control limits may be used.	**For blanks:** Inspect the system and reanalyze the blank. **For samples:** Re-analyze the sample unless obvious matrix interference is documented. If the %Rs are within limits in the re-analysis, report the second analysis. If %Rs are out-of-limits a second time, report data from first analysis and narrate.		
	Laboratory Blank	After analysis of standards and prior to sample analysis, or when contamination is present.	No analyte detected equal to or above the LOQ	1) Re-analyze blank 2) Identify and correct problem 3) Re-analyze blank and affected samples 4) Qualify data		
	Laboratory Control Spike (LCS)	Once every analytical batch of 20 or fewer samples	Recoveries for 85% of “Standard” compounds must be 70–130%. No recovery may be < 50%. If specified by the client, in-house generated control limits may be used.	Check the system and reanalyze the standard. Re-prepare the standard if necessary to determine the source of error. Re-calibrate the instrument if the primary standard is found to be in error.		

QAPP Worksheet #24 - Analytical Instrument Calibration Table (Continued)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Responsible Person	SOP Reference
GC/MS EATL	Laboratory Duplicates – Laboratory Control Spike Duplicates (LCSD)	Once every analytical batch of 20 or fewer samples	RPD within +/-25% for positive hits	Narrate exceedances. If more than 5% of compound list is outside criteria or if compound has >40%RPD, investigate the cause and perform maintenance as required. If instrument maintenance is required, calibrate as needed.	Department Supervisor; however, other trained analysts in the team may be responsible	EATL SOP# 6 rev. 37
	Hold Time	N/A	SUMMA Canisters - 30 days (EPA Region 9 - 14 days) Tedlar® Bags - 72 hours (Method Modification)	Contact client and qualify data		
	LOQ	N/A	At or above the low standard of the current ICAL	N/A		
	DL with LOD Verification	Initially and once per 12 month period	LOD - Response with a minimum signal to noise ratio of 3:1	N/A		
	Report results between DL and LOQ	N/A	Upon request	Qualify results as estimated		

Notes:

BFB	bromofluorobenzene
CA	corrective action
CCV	continuing calibration verification
DL	detection limit
GC/MS	gas chromatograph/mass spectrometer
HT	hold time
ICAL	initial calibration
ICV	initial calibration verification
IS	internal standard
LCS	laboratory control sample
LD	laboratory duplicate
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
N/A	not applicable
%	percent
QAPP	quality assurance project plant
%R	percent recovery
RF	response factor
RPD	relative percent difference
RSD	relative standard deviation
RT	retention time
SOP	standard operating procedure

QAPP Worksheet #25 - Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance/Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
GC/MS (Sub-Slab Soil Gas/Soil Gas/Indoor/Outdoor Air)	Tune check (using BFB or DFTPP)	Daily	Spectrum must meet the mass intensity or ion abundance criteria in EPA method	Clean source and recalibrate the instrument	Eurofins Air Toxics Bench Analyst/Scientist	EATL SOP# 6 rev. 37
	Change in-line filter, septa, injection port liners	As needed	No visible wear on septa and liners or build-up on filter	Replace filters	Eurofins Air Toxics Bench Analyst/Scientist	
	Clip first 6-12 inches of capillary column	As needed	No visible contamination	Replace capillary column per manufacturer instructions	Eurofins Air Toxics Bench Analyst/Scientist	
	Replace column	As needed	ICAL/ICV and CV pass	Replace column per manufacturer instructions	Eurofins Air Toxics Bench Analyst/Scientist	

Notes:

All maintenance activities will be recorded in an instrument maintenance logbook.

BFB	bromofluorobenzene
CV	calibration verification
DFTPP	decafluorotriphenylphosphine
GC/MS	gas chromatograph/mass spectrometer
ICAL	initial calibration
ICV	initial calibration verification
SOP	standard operating procedure

QAPP Worksheet #26 - Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Geosyntec Field Technician
Sample Packaging (Personnel/Organization): Geosyntec Field Technician
Coordination of Shipment (Personnel/Organization): Geosyntec Field Technician
Type of Shipment/Carrier: Laboratory courier or commercial carrier
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Eurofins Air Toxics, Inc. sample custodian
Sample Custody and Storage (Personnel/Organization): Eurofins Air Toxics, Inc. sample custodian
Sample Preparation (Personnel/Organization): Eurofins Air Toxics, Inc. sample preparation group
Sample Determinative Analysis (Personnel/Organization): Various Eurofins Air Toxics, Inc. bench chemists and technicians
SAMPLE ARCHIVING
Field Sample Storage (Number of days from sample collection): Samples from the reusable canisters are disposed after analysis and verification of results against lab and project requirements. Other samples, 30 days, or as required on a project-specific basis.
Sample Extract/Digestate Storage (Number of days from extraction/digestion): not applicable
Biological Sample Storage (Number of days from sample collection): not applicable
SAMPLE DISPOSAL
Personnel/Organization: Eurofins Air Toxics, Inc. sample custodian

QAPP Worksheet #27 - Sample Custody Requirements

Sample Number

Samples submitted to the analytical laboratory will be uniquely named using the below guidelines and the following sample type abbreviations:

IA	Indoor air
OA	Outdoor air
CS	Crawl space air
SSV	Sub-slab vapor

Off-Site Residential Properties

Abbreviated street address – sample type – sequential number.

Ex) 338 Elaine Ct - IA - 01

On-Site Commercial/Industrial Properties

Building number – sample type – sequential number

Ex) Bldg 42 - SSV - 02

Field duplicates will be identified with a “DUP” followed by the date (YYYY-MM-DD). The original sample corresponding to each field duplicate will be noted on the field forms or in a field book.

Field blanks will be identified with a “FB” followed by the date (YYYY-MM-DD).

Sample Labeling

Sample labels/tags are necessary to prevent misidentification of samples. Sample labels/tags will be filled out in indelible ink and affixed to sample containers at the time of sample collection. At a minimum, each sample container will be labeled with the following:

- Sample identification number;
- Canister/flow controller identification numbers;
- Before and after canister pressure measurements;
- Sample collection date (month/day/year);
- Time of collection (24-hour clock) or start/stop/total time for time integrated samples;
- Sampler’s initials; and
- Analyses required.

Sample Handling and Shipping

QAPP Worksheet #27 - Sample Custody Requirements (Continued)

Immediately after samples are collected and labeled, each will be placed in a re-sealable plastic bag and then placed into a sample cooler containing ice if required for preservation as indicated in Worksheet #19. Samples will be shipped to the laboratory either by using a laboratory provided courier or commercial carrier. If samples are collected on a weekend or a holiday, they will be stored and shipped off-site the next business day.

Chain-of-Custody

To establish the documentation necessary to trace sample possession from the time of collection through analysis and disposal, a COC record will be completely filled out and will accompany every sample. Samples will be delivered to the laboratory for analysis as soon as practicable.

A sample is considered to be in a person's custody if the following conditions have been observed:

- The item is in the actual possession of the person;
- The item is in the view of the person after being in actual possession of the person;
- The item is locked in a secure area;
- The item is placed in an area restricted to authorized personnel; or
- The item is placed in a container and secured with a tamper indicating seal, such that the sample cannot be reached without breaking the seal.

The COC record will be the controlling document to ensure that the sample custody is maintained. Sampling personnel will initiate the COC record in the field once a sample is collected. Each time the sample custody is transferred, the former custodian will sign the COC on the "Relinquished By" line, and the new custodian will sign the COC on the "Received By" line. The date, time, and the name of their project or company affiliation will accompany each signature. The waybill number and carrier company name will be recorded on the COC when a commercial carrier is used. The shipping container will be secured with two custody seals (one on the front and one on the back), thereby allowing for custody to be maintained by the shipping personnel until receipt of the laboratory.

Sample custody will be the responsibility of sampling personnel from the time of sample collection until the samples are accepted by the laboratory via courier or commercial carrier. Thereafter, the laboratory performing the analysis will maintain custody.

Field Logbooks

A permanently bound field logbook with consecutively numbered pages, used for sampling activities only, will be assigned to this project. All entries will be recorded in indelible ink. At the end of each workday, the logbook pages will be signed by the responsible sampler, and any unused portions of the logbook pages will be crossed out, signed, and dated. If it is necessary to transfer the logbook to another person, the person relinquishing the logbook will sign and date the last page used, and the person receiving the logbook will sign and date the next page to be used.

At a minimum, the logbook will contain the following information:

QAPP Worksheet #27 - Sample Custody Requirements (Continued)

- Project name and location;
- Date and time;
- Personnel in attendance;
- General weather information;
- Work performed;
- Field observations;
- Sampling performed, including specifics such as location, type of sample, type of analyses, and sample identification;
- Field analyses performed, including results, instrument checks, problems, and calibration records for field instruments;
- Descriptions of deviations from this QAPP;
- Problems encountered and CA taken;
- Identification of field QC samples;
- QC activities;
- Verbal or written instructions; and
- Any other events that may affect the samples.

Document Corrections

Changes or corrections on any project documentation will be made by crossing out the erroneous item with a single line and initialing (by the person performing the correction) and dating the correction. The original item, although erroneous, must remain legible beneath the cross-out line. The new information should be written clearly above the crossed-out item.

QAPP Worksheet #28 - Laboratory QC Samples Tables

Matrix: Soil Gas, Sub-Slab Soil Gas, and Indoor Air
Analytical Group: VOC
Analytical Method / SOP Reference: EPA TO-15/EATL SOP #6, rev 37

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
MB	One per analytical batch of 20 or fewer samples	No analyte detected equal to or above the LOQ	1) Re-analyze blank 2) Identify and correct problem 3) Re-analyze blank and affected samples 4) Qualify data.	Analyst	Bias	No analytes detected less than half the LOQ
LCS	One per analytical batch of 20 or fewer samples	%R within laboratory generated limits	1) Re-analyze blank 2) Identify and correct problem 3) Qualify data	Analyst	Accuracy	Per EPA TO-15

Notes:

EPA	Environmental Protection Agency, United States
LCS	laboratory control sample
LOQ	limit of quantitation
MB	method blank
%R	percent recovery
QC	quality control
SOP	standard operating procedure
VOC	volatile organic compounds

QAPP Worksheet #29 - Project Documents and Records Table

Document	**Where Maintained**
Planning documents (Work Plan, QAPP, Health & Safety Plan)	Geosyntec/BASF project file
Field forms/logbooks	Geosyntec project file
Sample labels	Geosyntec and Eurofins Air Toxics, Inc.
COC Forms	Geosyntec and Eurofins Air Toxics, Inc.
Shipping records	Geosyntec project file
Laboratory data package including: Sample receipt and login Laboratory internal COC Instrument calibration logs Sample preparation logs Sample analysis/run logs	Geosyntec and Eurofins Air Toxics, Inc.
Data validation report	Geosyntec and Eurofins Air Toxics, Inc.

Notes:

COC	chain-of-custody
QAPP	quality assurance project plan

QAPP Worksheet #30 - Analytical Services Table

Matrix	Analytical Group	Sample Locations/ ID Number	Analytical Method	Data Package Turnaround Time	Laboratory / Organization [a]	Backup Laboratory / Organization
Sub-Slab Soil Gas, Soil Gas, Indoor/Outdoor air	VOCs	All samples	EPA TO-15 Low-Level / Standard	15 business days	EATL 180 Blue Ravine Road, Suite B Folsom, California 95630 Ausha Scott 916-605-3344	

Notes:

[a] The laboratory providing analytical services for this project is a National Environmental Laboratory Accreditation Conference (NELAC)-certified analytical laboratory.

EATL	Eurofins Air Toxics Laboratory
EPA	Environmental Protection Agency, United States
ID	identification
VOC	volatile organic compound

QAPP Worksheet #31 - Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing CA	Person(s) Responsible for Monitoring Effectiveness of CA
Field Readiness Review	Prior to mobilization of the project and prior to initiating major phases of work	Internal	Geosyntec	Project Manager	Field Manager	Field Staff	Project Manager and Field Manager
Field Documentation Review	Once at the end of sampling	Internal	Geosyntec	Field Manager	Geosyntec Project Manager	Geosyntec Project Manager	Field Manager
Data Review Surveillance	Once for project duration less than six months	Internal	Geosyntec	Lab Project Manager	Geosyntec Project Manager	Lab Project Manager	Lab Project Manager

Notes:

CA	corrective action
EPA	Environmental Protection Agency

QAPP Worksheet #32 - Assessment Findings and Corrective Action Response Table

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action (CA) Response Documentation	Individual(s) Receiving CA Response	Timeframe for Response
Data Review Surveillance	Surveillance Report	Geosyntec Project Manager and Lab Project Manager	7 days after completion of the inspection	CA Report	Lab Project Manager	14 days after notification

Note:

CA	corrective action

QAPP Worksheet #33 - Quality Assurance Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation	Report Recipient(s)
None.				

QAPP Worksheet #34 - Data Verification (Step I) Process Table

Data Review Input	Description	Responsible for Verification	Internal / External
Field logbook	Field logbooks will be reviewed weekly and verified that the information is complete.	Field Manager	I
COC forms	COC forms will be reviewed daily upon their completion and verified for completeness.	Field Manager	I
Sample receipt	For samples shipped via courier or commercial carrier, the Lab Project Manager will verify receipt of samples by the laboratory the day following shipment.	Lab Project Manager	E
Sample logins	Sample login information will be reviewed and verified for completeness in accordance with the COC forms.	Lab Project Manager	E
Laboratory data prior to release	Laboratory data will be reviewed and verified for completeness against analyses requested on the COC forms.	Laboratory Project Manager	E
Laboratory data due at turnaround time listed on COC	Laboratory data will be verified that the analyses reported are consistent with the analyses requested on the COC forms.	Lab Project Manager	I
Laboratory data packages	All laboratory data packages will be verified by the laboratory performing the work for completeness. Data packages will then be reviewed by the Lab Project Manager for completeness.	Laboratory Project Manager	E
Field and electronic data	100% of manual entries will be reviewed against the hardcopy information and 10% of electronic uploads will be checked against the hardcopy.	Project Staff	I

Notes:

COC	chain-of-custody
E	external
I	internal

QAPP Worksheet #35 - Data Validation (Step II) Process Table

Data Review Input	Description	Responsible for Validation	Internal / External
Field logbook	Field logbooks will be reviewed weekly for accuracy associated with each sampling event. The inspection will be documented in daily QC reports.	Field Manager	I
COC forms	COC forms will be reviewed daily to ensure that project information, sample analyses requested, number of field QC samples collected, and % stage 3 or 4 validation chosen is accurate and in accordance with the requirements in this QAPP.	Field Manager	I
Sample receipt	The sample cooler will be checked for compliance with temperature and packaging requirements.	Lab Project Manager	E
Sample logins	Sample login will be reviewed for accuracy against the COC form.	Laboratory Project Manager	E
Laboratory data prior to release	Laboratory data will be reviewed to ensure that the data is accurate and meets the requirements in this QAPP. Prior to release, data will be validated as follows:	Laboratory Project Manager	E
	100% of the data comply with the method- and project-specific requirements; any deviations or failure to meet criteria are documented for the project file.	Laboratory Project Manager	E
	100% of manual entries are free of transcription errors and manual calculations are accurate; computer calculations are spot-checked to verify program validity; data reported are compliant with method- and project-specific QC requirements; raw data and supporting materials are complete; spectral assignments are confirmed; descriptions of deviations from method or project requirements are documented; significant figures and rounding have been appropriately used; reported values include dilution factors; and results are reasonable.	Laboratory Project Manager	E
	Data reported are compliant with method- and project-specific QC requirements; the reported information is complete; the information in the report narrative is complete and accurate; and results are reasonable.	Laboratory Project Manager	E
	Data reported are compliant with method- and project-specific QC; analytical methods are performed in compliance with approved SOPs. This review may be conducted after release of data since they are done only on 10% of the data.	Laboratory Project Manager	E
Laboratory data due at turnaround time listed on COC	Laboratory data will be reviewed to ensure that the data reported met the analyte list and limits listed in Worksheet #15.	Laboratory Project Manager	E

QAPP Worksheet #35 - Data Validation (Step II) Process Table (Continued)

Data Review Input	Description	Responsible for Validation	Internal / External
Laboratory data packages	All laboratory data packages will be validated by the laboratory performing the work for technical accuracy prior to submittal.	Laboratory Project Manager	E
	Data packages will then be reviewed for accuracy against the laboratory data that was faxed/e-mailed at the turnaround time listed on the COC.	Laboratory Project Manager	E
	Data packages will be evaluated internally by undergoing data validation. The data validation will include reviewing completeness, chain-of-custody forms, sample holding times, analytical quantitation limits, field QA/QC samples, and laboratory QA/QC results (method blanks, surrogates, continuing calibration verification samples and laboratory control samples). Effectiveness of sample procedures will be evaluated by calculating the relative percent difference between primary and duplicate samples, using a data quality objective of +/- thirty percent (30%). The impact of data deficiencies will also be evaluated, and recommendations to rectify unacceptable deficiencies will be developed.	Geosyntec Data Validator	I
Data validation reports	Data validation reports will be reviewed in conjunction with the project DQOs and DQIs.	Geosyntec Technical Lead	I

Notes:

COC	chain-of-custody
E	external
I	internal
QAPP	quality assurance project plan
QC	quality control
SOP	standard operating procedure

QAPP Worksheet #36 - Data Validation (Step II) Summary Table

Matrix	Analytical Group	Validation Criteria [b]	Data Validator
Sub-Slab and Soil Gas	VOC	Tier II data validation standards.	Geosyntec Data Quality Manager - Julia Klens-Caprio[1]
Indoor/Outdoor Air	VOC	Tier IV data validation standards.	Geosyntec Data Quality Manager - Julia Klens-Caprio

Notes:

VOC	volatile organic compound

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[1] Julia Klens-Caprio (Geosyntec) is considered to be an independent validator because she is independent of the client, lab, and of the Geosyntec team performing the project work (data collection, data analysis, report-writing, etc.). Julia is a quality assurance manager as Geosyntec with over 25 years of experience. She has an M.B.A. in Quality Management and is an ASQ Certified Quality Manager.

QAPP Worksheet #37 - Usability Assessment

Data Quality Assessment

After data are validated, the project technical lead will review and assess field and laboratory quality control. Data validation reports will be reviewed and assessed for meeting DQOs. The project technical lead will review the data validation reports for any deviations and to ensure that the reviewer has assigned data qualifiers. Data qualifiers are used to indicate uncertainties associated with the data. The following data qualifiers will be used:

J = Result is estimated

U = Analyte is not detected at or above the stated limit of quantitation (LOQ)

R = Data are rejected

UJ = Analyte is not detected, but there is an uncertainty about the LOQ

Data will be reported in tabular format to be included in the report.

Measurement Quality Objective for Chemical Data

The primary measurement quality objective for the monitoring program relates to the precision and accuracy, including detections and LOQs, for the analytical methods performed. All analytical results will be evaluated in accordance with PARCCS parameters to document the quality of the data and to ensure that the data are of sufficient quality to meet the project objectives. The following subsections describe each of the PARCCS parameters and how they will be assessed within this project.

Precision

Precision is the degree of mutual agreement between individual measurements of the same property under similar conditions and expressed as relative percent difference (RPD). Laboratory analytical precision is determined by analyzing laboratory duplicates (LDs) or LCSs in duplicate, and calculating the RPD between the duplicate results. Field analytical precision is determined by analyzing field duplicates where samples are collected simultaneously (if possible) and is a measurement of the precision of both sample collection and handling and analytical procedures. RPD is calculated as follows:

$$\text{RPD} = \frac{|\text{Sample 1 result} - \text{Sample 2 result}|}{\left(\frac{\text{Sample 1 result} + \text{Sample 2 result}}{2}\right)} \times 100\%$$

Field and laboratory measurement performance criteria are provided in Worksheets #12 and #28.

Accuracy

A program of sample spiking will be conducted to evaluate laboratory accuracy. This program includes analysis of LCSs or blank spikes, surrogate standards, and method blanks (MBs). LCSs are analyzed at a frequency of 5% (1 in 20 project samples). Surrogate standards, as applicable to the method, are added to every sample analyzed for organic constituents. The results of the spiked samples are used to calculate the % recovery for evaluating accuracy.

QAPP Worksheet #37 - Usability Assessment (Continued)

$$\%\,\mathrm{R} = \frac{\text{Spiked sample result}}{\text{True concentration}} \times 100\%$$

Results that fall outside the accuracy goals will be further evaluated based on the results of other QC samples. Refer to tables in Worksheet #28 for accuracy limits for each method.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a population, variations in a parameter at a sampling point, or an environmental condition that they are intended to represent. Representative data will be obtained for this project through careful selection of sampling locations and analytical parameters. Representative data will also be obtained through proper collection and handling of samples to avoid interference and minimize contamination.

Representativeness of data will also be ensured through the consistent application of established field and laboratory procedures. Laboratory blank samples will be evaluated for the presence of contaminants to aid in evaluating the representativeness of sample results. Data determined to be nonrepresentative, by comparison with existing data, will be used only if accompanied by appropriate qualifiers and limits of uncertainty.

Completeness

Completeness is a measure of the percentage of project-specific data that are considered valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this QAPP, and when none of the QC criteria that affect data usability is exceeded to the extent that data are rejected (e.g., data qualified as estimated [J qualified] are included in the usable data). When all data validation is completed, the % completeness value will be calculated by dividing the number of useable sample results (i.e., not rejected [R-qualified] data) by the total number of sample results generated for this investigation.

$$\%\ \text{completeness} = \frac{\text{number of valid analyte results}}{\text{number of expected results}} \times 100\%$$

Completeness will also be evaluated as part of the data quality assessment process against project-specific requirements. This evaluation will help determine whether any limitations are associated with the decisions to be made based on the data collected. The completeness goal for the VI project data is 90%.

Comparability

Comparability expresses the confidence with which one data set can be compared with another. Comparability of data will be achieved by consistently following standard field and laboratory procedures and by using standard measurement units in reporting analytical data.

QAPP Worksheet #37 - Usability Assessment (Continued)

Sensitivity

Sensitivity assesses the ability of the laboratory to detect target analytes using the methods and instruments selected for this project. Worksheet #15 lists the project action limits and laboratory detection limits (DLs). Based on laboratory DL studies, the EPA methods and laboratory instrumentation have been selected for use on this project in order to detect target analytes at the project action limits.

Usability Assessment

A usability assessment to determine how well the data collected support the project objectives and decisions to be made will be performed by the project team. Any deviations from proposed field activities will be reviewed, and their effect on data usability evaluated. The analytical results will be compared to the Data Quality Indicators (DQIs) presented on Worksheets #12 and #28 to determine whether the measurement performance criteria were met. Upon completion of the verification and validation processes noted on Worksheet #34 and Worksheet #35, the DQIs will be evaluated for each analytical group. Based on the results of this examination, conclusions regarding the validity and usability of data for each analytical group will be drawn and a data quality assessment will be prepared, if necessary, to explain any limitations on the use of project data. This assessment and will be included in a final report for this phase of the project.

REFERENCES

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U.S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Environmental Protection Agency, United States (EPA). 2002. *Guidance for Quality Assurance Project Plans. EPA QA/G-5*. EPA/240/R-02/009. Office of Environmental Information. December.

Environmental Protection Agency, United States (EPA). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*. EPA QA/G-4. EPA/240/B-06/001. Office of Environmental Information. February.

Environmental Protection Agency, United States (EPA). 2012. *Conceptual Model Scenarios for the Vapor Intrusion Pathway*. EPA 530-R-10-003. Office of Solid Waste and Emergency Response. February.

Environmental Protection Agency, United States (EPA). 2015. *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*. OSWER 9200.2-154. Office of Solid Waste and Emergency Response. June.

Environmental Protection Agency, United States (EPA). 2016. *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review*. EPA-540-R-2016-002. (OLEM 9355.0-134). Office of Superfund Remediation and Technology Innovation. September.

APPENDIX E
Health and Safety Plan

Prepared for

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HEALTH AND SAFETY PLAN

Flint Group Pigments Huntington Facility
24th Street and 5th Avenue
Huntington, West Virginia 25703

Prepared by

Geosyntec consultants

engineers | scientists | innovators

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Project Number: MP1480

29 March 2017

Privileged and Confidential – For Discussion Only
Prepared at the Request of Counsel

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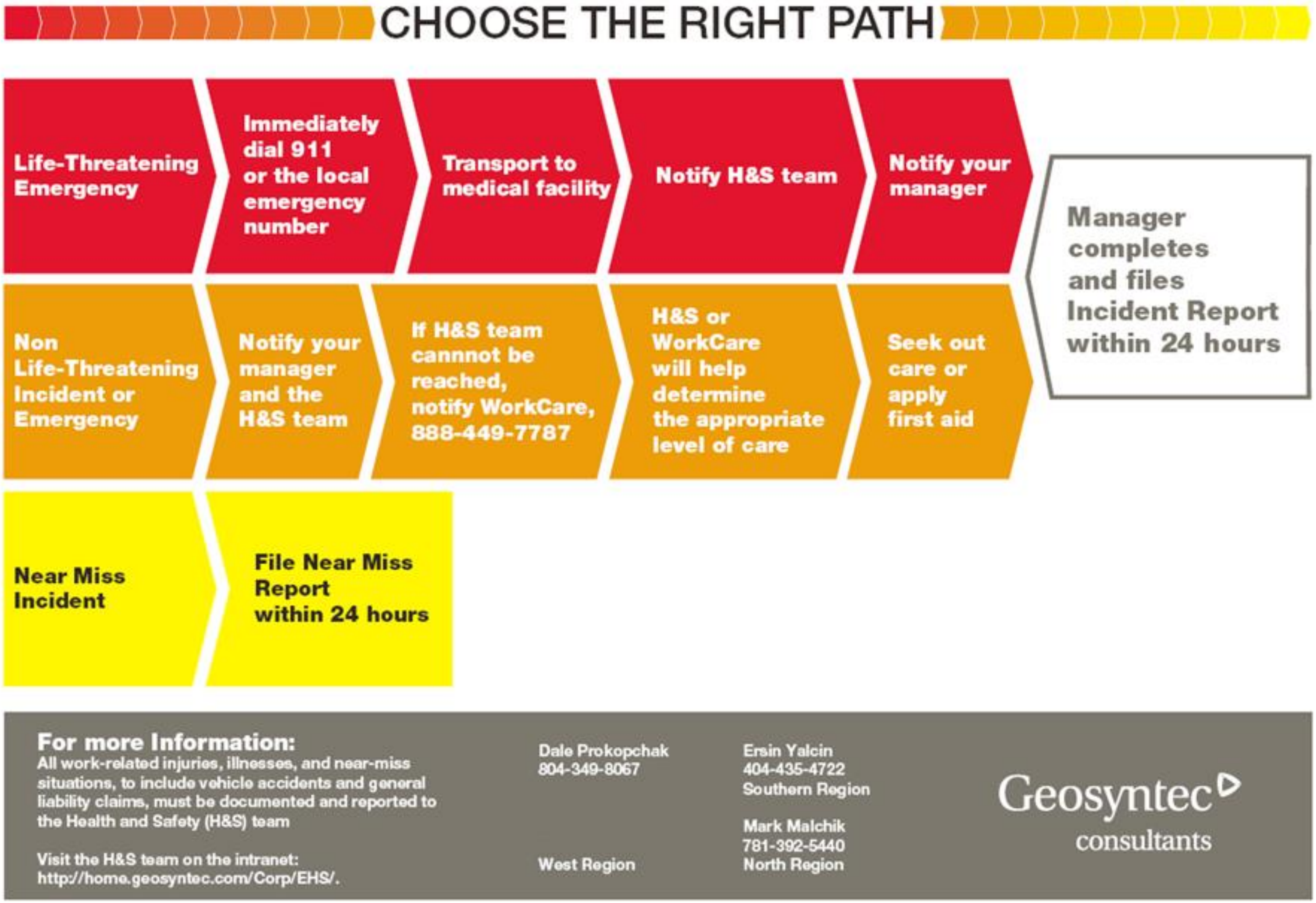
H&S INCIDENT RESPONSE PRODECURES



CHOOSE THE RIGHT PATH

Life-Threatening Emergency → **Immediately dial 911 or the local emergency number** → **Transport to medical facility** → **Notify H&S team** → **Notify your manager** → **Manager completes and files Incident Report within 24 hours**

Non Life-Threatening Incident or Emergency → **Notify your manager and the H&S team** → **If H&S team cannnot be reached, notify WorkCare, 888-449-7787** → **H&S or WorkCare will help determine the appropriate level of care** → **Seek out care or apply first aid** → **Manager completes and files Incident Report within 24 hours**

Near Miss Incident → **File Near Miss Report within 24 hours**

For more Information:
All work-related injuries, illnesses, and near-miss situations, to include vehicle accidents and general liability claims, must be documented and reported to the Health and Safety (H&S) team

Visit the H&S team on the intranet:
http://home.geosyntec.com/Corp/EHS/.

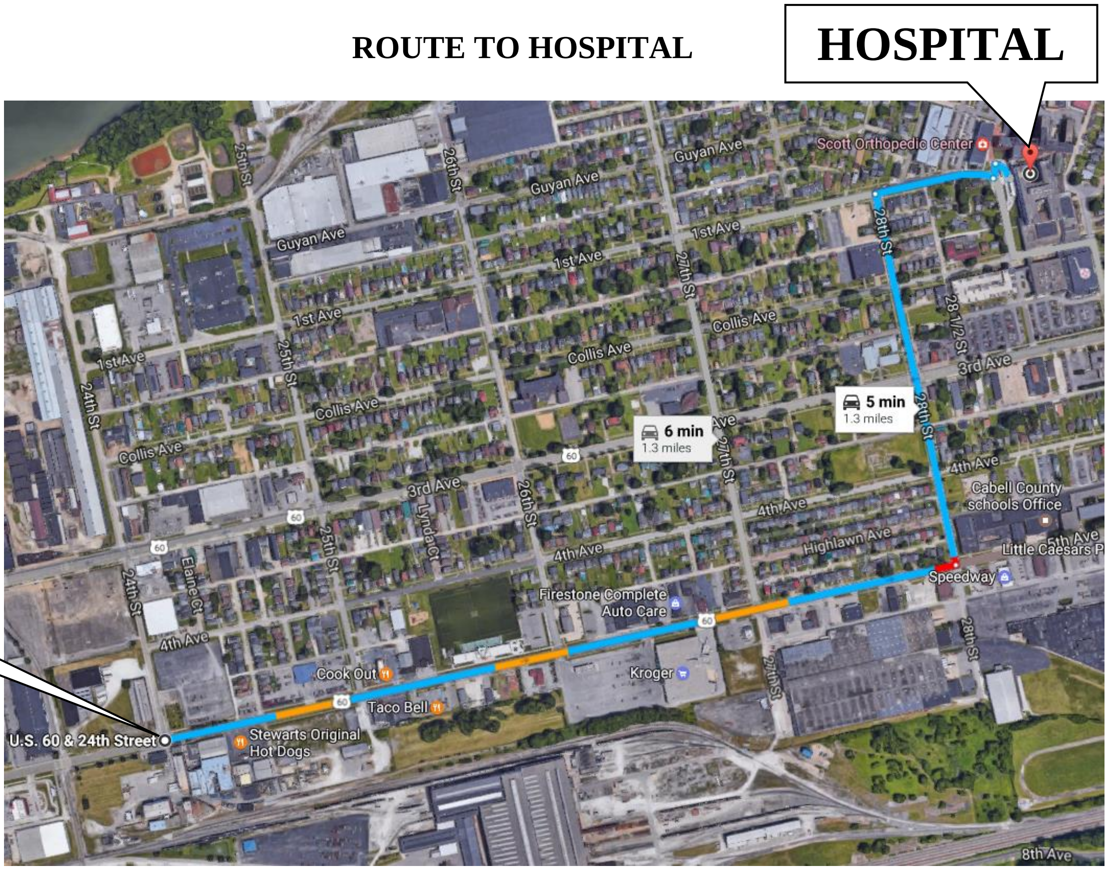
Dale Prokopchak
804-349-8067
West Region

Ersin Yalcin
404-435-4722
Southern Region

Mark Malchik
781-392-5440
North Region

Geosyntec consultants

ROUTE TO HOSPITAL



Drive 1.3 miles. Approximate driving time is 5 minutes

St. Mary's Medical Center

304-526-1234
2900 First Avenue
Huntington, WV 25702

Written Directions to Hospital from Site:

1.	Starting at the intersection of 24th Street and 5th Avenue	
2.	Head east on 5th Avenue toward Homestead Place	0.8 mi
3.	Turn left onto 28th Street	0.4 mi
4.	Turn right onto 1st Avenue	0.1 mi
5.	Hospital will be on the left	

ROUTE TO URGENT CARE FACILITY

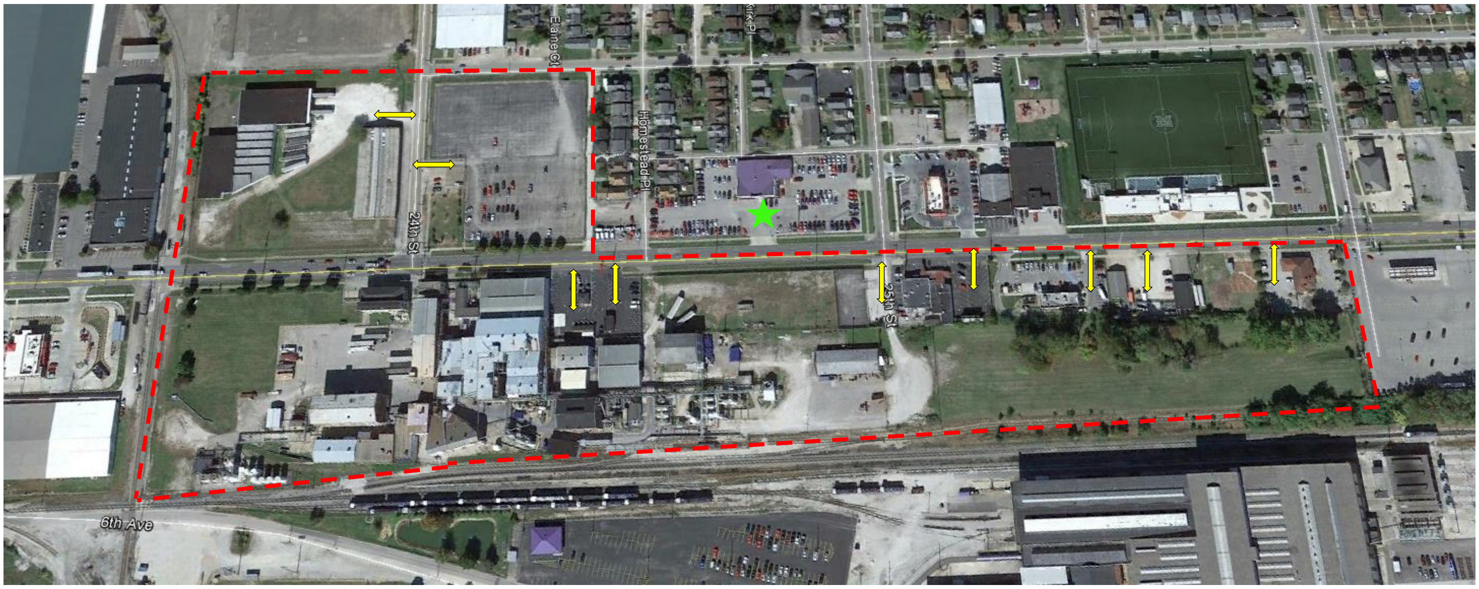
St. Mary's Urgent Care

304-399-7182
2815 5th Avenue
Huntington, WV 25702

Directions to Urgent Care from the Site:

1. Starting at the intersection of 24th Street and 5th Avenue
2. Head east on 5th Avenue toward Homestead Place for 0.8 miles – Destination will be on the right

SITE MAP



Site Boundary – –

Entrances/Exits ⇔

Rally Point ★

1. INTRODUCTION

This site-specific Health and Safety Plan (HASP) was prepared to address project-specific hazards known or suspected to be present associated with the existing conditions and work to be performed at the work site(s). This HASP was prepared to meet the requirements specified in Occupational Safety and Health (OSHA) Hazardous Waste Operations Emergency and Response (HAZWOPER) program, Geosyntec Consultants, Inc. (Geosyntec)'s Health and Safety (H&S) Procedure HS 301, and the H&S requirements of the client.

2. SIGNATURES

2.1 Preparers and Reviewers

This HASP must be maintained on-site when field work is being performed. The Site Health and Safety Officer (SHSO) can change or amend this document, in agreement with the Health and Safety Coordinator (HSC) or Project Manager (PM). Amendments (e.g., changes in personal protective equipment, addition of tasks, etc.) must be documented in Section 19 and in

Appendix A. This HASP must be reviewed and amended on an annual basis for projects lasting more than one year.

Prepared by:

	SHSO	Date

Reviewed by:

	HSC	Date

Approved by:

	Project Manager	Date

This HASP has been given to the following H&S approved subcontractor(s).

Subcontractor	Representative	Date
Subcontractor	Representative	Date
Subcontractor	Representative	Date

2.2 Site Workers

This HASP must be reviewed by personnel prior to site work. Workers not in attendance at the initial meeting must be trained by the SHSO on the information covered in the pre-entry briefing. After reading the HASP and attending a pre-entry briefing, Geosyntec employees and other parties covered under this HASP must sign the following acknowledgment statement.

"I have read, understand, and will perform my work in accordance with the information set forth in this HASP."

Signature	**Printed Name**	**Date**

3. EMERGENCY CONTACT INFORMATION

Contact	Telephone Numbers	
	Office	**Alternate (Type)**
Fire Department	304-696-5950	911
Police Department	304-696-4470	911
Site Emergency Response (if applicable)		
Hospital – St. Mary's Medical Center	304-526-1234	
Director of H&S – Dale Prokopchak	(804) 332-6376	(804) 349-8067 (Cell)
H&S Regional Manager – Mark Malchik	(978) 206-5777	(781) 392-5440
Project Manager – Theresa Gabris	(202) 370-4350	(202) 839-2494
Site Health & Safety Officer – TBD		
H&S Coordinator – Mike Hansen	(410) 910-7640	(446) 812-1430
Principal in-Charge – Jim Culp	(412) 275-8001	(412) 389-8753
Utility Emergencies –	811	
Work Care –	(888) 449-7787	(714) 978-7488
Client Contact – Vernon Burrows	(973) -665-4829	

4. APPLICABILITY OF THIS HASP

This HASP was prepared in accordance with Geosyntec's H&S Procedures for use by Geosyntec project staff and subcontractors. Subcontractors, at a minimum, shall ensure that their employees, and those of its lower tier subcontractors, comply with these procedures and other health, safety and security provisions in the Subcontract. Compliance with this HASP shall represent the minimum requirements to be met by subcontractors, who shall be responsible for examining all requirements and determining whether additional or more stringent health, safety and security provisions are appropriate for their portion of the work and implementing them accordingly. Therefore, for firms executing all or any portion of the work, this document and its contents should not be used without a thorough peer review by their health and safety managers. Prior to commencing work, such firms are responsible for reviewing and supplementing the HASP to add appropriate procedures specific to their portion of the work.

5. SITE/TASK/HAZARD DESCRIPTION

5.1 Site Background

The following is a brief description of the site, including information as to the location, approximate size, previous usage, and current usage. A description of the tasks to be performed is also presented.

Site Location:	24th Street and 5th Avenue Huntington, West Virginia 25703
Approximate Size of Site:	32.77 acres
Previous Site Usage:	Dyestuffs and pigment manufacturing
Current Site Usage:	Pigment manufacturing

Description of Surrounding Property/Population:

North:	Residential, industrial, commercial	**East:**	Commercial
South:	Industrial, commercial	**West:**	Industrial, commercial

Summary of Previous Site Investigations (if available/applicable):

Initial RCRA Facility Investigation, Site Wide Groundwater Investigation, and a RFI Phase II investigation identified the following chemicals of concern: BTEX, Carbon tetrachloride, Tetrachloroethene, Trichloroethene, Vinyl chloride, 1,1,2,2-Tetrachloroethane, and 1,2,4-Trichlorobenzene

Task Descriptions

Task 1: Onsite and Offsite Vapor Intrusion Investigation (VI)

Prior to installing sub-slab soil gas probes and collecting indoor and outdoor ambient air samples, personnel will conduct an onsite building survey to assess potential vapor intrusion areas of concern. Onsite personnel will walk the entire footprint of the building noting information regarding condition of building and potentials areas of concern. Slip trip fall and road traffic are the two major areas of hazard associated with this activity. Steel toe boots will be worn at all times while onsite and a high visibility vest will be worn when working near roadways or within parking lots.

After a building survey has been completed. Personnel will collect indoor air samples co-located with sub-slab soil gas locations, from different breathing zone of all onsite buildings. Outdoor air samples will also be collect to access the ambient conditions.

Sub-slab soil gas probes will be installed by drilling through the slab with a pneumatic hammer drill with an auger bit attachment. Onsite personnel will be required to wear but not limited to, work gloves, nitrile gloves, eye protection, hearing protection, and steel toe boots, during drilling activities. Associated hazards with drilling include operation of a power tool, electrocution, and operation of generators. Following installation of sub-slab soil gas probes, points will be monitoring and sampled with Summa™ canisters and sent to lab for analysis. Air breathing space surrounding temporary sub-slab soil gas sampling probes will be monitored with a photo ionization detector (PID). Lastly temporary points will be decommissioned with Portland cement.

Task Hazard Analyses (THAs) associated with these tasks are presented in Appendix B.

5.2 Chemical Hazards

The classes of chemicals that are known or suspected to be present that may be encountered while performing site work include the following:

- Benzene, toluene, ethylbenzene, xylenes (BTEX)
- Volatile Organic Compounds (VOCs)
- Chlorinated volatile organic compounds (VOCs)
- Semi-volatile organic compounds (SVOCs)

Controls for these hazards are presented in the THAs included in Appendix B. A summary of these chemical hazards is presented in Appendix C.

5.3 Physical Hazards

The following physical hazards have been identified associated with the work to be performed and the site conditions.

- Cold stress
- Compressed gases
- Drilling (including indoor)
- Electrocution
- Eye injury
- Hand/Foot injury
- Heat stress
- Knives/Blades
- Lifting heavy loads
- Loud noise/Vibration
- Portable power/Hand tool
- Slips, trips, and falls
- Thoroughfares/Traffic
- Urban environments
- Utility protection

Controls for these hazards are presented in the THAs included in Appendix B.

5.4 Biological Hazards

The following biological hazards have been identified associated with the work to be performed and the site conditions.

- Allergic reaction to poisonous plants
- Biting/mauling animals (bears, dogs, alligators, mountain lions, etc.)
- Biting/stinging insects
- Rats/vermin
- Mold

Controls for these hazards are presented in the THAs included in Appendix B.

6. GENERAL SAFE WORK PRACTICES

The following general safe work practices must be adhered to while performing site work:

- Basic personal protective equipment (PPE) shall be worn, including hard hats, safety glasses, hard-toed boots, and high-visibility vests. If conditions allow, the requirement for hard hats and hard-toed boots may be reduced with approval of the SHSO and PM.
- Minimize contact with impacted materials. Do not place equipment on the ground. Do not sit or kneel on potentially contaminated surfaces.
- Smoking, eating, or drinking after entering the work zone and before personal decontamination is not allowed. Employees who are suspected of being under the influence of illegal drugs or alcohol will be removed from the site. Workers taking prescribed medication that may cause drowsiness shall not operate heavy equipment and are prohibited from performing tasks where Level C or B PPE is required.
- Practice good housekeeping.
- Use of contact lenses is not allowed under certain hazardous working conditions.
- The following conditions must be observed when operating a motor vehicle:
    - Wearing of seat belts is mandatory.
    - The use of headlights is mandatory during periods of rain, fog, or other adverse weather or low-light conditions.
    - A backup warning system or use of vehicle horn is mandatory when the vehicle is engaged in a backward motion.
    - Posted traffic signs and directions from flagmen must be observed.
    - Equipment and/or samples transported in vehicles must be secured from movement.

  - The use of vehicles acquired by Geosyntec by non-Geosyntec personnel is prohibited.
- In an unknown situation, always assume the worst reasonable conditions.
- Be observant of your immediate surroundings and the surroundings of others. It is a team effort to notice and warn of dangerous situations. Withdrawal from a hazardous situation to reassess procedures is the preferred course of action.
- Conflicting situations may arise concerning safety requirements and working conditions. These must be addressed and resolved rapidly by the SHSO and PM to relieve motivations or pressures to circumvent established safety policies.
- Unauthorized breaches of specified safety protocol are not allowed. Workers unwilling or unable to comply with established procedures will be asked to leave the work site.

7. EMERGENCY RESPONSE

This section discusses emergency response procedures and response equipment to be maintained on-site. A table presenting a list of contacts and telephone numbers for the applicable local and off-site emergency responders is provided inside the front cover of this HASP (after figures).

7.1 Injury and Emergency Response Procedures

In the event of an **injury** to an employee, the instructions for injury response and reporting, located in the front of this HASP, must be implemented immediately. In the event that an **emergency** develops, the following procedures are to be implemented:

- The SHSO, or designated alternate, should be immediately notified via the on-site communication system. The SHSO assumes control of the emergency response.
- If applicable, the SHSO must immediately notify off-site emergency responders (e.g., fire department, hospital, police department, etc.) and must inform the response team of the nature and location of the emergency on-site.
- If applicable, the SHSO may call for evacuation of the site. Site workers should move to their respective refuge stations using the evacuation routes provided on the Site Map.
- For small fires, flames should be extinguished using the appropriate type of fire extinguisher. Large fires should be handled by the local fire department.
- If a worker is injured, the procedures presented in “Instructions for Injury Response,” located in the front of this HASP, must be implemented immediately.
- After an incident has stabilized, the procedures presented in “Instructions for Incident Reporting,” located in the front of this HASP, must be followed.

7.2 Emergency Response Equipment

Emergency response equipment will be maintained in the work area as necessary for this project. Examples of emergency response equipment include first aid kits, fire extinguishers (Type ABC), and eyewash bottles.

8. KEY PERSONNEL AND HEALTH AND SAFETY RESPONSIBILITIES

Project personnel and their responsibilities in regard to health and safety concerns on this project are as follows:

Project Manager (PM): Theresa Gabris

- Approve this HASP and amendments, if any;
- Monitor the field logbooks for health and safety work practices employed;
- Coordinate with SHSO so that emergency response procedures are implemented;
- Check that corrective actions are implemented;
- Check and document that qualified personnel receive this plan and are aware of its provisions and potential hazards associated with site operations, and that they are instructed in safe work practices and familiar with emergency response procedures; and
- Provide for appropriate monitoring, PPE, and decontamination materials.

Site Health and Safety Officer (SHSO): TBD

- Prepare and implement project HASP and amendments, if any, and report to the PM for action if deviations from the anticipated conditions exist and authorize the cessation of work if necessary;
- Check that site personnel meet the training and medical requirements;
- Conduct pre-entry briefing and daily tailgate safety meetings;
- Check that monitoring equipment and PPE are operating correctly according to manufacturer’s instructions and such equipment is utilized by on-site personnel. Calibrate or check calibration of monitoring equipment and record results;
- Check that decontamination procedures are being implemented;
- Implement site emergency response and follow-up procedures;
- Notify the HSC in the event an emergency occurs; and
- Perform and document weekly inspections.

Health and Safety Coordinator: Mike Hansen

- Review and audit HASP and amendments;

- Notify Director of H&S when an emergency occurs;
- Assist with the implementation of the corporate health and safety program; and
- Consult with staff on health and safety issues.

<u>Site Workers:</u>

- Provide verification of required health and safety training and medical surveillance prior to arriving at the site;
- Notify supervisors of workplace accomodation requirements as the result of physical limitations or medical conditions;
- Attend pre-entry briefings and daily tailgate safety meetings;
- Immediately report accidents and/or unsafe conditions to the SHSO;
- Be familiar with and abide by the HASP; and
- Be ultimately responsible for his or her own safety.

9. WORKER TRAINING AND MEDICAL SURVEILLANCE

Personnel involved in field activities subject to OSHA HAZWOPER 29 Code of Federal Regulations (CFR) 1910.120 will be required to participate in both a health and safety training program that complies with criteria primarily set forth by the OSHA HAZWOPER in 29 CFR 1910.120(e) and a medical surveillance program covered under 29 CFR 1910.120(f), or equivalent regulations based on the jurisdiction in which the project is performed.

9.1 Pre-Assignment and Annual Refresher Training

Prior to arrival on-site, the Geosyntec PM will be responsible for monitoring that their staff meet the requirements of pre-assignment training (40/24 hours per Procedure HS 301). In addition, personnel must be able to document dates of attendance at an annual 8-hour refresher and three days of fieldwork under a qualified supervisor. Failure to provide this documentation will prohibit entry to the active work area(s) (i.e., Exclusion Zone).

9.2 Site Supervisor Training

Consistent with OSHA 29 CFR 1910.120 (e)(4), prior to arrival on-site, individuals designated as site supervisors require an additional eight hours of specialized training.

9.3 Initial Site Safety Orientation and HASP Review

In addition to complying with 29 CFR 1910(e), site personnel will attend an initial safety orientation during which the HASP and applicable THAs will be reviewed prior to initiating field activities. This review will include the following:

- Understanding the lines of authority regarding health and safety and site personnel roles and responsibilities;
- Information of specific hazard agents related to the site and site operations will be discussed, such as health hazards of site chemicals and specific safety hazards of processes, tools, and equipment;
- Training in the proper use, maintenance, and decon protocol of PPE and Level(s) of Protection;
- Appropriate work practices and engineering controls to reduce/eliminate exposures to site hazards will be reviewed;
- Personnel will be informed of means for normal site and emergency communication(s);
- Air monitoring strategies will be discussed to include the frequency/types, action levels, sampling techniques, pre/post calibration techniques;
- Unique/site specific medical surveillance requirements that need to be considered based on site contaminants;
- Understanding site control measures, work zones, and proper decontamination procedures for personnel/tools/vehicles, etc. to reduce the potential for both on-/off-site contamination;
- Personnel will be trained to respond quickly and properly in the event of an emergency; and
- Personnel involved in specific hazardous activities, such as confined space entry, drum handling, sampling unknowns, etc. will receive specialized training in the appropriate techniques to employ prior to commencing these operations.

9.4 Baseline Medical Surveillance Exam

The baseline medical examination is used to identify physical capabilities and certain medical limitations that may have an impact on the candidate’s ability to perform in the position and/or job activity for which he/she is being considered, as well as to establish certain baseline medical parameters. The initial test results can then be compared against future periodic or project-specific monitoring results.

9.5 Periodic/Annual/Biennial Medical Exam

The periodic medical examination is used to evaluate an employee’s continued fitness for duty and to assess possible impact(s) occupational exposures may have had on their health status. The periodic examination includes an update to the medical and work history, results of previous occupational exposure assessments, and a detailed medical exam tailored to the job description.

The Medical Director from WorkCare determines the frequency of the periodic medical exams based on regulatory requirements, the position/work activities of the employee, and the level of exposure to physical, chemical, and biological agents.

9.6 Exposure/Activity/Project-Specific Medical Testing

Exposure-specific medical tests and/or evaluation of biological indices may be conducted to establish a baseline for certain project-specific parameters, to monitor the effectiveness of hazard controls, and/or to assess the impact of occupational exposures associated with a particular work activity or project. The Medical Director, in coordination with the H&S Department, will require or recommend an exposure-specific exam when deemed appropriate based on knowledge of project hazards, occurance of employee health symptoms, or an unexpected exposure event. Requests for exposure-specific examinations will be forwarded to the H&S Department, who will process the requests in collaboration with the Medical Director. The Medical Director will determine the type and frequency of the exposure-specific medical exams for employees designated to participate based on sound medical practice, latest toxicology information, and current regulatory requirements.

9.7 Exit Exam

An exit medical examination is offered when an employee leaves the medical surveillance program, either because of termination of employment with Geosyntec or because of reassignment to a position not designated or identified to participate in the medical surveillance program. This optional exit examination may be used to assess potential changes in medical status that have occurred during the course of employees' previous work activities, and to establish a medical baseline at the time of departure.

9.8 Exit/Termination

An exit medical examination is offered when an employee leaves the medical surveillance program, either because of termination of employment with Geosyntec or because of reassignment to a position not designated or identified to participate in the medical surveillance program. This optional exit examination assesses potential adverse impacts occupational exposures may have contributed to the employee's health status.

10. MAPS AND SITE CONTROL

10.1 Routes to Hospital and Urgent Care Facility

A hospital and an urgent care facility near the site have been identified. Maps to the hospital and urgent care are included after the Table of Contents of this HASP. Both figures also include the facility name and phone number.

10.2 Site Map

A site map is located inside the cover of this HASP. The site map is intended to show the location of the work zone(s), to provide on-site orientation, and to delineate evacuation routes. Changes may be made to the site map by the SHSO based on changing site conditions. The site map should be accessible in the work area.

10.3 Buddy System

The buddy system is required when work is performed in hazardous areas. The buddy system includes maintaining regular contact with one or more onsite Geosyntec personnel, clients, and/or contractors to periodically check on the condition of site workers such that each employee in the work group is observed by (or in verbal contact with) at least one other employee in the work group. For field visits with only one employee onsite, the buddy system shall be implemented via periodic telephone contact with offsite Geosyntec personnel.The purpose of the buddy system is to provide rapid assistance to employees in the event of an emergency.

10.4 Controlled Work Zones

APPLIES TO TASK: ☐① ☐② ☐③ ☐④ ☐⑤ ☐⑥ ☐⑦ ☐⑧ ☒ NOT APPLICABLE

Three controlled work zones, including an Exclusion Zone, a Contaminant Reduction Zone (CRZ), and a Support Zone, are required for the task(s) indicated above. Geosyntec employees must not be allowed into the CRZ or Exclusion Zone or the Work Zone until they have received the proper personal protective equipment (PPE) and they have read, understand, and meet the requirements outlined in this HASP. The Exclusion Zone is defined as the area on site where contamination is suspected and tasks are to be performed. The CRZ is defined as the area where equipment and workers are to be decontaminated as they leave the Exclusion Zone. The Support Zone is defined as the command area and may serve as a staging and storage area for supplies. The location and extent of the work zones may be modified as necessary as site investigation information becomes available. For sites that do not require the three controlled work zones, the area(s) where work is to be performed shall be called the Work Zone.

Visitors to the site may need to be continually escorted for safety purposes. Visitors under Geosyntec’s direction need to check in with the SHSO upon visiting the site.

For the tasks identified above, the boundaries of the Exclusion Zone, CRZ, and Support Zone, or the Work Zone, shall be marked using appropriate methods, including but not limited to warning tape, signs, traffic cones, fencing, or other appropriate means.

10.5 Site Access

Certain sites require controlled access to the work area. Examples of access controls include sign in/sign out logs, checking in with guards, and donning identification badges. Geosyntec personnel will adhere to the site-specific access requirements and monitor that subcontractors and other Geosytnec visitors abide by site-specific access control requirements.

10.6 Inspections

☐ APPLICABLE ☒ NOT APPLICABLE

Based on the hazards identified for the project, periodic health and safety inspections may be performed. The H&S Inspection Checklist records should be kept on file at the project site. The frequency for periodic inspections is:

☐ Weekly

☐ Monthly

☐ Other: ______________________

11. TAILGATE MEETINGS

Tailgate meetings must be held daily prior to starting work to discuss important health and safety issues concerning tasks to be performed during that shift. Non-Geosyntec site workers should also communicate health and safety concerns associated with the tasks they will be performing. Topics discussed in the tailgate meetings must be documented.

12. STOP WORK AUTHORITY

In accordance with the Company's Procedure HS 203 – Stop Work Authority, Geosyntec personnel and subcontractor personnel have the authority and responsibility to issue a Stop Work Order if unsafe actions and/or conditions are identified. The Stop Work Authority (SWA) process involves a stop, notify, correct, and resume approach for resolving observed unsafe work actions or conditions. The person issuing the work stoppage will first notify workers engaged in or affected by the unsafe activity or condition and require that associated work be stopped. After this Stop Work Order is issued, the Geosyntec project manager and the supervisors for affected or concerned contractors will also be notified. The Geosyntec project manager will document the issuance of the Stop Work Order on the form provided in Procedure HS 203. Work will not resume until the issues and concerns of the Stop Work Order have been adequately addressed.

13. AIR MONITORING

APPLIES TO TASK: ☒① ☐② ☐③ ☐④ ☐⑤ ☐⑥ ☐⑦ ☐⑧ ☐ NOT APPLICABLE

Air monitoring will be performed to evaluate airborne chemical and/or dust exposure levels within the breathing zone of site workers. Hazardous conditions may include concentrations that may cause acute or chronic illness, potential oxygen deficient environments, or potential explosive environments. Air monitoring may also be performed to evaluate the adequacy of engineering, administrative, and/or PPE controls. Air monitoring may be "real-time" (e.g., the instrument provides immediate results at the project), using multi-gas meters, photoionization detectors

(PIDs), or colorimetric tubes. Personal monitoring may also be performed by collecting samples and forwarding to a laboratory for analysis and quantification.

The type(s) of air monitoring equipment required and associated action levels are outlined in Appendix D. Monitoring equipment must be calibrated based on the manufacturer's requirements. Calibration results and air monitoring measurements must be documented. Based on the results noted and site activities or scope of work changes, the frequency of air monitoring may be adjusted on site by the SHSO with the consent of the Project Manager and communication with the HSC.

14. PERSONAL PROTECTIVE EQUIPMENT

The levels of PPE required for each task are presented in Appendix E. Required equipment and types of protective clothing materials, as well as an indication of the initial level of protection to be utilized, are listed. The level of protection may be upgraded or downgraded by the SHSO according to controls requirements in Appendix E or according to action levels provided in Appendix D.

If respirators are worn, workers must abide by the company's Respiratory Protection Program in accordance with company's Respiratory Protection Program (HS 112).

15. DECONTAMINATION

The SHSO and Project Manager will determine the type and level of decontamination procedures for both personnel and equipment based on evaluation of specific work activities in the controlled work zones. Medical treatment will take precedence over decontamination in the event of a life threatening and/or serious injury/illness. Personnel will perform decontamination in designated and identified areas upon leaving "hot zones" where the potential exists for exposure to hazardous chemical, biological, or environmental conditions.

Decontamination of personnel in Level D (modified) will consist of proper containerization and disposal of coveralls, disposable boots, and gloves (if applicable).

Decontamination of personnel in Level C, if applicable, will consist, at a minimum, of:

- Removal and cleaning/disposal of boot covers, coveralls, and outer gloves;
- Removal, cleaning, and storage of respiratory protection;
- Washing of non-disposable PPE suspected of being contaminated using a soap solution followed by a water rinse; and
- Removal and disposal of inner gloves.

Hand tools and sampling equipment shall be decontaminated as needed by washing in decontamination basins with appropriate solutions, or, if possible, by dry decontamination. Wash solutions and PPE may require disposal at a licensed waste facility.

16. SPILL CONTAINMENT

The task(s) for this project may involve the handling of drums and/or containers that contain stored chemicals, hazardous materials, and/or wastes. The drums and/or containers may have been spilled/dislodged during site activities due to compromised construction of the drum/container, transportation accidents, improper packaging practices, and improper handling of hazardous materials during on/off loading. Containers shall be inspected and their integrity assured prior to being moved and/or handled. If the integrity of the container is in question, the container shall be over packed or its contents transferred. Operations shall be organized and coordinated to minimize movement of such containers. Where spills, leaks, or ruptures may potentially occur, a supply of sorbents shall be located in the immediate area. Additional preventative measures include:

- UN-approved 55-gallon drums, bins, and/or Baker tanks will be inspected for visible defects upon delivery to the site;
- UN-approved 55-galon drums will also be inspected to ensure each drum includes a resealable lid with a small resealable sampling port near the top, or on the side of the drum and that the enclosure is not deformed and/or distorted;
- Drums will not be completely filled to allow for possible expansion of liquid and will be set on wooden pallets to facilitate transport by forklift;
- The storage area will be inspected to check for leaks weekly while the containers are being filled and immediately after a relocation to a temporary on-site storage area; and
- Flat areas will be selected for temporary storage away from high-traffic work areas/zones and storm/sewer drains.

In the event of an unplanned release or spill of unknown or hazardous substances, the site supervisor will designate personnel who will support the spill containment, control, and/or clean-up procedures. The team will request additional off-site emergency response assistance if necessary based on the type of spill, volume, potential toxicity, etc.

The spill area will be isolated and restricted to only authorized personnel designated to assist with the containment, control, or clean-up activity. Authorized personnel will be trained to contain and clean spills from typical materials and quantities used at the project location. Physical barriers will be set up to warn unauthorized personnel to stay clear and evacuate the affected area. The spill, leak, or incident will be assessed by the team and characterized to determine the appropriate course(s) of action(s) to consider:

- Small spills (i.e., maximum volume of 55 gallons of a liquid or 100 pounds of a solid) may be remediated using absorbent materials by designated personnel;
- Large spills (i.e., liquid volumes greater than 55 gallons or solid weights greater than 100 pounds) and/or spills of highly toxic materials may require assistance by off-site hazardous materials (HAZMAT) teams;

- Attempts shall be made to identify and stop the source(s) of spillage immediately while donning proper PPE (based on action levels and the air monitoring program) and performing air monitoring;
- The site supervisor will direct spill-response operations and stay at the spill area until it has been cleaned, inspected, and cleared for re-entry; and
- The site supervisor will prepare a spill incident and clean-up report and will communicate findings to the Project and Branch Manager and H&S Department.

17. CONFINED SPACE ENTRY

☐ APPLICABLE ☒ NOT APPLICABLE

The task(s) for this project involve confined-space entry. Workers must abide by the company's Confined Space Entry Program (Procedure HS 118).

18. GLOBALLY-HARMONIZED SYSTEM FOR HAZARD COMMUNICATION

☒ APPLICABLE ☐ NOT APPLICABLE

The following procedures must be followed for chemicals brought onto the site by Geosyntec personnel or by subcontractors (i.e., decontamination solution, sampling preservatives, KB-1® solution, sodium permanganate, etc.) while performing the tasks of this project:

- Labels on primary chemical containers must not be defaced;
- Chemicals must be stored in appropriate storage containers;
- Secondary containers and storage cabinets must be correctly and clearly labeled;
- Chemicals incompatible with each other must not be stored together;
- Workers must receive training on the chemical hazards; and
- Safety Data Sheets (SDSs) must be added to Appendix F.

When chemicals are used on-site, workers must abide by Geosyntec's GHS Hazard Communication Program (Procedure HS 115).

19. HASP AMENDMENTS

Over the course of this project, it is possible that the project-specific hazards and working conditions will change. This HASP may be reviewed and amended as necessary to effectively describe the changing working conditions and measures to mitigate the potential health and safety issues that may arise during the project. Amendments to the HASP should be briefly described in the following spaces provided. The full text of the amendments should be provided in

Appendix A and/or additional THAs should be added to Appendix B.

AMENDMENT 1:

Date: __________ Project Manager: ________________ HSC: ______________

Brief Description of Amendment:

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AMENDMENT 2:

Date: __________ Project Manager: ________________ HSC: ______________

Brief Description of Amendment:

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AMENDMENT 3:

Date: __________ Project Manager: ________________ HSC: ______________

Brief Description of Amendment:

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Appendix A: HASP Amendments

Discuss details of amendments to this HASP here. Include amendment number, date, and details of amendments.

Appendix B: Task Hazard Analyses

TASKS	
① Onsite and Offsite Vapor Intrusion Investigation	⑤
②	⑥
③	⑦
④	⑧

THAs for these tasks are presented in the following pages.

THAs

TASK HAZARD ANALYSIS (Ver. 2, June 2015)

Geosyntec HS Procedures referenced herein are available on Geosyntec's H&S SharePoint site and should be consulted, as appropriate, per project-specific needs. This THA prepared per HS-106-Accident Prevention Program, HS-204-Task Hazard Analysis, and meets the requirements for a "Site-Specific Health and Safety Plan" per Geosyntec HS Procedures and regulations referenced herein (see Section B.14.).

PART A – SITE SAFETY PLAN

A.1. PROJECT/TASK INFORMATION

TASK:	Outdoor, Indoor and Sub-Slab Vapor Intrusion Investigation		
Project Name:	BASF Huntington	**Project Number/Org:**	MP1480/1770
Project Address:	24th Street and 5th Avenue		
Description of Task & Worksite:	Vapor Intrusion Investigation at an pigment manufacturing facility and surrounding properties, including residential.		

Geosyntec Personnel	**Name**	**Desktop Office Phone**	**Cell Phone**
Task Lead	TBD		
Site Lead/HS Officer	TBD		
Project Manager	Theresa Gabris	202-370-4350	202-839-2494
Project Director	Jim Culp	412-275-8001	412-389-8753
HS Coordinator	Mike Hansen	410-910-7640	446-812-1430
Regional HS Mngr.	Mark P. Malchik	978-206-5777	781-392-5440
Corp. HS Director	Dale Prokopchak	804-332-6376	804-349-8067
Client Contact(s):	Vernon Burrows	973-665-4829	
Subcontractor(s):	☒ Not Applicable ☐ Applicable, provide contact information below:		

A.2. EMERGENCY RESPONSE

Based on analysis of worksite factors, client/regulatory requirements, availability of emergency services.

Consider all Relevant Risk Factors & Response Procedures *(fire/explosion, medical, chemicals/spills, security, site factors, weather, communications).*
EXPLANATORY NOTES, CLARIFICATIONS:

Available Means of Jobsite Emergency Communication/Alerting	☒ Verbal ☒ Cell Phone ☐ Land Line ☐ 2-Way Radio ☐ On-site alarm/signal system ☐ Other:
To Summon Emergency Services Police, Fire, Ambulance	☒ **DIAL 911**, for external responders ☐ **Other**:
Other Emergency Contacts, as needed *(such as security, spill responder, utility):*	N/A
Nearest Emergency Medical Services	Hospital Name: St. Mary's Medical Center Address: 2900 First Avenue, Huntington, WV 25702 Phone #: 304-526-1234 ☒ See Attached Directions
For **Non-Emergency Urgent Care**	☒ Contact WorkCare, 24/7 at: 800-455-6155, menu option "3" ☐ Other:
Job-site **Evacuation** Procedure, Rally Point, Place of refuge:	Meet in the parking lot of Turnpike Ford of Huntington across the street from the site on 5th Avenue.
Special Emergency Equipment/Procedures	First aid kit, eye wash kit

IMPORTANT: After initial emergency response actions and incident stabilization, contact appropriate project personnel listed in Part A.1.

A.3. SUMMARY OF WORK STEPS, HAZARDS, CONTROLS

Based on **PART B, "HAZARD ANALYSIS,"** and worksite/client/project factors.

Summary/outline of work steps/hazards/controls, with references to applicable Sections in Parts B and C, as applicable:

Geosyntec personnel will conduct a vapor intrusion investigation which involves four main tasks. These four tasks include; presampling building survey, indoor air samples/outdoor ambient air samples, temporary soil gas probe installation, temporary soil gas probe sampling and abandonment are listed below with their associated hazards and controls.

WORK STEPS	**HAZARDS**	**CONTROLS**

Task 1: Pre-Sampling Building Survey	- *Slip Trip Falls* - *Hot/Cold weather work* - *Dehydration* - *Wind/Sun burn from working outdoors*	- *Pay close attention to foot placement; do not talk on the phone and walk at the same time. Keep walking paths clear of debris or equipment.* - *Dress for the weather conditions.* - *Keep hydrated by drinking plenty of fluids and use the buddy system to notice signs of heat/cold stress of fellow employees.* - *Wear appropriate clothing to protect exposed skin from the heat/cold.*
Task 2: Indoor Air Samples/Outdoor Ambient Air Samples	- *Slip Trip Falls* - *Hot/Cold weather work* - *Dehydration* - *Wind/Sun burn from working outdoors* - *Heavy Lifting* - *Hand tools and pinch points*	- *Pay close attention to foot placement; do not talk on the phone and walk at the same time. Keep walking paths clear of debris or equipment.* - *Dress for the weather conditions.* - *Keep hydrated by drinking plenty of fluids and use the buddy system to notice signs of heat/cold stress of fellow employees.* - *Wear appropriate clothing to protect exposed skin from the heat/cold.* - Use proper lifting techniques. Lift with your legs not your back, and all equipment and supplies over 50 pounds require a two man lift. - Wear work gloves as need when using hand tools.
Task 3: Temporary Soil Gas Probe Installation	- *Power tools (Pneumatic Hammer Drill)* - *Noises caused by Pneumatic Hammer Drill* - *Heavy lifting* - *Extension cords* - *Electrical hazard* - *Underground utilities*	- *Wear safety glasses, work gloves, steel toe boots during operation of Pneumatic Hammer Drill. Only trained Geosyntec personnel will operate Hammer Drill. Always follow the intended use of the power tool.* - *Wear hearing protect while Hammer drill is in operation.* - *Use proper lifting techniques. Lift with your legs not your back, and all equipment and supplies over 50 pounds require a two man lift.* - *Inspect extension cords prior to use for and damage to exterior protective wire coating. Do not use any extension cords which appear damaged.* - *Use of a ground fault circuit interrupter.* - *Place/ed phone calls to clients facility maintenance department and PA One Call.* -
Task 4: Temporary Soil Gas Probe Sampling and Abandonment	- *Heavy Lifting* - *Dehydration* - *Hand Tools and pinch points* - *Compressed cylinders for Instrument calibration and Helium compressed gas cylinder* - *Powdered Cement*	- *Use proper lifting techniques. Lift with your legs not your back, and all equipment and supplies over 50 pounds require a two man lift.* - *Keep hydrated by drinking plenty of fluids and use the buddy system to notice signs of heat stress of fellow employees.* - *Wear work gloves as need when using hand tools.* - *Disconnect and connect compressed gas regulars carefully. Do not transport compressed cylinders with regulators attached.* - *Use nitrile gloves while mixing and applying quick drying cement to Temporary soil gas probes.*

A.4. H&S EQUIPMENT LIST

List worksite equipment for worker protection; provide details in Explanatory Notes, Clarifications.

EXPLANATORY NOTES, CLARIFICATIONS:

☒	**ROUTINE PPE**	☒ Standard work clothes appropriate for task ☒ Hard-toed boots/shoes ☒ Hardhat ☒ Safety glasses	☒ Work gloves appropriate for task ☒ Noise/hearing protection ☒ High-visibility/reflective vest ☐ Ice creepers (boot attachments)	
		☒ Basic PPE for protection from low-hazard chemical contact & dust (nitrile gloves, Tyvek suit, dust mask, boot covers).		
☒	**ROUTINE H&S EQUIPMENT/GEAR**	☒ First Aid Kit ☐ Fire extinguisher ☒ Emergency eyewash bottle(s) ☐ Insect control (repellant, wasp spray, other) ☐ Caution tape	☒ Sun protection (sunscreen, shade canopy, other) ☐ Project-supplied drinking water and/or hygiene facilities ☐ Poison ivy skin wash (Technu or similar) ☐ Vehicle emergency kit (flares, lights, reflective device) ☒ Traffic control warning devices (cones, or similar)	
		☐ Other:		
☐	**NON-ROUTINE PERSONAL PROTECTIVE EQUIPMENT (PPE)** (Indicate specific types of PPE in Explanatory Notes, Clarifications)	☐ Goggles and/or face shield ☐ Chemical protective gloves ☐ Coveralls (Tyvek, or other) ☐ Outer boots, boot covers	☐ Disposable n-95 dust mask ☐ Half-face respirator (APR), cartridges ☐ Full-face respirator (APR), cartridges ☐ Personal flotation device	☐ Fire retardant clothing ☐ Arc Flash Protection ☐ Electrical-Hazard-rated boots, gloves ☐ Personal fall apparatus
		☐ Other:		
☐	**SPECIAL HAZARD CONTROLS**	☐ Portable GFCI	☐ Lockout/tagout equipment	☐ Ventilation equipment (fan, blower)
		☐ Eyewash - 15 min. flow	☐ Emergency deluge shower	☐ Air horn, alarm
		☐ Other:		
☒	**DECON, PPE DISPOSAL**	☒ Receptacle for disposable PPE	☒ Hand washing provisions	☐ Decon solution, related supplies
		☐ Other:		
☐	**AIR MONITORING EQUIPMENT, OTHER EQUIPMENT FOR WORKER EXPOSURE TESTING**	List equipment/devices to be brought to worksite; Use in accordance with procedures in Part C:		

PART B – HAZARD ANALYSIS and CONTROLS *Complete Section B.1., then subsequent sections as applicable to the task(s).*

B.1. ROUTINE HAZARD PREPAREDNESS **This section required for all tasks.**

Explanatory Notes, Clarifications: Basic hazards include operation of Pneumatic Hammer Drill, heavy lifting when transporting equipment, and pinch points when using hand tools. Will be required to sample in homes.

General Safety, Wellness, Preparedness – Delineate site-specific HS aspects, as appropriate, in "Explanatory Notes, Clarifications," above.

☒ **General premises** hazards - housekeeping, rough terrain, trip hazards, steep slope, remote location.

☒ **Weather/climate-related hazards** – cold stress measures, severe weather shelter/refuge, "30/30 rule" for lightning. Wear appropriate clothing for weather conditions.

☒ **Plant/Insect/Animal Hazards** - Precautions: poison ivy wash; insect repellant; check for ticks; hornet nest spray; animal precautions.

☒ **Worksite traffic hazards** – Implement measures to protect personnel (high visibility/reflective clothing, on-person lighting, traffic control measures).

☐ **Illumination hazards/night work** - Illuminate work areas and/or access routes, use reflective/hi-visibility clothing or on-person lighting, as appropriate.

☒ **Lifting, manual material handling** – use proper lifting procedures, seek help for >50 lbs.

Geosyntec Procedures: *HS-124-Heat Stress, HS-125-Cold Stress, HS-127-Ticks, HS-208-Housekeeping, HS-210-Walking and Working Surfaces, HS-401-Back Injury Prevention, HS 517 Traffic Safety*

Routine Personal Protection – Delineate site-specific HS aspects, as appropriate, in "Explanatory Notes, Clarifications," above.

☒ **Head protection from overhead hazards** - Wear hardhat or "bump cap" as appropriate for hazard.

☒ **Hand protection** - Wear protective work gloves appropriate for the hazard and work tasks.

☒ **Eye protection** - Wear safety glasses (with side shield or wrap around, either clear or shaded for sun protection), or other appropriate eye protection.

☒ **Foot protection, rough terrain** - Wear work boots/shoes with hard toes, ankle support, puncture resistance, traction, as appropriate for conditions.

☒ **Hearing protection** – use earplugs, earmuffs (or both) as appropriate for conditions; at a minimum where noise levels exceed 85dBA.

☒ **Dust, unsanitary conditions** – For general protection against minimal non-specific hazards, use protective clothing and/or disposable dust mask, as needed.

Geosyntec Procedures: *HS-109-Hearing Conservation, HS 112-Respiratory Protection, HS-113-Personal Protective Equipment, HS-207-Working Alone, HS-105-Driver and Vehicle Safety*

Tools, Equipment, Machinery – Delineate site-specific HS aspects, as appropriate, in "Explanatory Notes, Clarifications," above.

☒ **Manual hand tools -** proper tool for the job, maintain in good condition, use vise/clamp to hold work piece, proper follow through, stay clear of "line of fire."

☐ **Knives, cutting tools -** Utility/folding/collapsible knives and fixed open-bladed knives/cutting tools are *not* permitted, unless specifically authorized. Cutting tools with automatically-retracting blades, or with enclosed/guarded blades are permitted. See HS-502-*Manual Hand Tools* for additional Information.

☒ ***Working near*** **powered tools/equipment/machinery** – safe distance, heed warning signs, stay out of "line of fire," use PPE (for eye/hearing/dust protection).

☒ ***Operation/use of*** **powered tools/equipment/machinery – See Section B.5.**

HS-502-Manual Hand Tools

Security– Delineate site-specific HS aspects, as appropriate, in "Explanatory Notes, Clarifications," above.

☒ **High crime, urban** – Use appropriate measures for personal security (such as buddy system, security service, work scheduling, other measures)

☐ **Working alone** - Establish "check in" procedure with supervisor/project manager.

Geosyntec Procedures: *HS-207-Working Alone*

Routine Driving Hazards – **Delineate site-specific HS aspects, as appropriate, in "Explanatory Notes, Clarifications," above.**

☒ **Routine work travel** - Use routine safe/defensive driving practices (seat belts, safe speeds, eyes ahead, no tailgating, limit distractions, safe cell phone use, no texting, clear windows, account for weather/road conditions, adequate sleep, other measures as appropriate).

☒ **Unfamiliar location** - Plan travel route before driving (assemble maps, enter destination in GPS).

☒ **Long Distance or During Sleep Hours** – Minimize fatigue: rest breaks, light snacks (avoid heavy meals), stay hydrated, fresh air, no loud music, clean windshield.

☒ **Unfamiliar vehicle** – Become familiar with vehicle operational controls and handling characteristics before operating vehicle.

Geosyntec Procedures: *HS-105-Driver and Vehicle Safety*

B.2. SPECIAL DRIVING/TRAFFIC/TRANSPORTATION HAZARDS ☐Applicable ☒ Not Applicable, Not Anticipated

B.3. WATER/BOATING HAZARDS ☐ Applicable ☒ Not Applicable or Not Anticipated

B.4. FALL HAZARDS ☐ Applicable ☒ Not Applicable, Not Anticipated

B.5. POWERED TOOLS, EQUIPMENT, MACHINERY ☒ Applicable ☐ Not Applicable, Not Anticipated

EXPLANATORY NOTES, CLARIFICATIONS: Geosyntec personnel will wear safety glasses, work gloves, hear protection, and steel toe boots during operation of Pneumatic hammer drill. It is not anticipated that a significant amount of dust will be generated during installation of temporary soil gas probes.

☒	**POWERED HAND TOOLS** ☐ Battery-operated ☒ Electric-powered, 120v/240v ☐ Fuel-powered ☒ Pneumatic ☐ Powder-actuated Hazards: Eye/hand/body injury, fuel-related hazards, Inhalation hazards, noise, sparks, heat, fire hazard, electrical hazards	☒ For all power tools: • Inspect tools to ensure safe operating condition before each use. • Use tool in accordance with manufacturer's specifications. • Ensure guards are in place and no hazardous equipment modifications. • Use PPE or other safety practices, as appropriate, for eye/hearing/hand/head/body protection. • Provide training or verify operator competency for use of power tool. • Stay clear of hazard zone, "line of fire," when working near where power tools are used. • For spark/heat generating tool, control fire hazards, segregate combustible/flammable materials. • Use vise/clamp/work bench or other appropriate means to hold/secure the work piece. ☐ Use respirators, ventilation, wet methods, other appropriate means to control inhalation hazard. ☐ See fuel-safety practices in Section B.13., "Commercial Chemical Products." ☐ For electrical hazards, see Section B.8., "Electrical Hazards". ***Geosyntec Procedure(s):*** *HS-109-Hearing Conservation, HS-113-Personal Protective Equipment, HS-121-Electrical Safety, HS-503-Powered Hand Tools, Others as applicable*
☐	**OPERATION OF EQUIPMENT/MACHINERY** ☐ Point-of-operation hazards ☐ Pinch points, moving parts ☐ 'Struck-by,' 'caught between' ☐ Hot surfaces, heat ☐ Extension cords, flexible wire ☐ Fuel related (gas or liquid) ☐ Hydraulic pressure ☐ Pneumatic pressure ☐ Kinetic, stored energy ☐ Noise ☐ Emissions, discharge gases ☐ Working at heights, falls ☐ Lifting, repetitive motion ☐ Illumination ☐ Electrical	☐ General safety requirements for equipment, machinery: • Arrange worksite for safe access to equipment/machinery. • Use equipment/machinery in accordance with manufacturer's use and safety instructions. • Ensure point-of-operation, mechanical power transmission, other moving parts are guarded with protective devices; do not override interlocks, guards, protective devices. • Secure long hair/loose clothing/hanging jewelry near moving/rotating parts. • Heed warning signs/labels, keep safe distance; avoid locations of "struck by" and "caught between" hazards. • Implement lockout/tagout for repairs/adjustments/tooling changes. ☐ Use safe lifting practices for movement of heavy portable equipment ☐ Implement safe work practices for compressed air, pressurized systems (pneumatic/hydraulic), stored energy. ☐ For climbing/fall hazards associated with large equipment, see Section B.4., "Fall Hazards." ☐ For electrical hazards, see Section B.8., "Electrical Hazards." ☐ Operate fuel-powered equipment in well ventilated location. ☐ Use safe practices for fuels, see Section B.13., "Commercial Chemical Products." ***Geosyntec Procedure(s):*** *HS-109-Hearing Conservation, HS-113-Personal Protective Equipment, HS-119-Lockout/Tagout, HS-121-Electrical Safety, HS-503-Powered Hand Tools, Others as applicable*
☐	**LOCKOUT/TAGOUT OF HAZARDOUS ENERGY**	☐ Implement control-of-hazardous-energy practices (lockout/tagout), provide lockout/tagout locks and devices, training workers, designate "authorized" personnel, notify "affected" personnel. ***Geosyntec Procedure(s):*** *HS-119-Lockout Tagout*
☐	**WELDING, CUTTING, HOT WORK (GAS OR ARC)** UV/IR light-eye/skin burns, hot-work hazards, toxic welding fumes, compressed gases, electrical shock	☐ General safe work practices: • Hot work permit system to be implemented. • Operator properly protected (eye protection, clothing, apron, etc.). • Fire hazard controls (watcher, fire extinguisher, water, isolate combustibles). • Protect nearby personnel from hazardous UV, IR light (shielding, curtain). ☐ For gas welding/cutting, use gas cylinder safe practices (secured, upright, caps on when not in use, prevent Damage; never secure gas cylinders to metal bench used for arc welding). ☐ For arc welding, follow electrical safe work practices. See Section B.8., "Electrical Hazards." ☐ See Section B.13., "Commercial Chemical Products," for hazards of welding rods (toxic metals), welding gases. ***Geosyntec Procedure(s):*** *HS-511-Welding, Cutting and Other Hot Work*

☐	**COMPRESSED AIR, COMPRESSOR** (for compressed gases, see Section B.13., "Compressed Gases")	☐ Never direct nozzle toward body; do not use compressed air for cleaning clothes. ☐ If compressed air is used for cleaning, restrict pressure to 30 psi or below, equip nozzle with chip guard. ☐ Use eye protection. ☐ Ensure air tank, hoses, fittings are in good repair using factory fittings.
☐	**PORTABLE GENERATOR** Hazards: Electrical shock, carbon monoxide in exhaust, fuel-related fire, injury from mechanical hazards, lifting	☐ Follow general safety practices for Operation of Equipment/Machinery (above), and as follows: • Use in accordance with manufacturer's instructions. • Keep generator and work area dry. • Never use indoors, or near building air intake vents due to carbon monoxide hazard. • Provide for ventilation and/or air monitoring where hazardous accumulation of exhaust emissions is possible. • Use hearing protection in close proximity to operating generator, as needed. • Use power cords/extension cords specified by instructions. • Use ground-fault circuit interrupters (GFCIs) in accordance with manufacturer's instructions. • See Section B.8., "Electrical Hazards." • Shut down equipment before refueling. See safe practices for flammable/combustible liquids in Section B.13., "Commercial Chemical Products." ***Geosyntec Procedures:*** *HS-109-Hearing Conservation, HS-111-Air Monitoring, HS-115-Hazard Communication (for fuel), HS-121-Electrical Safety, Others as applicable*
☐	**PORTABLE HEATERS (electric or fuel powered)** Hazards: Electric-powered: Electrical shock, fires from hot surfaces. Fuel powered: Carbon monoxide in exhaust, fires from hot surfaces, fuel-related fires	☐ Follow general safety practices for Operation of Equipment/Machinery (above), and as follows: • Keep heater dry, and locate heater on level surface away from high traffic areas. • Never use fuel-powered heaters indoors, or near air intake vents, due to carbon monoxide hazard. • Provide for ventilation and/or air monitoring where hazardous accumulation of exhaust emissions is possible. • Keep combustible materials at least 3 feet from hot surfaces. • Do not use an extension cord or power strip to power an electric heater. • For electric heaters, See Section B.8., "Electrical Hazards." • Shut down fuel-powered equipment before refueling. See safe practices for flammable/combustible liquids and/or compressed gases in Section B.13., "Commercial Chemical Products." ***Geosyntec Procedures:*** *HS-111-Air Monitoring, HS-115-Hazard Communication (for fuel, HS-121-Electrical Safety, Others as applicable*

B.6. DRILLING ☐ Applicable ☒ Not Applicable, Not Anticipated

B.7. CONSTRUCTION, HEAVY EQUIPMENT, LIFT EQUIPMENT ☐ Applicable ☒ Not Applicable, Not Anticipated

B.8. ELECTRICAL HAZARDS ☒ Applicable ☐ Not Applicable, Not Anticipated

EXPLANATORY NOTES, CLARIFICATIONS: Geosyntec will inspect all electrical equipment and will use extension cords when necessary.

☒	**BASIC ELECTRICAL HAZARDS TO SKILLED NON ELECTRICAL WORKERS** Equipment/tool use/operation, use of extension cords, working near electrical equipment. Hazards: Electrical shock, secondary hazards (falls, other injuries).	☒ Follow safe work practices: • Control water-related/wet-location hazards in a manner appropriate for the job tasks/equipment/tool. • Never touch electrical equipment if you are wet, or standing in water or on wet surfaces. • Use extension cords/power cords properly, prevent damage, take out of service if damaged. • Inspect tool/equipment/extension cords/power cords/welding cables before each use; do not use if damaged. • Use GFCI-protected outlet or portable GFCI in wet locations, outdoors, basements, concrete floors. • Ensure live parts are guarded, enclosures secure. • Enclosures, circuits properly labeled. ***Geosyntec Procedure(s):*** *HS-121-Electrical Safety*
☐	**HANDS-ON ELECTRICAL WORK BY ELECTRICAL WORKER/TECHNICIAN:** ☐ Voltage < 50 v ☐ Voltage 50-600v ☐ Voltage > 600v ☐ AC ☐ DC ☐ 3-phase ☐ Battery and/or solar power ☐ Capacitor/transformer	☐ Implement electrical safe work practices pertaining to: • Worker training/qualification (Level 1, Level 2, Level 3) • General electrical safe work practices, grounding, use of GFCIs • Safe work practices during diagnostics/troubleshooting, maintenance, repair • Safe design features for electrical equipment • Arc flash protection ***Geosyntec Procedure(s):*** *HS-121-Electrical Safety, HS-129-High Voltage Electricity Safety*
☐	**LOCKOUT/TAGOUT OF ELECTRICAL ENERGY**	☐ Implement control-of-hazardous-energy practices (lockout/tagout), provide lockout/tagout locks and devices, training workers, designate "authorized" personnel, notify "affected" personnel. ***Geosyntec Procedure(s):*** *HS-119-Lockout Tagout, HS-121-Electrical Safety*
☐	**IMPORTANT!** This work may/will include close proximity to electric utility lines.	☐ Follow safe work practices per Section B.9., "Utility Related Hazards"

B.9. UTILITY RELATED HAZARDS ☒ Applicable ☐ Not Applicable, Not Anticipated

EXPLANATORY NOTES, CLARIFICATIONS: Unknown underground utilities in the area.

☐	**OVERHEAD, ABOVE-GROUND UTILITIES**	☐ Maintain proper clearance, employ other appropriate precautions for the conditions. ***Geosyntec Procedure(s):*** *HS-304-Overhead Electrical Lines*

☒	**UNDERGROUND UTILITIES**	☒ Confirm appropriate underground utility clearance procedures have been completed prior to ground penetrations, and employ other utility clearance/locator practices, as appropriate for conditions. ☐ Hand digging or vacuum post-holing within 3' of utility locations or other high risk condition.

B.10. CONFINED SPACE ENTRY, HAZARDOUS ENCLOSED SPACES ☐ Applicable ☒ Not Applicable, Not Anticipated

B.11. STORAGE OF BULK MATERIALS ☐ Applicable ☒ Not Applicable, Not Anticipated

B.12. INFECTIOUS / ALLERGENIC BIOHAZARDS ☐ Applicable ☒ Not Applicable, Not Anticipated

B.13. COMMERCIAL CHEMICAL PRODUCTS ☒ Applicable ☐ Not Applicable, Not Anticipated

EXPLANATORY NOTES, CLARIFICATIONS: Geosyntec will be using Isobutylene to calibrate PIDs and a Methane and Carbon Dioxide gas mixture to calibrate GEM landfill gas meters. Helium will also be used as a tracer gas during temporary soil gas sampling. All cylinders will be used in a well ventilated area.

☐	**PRODUCTS REGULATED BY HAZARD COMMUNICATION STANDARD**	☐ Safety Data Sheets available, either on site or readily available within same work shift, containers labelled properly, workers trained/oriented on hazards ☐ For subcontractor use of chemical products, coordinate/discuss during safety meetings. ☐ Conduct air monitoring, as appropriate (see Part C, "Air Monitoring, Worker Exposure Monitoring").
☒	**COMPRESSED GAS (flammable or nonflammable)**	☒ Secure cylinders upright, caps on when not in use, handle with care, prevent damage. ☐ Propane cylinders not in use must be stored outdoors in cage or similar secure enclosure. ☐ Ensure acetylene cylinders NOT secured to steel arc welding bench. ☒ Store/use in a manner to prevent asphyxiation hazard. ☐ Segregate oxygen and fuel gases by distance (20') or barrier. ☐ Control ignition sources. ☐ "No smoking" signage at cylinder storage area for flammable gases. ☒ Use/store in a manner to control inhalation exposure hazards, PPE, air monitoring.
☐	**FLAMMABLE/COMBUSTIBLE LIQUIDS**	☐ Proper storage (flam. storage cabinets, other storage precautions). ☐ Use proper fuel safety can (metal fuel can preferred). ☐ Control ignition sources. ☐ Grounding and bonding where appropriate.
☐	**ACIDS, CAUSTICS, OTHER CORROSIVES**	☐ Handle with care, use appropriate eye/face/skin protection. ☐ Eyewash, deluge shower, drench hose, hand washing (with water), as appropriate.
☐	**TOXIC**	☐ For toxic substances, use/store in a manner to control exposure hazards (inhalation, ingestion, skin contact, skin absorption); use PPE as appropriate, conduct air monitoring as appropriate.
☐	**EMISSIONS FROM FUEL COMBUSTION, INDUSTRIAL PROCESSES** ☐ Gasoline ☐ Diesel ☐ Propane/Natural Gas ☐ Welding/cutting/hot work ☐ Vehicle/equipment exhaust ☐ Other	☐ Position outdoor personnel upwind of exhaust source. ☐ Use blowers, fans to provide fresh air to work area and dissipate atmospheric hazards. ☐ Use respiratory protection for high levels of smoke, exhaust particulates, soot. ☐ Conduct air monitoring as appropriate (see Part C, "Air Monitoring").
☐	**OTHER HAZARDS**	☐ Describe other hazardous substances and safety measures under "Explanatory Notes, Clarifications," above.
☐	**CHEMICAL/HAZMAT STORAGE** Check this when jobsite requirements include special provisions for chemical storage.	☐ Chemical storage cabinet, cage, storage room, or similar. ☐ Ensure incompatible chemicals are segregated. ☐ Provide secondary containment. ☐ Locate special safety equipment near chemical storage

Geosyntec Procedures: *HS-115-Hazard Communication, HS-111-Air Monitoring, HS-112-Respiratory Protection, HS-113-Personal Protective Equipment, HS-114-Safety Training Programs, Others as applicable*

B.14. SITE CONTAMINANTS, CHEMICAL WASTES ☒ Applicable ☐ Not Applicable, Not Anticipated

EXPLANATORY NOTES, CLARIFICATIONS: Site specific constituents of concern are BTEX, Carbon tetrachloride, Tetrachloroethene, Trichloroethene, Vinyl chloride, 1,1,2,2-Tetrachloroethane, and 1,2,4-Trichlorobenzene. Geosyntec will have limited exposure to VOCs in the form of vapors from purging of temporary soil gas probes. Tedlar bags with purged soil gas will dispensed away from breathing zone to prevent any direct exposure.

CHECK ALL THAT APPLY. Provide explanatory notes above.

☒ Soil/groundwater contaminants (historical release)
☐ Recent release, known high concentrations
☐ Former chemical disposal site, landfill
☐ Urban fill, residual contaminants
☐ Containerized waste (drums, process equipment)
☐ Buried drums (known or potential)
☐ Large containers, potential for spills

☐ Oxygen deficiency
☒ Chlorinated volatile organic compounds (CVOCs)
☒ BTEX, petroleum derived VOCs
☐ Fuel oils, petroleum, waste oil, lubricants
☐ Metals, metal compounds, metal dusts
☐ Elemental mercury

☐ Corrosive, acids/caustics, strong irritants
☐ Sulfides, hydrogen sulfide (H_2S)
☐ Cyanides, hydrogen cyanide (HCN)
☐ Asbestos
☐ Lead paint
☐ Pesticides, herbicides, fungicides
☐ Sensitizers

☐ Contaminated building surfaces
☐ Unexploded ordnance
☐ Explosive dust

☐ Polyaromatic hydrocarbons (PAHs)
☐ Polychlorinated biphenyls (PCBs)
☐ Potential for flammable vapors
☐ Potential for flammable gas (methane)

☐ Radioactive contaminants
☐ Other (see Explanatory Notes, above)

☐ **FOR WORK CONSISTING OF CLEANUP OPERATIONS, CORRECTIVE ACTIONS, PRELIMINARY INVESTIGATIONS at an "UNCONTROLLED HAZ. WASTE SITE" (per HAZWOPER, 29 CFR 1910.120), implement the following as applicable to the work:**

- Implement site control plan via Exclusion Zone(s), Contaminant Reduction Zone(s) and Support Zone (aka EZ, CRZ, SZ)
- Workers to be aware of and trained on hazards per OSHA Hazard Communication Standard.
- Include site map/figure depicting work locations and other relevant site-specific information.
- Site workers in EZ or CRZ to have OSHA 40-hour training, current 8-hour refresher, 3 days supervised field experience.
- Site supervisor(s) required to have 8-hr. Supervisor training.
- Site workers in EZ or CRZ to participate in Medical Monitoring program, as applicable.
- Implement site-specific procedures for worker protection via engineering controls, work practices, personal protective equipment (PPE), air monitoring, decontamination procedures, spill containment, emergency preparedness and response.
- Conduct air monitoring, as appropriate (see Part C, "Air Monitoring, Worker Exposure Monitoring").

IMPORTANT: Provide supplemental information to sufficiently detail site-specific procedures for the above elements, as appropriate for the work.

Geosyntec Procedures: *HS-301-HAZWOPER, HS-108-Medical Monitoring Surveillance, HS-111-Air Monitoring, HS-112-Respiratory Protection, HS-113-Personal Protective Equipment, HS-114-Safety Training Programs, HS-115-Hazard Communication, HS-405-Drum Sampling, Others as applicable*

☒ **FOR SITE WITH CHEMICAL CONTAMINANTS OR WASTE BUT NOT REGULATED BY HAZWOPER**

- Workers to be knowledgeable/aware of chemical hazards thru safety training/orientation and availability of hazard information
- Implement controls to minimize worker exposure through engineering controls, work practices, PPE, as appropriate.
- Conduct air monitoring/sampling to monitor/evaluate worker exposure, as applicable.

Geosyntec Procedures: *HS-111-Air Monitoring, HS-112-Respiratory Protection, HS-113-Personal Protective Equipment, HS-114-Safety Training Programs, HS-115-Hazard Communication, Others as applicable*

☐	**OFF-SITE MIGRATION OF CONTAMINANTS**	☐ Implement controls to minimize hazard migration (dust suppression, covers, foam, etc.) ☐ Community/perimeter air monitoring to be conducted per perimeter air monitoring plan.
☐	**SPILL CONTAINMENT, CONTAINERS**	☐ Describe above any site-specific procedures for spill containment, container handling, as applicable. ***Geosyntec Procedures**: HS-406-Unknown Hazardous Waste Drum Handling*

B.15. RADIATION HAZARDS (Other than Sunlight) ☐ Applicable ☒ Not Applicable, Not Anticipated

B.16. HAZMAT/DANGEROUS GOODS SHIPPING/TRANSPORTATION ☐ Applicable ☒ Not Applicable, Not Anticipated

PART C – AIR MONITORING, WORKER EXPOSURE MONITORING

C.1. AIR MONITORING (Direct-Reading Instruments) ☒ Applicable ☐ Not Applicable, Not Anticipated

EXPLANATORY NOTES, CLARIFICATIONS: Geosyntec personnel will monitor breathing zones with a PID. An action level of 1 part per million will be implemented: when breathing zone concentrations reach this level on a sustained basis, work will be temporarily discontinued to allow vapors to dissipate.

☒	**AIR-TESTING PARAMETERS**	☒ VOCs, GASES ☒ PID, Lamp energy: 10.6 eV ☐ FID ☐ Carbon monoxide ☐ Hydrogen sulfide ☐ Oxygen (O_2)	☐ Flammable gas (LEL) ☐ Particulate (dust) ☒ Calibration kit for each parameter ☐ Other:

☐	**ACTION LEVELS FOR O2/LEL**	☐ Oxygen	≤19.5% - ventilate to raise O_2 to acceptable levels, or use Level B. ≥23.0% - ventilate to lower O_2 to acceptable levels, or use Level B and control fire hazards & ignition sources.
		☐ LEL	Confirm at least 12% oxygen is present to ensure accuracy of LEL readings. At <10% LEL - Continue working, continue to monitor LEL levels At ≥10% LEL- Immediately withdraw from area. Resume work ONLY after LEL readings reduced to <10%.

☒	**ACTION LEVELS FOR TOXICS** (sustained breathing zone concentrations)	**Parameters**	**Level D, Modified D***	**Use levels C or B*, as indicated below, OR take action to reduce breathing zone level to concentration acceptable for Level D*.**
		☒ VOCs	< 1 ppm >1 ppm stop work and increase ventilation to work area.	__ ppm to __ ppm: Level C (air purifying respirator) > __ ppm: Level B (air-supplied respirator)
		☐ Carbon Monoxide	< 35 ppm	≥35 ppm - Level B (air-supplied respirator)
		☐ Hydrogen Sulfide	< 10 ppm	≥10 ppm - Level B (air-supplied respirator)
		☐ Total Dust	< ___ mg/m^3	>___ mg/m^3 - Level C (air-purifying respirator)
		☐		
		☐		

*** Levels of Protection:**	**Level D** (standard work clothes, basic personal protective wear, no chemical protective clothing, no respiratory protection) **Modified Level D** (chemical protective clothing in addition to standard work clothes, no respiratory protection) **Level C** (air purifying respirator or dust mask, in addition to chemical protective clothing) **Level B or A** (air supplied respirator, chemical protective suit; fully-encapsulating suit for Level A)

Geosyntec Procedures: *HS-111-Air Monitoring*

C.2. OTHER WORKER EXPOSURE MONITORING ☐ Applicable ☒ Not Applicable, Not Anticipated

☐ Air Sampling *(sample collection, passive dosimeter)*	☐ Ionizing or Non-ionizing Radiation Testing	☐ Heat Stress Testing
☐ Wipe/Bulk Sampling *(to evaluate worker exposure)*	☐ Noise Testing	☐ Other

EXPLANATORY NOTES, CLARIFICATIONS:

Geosyntec Procedures: *HS-109-Hearing Protection, HS-111-Air Monitoring, HS-124-Heat Stress Prevention, HS-126-Radiation Safety Program, HS-128-Ionizing and Non-ionizing Radiation, HS-601-Asbestos, HS-602-Lead*

PART D – APPROVALS, ACKNOWLEDGEMENTS

D.1. THA PREPARATION, REVIEW/APPROVAL SIGNATURES - THA typically prepared by project staff, reviewed/approved by Project Manager, Supervisor, qualified/knowledgeable designee, with support of HS personnel as deemed appropriate by the Project Manager.			
THA PREPARED BY: (minimum one person)	***Printed Name***	***Signature***	***Date***
	Sarah Mitcheltree		3/29/2017
THA REVIEWED/ APPROVED BY: (minimum one person)	***Printed Name***	***Signature***	***Date***

D.2. FIELD CREW ACKNOWLEDGEMENTS

GEOSYNTEC FIELD CREW

Please sign below to acknowledge you reviewed and understand this THA, participated in project safety briefing and had an opportunity to ask questions about the information herein.

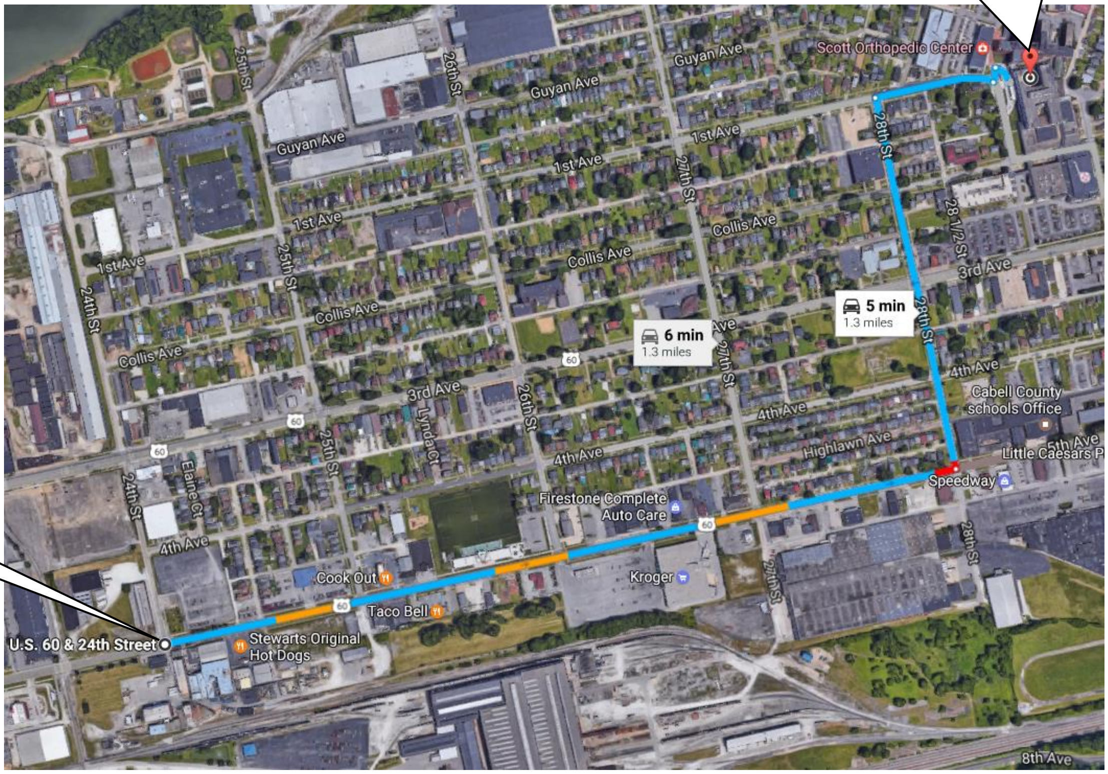
Printed Name	Signature	Employee No.	Date

SUBCONTRACTOR'S FIELD CREW

Please sign below to acknowledge that this THA was made available to you, and you had an opportunity to ask questions about the information herein.

Printed Name	Signature	Company Name	Date

ROUTE TO HOSPITAL



Drive 1.3 miles. Approximate driving time is 5 minutes

St. Mary's Medical Center

304-526-1234
2900 First Avenue
Huntington, WV 25702

Written Directions to Hospital from Site:

1.	Starting at the intersection of 24th Street and 5th Avenue	
2.	Head east on 5th Avenue toward Homestead Place	0.8 mi
3.	Turn left onto 28th Street	0.4 mi
4.	Turn right onto 1st Avenue	0.1 mi
5.	Hospital will be on the left	

ROUTE TO URGENT CARE FACILITY

St. Mary's Urgent Care

304-399-7182
2815 5th Avenue
Huntington, WV 25702

Directions to Urgent Care from the Site:

1. Starting at the intersection of 24th Street and 5th Avenue
2. Head east on 5th Avenue toward Homestead Place for 0.8 miles – Destination will be on the right

Appendix C: Summary of Chemical Hazards

Petroleum Hydrocarbons

Petroleum hydrocarbons likely at the site include tar and/or fuel-related materials in soils and sediments. Gasoline, diesel, oil, and heavier hydrocarbons, such as grease, may be present. Volatile components of gasoline include benzene, toluene, ethylbenzene, and xylenes (BTEX).

The primary exposure routes for petroleum hydrocarbons during site activities are inhalation, dermal contact, and ingestion of contaminated soil, sediment, dust, or water. Lighter petroleum hydrocarbons such as gasoline and benzene readily volatilize and are primarily an inhalation concern, whereas the primary route of exposure to heavier petroleum hydrocarbons such as aromatic hydrocarbons, oil, and grease is dermal contact. The target organs primarily affected by prolonged exposure to petroleum hydrocarbons are the respiratory system, central nervous system, kidneys, liver, and skin. Prolonged dermal contact with petroleum hydrocarbons can cause irritation or dermatitis. The BTEX compounds are known or suspected human carcinogens.

Petroleum hydrocarbons such as gasoline are also flammable and can be a physical hazard when present in high concentrations. Combustion of petroleum hydrocarbons can produce carbon dioxide, carbon monoxide, aldehydes, fumes, smoke (particulate matter) and other products of incomplete combustion. Intentional and inadvertent combustion of petroleum hydrocarbons is not expected during sampling activities; however, personnel will evacuate the area should a fire occur. The table below summarizes BTEX exposure limits.

Chemical Name	PEL[1]	TLV[2]
Benzene	1	0.5
Toluene	200	50
Ethylbenzene	100	100
Xylene	100	100

[1] OSHA Permissible Exposure Limit (in parts per million)
[2] ACGIH Threshold Limit Value (in parts per million)

OSHA PEL for coal tar pitch volatiles is 0.2 mg/m^3 and NIOSH REL is 0.1 mg/m^3, TLV 0.2 mg/m^3 is for 8 hour time weighted average (TWA).

Chlorinated Solvents/Volatile Organic Compounds (VOCs)

Chlorinated VOCs are widely used as solvents in industrial operations such as degreasing, manufacturing, cleaning and dry cleaning, and are also present in household products and automotive fluids. They readily form vapors which can accumulate in indoor air spaces (i.e., via migration through the subsurface) and react with ozone to form sub-micron sized particles with the potential to cause adverse respiratory health effects. Free product releases (via surface or subsurface discharges or inadequate disposal) can migrate downward to significant depths and through fine-grained deposits to groundwater, and can persist as wide-scale sources of vapor plumes for long periods of time.

Several chlorinated hydrocarbons have been identified in soil, indoor air vapor, and groundwater at the site including perchloroethylene (PCE), trichloroethylene (TCE), and 1,2-dichloroethane (DCA). The likely routes of exposure to chlorinated solvents include inhalation, ingestion and direct contact with the skin or eye. The toxicity of chlorinated solvents varies; many affect the CNS and some are identified as carcinogens. PCE can affect the CNS and cause irritation of the skin, eyes, and upper respiratory tract. TCE can depress the CNS, affect kidneys, liver, and lungs and can cause rapid and irregular heartbeat. Toxic effects are increased when combined with alcohol, caffeine, and other drugs. DCA can cause CNS depression and damage to the liver, kidneys, heart, and digestive system. Eye contact with DCA can cause irritation and serious injury if not removed promptly. DCA and TCE are flammable liquids; the LEL of both solvents are approximately 6% and their flash points are less than 100°F. PCE is not considered flammable. These chlorinated solvents are only slightly soluble in water.

Exposure levels will be maintained below OSHA PEL or NIOSH REL as shown in the table below.

Chemical Name	**PEL[1]**	**REL[2]**
1,2 DCA	50	1
TCE	100	Ca
PCE	100	Ca

[1] OSHA Permissible Exposure Limit (PEL) in parts per million
[2] ACGIH Threshold Limit Value (TLV) in parts per million
Ca = Carcinogenic

Appendix D: Air Monitoring

Applies to Task: ☒ ① ☐ ② ☐ ③ ☐ ④ ☐ ⑤ ☐ ⑥ ☐ ⑦ ☐ ⑧

☒ *Photoionization Detector (PID)*

Brand/Model No.: ___________ **MiniRae 2000 or similar** ____

Monitoring Frequency: **Continuously** ____

Breathing Zone Reading (ppm)	**Action**
___0__ to __1___	Level D PPE
_____ to _____	Level C PPE
Greater than 1___________ ____________	Stop work. Evacuate the area. If upon return, levels still exceed the action level, stop work and implement engineering controls.

Note: ___________________________________

☐ *Oxygen (O_2) Meter*

Brand/Model No.: ____________________

Monitoring Frequency: ________________

Reading (%)	**Action**
Less than 19.5	Stop work. Evacuate the area.
19.5 to 23.5	Continue to work with caution.
Greater than 23.5	Stop work. Evacuate the area.

Note: ___________________________________

☐ *Explosimeter*

Brand/Model No.: ____________________

Monitoring Frequency: ________________

Source (% LEL)

Reading	**Action**
1 to 10	Continue with caution.
Greater than 10	Stop work. Evacuate the area. If upon return, concentration still exceeds 10% LEL, ventilate until concentration is back to <10% LEL.

Note: ___________________________________

☐ *Flame Ionization Detector (FID)*

Brand/Model No.: ____________________

Monitoring Frequency: ________________

Breathing Zone Reading (ppm)	**Action**
_____ to _____	Level D PPE
_____ to _____	Level C PPE
Greater than ____________ ____________	Stop work. Evacuate the area. If upon return, levels still exceed ____, stop work and implement engineering controls.

Note: ___________________________________

☐ *Chemical Detector Tube*

Brand/Model No.: ____________________

Monitoring Frequency: ________________

Breathing Zone Reading (ppm)	**Action**
_____ to _____	Level D PPE
_____ to _____	Level C PPE
Greater than ____________ ____________	Stop work. Evacuate the area. If upon return, levels still exceed ____, stop work and implement engineering controls.

Note: ___________________________________

☐ *Other*

Brand/Model No.: ____________________

Monitoring Frequency: ________________

Breathing Zone Reading	**Action**
_____ to _____	Level D PPE
_____ to _____	Level C PPE
Greater than ____________ ____________	Stop work. Evacuate the area. If upon return, levels still exceed ____, stop work and implement engineering controls.

Note: ___________________________________

Appendix E: Personal Protective Equipment

	Task ①	Task ②	Task ③	Task ④	Task ⑤	Task ⑥	Task ⑦	Task ⑧
Potential PPE Level per Task:	☒ D ☐ C	☐ D ☐ C	☐ D ☐ C	☐ D ☐ C	☐ D ☐ C	☐ D ☐ C	☐ D ☐ C	☐ D ☐ C

Modified Level D		***Level C***	
Equipment	***Material/Type***	***Equipment***	***Material/Type***
☒ Safety glasses		☐ Full-face air-purifying respirator	Cartridge Type:
☒ Hard-toed boots		☐ Half-mask air-purifying respirator	Cartridge Type:
☐ Protective clothing		☐ Safety glasses	
☒ Hard hat*		☐ Hard-toed boots	
☒ Hearing protection*		☐ Protective clothing	
☒ High-visibility vest*		☐ Hard hat	
☐ Outer boots*		☐ Hearing protection*	
☒ Outer gloves*		☐ High-visibility vest*	
☐ Other:		☐ Outer boots*	
		☐ Outer gloves*	
		☐ Inner gloves*	
		☐ Other:	

* PPE items may be downgraded (only with concurrence of SHSO and PM).

Appendix F: Safety Data Sheets

Included in this HASP	Chemical
☐	Acetone
☐	Alconox
☐	Ammonia
☐	Bentonite
☐	Diesel Fuel Oil No. 2-D
☐	Gasoline
☒	Helium
☐	Hexane
☐	Hydrochloric Acid
☐	Hydrogen
☒	Isobutylene Calibration Gas
☐	Isopropyl Alcohol
☐	KB-1
☒	Methane Calibration Gas
☐	Nitric Acid
☐	Permanganate
☒	Portland Cement
☐	Sulfuric Acid
☐	Other: _____
☐	Other: _____
☐	Other: _____
☐	Other: _____

Note: SDSs are for chemicals that used to perform project work, not site contaminants.

SDSs

Material Safety Data Sheet

Helium

Section 1. Chemical product and company identification

Product name	:	Helium
Supplier	:	AIRGAS INC., on behalf of its subsidiaries 259 North Radnor-Chester Road Suite 100 Radnor, PA 19087-5283 1-610-687-5253
Product use	:	Synthetic/Analytical chemistry.
Synonym	:	helium (dot); Helium-4; He; o-Helium; UN 1046; UN 1963; Liquid Helium; Helium, Refrigerated Liquid
MSDS #	:	001025
Date of Preparation/Revision	:	**5/6/2013.**
In case of emergency	:	1-866-734-3438

Section 2. Hazards identification

Physical state : Gas. [Colorless, Odorless Gas, Cryogenic liquid and gas]

Emergency overview : WARNING!

GAS:
CONTENTS UNDER PRESURE.
Do not puncture or incinerate container.
Can cause rapid suffocation.
May cause severe frostbite.
LIQUID:
Extremely cold liquid and gas under pressure.
Can cause rapid suffocation.
May cause severe frostbite.

Do not puncture or incinerate container.

Contact with rapidly expanding gases or liquids can cause frostbite.

Routes of entry : Inhalation

Potential acute health effects

- **Eyes** : Contact with rapidly expanding gas may cause burns or frostbite. Contact with cryogenic liquid can cause frostbite and cryogenic burns.
- **Skin** : Contact with rapidly expanding gas may cause burns or frostbite. Contact with cryogenic liquid can cause frostbite and cryogenic burns.
- **Inhalation** : Acts as a simple asphyxiant.
- **Ingestion** : Ingestion is not a normal route of exposure for gases. Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Medical conditions aggravated by over-exposure : Acute or chronic respiratory conditions may be aggravated by overexposure to this gas.

See toxicological information (Section 11)

Section 3. Composition, Information on Ingredients

Name	CAS number	% Volume	Exposure limits
Helium	7440-59-7	100	Oxygen Depletion [Asphyxiant]

Section 4. First aid measures

No action shall be taken involving any personal risk or without suitable training.If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus.It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Eye contact : Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.

Skin contact : None expected.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Inhalation : Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Ingestion : As this product is a gas, refer to the inhalation section.

Section 5. Fire-fighting measures

Flammability of the product : Non-flammable.

Products of combustion : No specific data.

Fire-fighting media and instructions : Use an extinguishing agent suitable for the surrounding fire.

Apply water from a safe distance to cool container and protect surrounding area. If involved in fire, shut off flow immediately if it can be done without risk.

Contains gas under pressure. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions : Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (section 8). Shut off gas supply if this can be done safely. Isolate area until gas has dispersed.

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Methods for cleaning up : Immediately contact emergency personnel. Stop leak if without risk. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Handling : High pressure gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Never allow any unprotected part of the body to touch uninsulated pipes or vessels that contain cryogenic liquids. Prevent entrapment of liquid in closed systems or piping without pressure relief devices. Some materials may become brittle at low temperatures and will easily fracture.

Storage : Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).

For additional information concerning storage and handling refer to Compressed Gas Association pamphlets P-1 Safe Handling of Compressed Gases in Containers and P-12 Safe Handling of Cryogenic Liquids available from the Compressed Gas Association, Inc.

Section 8. Exposure controls/personal protection

Engineering controls	: Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.
Personal protection	
Eyes	: Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts. When working with cryogenic liquids, wear a full face shield.
Skin	: Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Respiratory	: Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator. The applicable standards are (US) 29 CFR 1910.134 and (Canada) Z94.4-93
Hands	: Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Insulated gloves suitable for low temperatures
Personal protection in case of a large spill	: Self-contained breathing apparatus (SCBA) should be used to avoid inhalation of the product.

Product name	
helium	Oxygen Depletion [Asphyxiant]

Consult local authorities for acceptable exposure limits.

Section 9. Physical and chemical properties

Molecular weight	: 4 g/mole
Molecular formula	: He
Boiling/condensation point	: -268.9°C (-452°F)
Melting/freezing point	: -272.2°C (-458°F)
Critical temperature	: -267.9°C (-450.2°F)
Vapor density	: 0.14 (Air = 1) Liquid Density@BP: 7.8 lb/ft3 (125 kg/m3)
Specific Volume (ft ^{3}/lb)	: 96.1538
Gas Density (lb/ft ^{3})	: 0.0104

Section 10. Stability and reactivity

Stability and reactivity	: The product is stable.
Hazardous decomposition products	: Under normal conditions of storage and use, hazardous decomposition products should not be produced.
Hazardous polymerization	: Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Toxicity data	
Other toxic effects on humans	: No specific information is available in our database regarding the other toxic effects of this material to humans.
Specific effects	
Carcinogenic effects	: No known significant effects or critical hazards.
Mutagenic effects	: No known significant effects or critical hazards.
Reproduction toxicity	: No known significant effects or critical hazards.

Section 12. Ecological information

Aquatic ecotoxicity

Not available.

Environmental fate : Not available.

Environmental hazards : No known significant effects or critical hazards.

Toxicity to the environment : Not available.

Section 13. Disposal considerations

Product removed from the cylinder must be disposed of in accordance with appropriate Federal, State, local regulation.Return cylinders with residual product to Airgas, Inc.Do not dispose of locally.

Section 14. Transport information

Regulatory information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	UN1046 UN1963	HELIUM, COMPRESSED Helium, refrigerated liquid	2.2	Not applicable (gas).		**Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: 75 kg **Cargo aircraft** Quantity limitation: 150 kg
TDG Classification	UN1046 UN1963	HELIUM, COMPRESSED Helium, refrigerated liquid	2.2	Not applicable (gas).		**Explosive Limit and Limited Quantity Index** 0.125 **Passenger Carrying Road or Rail Index** 75
Mexico Classification	UN1046 UN1963	HELIUM, COMPRESSED Helium, refrigerated liquid	2.2	Not applicable (gas).		-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Section 15. Regulatory information

United States

U.S. Federal regulations : **United States inventory (TSCA 8b):** This material is listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: helium
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: helium: Sudden release of pressure

Clean Water Act (CWA) 307: No products were found.

Clean Water Act (CWA) 311: No products were found.

Clean Air Act (CAA) 112 regulated flammable substances: No products were found.

Clean Air Act (CAA) 112 regulated toxic substances: No products were found.

State regulations : **Connecticut Carcinogen Reporting:** This material is not listed.
Connecticut Hazardous Material Survey: This material is not listed.
Florida substances: This material is not listed.
Illinois Chemical Safety Act: This material is not listed.
Illinois Toxic Substances Disclosure to Employee Act: This material is not listed.
Louisiana Reporting: This material is not listed.
Louisiana Spill: This material is not listed.
Massachusetts Spill: This material is not listed.
Massachusetts Substances: This material is listed.
Michigan Critical Material: This material is not listed.
Minnesota Hazardous Substances: This material is not listed.
New Jersey Hazardous Substances: This material is listed.
New Jersey Spill: This material is not listed.
New Jersey Toxic Catastrophe Prevention Act: This material is not listed.
New York Acutely Hazardous Substances: This material is not listed.
New York Toxic Chemical Release Reporting: This material is not listed.
Pennsylvania RTK Hazardous Substances: This material is listed.
Rhode Island Hazardous Substances: This material is not listed.

Canada

WHMIS (Canada) : Class A: Compressed gas.

CEPA Toxic substances: This material is not listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is not listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

United States

Label requirements : GAS:
CONTENTS UNDER PRESURE.
Do not puncture or incinerate container.
Can cause rapid suffocation.
May cause severe frostbite.
LIQUID:
Extremely cold liquid and gas under pressure.
Can cause rapid suffocation.
May cause severe frostbite.

Canada

Label requirements : Class A: Compressed gas.

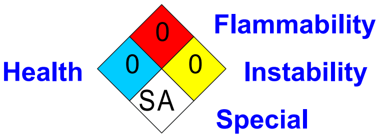
Hazardous Material Information System (U.S.A.) :

Health	1
Flammability	0
Physical hazards	0

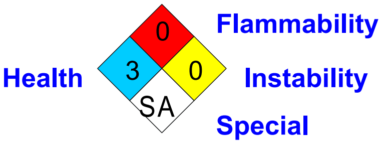
liquid:

Health	3
Fire hazard	0
Reactivity	0
Personal protection	

National Fire Protection Association (U.S.A.) :



liquid:



Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Material Safety Data Sheet

Isobutylene

Section 1. Chemical product and company identification

Product name : Isobutylene

Supplier : AIRGAS INC., on behalf of its subsidiaries
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Product use : Synthetic/Analytical chemistry.

Synonym : Propene, 2-methyl-; γ-Butylene; Isobutene; Isobutylene; Isopropylidenemethylene; 1,1-Dimethylethylene; 2-Methyl-1-propene; 2-Methylpropene; iso-C4H8; Methylpropene; 2-Methylpropene-isobutylene; UN 1055; UN 1075

MSDS # : 001031

Date of Preparation/ Revision : **11/22/2013.**

In case of emergency : 1-866-734-3438

Section 2. Hazards identification

Physical state : Gas. [COLORLESS LIQUEFIED COMPRESSED GAS WITH A SWEET GASOLINELIKE ODOR]

Emergency overview : WARNING!

FLAMMABLE GAS.
MAY CAUSE FLASH FIRE.
CONTENTS UNDER PRESSURE.

Keep away from heat, sparks and flame. Do not puncture or incinerate container. Use only with adequate ventilation. Keep container closed.

Contact with rapidly expanding gases can cause frostbite.

Routes of entry : Inhalation

Potential acute health effects

Eyes : Contact with rapidly expanding gas may cause burns or frostbite.

Skin : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : Acts as a simple asphyxiant.

Ingestion : Ingestion is not a normal route of exposure for gases

Medical conditions aggravated by over-exposure : Acute or chronic respiratory conditions may be aggravated by overexposure to this gas.

See toxicological information (Section 11)

Section 3. Composition, Information on Ingredients

Name	CAS number	% Volume	Exposure limits
Isobutylene	115-11-7	100	**ACGIH TLV (United States, 3/2012).** TWA: 250 ppm 8 hours.

Section 4. First aid measures

No action shall be taken involving any personal risk or without suitable training.If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus.It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Eye contact : Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.

Skin contact	:	In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. To avoid the risk of static discharges and gas ignition, soak contaminated clothing thoroughly with water before removing it. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.
Frostbite	:	Try to warm up the frozen tissues and seek medical attention.
Inhalation	:	Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.
Ingestion	:	As this product is a gas, refer to the inhalation section.

Section 5. Fire-fighting measures

Flammability of the product	:	Flammable.
Auto-ignition temperature	:	465°C (869°F)
Flammable limits	:	Lower: 1.8% Upper: 9.6%
Products of combustion	:	Decomposition products may include the following materials: carbon dioxide carbon monoxide
Fire hazards in the presence of various substances	:	Extremely flammable in the presence of the following materials or conditions: open flames, sparks and static discharge and oxidizing materials.
Fire-fighting media and instructions	:	In case of fire, use water spray (fog), foam or dry chemical. In case of fire, allow gas to burn if flow cannot be shut off immediately. Apply water from a safe distance to cool container and protect surrounding area. If involved in fire, shut off flow immediately if it can be done without risk. Contains gas under pressure. Flammable gas. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion.
Special protective equipment for fire-fighters	:	Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions	:	Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (section 8). Shut off gas supply if this can be done safely. Isolate area until gas has dispersed.
Environmental precautions	:	Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.
Methods for cleaning up	:	Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Handling	:	Use only with adequate ventilation. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. High pressure gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Keep container closed. Keep away from heat, sparks and flame. To avoid fire, eliminate ignition sources. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.
Storage	:	Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame). Segregate from oxidizing materials. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).

Section 8. Exposure controls/personal protection

Engineering controls	Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.
Personal protection	
Eyes	Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts.
Skin	Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Respiratory	Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator. The applicable standards are (US) 29 CFR 1910.134 and (Canada) Z94.4-93
Hands	Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Personal protection in case of a large spill	Self-contained breathing apparatus (SCBA) should be used to avoid inhalation of the product.

Product name	
2-methylpropene	**ACGIH TLV (United States, 3/2012).** TWA: 250 ppm 8 hours.

Consult local authorities for acceptable exposure limits.

Section 9. Physical and chemical properties

Molecular weight	56.12 g/mole
Molecular formula	C4-H8
Boiling/condensation point	-6.9°C (19.6°F)
Melting/freezing point	-140°C (-220°F)
Critical temperature	144.8°C (292.6°F)
Vapor pressure	24.3 (psig)
Vapor density	1.9 (Air = 1)
Specific Volume (ft ^{3}/lb)	6.6845
Gas Density (lb/ft ^{3})	0.1496

Section 10. Stability and reactivity

Stability and reactivity	The product is stable.
Incompatibility with various substances	Extremely reactive or incompatible with the following materials: oxidizing materials.
Hazardous decomposition products	Under normal conditions of storage and use, hazardous decomposition products should not be produced.
Hazardous polymerization	Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Toxicity data

Product/ingredient name	Result	Species	Dose	Exposure
2-methylpropene	LC50 Inhalation Vapor	Rat	550000 mg/m³	4 hours

Chronic effects on humans : **CARCINOGENIC EFFECTS**: A4 (Not classifiable for humans or animals.) by ACGIH.

Other toxic effects on humans : No specific information is available in our database regarding the other toxic effects of this material to humans.

Specific effects

Carcinogenic effects : No known significant effects or critical hazards.

Mutagenic effects : No known significant effects or critical hazards.

Reproduction toxicity : No known significant effects or critical hazards.

Section 12. Ecological information

Aquatic ecotoxicity

Not available.

Products of degradation : Products of degradation: carbon oxides (CO, CO_2) and water.

Environmental fate : Not available.

Environmental hazards : No known significant effects or critical hazards.

Toxicity to the environment : Not available.

Section 13. Disposal considerations

Product removed from the cylinder must be disposed of in accordance with appropriate Federal, State, local regulation.Return cylinders with residual product to Airgas, Inc.Do not dispose of locally.

Section 14. Transport information

Regulatory information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	UN1055	ISOBUTYLENE	2.1	Not applicable (gas).		**Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: Forbidden. **Cargo aircraft** Quantity limitation: 150 kg **Special provisions** 19, T50

TDG Classification	UN1055	ISOBUTYLENE	2.1	Not applicable (gas).		**Explosive Limit and Limited Quantity Index** 0.125 **ERAP Index** 3000 **Passenger Carrying Ship Index** Forbidden **Passenger Carrying Road or Rail Index** Forbidden **Special provisions** 29
Mexico Classification	UN1055	ISOBUTYLENE	2.1	Not applicable (gas).		-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Section 15. Regulatory information

United States

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined
United States inventory (TSCA 8b): This material is listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: 2-methylpropene
SARA 311/312 MSDS distribution - chemical inventory - hazard identification:
2-methylpropene: Fire hazard, Sudden release of pressure

Clean Water Act (CWA) 307: No products were found.

Clean Water Act (CWA) 311: No products were found.

Clean Air Act (CAA) 112 regulated flammable substances: 2-methylpropene

Clean Air Act (CAA) 112 regulated toxic substances: No products were found.

State regulations : **Connecticut Carcinogen Reporting:** This material is not listed.
Connecticut Hazardous Material Survey: This material is not listed.
Florida substances: This material is not listed.
Illinois Chemical Safety Act: This material is not listed.
Illinois Toxic Substances Disclosure to Employee Act: This material is not listed.
Louisiana Reporting: This material is not listed.
Louisiana Spill: This material is not listed.
Massachusetts Spill: This material is not listed.
Massachusetts Substances: This material is listed.
Michigan Critical Material: This material is not listed.
Minnesota Hazardous Substances: This material is not listed.
New Jersey Hazardous Substances: This material is listed.

New Jersey Spill: This material is not listed.
New Jersey Toxic Catastrophe Prevention Act: This material is not listed.
New York Acutely Hazardous Substances: This material is not listed.
New York Toxic Chemical Release Reporting: This material is not listed.
Pennsylvania RTK Hazardous Substances: This material is listed.
Rhode Island Hazardous Substances: This material is not listed.

Canada

WHMIS (Canada) : Class A: Compressed gas.
Class B-1: Flammable gas.

CEPA Toxic substances: This material is not listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is not listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

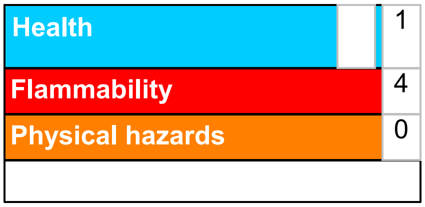
United States

Label requirements : FLAMMABLE GAS.
MAY CAUSE FLASH FIRE.
CONTENTS UNDER PRESSURE.

Canada

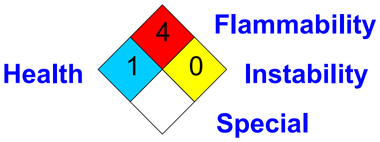
Label requirements : Class A: Compressed gas.
Class B-1: Flammable gas.

Hazardous Material Information System (U.S.A.) :



Health	1
Flammability	4
Physical hazards	0

National Fire Protection Association (U.S.A.) :



Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Material Safety Data Sheet

Methane

Section 1. Chemical product and company identification

Product name : Methane

Supplier : AIRGAS INC., on behalf of its subsidiaries
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Product use : Synthetic/Analytical chemistry.

Synonym : fire damp; marsh gas; methane (dot); methyl hydride

MSDS # : 001033

Date of Preparation/Revision : **4/1/2013.**

In case of emergency : 1-866-734-3438

Section 2. Hazards identification

Physical state : Gas. [COLORLESS GAS; MAY BE A LIQUID UNDER PRESSURE OR REFRIGERATION.]

Emergency overview : WARNING!

GAS:
CONTENTS UNDER PRESURE.
Extremely flammable.
May cause flash fire.
Do not puncture or incinerate container.
Can cause rapid suffocation.
May cause severe frostbite.
LIQUID:
Extremely flammable.
Extremely cold liquid and gas under pressure.
Can cause rapid suffocation.
May cause severe frostbite.

Keep away from heat, sparks and flame. Do not puncture or incinerate container. Use only with adequate ventilation. Keep container closed.

Contact with rapidly expanding gases or liquids can cause frostbite.

Routes of entry : Inhalation

Potential acute health effects

Eyes : Contact with rapidly expanding gas may cause burns or frostbite. Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Skin : Contact with rapidly expanding gas may cause burns or frostbite. Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Inhalation : Acts as a simple asphyxiant.

Ingestion : Ingestion is not a normal route of exposure for gases. Contact with cryogenic liquid can cause frostbite and cryogenic burns.

Medical conditions aggravated by over-exposure : Acute or chronic respiratory conditions may be aggravated by overexposure to this gas.

See toxicological information (Section 11)

Section 3. Composition, Information on Ingredients

Name	CAS number	% Volume	Exposure limits
Methane	74-82-8	100	**ACGIH TLV (United States, 1/2009).** TWA: 1000 ppm 8 hour(s).

Section 4. First aid measures

No action shall be taken involving any personal risk or without suitable training.If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus.It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

Eye contact : Check for and remove any contact lenses. Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical attention immediately.

Skin contact : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. To avoid the risk of static discharges and gas ignition, soak contaminated clothing thoroughly with water before removing it. Wash clothing before reuse. Clean shoes thoroughly before reuse. Get medical attention immediately.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Inhalation : Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Ingestion : As this product is a gas, refer to the inhalation section.

Section 5. Fire-fighting measures

Flammability of the product : Flammable.

Auto-ignition temperature : 539.85°C (1003.7°F)

Flash point : Closed cup: -188.15°C (-306.7°F).

Flammable limits : Lower: 5% Upper: 15%

Products of combustion : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Fire hazards in the presence of various substances : Extremely flammable in the presence of the following materials or conditions: open flames, sparks and static discharge and oxidizing materials.

Fire-fighting media and instructions : In case of fire, use water spray (fog), foam or dry chemical.

In case of fire, allow gas to burn if flow cannot be shut off immediately. Apply water from a safe distance to cool container and protect surrounding area. If involved in fire, shut off flow immediately if it can be done without risk.

Contains gas under pressure. Flammable gas. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions : Immediately contact emergency personnel. Keep unnecessary personnel away. Use suitable protective equipment (section 8). Shut off gas supply if this can be done safely. Isolate area until gas has dispersed.

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Methods for cleaning up : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Handling	: Use only with adequate ventilation. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. High pressure gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Keep container closed. Keep away from heat, sparks and flame. To avoid fire, eliminate ignition sources. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement. Never allow any unprotected part of the body to touch uninsulated pipes or vessels that contain cryogenic liquids. Prevent entrapment of liquid in closed systems or piping without pressure relief devices. Some materials may become brittle at low temperatures and will easily fracture.
Storage	: Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame). Segregate from oxidizing materials. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F). For additional information concerning storage and handling refer to Compressed Gas Association pamphlets P-1 Safe Handling of Compressed Gases in Containers and P-12 Safe Handling of Cryogenic Liquids available from the Compressed Gas Association, Inc.

Section 8. Exposure controls/personal protection

Engineering controls	: Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.
Personal protection	
Eyes	: Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists or dusts. When working with cryogenic liquids, wear a full face shield.
Skin	: Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Respiratory	: Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator. The applicable standards are (US) 29 CFR 1910.134 and (Canada) Z94.4-93
Hands	: Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Insulated gloves suitable for low temperatures
Personal protection in case of a large spill	: Self-contained breathing apparatus (SCBA) should be used to avoid inhalation of the product.

Product name	
methane	**ACGIH TLV (United States, 1/2009).** TWA: 1000 ppm 8 hour(s).

Consult local authorities for acceptable exposure limits.

Section 9. Physical and chemical properties

Molecular weight : 16.05 g/mole

Molecular formula : C-H4

Boiling/condensation point : -161.6°C (-258.9°F)

Melting/freezing point : -182.6°C (-296.7°F)

Critical temperature : -82.4°C (-116.3°F)

Vapor density : 0.55 (Air = 1) Liquid Density@BP: 26.5 lb/ft3 (424.5 kg/m3)

Specific Volume (ft ^{3}/lb) : 23.6128

Gas Density (lb/ft ^{3}) : 0.04235

Section 10. Stability and reactivity

Stability and reactivity : The product is stable.

Incompatibility with various substances : Extremely reactive or incompatible with the following materials: oxidizing materials.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Toxicity data

Other toxic effects on humans : No specific information is available in our database regarding the other toxic effects of this material to humans.

Specific effects

Carcinogenic effects : No known significant effects or critical hazards.

Mutagenic effects : No known significant effects or critical hazards.

Reproduction toxicity : No known significant effects or critical hazards.

Section 12. Ecological information

Aquatic ecotoxicity

Not available.

Products of degradation : Products of degradation: carbon oxides (CO, CO_2) and water.

Environmental fate : Not available.

Environmental hazards : No known significant effects or critical hazards.

Toxicity to the environment : Not available.

Section 13. Disposal considerations

Product removed from the cylinder must be disposed of in accordance with appropriate Federal, State, local regulation.Return cylinders with residual product to Airgas, Inc.Do not dispose of locally.

Section 14. Transport information

Regulatory information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	UN1971	Methane, compressed or Methane or Natural gas, compressed (with high methane content)(Methane)	2.1	Not applicable (gas).		-
	UN1972	Methane, refrigerated liquid				

TDG Classification	UN1971 UN1972	(Methane)Methane, compressed or Methane or Natural gas, compressed (with high methane content) Methane, refrigerated liquid	2.1	Not applicable (gas).		**Explosive Limit and Limited Quantity Index** 0.125 **ERAP Index** 3000 **Passenger Carrying Ship Index** Forbidden **Passenger Carrying Road or Rail Index** Forbidden
Mexico Classification	UN1971 UN1972	(Methane)Methane, compressed or Methane or Natural gas, compressed (with high methane content) Methane, refrigerated liquid	2.1	Not applicable (gas).		-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Section 15. Regulatory information

United States

U.S. Federal regulations : **United States inventory (TSCA 8b):** This material is listed or exempted.

SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: methane
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: methane: Fire hazard, Sudden release of pressure

Clean Water Act (CWA) 307: No products were found.

Clean Water Act (CWA) 311: No products were found.

Clean Air Act (CAA) 112 regulated flammable substances: methane

Clean Air Act (CAA) 112 regulated toxic substances: No products were found.

State regulations : **Connecticut Carcinogen Reporting:** This material is not listed.
Connecticut Hazardous Material Survey: This material is not listed.
Florida substances: This material is not listed.
Illinois Chemical Safety Act: This material is not listed.
Illinois Toxic Substances Disclosure to Employee Act: This material is not listed.
Louisiana Reporting: This material is not listed.
Louisiana Spill: This material is not listed.
Massachusetts Spill: This material is not listed.
Massachusetts Substances: This material is listed.
Michigan Critical Material: This material is not listed.
Minnesota Hazardous Substances: This material is not listed.
New Jersey Hazardous Substances: This material is listed.

New Jersey Spill: This material is not listed.
New Jersey Toxic Catastrophe Prevention Act: This material is not listed.
New York Acutely Hazardous Substances: This material is not listed.
New York Toxic Chemical Release Reporting: This material is not listed.
Pennsylvania RTK Hazardous Substances: This material is listed.
Rhode Island Hazardous Substances: This material is not listed.

Canada

WHMIS (Canada) : Class A: Compressed gas.
Class B-1: Flammable gas.

CEPA Toxic substances: This material is listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

United States

Label requirements : GAS:
CONTENTS UNDER PRESURE.
Extremely flammable.
May cause flash fire.
Do not puncture or incinerate container.
Can cause rapid suffocation.
May cause severe frostbite.
LIQUID:
Extremely flammable.
Extremely cold liquid and gas under pressure.
Can cause rapid suffocation.
May cause severe frostbite.

Canada

Label requirements : Class A: Compressed gas.
Class B-1: Flammable gas.

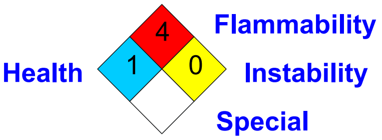
Hazardous Material Information System (U.S.A.) :

Health	1
Flammability	4
Physical hazards	0

liquid:

Health	3
Fire hazard	4
Reactivity	1
Personal protection	

National Fire Protection Association (U.S.A.) :



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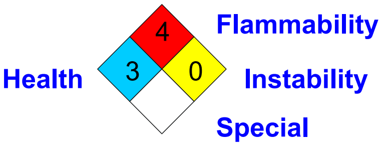

Notice to reader

Safety Data Sheet

Material Name: Portland Cement (ASTM Type I/II, ASTM Type III, ASTM Type V, Block, Plastic, Fast Set, Low Heat of Hydration)

Synonyms: Portland Cement; also known as Cement or Hydraulic Cement, Mortar, Class G

* * * Section 1 - Product and Company Identification * * *

Manufacturer Information

CALPORTLAND COMPANY
2025 E. Financial Way
Glendora, CA 91741
Phone: 626-852-6200
www.calportland.com

* * * Section 2 - Hazards Identification * * *

GHS Classification:

Acute Toxicity Oral - Category 4
Acute Toxicity Dermal - Category 4
Acute Toxicity Inhalation - Category 3
Skin Corrosion/Irritation - Category 1B
Eye Damage - Category 1
Respiratory Sensitization - Category 1
Skin Sensitization - Category 1
Carcinogenicity - Category 1A
Specific Target Organ Toxicity Repeat Exposure - Category 1

GHS LABEL ELEMENTS

Symbol(s)

Signal Word

Danger

Hazard Statements

Harmful if swallowed.
Harmful in contact with skin.
Toxic if inhaled.
Causes severe skin burns and eye damage.
Causes serious eye damage.
May cause allergy or asthma symptoms or breathing difficulties if inhaled.
May cause an allergic skin reaction.
May cause cancer.
Causes damage to organs through prolonged or repeated exposure (lungs).

Precautionary Statements

Prevention

Wash thoroughly after handling.
Do not eat, drink or smoke when using this product.
Wear protective gloves/protective clothing/eye protection/face protection.
Contaminated work clothing must not be allowed out of the workplace.
Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Do not breathe dust/fume/gas/mist/vapors/spray.
Use only outdoors or in a well-ventilated area.
In case of inadequate ventilation wear respiratory protection.

Response

If swallowed: Rinse mouth. Do NOT induce vomiting. Immediately call a poison center/doctor.
If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower. Immediately call a poison center or doctor/physician. Wash contaminated clothing before reuse.
If inhaled: Remove victim to fresh air and keep at rest in a position comfortable for breathing. If experiencing respiratory symptoms: Call a poison center or doctor/physician.
If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center/doctor.

Storage

Store in a well-ventilated place.
Store in an appropriate container or containment structure.

Disposal

Dispose of contents/container in accordance with local/regional/international regulations.

* * * Section 3 - Composition / Information on Ingredients * * *

CAS #	Component	Percent
65997-15-1	Cement, portland, chemicals	78-95
1317-65-3	Limestone	0-15
13397-24-5	Gypsum ($Ca(SO_4).2H_2O$)	5-7
14808-60-7	Quartz	0-0.3

Component Information/Information on Non-Hazardous Components

General Product Information

Trace Elements: Portland cement is made from materials mined from the earth and is processed using energy provided by fuels. Trace amounts of naturally occurring, potentially harmful chemical might be detected during chemical analysis. For example, Portland cement may contain up to 1.50 % insoluble residue, some of which may be free crystalline silica. Other trace constituents may include calcium oxide, free magnesium oxide, potassium and sodium sulfate compounds, and trace metal compounds.

* * * Section 4 - First Aid Measures * * *

First Aid: Eyes

Immediately flush eyes thoroughly with water. Continue flushing eye for at least 15 minutes, including under lids, to remove all particles. Call physician immediately.

First Aid: Skin

Wash skin with cool water and pH-neutral soap or a mild detergent intended for use on skin. Seek medical treatment in all cases of prolonged exposure to wet cement, cement mixtures, liquids from fresh cement products, or prolonged wet skin exposure to the dry cement.

First Aid: Ingestion

Do not induce vomiting. If conscious, have the victim drink plenty of water and call a physician immediately.

First Aid: Inhalation

Remove to fresh air. Seek medical help if coughing and other symptoms do not subside. (Inhalation of gross amounts of Portland cement requires immediate medical attention.)

* * * Section 5 - Fire Fighting Measures * * *

General Fire Hazards

See Section 9 for Flammability Properties.
Non-combustible.

Hazardous Combustion Products

None

Extinguishing Media

Use appropriate extinguishing media for surrounding fire.

Unsuitable Extinguishing Media

None

Fire Fighting Equipment/Instructions

Firefighters should wear full protective gear.

* * * Section 6 - Accidental Release Measures * * *

Recovery and Neutralization

Stop the flow of material, if this is without risk.

Materials and Methods for Clean-Up

Collect dry material using a scoop. Avoid actions that cause dust to become airborne. Avoid inhalation of dust and contact with skin. Scrape up wet material and place in an appropriate container. Allow the material to dry before disposal.

Emergency Measures

Isolate area. Keep unnecessary personnel away.

Personal Precautions and Protective Equipment

Wear appropriate personal protective equipment as described in Section 8.

Environmental Precautions

Do not attempt to wash Portland cement down sewers or storm drains.

Prevention of Secondary Hazards

None

* * * Section 7 - Handling and Storage * * *

Handling Procedures

Avoid prolonged or repeated breathing of dust. Avoid contact with eyes and skin. Promptly remove dusty clothing or clothing which is wet with cement fluids and launder before reuse. Wash thoroughly after exposure to dust or wet cement mixtures.

Storage Procedures

Store product in a cool, dry, ventilated area. Protect against physical damage and moisture. Keep cement dry until used. Normal temperature and pressures do not affect the material.

Incompatibilities

Wet Portland cement is alkaline. As such it is incompatible with acids, ammonium salts and aluminum metal.

* * * Section 8 - Exposure Controls / Personal Protection * * *

Component Exposure Limits

Cement, portland, chemicals (65997-15-1)

ACGIH:	1 mg/m3 TWA (particulate matter containing no asbestos and <1% crystalline silica, respirable fraction)
OSHA (Final):	15 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)
OSHA (Vacated):	10 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)
NIOSH:	10 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable dust)
Alberta:	10 mg/m3 TWA
British Columbia:	10 mg/m3 TWA (total particulate matter containing no Asbestos and <1% Crystalline silica, total particulate); 3 mg/m3 TWA (particulate matter containing no Asbestos and <1% Crystalline silica, respirable particulate)
Manitoba:	1 mg/m3 TWA (particulate matter containing no Asbestos and <1% Crystalline silica, respirable fraction)
New Brunswick:	10 mg/m3 TWA (particulate matter containing no Asbestos and <1% Crystalline silica)
NW Territories:	5 mg/m3 TWA (respirable mass); 10 mg/m3 TWA (total mass)
Nova Scotia:	1 mg/m3 TWA (particulate matter containing no Asbestos and <1% Crystalline silica, respirable fraction)
Nunavut:	5 mg/m3 TWA (respirable mass); 10 mg/m3 TWA (total mass)
Ontario:	10 mg/m3 TWA (containing no Asbestos and <1% Crystalline silica, total dust)
Quebec:	10 mg/m3 TWAEV (containing no Asbestos and <1% Crystalline silica, total dust); 5 mg/m3 TWAEV (containing no Asbestos and <1% Crystalline silica, respirable dust)
Saskatchewan:	10 mg/m3 TWA 20 mg/m3 STEL
Yukon:	30 mppcf TWA; 10 mg/m3 TWA 20 mg/m3 STEL

Limestone (1317-65-3)

OSHA (Final):	15 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)
OSHA (Vacated):	15 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)
NIOSH:	10 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable dust)
Alberta:	10 mg/m3 TWA
British Columbia:	10 mg/m3 TWA (total dust); 3 mg/m3 TWA (respirable fraction) 20 mg/m3 STEL
New Brunswick:	10 mg/m3 TWA (particulate matter containing no Asbestos and <1% Crystalline silica)
NW Territories:	5 mg/m3 TWA (respirable mass); 10 mg/m3 TWA (total mass)
Nunavut:	5 mg/m3 TWA (respirable mass); 10 mg/m3 TWA (total mass)
Quebec:	10 mg/m3 TWAEV (Limestone, containing no Asbestos and <1% Crystalline silica, total dust)
Saskatchewan:	10 mg/m3 TWA 20 mg/m3 STEL
Yukon:	30 mppcf TWA; 10 mg/m3 TWA 20 mg/m3 STEL

Gypsum (Ca(SO4).2H2O) (13397-24-5)

ACGIH:	10 mg/m3 TWA (inhalable fraction, listed under Calcium sulfate)
OSHA (Final):	15 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)
OSHA (Vacated):	15 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)
NIOSH:	10 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable dust)
Alberta:	10 mg/m3 TWA (listed under Calcium sulphate)
British Columbia:	10 mg/m3 TWA (total dust); 3 mg/m3 TWA (respirable fraction) 20 mg/m3 STEL
Manitoba:	10 mg/m3 TWA (inhalable fraction, listed under Calcium sulfate)
NW Territories:	5 mg/m3 TWA (respirable mass); 10 mg/m3 TWA (total mass)
Nova Scotia:	10 mg/m3 TWA (inhalable fraction, listed under Calcium sulfate)
Nunavut:	5 mg/m3 TWA (respirable mass); 10 mg/m3 TWA (total mass)
Ontario:	10 mg/m3 TWA (inhalable, listed under Calcium sulfate)
Quebec:	10 mg/m3 TWAEV (containing no Asbestos and <1% Crystalline silica, total dust); 5 mg/m3 TWAEV (containing no Asbestos and <1% Crystalline silica, respirable dust)
Saskatchewan:	10 mg/m3 TWA 20 mg/m3 STEL
Yukon:	30 mppcf TWA; 10 mg/m3 TWA 20 mg/m3 STEL

Quartz (14808-60-7)

ACGIH:	0.025 mg/m3 TWA (respirable fraction)
OSHA (Vacated):	0.1 mg/m3 TWA (respirable dust)
NIOSH:	0.05 mg/m3 TWA (respirable dust)
Alberta:	0.025 mg/m3 TWA (respirable particulate)
British Columbia:	ACGIH Category A2 - Suspected Human Carcinogen; IARC Category 1 - Human Carcinogen 0.025 mg/m3 TWA (respirable)
Manitoba:	0.025 mg/m3 TWA (respirable fraction)
New Brunswick:	0.1 mg/m3 TWA (respirable fraction)
NW Territories:	0.1 mg/m3 TWA (respirable mass); 0.3 mg/m3 TWA (total mass)
Nova Scotia:	0.025 mg/m3 TWA (respirable fraction)
Nunavut:	0.1 mg/m3 TWA (respirable mass); 0.3 mg/m3 TWA (total mass)
Ontario:	0.10 mg/m3 TWA (respirable fraction) 0.10 mg/m3 TWA (designated substance regulation, respirable)
Quebec:	0.1 mg/m3 TWAEV (respirable dust)
Saskatchewan:	0.05 mg/m3 TWA (respirable fraction, listed under Silica - crystalline)
Yukon:	300 particle/mL TWA (listed under Silica)

Engineering Measures

Avoid actions that cause dust to become airborne. Use local exhaust or general dilution ventilation to control exposure within applicable limits.

Personal Protective Equipment: Respiratory

Use local or general ventilation to control exposures below applicable exposure limits. NIOSH or MSHA approved particulate filter respirators should be used in the context of respiratory protection program meeting the requirements of the OSHA respiratory protection standard [29 CFR 1910.134] to control exposures when ventilation or other controls are inadequate or discomfort or irritation is experienced. Respirator and/or filter cartridge selection should be based on American National Standards Institute (ANSI) Standards Z88.2 Practices for Respiratory Protection.

Personal Protective Equipment: Hands

Where prolonged exposure to unhardened concrete products might occur, wear impervious gloves to eliminate skin contact. Do not rely on barrier creams; barrier creams should not be used in place of gloves. Periodically wash areas contacted by wet cement or its dry ingredients with a pH neutral soap and water. Wash again at the end of the work. If irritation occurs, immediately wash the affected area and seek treatment.

Personal Protective Equipment: Eyes

When engaged in activities where wet concrete or its dry ingredients could contact the eye, wear safety glasses with side shields or goggles. In extremely dusty environments and unpredictable environments, wear unvented or indirectly vented goggles to avoid eye irritation or injury. Contact lenses should not be worn when working with Portland cement or fresh cement products.

Personal Protective Equipment: Skin and Body

Where prolonged exposure to unhardened concrete products might occur, wear impervious clothing to eliminate skin contact. Where required, wear boots that are impervious to water to eliminate foot and ankle exposure. If clothing becomes saturated with wet concrete, it should be removed and replaced with clean dry clothing.

* * * Section 9 - Physical & Chemical Properties * * *

Appearance:	Gray powder.	**Odor:**	None
Physical State:	Solid	**pH:**	12-13 (in water)
Vapor Pressure:	Not Applicable	**Vapor Density:**	Not Applicable
Boiling Point:	Not Applicable	**Melting Point:**	Not Applicable
Solubility (H2O):	Slightly soluble	**Specific Gravity:**	3.15
Evaporation Rate:	Not Applicable	**VOC:**	Not Determined
Octanol/H2O Coeff.:	Not Determined	**Flash Point:**	None
Flash Point Method:	None	**Upper Flammability Limit (UFL):**	None
Lower Flammability Limit (LFL):	None	**Burning Rate:**	None
Auto Ignition:	Not Combustible		

* * * Section 10 - Chemical Stability & Reactivity Information * * *

Chemical Stability

This is a stable material.

Hazardous Reaction Potential

Will not occur.

Conditions to Avoid

Unintentional contact with water.

Incompatible Products

Wet Portland cement is alkaline. As such it is incompatible with acids, ammonium salts and aluminum metal.

Hazardous Decomposition Products

Will not spontaneously occur. Adding water results in hydration and produces (caustic) calcium hydroxide.

* * * Section 11 - Toxicological Information * * *

Acute Toxicity

Component Analysis - LD50/LC50

Quartz (14808-60-7)

Oral LD50 Rat 500 mg/kg

Potential Health Effects: Skin Corrosion Property/Stimulativeness

Discomfort or pain cannot be relied upon to alert a person to a hazardous skin exposure. Consequently, the only effective means of avoiding skin injury or illness involves minimizing skin contact, particularly contact with wet cement. Exposed persons may not feel discomfort until hours after the exposure has ended and significant injury has occurred. Exposure during the handling or mixing of the dry ingredients in Portland cement may cause drying of the skin with consequent mild irritation or more significant effects attributable to aggravation of other conditions. Exposure to wet concrete may cause more severe skin effects including thickening, cracking or fissuring of the skin. Prolonged exposure can cause severe skin damage in the form of (caustic) chemical burns.

Potential Health Effects: Eye Critical Damage/ Stimulativeness

Exposure to airborne dust during the handling or mixing of the dry ingredients in Portland cement may cause immediate or delayed irritation or inflammation. Eye contact by splashes of wet concrete may cause effects ranging from moderate eye irritation to chemical burns and blindness. Such exposures require immediate first aid (see Section 4) and medical attention to prevent significant damage to the eye.

Potential Health Effects: Ingestion

Although inadvertent ingestion of small quantities of wet concrete or its dry ingredients are not known to be harmful, accidental ingestion of larger quantities can be harmful and requires immediate medical attention.

Potential Health Effects: Inhalation

Exposure to Portland cement in excess of the applicable TLV or PEL (see section 2) may cause or aggravate other lung conditions. The ingredients in Portland cement may contain trace amounts of crystalline silica. Exposure to these ingredients in excess of the applicable TLV or PEL (see Section 2) may cause or aggravate other lung conditions. Exposure to Portland cement may cause irritation to the moist mucous membranes of the nose, throat, and upper respiratory system. It may also leave unpleasant deposits in the nose.

Respiratory Organs Sensitization/Skin Sensitization

May cause allergy or asthma symptoms or breathing difficulties if inhaled. Some individuals may exhibit an allergic response upon exposure to wet concrete. The response may appear in a variety of forms ranging from a mild rash to severe skin ulcers. Persons already sensitized may react to their first contact with the product. Other persons may first experience this effect after years of contact with Portland cement products.

Generative Cell Mutagenicity

This product is not reported to have any mutagenic effects.

Carcinogenicity

A: General Product Information

May cause cancer.

Prolonged and repeated exposure to airborne free respirable crystalline silica can result in lung disease and/or lung cancer. IARC states that crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (Group 1).

B: Component Carcinogenicity

Cement, portland, chemicals (65997-15-1)

ACGIH:	A4 - Not Classifiable as a Human Carcinogen

Quartz (14808-60-7)

ACGIH:	A2 - Suspected Human Carcinogen
NIOSH:	potential occupational carcinogen
NTP:	Known Human Carcinogen (respirable size) (Select Carcinogen)
IARC:	Monograph 100C [2012] (listed under Crystalline silica inhaled in the form of quartz or cristobalite from occupational sources); Monograph 68 [1997] (Group 1 (carcinogenic to humans))

Reproductive Toxicity

This product is not reported to have any reproductive toxicity effects.

Specified Target Organ General Toxicity: Single Exposure

This product is not reported to have any single exposure specific target organ toxicity effects.

Specified Target Organ General Toxicity: Repeated Exposure

Causes damage to organs through prolonged or repeated exposure (lungs).

Aspiration Respiratory Organs Hazard

This product is not reported to have any aspiration hazards.

* * * Section 12 - Ecological Information * * *

Ecotoxicity

A: General Product Information

This product is not reported to have any ecotoxicity effects.

B: Component Analysis - Ecotoxicity - Aquatic Toxicity

No ecotoxicity data are available for this product's components.

Persistence/Degradability

No information available for the product.

Bioaccumulation

No information available for the product.

Mobility in Soil

No information available for the product.

* * * Section 13 - Disposal Considerations * * *

Waste Disposal Instructions

See Section 7 for Handling Procedures. See Section 8 for Personal Protective Equipment recommendations.

Disposal of Contaminated Containers or Packaging

Dispose of contents/container in accordance with local/regional/national/international regulations.

* * * Section 14 - Transportation Information * * *

DOT/TDG Information

Shipping Name: Not Regulated.

* * * Section 15 - Regulatory Information * * *

Regulatory Information

US Federal Regulations

Component Analysis

None of this products components are listed under SARA Section 302 (40 CFR 355 Appendix A), SARA Section 313 (40 CFR 372.65), or CERCLA (40 CFR 302.4).

State Regulations

Component Analysis - State

The following components appear on one or more of the following state hazardous substances lists:

Component	CAS	CA	MA	MN	NJ	PA	RI
Cement, portland, chemicals	65997-15-1	No	Yes	Yes	Yes	Yes	No
Limestone	1317-65-3	No	Yes	Yes	Yes	Yes	No
Gypsum (Ca(SO4).2H2O)	13397-24-5	No	No	Yes	Yes	Yes	No
Quartz	14808-60-7	No	Yes	Yes	Yes	Yes	No

The following statement(s) are provided under the California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65):

WARNING! This product contains chemicals known to the state of California to cause cancer, birth defects, or other reproductive harm.

Component Analysis - WHMIS IDL

No components are listed in the WHMIS IDL.

Status under Workplace Hazardous Materials Information System (WHMIS), Canada

Unhardened Ready-Mix concrete is considered to be a hazardous material under the Hazardous Products Act as defined by the Controlled Products Regulations (Class E - Corrosive Material) and is therefore subject to the labeling and MSDS requirements of the Workplace Hazardous Materials Information System (WHMIS).

Status under Canadian Environmental Protection Act

Not Listed

Additional Regulatory Information

Component Analysis - Inventory

Component	CAS #	TSCA	CAN	EEC
Cement, portland, chemicals	65997-15-1	Yes	DSL	EINECS
Limestone	1317-65-3	Yes	NDSL	EINECS
Gypsum (Ca(SO4).2H2O)	13397-24-5	No	DSL	No
Quartz	14808-60-7	Yes	DSL	EINECS

* * * Section 16 - Other Information * * *

Hazardous Material Information System (HMIS):	**Health**	**1**
	Flammability	**0**
	Physical Hazard	**0**
	Personal Protection	**B**

NFPA/HMIS Definitions: 0-Least, 1-Slight, 2-Moderate, 3-High, 4-Extreme
Protective Equipment: Safety glasses, gloves

Key/Legend

EPA = Environmental Protection Agency; TSCA = Toxic Substance Control Act; ACGIH = American Conference of Governmental Industrial Hygienists; IARC = International Agency for Research on Cancer; NIOSH = National Institute for Occupational Safety and Health; NTP = National Toxicology Program; OSHA = Occupational Safety and Health Administration., NJTSR = New Jersey Trade Secret Registry.

Literature References

None

Other Information

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