PNG ENVIRONMENTAL, INC.

MEMORANDUM

To: Steve Teel, Department of Ecology

From: Martin Acaster and John Kuhlman

Date: March 10, 2010

Subject: Milton's RI – Revised Vapor Intrusion Assessment Work Plan

PNG Environmental Inc. (PNG) has completed a preliminary assessment of the potential for Vapor Intrusion (VI) exposure at the Milton's remedial investigation (RI) site. The goal of the preliminary assessment was to determine whether any potential exists for toxic vapors to be present in the subsurface that could migrate and enter buildings in the Milton's site area. This memorandum presents a summary of the applicability of the Washington State Department of Ecology (Ecology) VI Assessment guidance, a discussion of preliminary assessment findings, and a proposed work plan for VI Assessment activities requested by Ecology for the Milton's site vicinity.

Based on Ecology's review of PNG's November 9, 2009 Soil Gas Sampling Report and February 25, 2010 comments on the draft Vapor Intrusion Assessment Work Plan submitted on January 8, 2010, Ecology has requested that at a minimum the work plan include the following:

- A preferential contaminant migration pathways investigation will be conducted for the former Milton's Dry Cleaners property to evaluate potential sources as they relate to future remediation efforts for shallow groundwater and soil vapor, and deeper groundwater plume(s). This will include a characterization of the building construction, identification of current and historic utilities and other piping or wells, interviews with former employees to identify site practices related to tetrachloroethene (PCE), and active investigation with techniques such as geophysical surveys and utility tracing using smoke or dye tracer methods.
- Indoor air and sub-slab samples will be collected from the former Milton's Dry Cleaners building due to its proximity to the contaminant source.
- Indoor air sampling on the Markel Property. Sample T67 showed the highest concentrations of PCE soil vapor concentrations (430 micrograms per cubic meter [ug/m^3]). Ecology's draft soil vapor guidance screening level for PCE is 4.2 ug/m^3.
- Indoor air sampling and, if allowed, sub-slab vapor sampling at the WFR Partnership "Rodeo Bingo" Property. Although indoor air sampling has been previously conducted at this property, Ecology has expressed concerns regarding the existing data and has requested additional sampling.
- Indoor air sampling in Fort Vancouver High School. Sample location T15 adjacent to the high school building showed the highest trichloroethene (TCE) soil vapor concentrations (12.9 ug/m^3). Ecology's draft soil vapor guidance screening level for TCE is 1 ug/m^3.

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- A general survey of building use (for example residential, commercial, industrial, schools and day care) and occupant exposure scenarios (children and/or adults) within the known groundwater contamination plume area shall be conducted to help evaluate the need for additional soil vapor investigation.

In addition, Ecology specified that this vapor intrusion work plan should be consistent with Ecology's draft soil vapor intrusion guidance document and other applicable guidance as referenced in the November 9, 2009 Soil Gas Sampling Report. Ecology's draft guidance indicates that the former Milton's Dry Cleaners Building, Markel Building, WFR Partnership Property, and Fort Vancouver High School properties require a Tier II VI Assessment category based on existing data. In our discussion on January 6, 2010, you agreed that the remainder of the Milton's site area will be evaluated through a general survey of building use that may be followed by additional Tier I VI Assessment activities. Following the general survey of the of the Milton's site area, PNG will coordinate with Ecology to discuss and refine the scope of any additional Tier I and Tier II VI Assessment that may be necessary for other potentially at risk and sensitive use properties (e.g. residences, child care, assisted living, or medical facilities) identified in the Milton's site area.

ECOLOGY VAPOR INTRUSION ASSESSMENT GUIDANCE

In accordance with Ecology's recently published draft guidance for vapor intrusion (Ecology 2009), PNG's preliminary assessment addressed the following questions:

- Are chemicals of sufficient volatility and toxicity known or reasonably suspected to be present?
- Are occupied buildings present (or could they be constructed in the future) above or near site contamination?

Ecology's draft guidance establishes a proposed methodology for characterizing and evaluating the vapor intrusion exposure pathway, and includes a decision matrix including triggers for supplemental investigation and cleanup tasks based on comparing site-specific vapor concentrations to default numeric soil gas and/or indoor air screening level values (SLVs). As indicated on Table B-1 of the draft guidance, Ecology's proposed risk-based shallow soil gas SLVs for the main chemicals of interest (COIs) identified at the Milton's site are as follows:

- PCE = 4.2 ug/m^3.
- TCE = 1 ug/m^3.

The soil gas SLVs are included along with recent soil gas data on Table 1 (attached). Ecology developed these soil gas SLVs based on dividing an "indoor air cleanup level" by a "residential attenuation factor" of 0.1. Ecology's proposed attenuation value of 0.1 applies to sub-slab and soil vapors collected within 15 feet of the ground surface and is three times lower (more conservative) than EPA's empirically-derived soil gas to indoor air attenuation factor for a 95th percentile upper confidence limit (EPA 2008) and orders of magnitude lower than the majority of attenuation factors.

VAPOR INTRUSION PRELIMINARY ASSESSMENT FINDINGS

To date PNG has collected soil gas samples at 19 locations in the Milton's site area. PCE and TCE were detected in all analyzed soil gas samples. PCE concentrations ranged from 0.7 to 430 ug/m³. TCE concentrations ranged from 0.17 to 12.9 ug/m³. PCE and/or TCE concentrations at 18 of 19 soil gas sampling locations exceeded the draft Ecology screening levels (4.2 ug/m³ for PCE and 1.0 ug/m³ for TCE) for soil gas collected from a depth of 15 feet or less.

Comparison of the analytical results for soil gas samples collected from soil borings distributed throughout the Milton's site area to the Ecology screening levels (Table 1) indicates that chemicals of sufficient volatility and toxicity (PCE and TCE) are present in the subsurface. Based on the distribution of the detected volatile organic compounds (VOCs) in the Milton's site area (Figure 1), occupied buildings are present above and near site contamination. Consequently, Ecology guidance considers further assessment to be necessary.

Based on a weight of evidence approach that includes groundwater and soil gas data, the distribution of PCE and TCE in soil gas and the ratio of PCE to TCE in the analyzed samples suggest there may be three potentially distinct or overlapping sources of these VOCs in the broader Milton's area of concern (AOC).

Sub-Area of Concern 1

The first sub-area of concern (AOC 1) appears to be located at the Milton's property and is characterized by the greatest PCE concentrations (43.6 to 430 ug/m³) and relatively high PCE to TCE ratios (39.3 to 120.8) (Figure 1). The Markel Building, located at 6615 NE Fourth Plain Boulevard, is located in the vicinity of the greatest PCE concentration and has been selected for Tier II VI Assessment as described below. Due to its proximity to the contaminant source, the former Milton's Dry Cleaners building has also been selected for Tier II VI Assessment. Both the PCE concentration and the PCE to TCE ratio decrease with increasing distance from the Milton's property. AOC 1 appears to extend as far south as NE Campus Drive (approximately 1,500 feet south of Milton's) as defined by soil gas sampling location GT58 (PCE at 1.87 ug/m³ and a PCE to TCE ratio of 0.75).

Ecology has also expressed concerns regarding existing indoor/outdoor air sampling data collected by PBS Engineering + Environmental at the WFR Partnership "Rodeo Bingo" Property (Ecology February 25, 2010). This property is located at 2901 NE 65th Avenue. Ecology's main concerns focus on the following general issues:

- Laboratory reporting limits for both indoor and outdoor air samples were above Model Toxics Control Act (MTCA) Method B cleanup levels and are not acceptable. In addition, the list of VOCs analyzed was incomplete as it did not include all of the degradation products of PCE.
- Building construction details were inadequately characterized which may have caused the sampling rationale and methodology to omit several important details. Samples were also collected over a 24-hour period rather than the standard eight hour period for commercial buildings.

Due to these concerns Ecology has requested indoor air samples, and if allowed, sub-slab samples, be collected from the WFR Partnership Property and that it be evaluated as part of the Tier II VI Assessment.

Sub-Area of Concern 2

The second sub-area (AOC 2) is located near a cluster of buildings located approximately 1,750 feet south of Milton's. This group of buildings includes the Christensen Group property at 2500 NE 65th Avenue, the C-Tran property at 2425 NE 65th Avenue, and the John C Hallman property located at 2511 NE 65th Avenue which is occupied by D&E Autocare and Triple J Towing. This second potential source area is characterized by lower PCE concentrations (ranging from 32.6 to 76.6 ug/m³) and lower PCE to TCE ratios (4.2 to 51.4) than those observed in AOC 1. AOC 2 appears to be separated from AOC 1 to the north by soil gas sampling location GT58 and groundwater samples collected at intervening locations where PCE was not detected.

Sub-Area of Concern 3

The third suspected sub-area (AOC 3) is located in the vicinity of Fort Vancouver High School. The Fort Vancouver High School Building, located approximately 3,250 feet southwest of Milton's at 5700 E 18th Street, is located in the vicinity of the greatest TCE concentrations (3.5 to 12.9 ug/m³) and has been selected for Tier II VI Assessment as described below. This third potential source area, when compared to both AOC 1 and AOC 2, is characterized by lower PCE concentrations (0.7 to 15 ug/m³) and PCE to TCE ratios that are near or below 1.0. The boundaries of AOC 3 have not been defined; however, the eastern extent of AOC 3 appears to be constrained by the western extent of AOC 2 (PCE:TCE >4.0).

These three AOC's comprise the broader Milton's AOC targeted by Ecology to be included in the general building use survey as described below.

PROPOSED SCOPE OF WORK

At Ecology's request, PNG has developed a phased work plan for the performance of VI Assessment tasks at the Former Milton's Dry Cleaners Building, Markel Building, WFR Partnership "Rodeo Bingo" property, and Fort Vancouver High School properties and a general survey of building use in the broader Milton's site AOC.

Although Ecology's draft guidance is subject to modification following the comment period, PNG's soil gas sampling approach is consistent with the guidance regarding sampling methodology, analytical testing methods, data evaluation, and attenuation factor concepts. Additionally, PNG methodology and Ecology's guidance are both fundamentally based on current published federal guidance documents including (among others) U.S. Environmental Protection Agency (EPA 2008, DiGiulio et al. 2006), and Interstate Technology and Regulatory Council (ITRC 2007). PNG's approach also incorporates current state-level vapor intrusion guidance published by California EPA (CalEPA 2005), and New Jersey Department of Environmental Protection (NJDEP 2005).

Among these published guidance documents, there is general consensus on the applicability and methodology of using properly-collected soil gas data to estimate the flux of vapors to indoor settings. We note, however, that Ecology's selection of a soil gas to indoor air attenuation factor value of 0.1 is much lower than attenuation values observed by EPA and implemented by other states.

Extensive literature documents that measurable background concentrations of VOCs are present in indoor and outdoor air, particularly in urban and suburban environments. Although PNG is not aware of a background indoor or outdoor air VOC evaluation at the subject site, many published studies provide empirical data that can be used to approximate the reasonable bounds of background indoor and outdoor air concentrations in similar localities (DEQ 2006; EPA 2008; EPA 1999; EPA 1998; NYSDOH 2006; CalARB 2001; Sexton et al., 2004; EPRI 2005). Based on these studies, indoor air background concentrations are generally observed to be greater than values reported for outdoor air, likely due to the contribution of common indoor air sources of volatile chemicals (EPA 2008, EPRI 2005). The literature confirms that PCE and other VOCs are common residential and urban background contaminants, but indicates that substantial variability in concentrations (two to three orders of magnitude) is observed. Background air quality data for selected VOCs are summarized for reference on Table 1.

The VI Assessment tasks to be performed will be conducted in accordance with Ecology's published draft guidance and are detailed below.

Former Milton's Dry Cleaners Building Preferential Pathways Evaluation

In a December 31, 2009 letter Ecology stated: "possible preferential pathways for contaminant migration (such as underground utility corridors, septic systems, dry wells, and water production wells) in the vicinity of the property and area of contamination must be evaluated." In an attempt to identify potential source areas and aid in identifying migration pathways, Ecology also requested that PNG characterize past dry cleaning practices such as chemical delivery, storage, use, and disposal practices. This investigation will be conducted in two stages with the first to include:

- Perform a thorough building and site survey to determine construction conditions and history, current and historic utility lines including discharge points, abandonment techniques for any historic utility lines, drainage pathways, dry wells, historic water wells, or other physical features that could represent or effect a migration pathway.
- Research information on past dry-cleaning chemical handling, including the historic locations and techniques for PCE delivery, storage, use, and disposal practices. Interviews will be conducted with former operators and site documents obtained and reviewed. Disposal records will be requested from former operators and obtained through agency file review. A summary of historic dry cleaning practices may also provide data as to locations to target for investigation.

Data described above will be compiled to update the site-specific conceptual model as it relates to potential source areas and pathways. PNG will prepare a focused work plan to investigate subsurface conditions in the unsaturated zone that will include multiple techniques:

- Confirm mapped and suspected utility locations and pathways using geophysical techniques such as ground penetrating radar, magnetometers, and electronic tracing.
- Perform smoke or dye testing of current and historic drainage features in an attempt to map lines and identify discharge pathways.

- Perform targeted excavations to verify geophysics or historic utility maps and evaluate the potential for source area or migration pathways.

Following the completion of the preferential pathways evaluation, PNG will incorporate historical site practice and utility information into the Tier II site specific work plan. Ecology has specifically requested indoor air and sub-slab vapor samples be collected at this site. The location and number of these samples will optimized based on results of the preferential pathway and past practices evaluation described above. Details of PNG's approach to indoor air and sub-slab vapor sampling are provided below with the general methodology for all of the targeted buildings.

Tier II Vapor Intrusion Assessment

PNG has developed a phased approach for Tier II VI Assessment activities for the four properties specified by Ecology. These properties include the former Milton's Dry Cleaners Property, Markel Building, WFR Partnership "Rodeo Bingo" Property, and Fort Vancouver High School properties.

Tier II VI Assessment activities for each of the facilities will be implemented in two steps and will include the following:

Development of Conceptual Site Model

- Obtain site access agreements for each of the four properties specified by Ecology to allow for Tier II VI Assessment activities.
- Conduct site occupant outreach meetings in conjunction with Ecology to educate owners and occupants of the four properties with regard to the scope and implication of the Tier II VI Assessment activities that will be performed at each facility. A critical element of this outreach is to identify the potential for the characterization of background concentrations of VOCs that may be present in the building that exceed Ecology's health based standards that may not be attributable to the Milton's site.
- Perform a site survey to determine property information to facilitate the development of a conceptual site model. Site information to be obtained would include: determining site occupancy and use; ownership; building type; evaluation of indoor air flow; identification of foundation and construction characteristics; identification of cracks, seams, or other preferential indoor vapor migration pathways in foundation materials; determination of heating, ventilation, and air conditioning systems; identifying factors that may influence indoor air quality; identifying types and locations of utilities; detailed floor plans; detailed building surroundings; and compilation of an inventory of products in use in the building that have the potential to affect indoor air quality.
- Develop a conceptual site model for each building. Each conceptual site model will include: a plan view drawing of the building showing its spatial relationship to the VOC source; a drawing of the airflow pathways for the building and its HVAC system including notations for any portions of the building that are pressurized during operation of the HVAC system; a cross-sectional view of the building, unsaturated zone, and shallow groundwater zone; and a narrative that provides explanations for any critical assumptions made in depicting site conditions.

- Update the site Health and Safety Plan to guide field safety protocols, in accordance with rules established by the Occupational Safety and Health Administration (OSHA) and Washington Industrial Safety and Health Act (WISHA).
- Perform site visit to mark proposed sampling locations for utility location purposes.
- Request utility identification through the public Northwest Utility Notification Center (NUNC) as required before drilling.
- Contract with a qualified local firm to attempt to identify underground utility trenches and conduits located at each planned drilling location to clear the selected locations for drilling and sampling.
- Develop and implement a site specific sampling and analysis plan for each building in the Tier II VI Assessment based on the conceptual model for each building. Sampling methodologies that would be applied at each building may include: indoor air sampling; sub-slab soil gas sampling; and outdoor ambient air sampling. Note that Ecology has specifically stated that both indoor air and sub-slab samples shall be collected at the former Milton's Dry Cleaners building.
- Meet with Ecology and the building owner to obtain approval for the site specific sampling and analysis plan.

Indoor Air Vapor Intrusion Assessment

- Prior to indoor air sampling, indoor sources of VOCs will be removed from the facility to the extent practicable. Potential indoor sources of VOCs may include: cleaning solutions; solvents, paints, adhesives, cigarette smoke, and automobile exhaust from attached garages. Following removal of these potential indoor VOC sources the building should be well ventilated before sampling begins.
- Time-integrated sub-slab soil vapor samples from vapor monitoring points installed through the facility floor and indoor and outdoor air samples will be collected from the breathing zones of each of the potentially impacted structures and their respective outdoor areas. Breathing zone height will be established by the site specific work plan but, in genera,l will target the most sensitive receptor (i.e. if children are commonly present in the structure, breathing zone height will be lower). Sub-slab soil vapor samples will be collected using one-liter Summa canisters. Indoor and outdoor air samples will be collected into six-liter Summa canisters. Canisters will be laboratory prepared and certified and under a vacuum of at least -28.5 inHg. Included with each canister is a flow control device that is calibrated by the laboratory to fill the canister at a specified rate. For the sub-slab samples the rate is approximately 0.2 liters per minute. Each sample will be collected over a 30-minute period. For the air samples at the Markel Building and the Fort Vancouver High School, the rate will be approximately three-quarters of a liter per hour. Each sample will be collected over an eight-hour period.
- The indoor and outdoor air samples will be collected from locations selected based on the site conceptual model developed for each building. The canister with the flow control device attached is placed in the desired location, the control

valve on the canister is opened, and the vacuum in the canister draws the sample in. After approximately eight hours and when the vacuum in the canister is between approximately -0.1 and -9 inHg, the canister valve is closed, the canister is removed from the sample location, the flow control device is removed from the canister, and the canister is labeled for shipment to the project laboratory for analysis.

- Analyze indoor air, sub-slab soil gas, and outdoor ambient air samples for target VOCs by EPA Method TO-15 SIM.
- Perform an evaluation of indoor air, sub-slab soil gas, and outdoor ambient air laboratory data to determine the likely contribution of soil gas to indoor air quality at each Tier II VI Assessment building location.
- Prepare a technical memorandum documenting the findings of Tier II VI Assessment for each building assessed. The technical memorandum will include recommendations for further actions that may be necessary at each building. Further actions may include: additional sampling of indoor air, sub-slab soil gas, and ambient outdoor air as well as design and implementation of engineering controls to eliminate or reduce soil gas migration to indoor air.

PNG will apply the following basic decision matrix to determine what further actions may be necessary:

- If indoor air and sub-slab soil gas VOC concentrations clearly do not exceed Ecology screening levels, additional VI Assessment is not warranted at that location, subject to Ecology approval. PNG notes that the Ecology guidance indicates that additional sampling may be necessary to evaluate seasonal variation in outdoor/indoor air and sub-slab soil gas concentrations.
- If indoor air and sub-slab soil gas VOC concentrations slightly exceed Ecology screening levels, additional vapor investigation and/or remedial action may be warranted at that location and will be further evaluated in consultation with Ecology.
- If indoor air and sub-slab soil gas VOC concentrations greatly exceed Ecology screening levels, additional vapor investigation and/or remedial action is likely to be warranted at that location and will be further evaluated in consultation with Ecology.

Milton's Site Area General Building Use Survey Activities

As directed by Ecology, PNG will perform a Tier I general building use survey of the Milton's site area to characterize property and building use as follows:

- Building ownership and construction details including: name of building (if any), actual street address of the building, owner of building, owner contact information, date of construction, type of construction, number of floors, total area of the ground floor and basement/crawlspace (if present), type of HVAC system in use in the building, and type of utilities that service the building.
- Building occupant details including: type of occupants, number of occupants, occupant site activities, and days and/or hours of use of each building by the building occupants.

- Survey will be performed initially via telephone followed up by door to door interviews if survey forms cannot be completed via telephone or building occupants cannot supply sufficient technical information.

PNG will compile a building survey summary documenting the source of the information provided for each property in the Milton's site area.

If determined to be necessary by the findings of the general survey of building use, additional Tier I and/or Tier II VI Assessment tasks may be necessary. Additional Tier I tasks may include additional soil gas sampling from locations that are exterior and adjacent to buildings at properties that are identified as potentially sensitive by the building use survey.

Following the collection of this additional data, the potential VI risk will be evaluated for specified buildings utilizing multiple lines of evidence potentially including: the Johnson Ettinger Model (JEM), regional and site specific soil characteristics, and soil, groundwater, and soil gas results. Tier I findings for the larger Milton's site area will be presented in a technical memorandum and discussed with Ecology. Copies of the completed building use survey forms will be provided to Ecology as part of the Tier I assessment. Based on Tier I VI Assessment findings the VI Assessment process may be terminated at that time or extended into Tier II VI Assessment for selected potentially sensitive use properties. Tier II VI Assessment if it is performed would include sub-slab soil gas sampling, indoor air sampling, and ambient outdoor air sampling as required per Ecology guidance.

PROPOSED SCHEDULE

PNG proposes to initiate VI Assessment work plan activities within one week after receiving Ecology approval to proceed with the VI Assessment work plan. The schedule for Tier II VI Assessment activities at the Markel Building and Fort Vancouver High School will be largely dependent on property owners and site operators allowing access to their buildings for performance of Tier II VI Assessment activities. Completion of the general survey of building use in the Milton's site vicinity will be dependent on the availability and willingness of site occupants to participate in the survey. The timing of access agreements may also cause adjustments in the proposed sampling order of any Tier I VI Assessment activities that may be required following completion of the general survey. PNG will attempt to perform Tier I VI Assessment field work in as timely a manner as the negotiation of site access agreements will allow. Tier II VI Assessment activities at areas other than the Markel Building and Fort Vancouver High School if determined to be necessary will be initiated at the completion of Tier I VI Assessment of the additional properties.

Attachments: Table 1 – Soil Gas Analytical Results – VOCs
Figure 1 – PCE and TCE in Soil Gas
Sampling and Analysis Plan
Quality Assurance Project Plan

REFERENCES

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TABLE

Table 1
Soil Gas Analytical Results (ug/m ^{3})
Milton's Dry Cleaners RI
Vancouver, Washington

Sample Identification	Sample Date	PCE	TCE	1,1-DCE	trans-1,2-DCE	cis-1,2-DCE	Vinyl Chloride
T14-SG	08/07/2008	0.7 J	8.5	0.12 J	1.6 U	0.26 J	1 U
T15-SG	08/07/2008	15	12.9	0.17 J	0.033 J	0.29 J	1 U
FD1 (T15 Duplicate)	08/07/2008	14.1	12.1	0.21 J	0.051 J	0.15 J	1 U
T16-SG	08/07/2008	10.6	9.7	0.15 J	0.17 J	0.31 J	0.054 J
T17-SG	08/07/2008	1.2 J	3.5	0.11 J	0.037 J	1.6 U	1 U
T18-SG	08/07/2008	12.1	11.7	0.076 J	1.6 U	1.6 U	1 U
T19-SG	08/07/2008	1.3 J	9	0.015 J	1.6 U	0.23 J	1 U
T49-SG	09/02/2009	3.5	0.425 J	1.25 U	1.25 U	0.386 J	0.0697 J
T51-SG	09/02/2009	**55.5**	0.661 J	0.355 J	1.16 U	1.16 U	0.749 U
T52-SG	09/02/2009	**108**	**2.4**	1.24 U	1.24 U	1.24 U	0.801 U
T53-SG	09/02/2009	**36**	**1.85**	1.19 U	1.19 U	0.536 J	0.764 U
T54-SG	09/02/2009	**32.7**	0.347 J	1.19 U	1.19 U	1.19 U	0.77 U
T54 Dup	09/02/2009	**36.6**	**1.04** J	0.127 J	1.22 U	1.22 U	0.785 U
T55-SG	09/03/2009	**15**	**1.23** J	0.227 J	1.07 U	1.07 U	0.692 U
T58-SG	09/02/2009	1.87 J	**2.5**	0.46 J	0.054 J	0.233 J	0.738 U
T59-SG	09/03/2009	**46**	**11**	4.96	1.19 U	0.269 J	0.0926 J
T60-SG	09/01/2009	**63.7**	**1.62**	0.392 J	1.19 U	1.19 U	0.118 J
T60 Dup	09/01/2009	**60.9**	0.457 J	1.22 U	1.22 U	0.0553 J	0.785 U
T61-SG	09/01/2009	**43.6**	0.557 J	1.15 U	1.15 U	0.839 J	0.738 U
T67-SG	09/02/2009	**430**	**3.56**	1.74	1.2 U	0.209 J	0.072 J
T71-SG	09/02/2009	**7.59**	0.167 J	1.23 U	1.23 U	1.23 U	0.796 U
T73-SG	09/03/2009	**76.6**	**1.49** J	1.22 U	1.22 U	0.0621 J	0.785 U
Ecology Screening Level Values [a]							
Indoor Air		0.42	0.1	91	32	16	0.28
Subslab		4.2	1	910	320	160	2.8
Soil Gas < 15 feet depth		4.2	1	910	320	160	2.8
Soil Gas > 15 feet depth		42	10	9,100	3,200	1,600	28
Ecology Reference (Milton's-specific)		42	10	NA	NA	NA	NA
Background & Ambient Air Concentrations							
Residential Background Indoor Air [a]		0.7 to 42	0.1 to 19	≤ 1	U	≤ 7	≤ 0.4
Background Ambient Outdoor Air [b,c]		0.2 to 3.4	0.2 to 2.7	NA	NA	NA	0.1 to 1.3

Notes:

[a] USEPA *Vapor Intrusion Database,* Table 4a (March 4, 2008), data represent range between 50th percentile and maximum values

[b] Oregon DEQ and USEPA *Portland Air Toxics Assessment* (2006), data represent mean values from five sampling locations

[c] USEPA *National-Scale Air Toxics Assessment,* Table 1 (2006), data represent range between 50th percentile and maximum values

Volatile Organic Compond (VOC) analysis by EPA Method TO-15 SIM

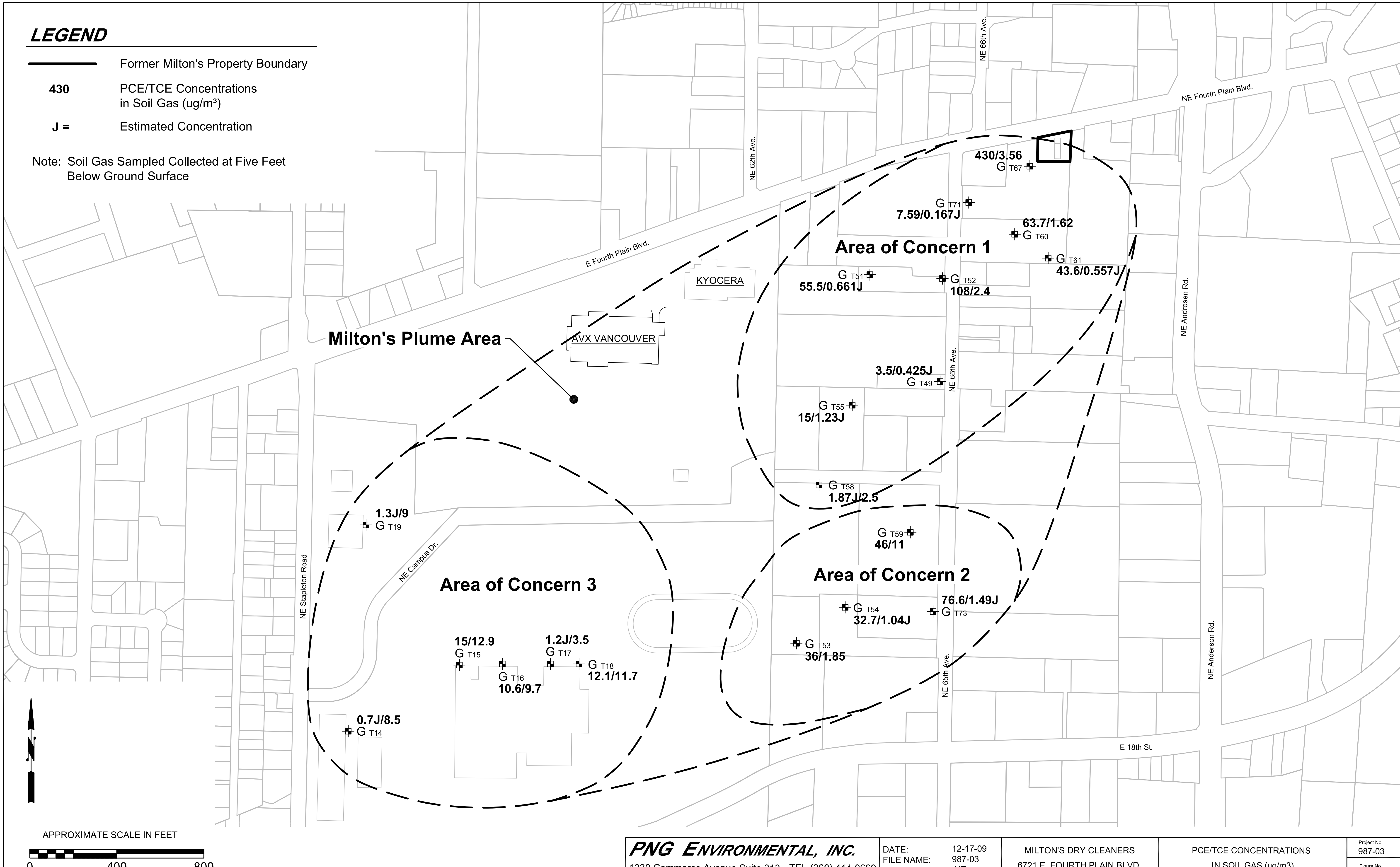
Soil gas screening levels provided by Ecology in work plan comment letter dated May 21, 2008.

ug/m^3 = micrograms per cubic meter

U = Undetected above the laboratory's method reporting limit (MRL).

J = Estimated value. The results fell between the laboratory's practical quantification limit (PQL) and the MRL.

FIGURE



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PCE/TCE CONCENTRATIONS IN SOIL GAS (ug/m3)

Project No. 987-03

Figure No. 1

APPENDIX A

SAP

APPENDIX A

SAMPLING AND ANALYSIS PLAN

REMEDIAL INVESTIGATION
Remedial Investigation/Risk Assessment/Feasibility Study
Milton's Dry Cleaners
Vancouver, Washington

Ecology Facility Site ID: 19779

Prepared for:

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987-03
March 10, 2010

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1 INTRODUCTION

This document presents the sampling and analysis plan (SAP) for a Remedial Investigation/Risk Assessment/Feasibility Study (RI/RA/FS) at the Milton's Dry Cleaner (Milton's) site located in Vancouver, Washington (Figure 1). Specific objectives for the RI/RA/FS are described in the RI/RA/FS Work Plan. This work is being conducted under Agreed Order No. DE4239 07/4-TC-S between Ms. Lila Rears/Mr. Pat Milton and the Washington State Department of Ecology (Ecology).

Groundwater, soil, and soil gas sampling for the RI will be conducted in conjunction with soil borings and monitoring well installation described in the main text of this SAP. When practical, limited procedural changes can be made to this plan, as long they are documented and minimum Quality Assurance/Quality Control (QA/QC) requirements are met. The reason for the change in procedure will be noted in the daily field reports.

1.1 SITE DESCRIPTION AND BACKGROUND

The Milton's site is located at 6721 NE Fourth Plain Boulevard in Vancouver, Washington. The history of the site and surrounding area and summaries of previous investigations are presented in the Site Description section of the RI/RA/FS Work Plan.

1.2 SUPPORTING DOCUMENTS

The RI/RA/FS Work Plan for the Milton's site provides the original objectives, approach, and rationale for the investigation. This Work Plan also provides details of previous studies and existing data. Future objectives and approach will change as additional site data is collected and analyzed allowing for refinement of the site conceptual model.

Project-specific standard operating procedures (SOPs) referenced in this SAP are provided in Appendix SAP-1. The SOPs describe specific procedures and methods to be used for the field and laboratory activities. Examples of standard field forms to be used during the completion of fieldwork described in the SAP are included in Appendix SAP-2.

The quality assurance project plan (QAPP), which details quality assurance goals, requirements, and guidelines for all sample analyses, was previously provided as Appendix B to the RI/RA/FS Work Plan.

The health and safety plan (HASP), previously submitted, addresses possible health hazards that could be encountered during fieldwork and the procedures to be followed to protect personnel. The site HASP will be modified if data indicates significantly different contaminant conditions exist then are currently anticipated at the site.

2 SAMPLING OBJECTIVES

The RI/RA/FS Work Plan includes a full discussion of the data needs and objectives for this investigation.

The investigation work will be conducted in phases with follow-up tasks performed to fill data gaps and/or further characterize the nature and extent of tetrachloroethene (PCE) contamination. This SAP covers all field activities currently expected under historic and future anticipated data needs for the multiple phases of investigation at the Milton's site. Field activities and procedures for investigation activities not covered within this SAP will be addressed in a SAP addendum after scoping of additional work is complete.

3 SAMPLE LOCATION AND FREQUENCY

The scope of work for the current phase of investigation includes the following field elements (for more information see the Vapor Intrusion Assessment Work Plan):

- A preferential contaminant migration pathways investigation will be conducted for the former Milton's Dry Cleaners property to evaluate potential sources as they relate to future remediation efforts for shallow groundwater and soil vapor, and deeper groundwater plume(s). This will include a characterization of the building construction, identification of current and historic utilities and other piping or wells, interviews with former employees to identify site practices related to PCE, and active investigation with techniques such as geophysical surveys and utility tracing using smoke or dye tracer methods.
- Indoor air and sub-slab samples shall also be collected from the former Milton's Dry Cleaners building due to its proximity to the contaminant source.
- Indoor air sampling on the Markel Property. Sample T67 showed the highest concentrations of PCE soil vapor concentrations (430 micrograms per cubic meter [ug/m^3]). Ecology's draft soil vapor guidance screening level for PCE is 4.2 ug/m^3.
- Indoor air sampling and, if allowed, sub-slab vapor sampling at the WFR Partnership "Rodeo Bingo" Property. Although indoor air sampling has been previously conducted at this property, Ecology has expressed concerns regarding the existing data and has requested additional sampling.
- Indoor air sampling in Fort Vancouver High School. Sample location T15 adjacent to the high school building showed the highest trichloroethene (TCE) soil vapor concentrations (12.9 ug/m^3). Ecology's draft soil vapor guidance screening level for TCE is 1 ug/m^3.
- A general survey of building use (for example residential, commercial, industrial, schools and day care) and occupant exposure scenarios (children and/or adults) within the known groundwater contamination plume area shall be conducted to help evaluate the need for additional soil vapor investigation.

Future investigation tasks will be determined based on site data and the conceptual site model. Similar to historic tasks, these tasks may include:

- Perform direct-push "Geoprobe" investigations to collect screening level data from soil, groundwater, and/or soil vapor.
- Drill and install monitoring wells the better define the groundwater plume area and extent. Monitoring wells may be screened in shallow aquifer zones or within the regional Troutdale formation.
- Drill and install permanent multi-level soil gas monitoring points to better define the soil vapor plume and extent.
- Conduct routine quarterly groundwater monitoring

Proposed field elements are discussed in detail in the phased work plans issued for the site.

4 SAMPLING METHODS AND PROCEDURES

Sampling methods and procedures that will be used during the RI include: field screening, Geoprobe drilling method, Sonic drilling method, monitoring well installation, monitoring well development and sampling, decontamination, surveying, groundwater monitoring, installation of a staff gauge in the bioswale, and management of investigation derived wastes (IDW). Details of these procedures are provided below. All SOPs are located in Appendix SAP-1.

4.1 FIELD SCREENING METHODS

Field screening will include the visual and olfactory observation of soil and water samples obtained during the RI. In addition, filed instrumentation will be utilized to screen soil for the presence of volatile organic compounds (VOCs). A description of these methods is provided below.

4.1.1 Soil Observation

Soil cores produced by the Geoprobe and Sonic drilling methods will be observed by the field geologist and each borehole will be logged using the unified soil classification systems (USCS) in general accordance with ASTM Method D-2488 as described in SOP 1 and SOP 2. The field geologist will note contact depths of changes in lithologic composition, soil characteristics, the presence of staining, odor, moisture, and any other relevant observation and include them on the respective boring log.

4.1.2 Photo Ionization Detector

Each sample will be field screened for the presence of VOCs using a photo-ionization detector (PID), and by observing staining, discoloration, or sheen as described in SOP 3. During field screening, the soil core is opened and immediately measured in close proximity by the PID. The PID will utilize a 11.7 Mv bulb (to detect chlorinated solvents potentially present). Depending on sample recovery, shallow (top of soil core), intermediate, and deep (bottom of the soil core) soil samples are then placed into dedicated new zipping plastic bags, sealed, labeled accordingly, and then screened by penetrating the bag with the PID probe. Volatile headspace readings are recorded at this time. This screening interval can be adjusted based on observance of heterogeneity in the soil or visual contamination. The bagged soil is then used to perform the sheen testing and visual observations. By performing this screening immediately upon retrieval of the soil core, effects of outside air temperature on the volatility of any contaminants are minimized. The soil will be observed by a geologist and logged as described in SOP 2 (Appendix SAP-1).

4.2 SONIC DRILLING METHOD PROCEDURES

The deep stratigraphic boring and the monitoring wells installed in the upper Troutdale Formation will be drilled using the Sonic drilling method (SOP 7). Sonic drilling consists of a dual-cased system that uses high frequency mechanical vibration to collect intact, minimally disturbed continuous core soil samples, and to advance drill casing into the ground for well construction. For purposes of this RI, the primary advantage of using sonic drilling is that it provides a unique combination of continuous cores, low disturbance, high soil sample quality, and relatively fast drilling rates in deep gravel conditions. Sonic drilling also generates as much as 50% less IDW waste soil cuttings compared to other common drilling methods. Since potential “cemented” gravel zones or other subtle changes in “deep zone” stratigraphy are important to the evaluation of aquifer flow and contaminant migration characteristics, sonic drilling techniques have been selected as most appropriate for borings that will be advanced in to the Troutdale Formation.

As an added precaution to isolate any potentially contaminated shallow groundwater, an oversized eight-inch diameter steel transmission casing will be installed from the ground surface penetrating five to ten feet into the water table. A bentonite seal will be placed inside the base of the casing, and drilling will then continue using smaller six-inch diameter steel casing. The temporary steel transmission casings can subsequently be removed following the completion of the soil boring. This “telescoping” method is an industry standard protection for drilling through contaminated or potentially-contaminated aquifers. If field evidence of gross contamination is observed at any time during drilling, the drilling work will be immediately stopped and re-evaluated, and Ecology will be immediately notified.

4.2.1 Soil Sampling

It is anticipated that soil samples will be recovered using a ten-foot long, four-inch diameter core barrel advanced during drilling to yield a continuous core. Each ten-foot long core section will be subdivided into shorter sections, placed in new clear plastic bags, and laid out in sequence for logging. A geologist will visually inspect all recovered samples as described in SOPs 1 and 2.

Soil samples collected for possible analysis will be removed from the sample sleeve using new laboratory-grade disposable gloves and placed directly into laboratory-prepared, wide-mouth glass jars and sealed with Teflon-lined lids. Sample containers will be labeled, placed in a cooler with ice, and shipped to an analytical laboratory in accordance with procedures contained in SOP 5.

One soil sample from the unsaturated zone in each boring indicating the highest contaminant indications (PID readings, odor, or discoloration) will be submitted for analysis. If no elevated PID readings are noted, no soil sample from that boring will be analyzed unless stated otherwise in subsequent work plans or as mandated by Ecology.

4.3 SONIC DRILLING MONITORING WELL CONSTRUCTION

A two-inch diameter monitoring well casing/screen assembly will be installed in each borehole as the steel casing is pulled from the ground (SOP 7).

The well casing will be constructed of Schedule 40 PVC with flush-threaded joints, a flush threaded 0.5-foot long sump, and a ten foot long Schedule 40 PVC well screen with machine cut slots (0.020-inch slot size). Two stainless steel centering guides will be used on each well: one at the base of the screen and one at the top of the screen. Each well will be constructed with a protective (flush mount or aboveground) monument and locking cap.

Each monitoring well assembly will be measured prior to placement in the borehole. It is not necessary to steam-clean the well assembly because it is sealed in plastic from the factory. Once the well assembly is in place, the borehole annulus will then be backfilled with #10-20 Colorado silica sand or equivalent to one foot above the top of the screen. The sand pack will be installed by slowly pouring sand from the ground surface or by placing the sand through a tremie pipe. The sand level will be measured with a stainless steel weighted tape during placement to detect bridging. The well casing will be surged with a clean surge block or stainless steel bailer during placement of the sand pack. If settlement occurs, additional sand will be placed in the borehole to bring the sand pack up to the desired depth.

A three-foot thick layer of bentonite chips will be placed on top of the sand pack in the deep wells to provide a barrier between the sand pack and bentonite slurry. The remaining annulus will be backfilled with bentonite (or equivalent) to within one foot of ground level, then grouted to ground surface with concrete that serves as a base for the protective steel monument. The top of the well casing will be cut uniform and flat such that it is at a depth just below grade. A file will be used to cut a "reference mark" on the outside of the north facing side of the well casing. A protective (aboveground or flush mount) monument will be installed and the well casing will be furnished with a locking cap.

Upon completion, the total depth of the well will be sounded such that construction details can be recorded to 0.01-foot accuracy. Total depth (length) of well, sump interval, screen intervals, and top of well below grade will be calculated and recorded.

Well development procedures will be performed after the construction of the monitoring well. These procedures are discussed in Section 4.5.

4.4 GEOPROBE DRILLING METHOD PROCEDURES

The Geoprobe investigation will include collection of soil, soil gas or vapor, and groundwater samples. The Geoprobe technique is particularly effective in obtaining excellent soil samples and screening-quality groundwater samples in fine to medium grained soil. With the drill platform consisting of a one-ton van or small trailer, access to boring locations is generally much better than with an auger or other large drilling equipment and produces less soil cuttings to manage. Borings are of small diameter (two inches or less) and can be effectively sealed with bentonite grout. (SOP 9 and 11)

Sampling and monitoring well construction techniques for geoprobe drilling methods are described below.

4.4.1 Soil Sampling

Continuous soil samples will be collected using a five-foot long Geoprobe "macro" sampling probe (1.5-inch outside diameter). Soil probes will be hydraulically pushed in five-foot intervals up to the target depth. Samples will be collected using 1.5-inch diameter macro tube samplers equipped with new, clear polyethylene liners.

Each sample core will be field screened for the presence of VOCs using a PID, staining, or the presence of a hydrocarbon sheen as described in SOP 3. For the field screening, the intact core is laid on the sampling table and a one-half inch drill is used to core the polyethylene at approximately one-foot intervals (with proper decontamination). This interval can be adjusted based on observance of heterogeneity in the soil or visual contamination. The removed soil is used to perform the sheen testing and visual observations. The cored holes are then screened with the PID and any volatile readings recorded. By performing this screening immediately upon retrieval of the soil core, effects of outside air temperature on the volatility of any contaminants are minimized.

Liners are then cut open lengthwise to allow further inspection and logging. The core will be observed by a geologist or geological engineer and logged as described in SOP 1 and SOP 2.

Soil samples from the boreholes will be selected for chemical analysis based on sampling objectives (i.e., depth, soil type, and field screening results). The selected soil samples will be removed from the plastic tubing using a decontaminated stainless steel spoon or new disposable glove and placed directly into a laboratory-prepared, wide mouth glass jars and sealed with Teflon-lined lids. Alternatively, the plastic tubing containing the sample interval of interest will be cut and capped at both ends. Samples will be placed in a cooler with ice and submitted to an analytical laboratory for analysis.

One soil sample from the unsaturated zone in each boring indicating the highest contaminant indications (PID readings, odor, or discoloration) will be submitted for analysis. If no elevated PID readings are noted, no soil sample from that boring will be analyzed.

4.4.2 Groundwater Sampling

The Geoprobe offers a very efficient technique for collecting screening-quality groundwater samples from shallow aquifers (SOP 16). Geoprobe rods will be pushed to the upper portion of the water-bearing zone. Groundwater samples will be collected by placing a temporary one-inch diameter stainless steel well screen into the rods and then pulling the rods back one to two feet to expose the screen to the water bearing zone. After measuring the water level with a decontaminated water level probe, new low-density polyethylene (LDPE) plastic tubing will be placed into the temporary well. If yields are sufficient, three or more screen casing volumes will be purged through the tubing prior to collecting a groundwater sample. Purging will continue as long as the turbidity decreases (i.e., indicating a more representative sample).

Groundwater samples may be collected at deeper sampling intervals at selected borings using the same methodology described above.

Laboratory-prepared glass bottles will be filled using the pump set on the lowest flow setting and LDPE tubing (SOP 17). The headspace at the top of the temporary well will be screened for VOCs using a PID. Samples will be placed in a chilled cooler and submitted to an analytical laboratory for analysis.

Field quality assurance for the Geoprobe groundwater sampling technique includes using new, decontaminated glass jars for the purge pump and properly decontaminating the stainless steel temporary well screen between samples. The temporary screen can be used for an equipment blank by pouring laboratory-prepared water through the screen and into VOA vials.

4.4.3 Soil Gas Sampling

Soil gas samples will be collected using truck-mounted, track-mounted, or portable direct push Geoprobe sampling equipment. The probes will be advanced to completion depths of a minimum of five feet below ground surface (bgs). Deeper soil gas samples may be warranted in certain locations to determine the source of contamination (groundwater versus vadose zone soil). At the target depth, the probe surface will be exposed and dedicated disposable tubing will be connected from the sampling point to the surface and sealed in place. Tubing will be connected to the sampling apparatus (valves, T-connectors, pump, etc.) as described in the SOP 24. A bentonite slurry seal will be placed around the rod to provide an airtight seal.

Volatile vapor readings will be measured in the field using a PID, and soil gas samples will be collected for VOC analysis using six-liter stainless steel summa canisters.

Procedures for collecting soil gas samples are provided in the SOPs included in SOPs 22 and 24.

4.4.4 Geoprobe Monitoring Well Construction

Monitoring wells will be installed by pushing a 3.25-inch diameter solid flight probe rod down to the completion depth. The bottom of the probe rod are equipped with an expendable tip. The well materials will be placed inside the probe rods. The rods will be slowly retrieved as the well installation progresses, leaving the expendable tip in the ground. Each well will consist of 0.0010-inch slotted well screen. The well screen will be pre-packed with 20-40 silica sand wrapped in a stainless steel wire mesh. A solid section of PVC will extend from the top of the well screen to the ground surface. A lockable compression well cap will be placed on top of each newly installed well.

The sand pack will be installed by slowly pouring sand from the ground surface. The sand level will be measured with a stainless steel weighted tape during placement to detect bridging. The well will be surged with a clean surge block or stainless steel bailer during placement of the sand pack. If settlement occurs, additional sand will be placed in the borehole to bring the sand pack up to the desired depth.

An annular seal consisting of bentonite chips will be placed on top of the filter pack to approximately one-foot bgs. A flush mounted monument will be cemented in place over each well. The well casing will be constructed of Schedule 40 PVC with flush-threaded joints, a flush threaded 0.5-foot long sump, and a 15 foot long Schedule 40 PVC well screen with machine cut slots (0.010-inch slot size). Each well will be constructed with a protective (flush mount or aboveground) monument and locking cap.

Each monitoring well assembly will be measured prior to placement in the borehole. It is not necessary to steam-clean the well assembly because it is sealed in plastic from the factory. Once the well assembly is in place, the borehole annulus will then be backfilled with #10-20 Colorado silica sand or equivalent to one foot above the top of the screen. The remaining annulus will be backfilled with bentonite (or equivalent) to within one foot of ground level, then grouted to ground surface with concrete that serves as a base for the protective steel monument. The steel monument will include a lockable cap. A compression fitting monitoring well cap will be installed on the top of the PVC well casing.

4.5 MONITORING WELL DEVELOPMENT

Each monitoring well will be developed prior to sampling by surging and pumping techniques (SOP 12). The wells will be surged with a surge block during well installation. A clean surge block will be lowered in to the well after the placement of the filter pack. The well will be surged repeatedly with the surge block until no more settlement of the filter pack is observed. If necessary, additional sand will be placed down the annulus to bring the filter pack up to the desired depth after surging is completed.

Once construction of the well is completed, groundwater will be extracted from the well. New LDPE tubing will be placed down the well and attached to a centrifugal or submersible pump. A minimum of ten casing volumes will be removed from the well. Pumping will terminate when field parameters (pH, specific conductance, and temperature) have stabilized and water clarity is no longer improving. The water generated from the well will handled as described in Section 4.10.

4.6 DECONTAMINATION PROCEDURES

Either a temporary decontamination pad will be constructed or a self-contained steam cleaning trailer will be used for steam cleaning. All down-hole drill tools and samplers will be steam-cleaned prior to arrival onsite and between each borehole location to minimize the potential for cross-contamination between boreholes. All materials generated during drilling, sampling, and decontamination will be handled as described in Section 4.11.

To protect site workers, all personnel engaged in site investigation and sampling activities will be required to undergo decontamination procedures when leaving contaminated areas. These procedures are detailed in the HASP (previously submitted). All personnel engaged in site investigation and sampling activities will have the appropriate training and medical monitoring required under OSHA (29 CFR 1920.120).

Non-disposable field sampling equipment will be decontaminated to remove possible residual contamination left from previous sampling locations. Equipment decontamination procedures will vary with different sampling equipment used, matrix samples, and anticipated contaminant level. Typical decontamination procedures are presented in SOP 4.

4.7 SURVEYING

A surveyor licensed in the State of Washington will survey the location of each monitoring well using the Washington State Plane coordinates. The surveyor will also measure the elevation of the top of the flush-mount cover plate, the ground surface, and the top of the PVC well casing (at the inscribed reference mark) with an accuracy of 0.01 foot relative to an established datum (e.g., benchmark). All information from the data will be recorded in the field notes.

4.8 GROUNDWATER MONITORING PROCEDURES

Groundwater monitoring procedures will include the collection of depth to water measures followed by the collection of water samples for chemical analysis. The procedures to perform the groundwater monitoring task is provided in detail below.

4.8.1 Water Level Measurement

Water level monitoring at the site will be done at the time of the groundwater sampling events. The well caps will be removed from each monitoring well prior to sampling to allow water levels to equilibrate. Since volatile organics are a target constituent for the site, a PID reading will be recorded from the top of the wellhead level with the well casing. This reading will be recorded along with any breathing zone monitoring on the Daily Safety Monitoring Record Form or Groundwater Sample Collection Form (Appendix SAP-2).

Depth to groundwater will be measured from each well using an electronic water level sounder or interface probe as described in SOP 10. Water levels will be recorded on a Groundwater Sampling Form (Appendix SAP-2) for each respective monitoring well. If separate-phase product is encountered, the thickness will be recorded. All instruments will be decontaminated between measurement events. If the relative chemical concentration of any chemicals in the wells is known from earlier sampling events or local groundwater flow conditions, the upgradient or “cleanest” wells will be measured first. Dedicated instruments will be used for any wells with separate-phase products; once an instrument is used in such a well, it will not be used in relatively “clean” wells.

If multiple wells are to be sampled, all water level measurements will be performed first in as short of timeframe as possible to prevent any fluctuations in water table or pieziometric surface due to purging. If more than one meter is used for measurements, the instruments will be “calibrated” for accuracy by comparison at the first well.

Periodically, wells will be sounded for verification of accuracy in construction documentation and/or buildup of materials in the sump or well screen. Sounding will be performed with a stainless steel weighted tape or water level sounder fitted with a stainless steel weight. Measurements will be accurate to 0.01 foot.

4.8.2 Purging and Field Measurements

The wells will be purged and sampled with a low-flow peristaltic, centrifugal, or submersible pump as described in SOPs 13, 17 and 19. To the extent known, wells with undetected contaminants or the lowest concentrations of contaminants will be sampled first.

The volume of water in each well will be calculated and a minimum of three casing volumes will be extracted prior to sampling if low-flow techniques cannot be used or are ineffective. Low-flow purging will be used to minimize the potential for the detection of metals that may be adsorbed to silt, clay and colloidal particles suspended in water due to disturbance caused by high flow purging. The pump will be set near the water table interface and lowered in response to declining water levels, as necessary. The purging rate will be no higher than 0.1 gallons per minute (gpm). All measurements will be recorded on the Groundwater Sampling Form (Appendix SAP-2). In addition, if sheen is observed during purging, it will be noted on the field form.

During purging, field parameters will be measured to assure adequate purging The minimum parameters include temperature, specific conductivity, and pH. Purging will continue until the parameters have stabilized. If the wells are turbid, the wells will be purged additional volumes in an effort to obtain non-turbid water prior to sample collection.

4.8.3 Groundwater Sample Collection

Samples will be collected immediately after purging, or within 24 hours if the well is pumped dry. Samples will be collected using new LDPE tubing at each well, and will be transferred into the sample vials via the tubing. The vials will be checked for the presence of air bubbles. If an air bubble is detected, the vial will be reopened and topped off so the sample is bubble free.

4.9 INSTALLATION OF STAFF GAUGE IN BIOSWALE

A staff gauge will be placed within the channel of the Bioswale at a location that is easily accessed for observation and measurement. Staff gauges provide a quick and easy visual indicator and measuring tool of the surface water level. The staff gauge is constructed with a durable porcelain enamel finish to resist corrosion. The staff gauge will include graduation marks every 1/10th foot. A reference mark will be permanently added to the staff gauge and surveyed by a licensed surveyor. The elevation of the water in the bioswale will be calculated by subtracting the distance from the water level to the reference point on the staff gauge. These measurements will be compared to the water levels collected from the monitoring wells.

4.10 INDOOR AND OUTDOOR AIR SAMPLING METHODS

Vapor intrusion assessment activities will require the collection of indoor and outdoor air samples. Sample collection methodologies are consistent with Ecology's draft guidance for vapor intrusion assessment.

4.10.1 Indoor Air Sampling

Indoor air samples will be collected using laboratory prepared six-liter Summa canisters equipped with 24-hour flow controllers for a residential site and eight-hour flow controllers for commercial or industrial sites. These sampling durations are based on typical residential versus occupational site occupancy duration as recommended in the published guidance *Vapor Intrusion Pathway: A Practical Guideline* (ITRC 2007). Indoor air sampling locations will be selected based on the site conceptual model developed for each property at which indoor air samples will be collected. At each sampling location the Summa canister inlets will be placed at a height appropriate to represent the breathing zone for the most sensitive receptor (i.e. three to five feet above ground surface for an average adult, closer to the ground surface if children are commonly present). In structures with basements, both occupied areas and basement areas will be sampled. In multiple story residential structures, at least one sample will be collected on each floor. Indoor air samples will be analyzed for VOCs by EPA Method TO-15.

Procedures for collecting indoor air samples are provided in SOP 26.

4.10.2 Outdoor Ambient Air Sampling

Outdoor ambient air samples will typically be collected concurrently with indoor air sampling and sub-slab soil gas sampling. Outdoor ambient air samples will be collected using laboratory prepared 6-liter Summa canisters equipped with flow controllers. Outdoor sample collection duration should bracket the indoor sampling periods by one to two hours before and after the indoor air sampling event. Outdoor air samples should be collected from a representative location, preferably upwind and away from wind obstructions such as trees and buildings. The Summa canister intake will be placed at a height of approximately three to five feet above ground surface (i.e. the approximate midpoint of the ground-story level of the building) and approximately five to fifteen feet away from the building. Representative sample locations should be placed to minimize bias towards obvious sources of volatile chemicals (e.g. gasoline stations, oil storage tanks, industrial facilities, etc.). Outdoor ambient air samples will be analyzed for VOCs by EPA Method TO-15.

Procedures for collecting outdoor ambient air samples are provided in SOP 25.

4.11 MANAGEMENT OF INVESTIGATION-DERIVED WASTES

The RI/RA/FS Investigation Derived Wastes Management Plan (IDWMP) (PNG February 27, 2009) details the approach that will be used for the management and disposal of wastes generated during the RI at the former Milton's Dry Cleaners. Investigation Derived Wastes (IDWs) are wastes resulting from activities such as borehole drilling, well installation, and sampling which may be potentially impacted with contaminants. It also includes material such as personal protective equipment (PPE), disposable sampling equipment, plastic sheeting, and all other wastes which may potentially be impacted with contaminants during investigation activities. IDW generated during the RI at the Milton's Site will be managed in a way that is protective of human health and the environment and in full accord with applicable regulatory requirements.

The IDWMP procedures will remain in effect throughout the course of the RI. The IDWMP will be amended, as necessary, if unaddressed conditions arise.

IDW must be properly managed in accordance with federal Resource Conservation and Recovery Act (RCRA) and Washington State Administrative Code. As such, this IDW Management Plan has been developed in part based on the "Management of Remediation Waste Under RCRA" (EPA 1998), the Washington Department of Ecology's Toxics Cleanup Program, and Ecology's Hazardous Waste and Toxics Reduction Program.

Investigation derived wastes for this project are expected to include:

- Solid wastes including drill cuttings, pre-existing solid wastes (concrete, asphalt, gravel, and other surface coverings), and spent carbon from liquid IDW treatment.
- Liquid wastes including purge water from well development and groundwater sampling activities and decontamination rinsate from decontamination activities.
- Field supplies including contact (i.e. disposal sampling equipment, PPE, plastic sheeting) and non-contact (i.e. general trash) wastes.

4.11.1 Solid Wastes

The following guidelines pertain to any investigation activity that generates solid IDW. This pertains to soil, surface materials (i.e., concrete and asphalt), and buried fill material generated during investigative activity. More information is provided in the IDWMP.

- All soil cuttings produced during the drilling of temporary borings and monitoring wells will be placed in labeled 55-gallon drums. The drums will be transported to the IDW treatment facility (Hart Industrial Complex, between buildings 2600 and 2650 NE Andresen Road, Vancouver, WA) pending characterization and subsequent disposal.
- The generation and handling of pre-existing solid wastes (concrete, asphalt, gravel, etc.) will be dictated by volume. Drilling activities generate very small volumes (several gallons) of pre-existing solid waste whereas excavation generates significantly larger volumes (tens of cubic feet). As no excavation or test pitting activities are planned under the current RI Work Plan, small volumes of pre-existing solid wastes will be handled in the same fashion as soil-cuttings. Should the need for test pits or excavation occur, the IDWMP will be modified and Ecology notified for approval.
- Carbon sorption canister breakthrough will be calculated based on groundwater analytical data. As needed replacement of carbon sorption canisters will be performed by Siemens Water Technologies, the preferred carbon treatment system vendor.

4.11.2 Liquid Wastes

The following guidelines pertain to any investigation activity that generates liquid IDW. This includes water generated during well development and sampling, groundwater sampling from a temporary well, aquifer testing, and decontamination procedures. Further information is provided in the IDWMP.

- Liquids generated during well purging and sampling will be containerized at the point of generation (i.e. at the well) into a labeled polyethylene transfer tank or labeled 55-gallon drum.
- Decontamination of reusable sampling equipment will immediately follow sampling at the well and the decontaminate rinsate will be placed into the polyethylene transfer tank/55-gallon drum.
- The IDW liquids shall be transported from the point of generation to the IDW treatment facility. Temporary storage containers will be sealed and secured prior to transfer.
- Once at the treatment facility IDW liquids will be combined into the pre-treatment polyethylene tank to be batch treated per each phase of work or volume demand.

Transporting and handling of liquid IDW will be minimized following best management practices. All transfer of liquid IDW will occur at the treatment facility directly from the polyethylene transfer tank/55-gallon drum to the pre-treatment secondary contained polyethylene tank.

4.11.3 Field Supplies

All investigation derived contact waste field supplies should be disposed of off-site and must be managed in accordance with Ecology's Rules and Regulations for Solid Waste Management facilities or Regulations for Hazardous Waste Management, as appropriate. In general, all non-contact IDWs can be treated as general refuse and disposed of in appropriate dumpsters or receptacles for pickup via city/county trash service.

4.11.4 IDW Storage Guidelines

The IDW generated during the RI will be stored at the IDW treatment facility located in the Hart Industrial Complex, between buildings 2600 and 2650 NE Andresen Road, Vancouver, Washington. The treatment facility will have restricted access including of fencing, locks, and signs. Storage of IDW will follow all applicable and appropriate federal and state guidelines including holding and disposal requirements. Additional information pertaining to IDW storage is provided in the IDWMP.

4.11.5 Disposal of IDW

IDW disposal procedures and guidelines are described in the IDWMP.

5 DOCUMENTATION

Data collected in the field will be recorded on standard environmental field forms (Appendix SAP-2). These forms consist of the following:

- Daily Field Activity Report.
- Daily Safety Monitoring Record.
- Field Boring Log/Well Construction Form.
- Well Development Form.
- Groundwater Sampling Form.
- Chain-of-Custody Form.
- Photo Log Form.

5.1 DAILY FIELD ACTIVITY REPORT

The daily field activity report will contain logistical information about the site conditions (weather, access problems, etc.), names of people on the site and the time they are there, and a general chronological narrative of the events. Instrument readings for health and safety will be recorded on this form.

5.2 DAILY SAFETY MONITORING RECORD

The daily safety monitoring record provides a table for documenting safety equipment calibration and routine monitoring during field exploration.

5.3 FIELD BORING LOG FORM

The field boring log form will contain descriptions and contact depths of borehole stratigraphy, depth to groundwater, locations of soil samples, sample recovery, and field screening results. Soils will be described using the Unified Soil Classification System (USCS) following ASTM Method D-2488.

5.4 WELL DEVELOPMENT FORM

The well development form documents data collected during surging and pumping activities associated with development or redevelopment of a monitoring well. The data recorded during well development procedures include pumping rates and volumes, and indicator parameters such as water temperature, pH, specific conductivity, and turbidity (or visual observation of water clarity). If a single well recovery test is being performed concurrent with development, this form is supplemented with an aquifer testing record.

5.5 GROUNDWATER SAMPLE COLLECTION FORM

The groundwater sample collection form will document groundwater sampling procedures and well performance for each well sampling event. The data will include sample location, sample name, date and time collected, and sampler's initials. The form will also include well and monument conditions, water level measurements, casing volume calculations, purge methods and rates, field parameter measurements (pH, temperature, and specific conductance), number and type of bottles filled, and other pertinent field data. A critical data element often observed is the sustainable yield of the well during purging. For many shallow wells with relatively low yield, this data is useful in future planning of remedial alternatives for groundwater.

5.6 CHAIN-OF-CUSTODY FORM

Chain-of-Custody form will be used to document the sample number, date and time collected, number of bottles submitted for each sample, name of the analytical methods to be conducted, and custody of the samples. This document in triplicate also serves as the work order for the analytical laboratory and often contains special instructions for analytical services.

5.7 PHOTO LOG FORM

A photo log form will be used to document all photographs taken during the investigation. The form will include the photo number, date and time the photo was taken, a description of the photograph, and the initials of the photographer. Each roll of film will be numbered.

5.8 BUILDING USE SURVEY FORM

Vapor intrusion assessment activities in the broader Milton's site area will require the performance of a general building use survey. The general building use survey data will characterize property and building use as follows:

- Building ownership and construction details including: name of building (if any), actual street address of the building, owner of building, owner contact information, date of construction, type of construction, number of floors, total area of the ground floor and basement/crawlspace (if present), type of HVAC system in use in the building, and type of utilities that service the building.
- Building occupant details including: type of occupants, number of occupants, occupant site activities, and days and/or hours of use of each building by the building occupants.

The Building Use Survey Form will be used to record data for each property that is included in the general building use survey.

6 SAMPLE HANDLING AND ANALYSIS

This section discusses the sampling handling and analysis methods to be used. The information presented includes sampling containers, packaging and shipping procedures, sample designation, quality assurance/quality control (QA/QC) samples, and requests for analysis.

6.1 SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES

Sample container requirements for soil, groundwater and vapor/air samples are based on the type of samples to be collected and the analytical methods to be performed on the samples. Samples containers, preservation and handling requirements, and holding times for applicable analytical methods are summarized in Table A-2.

Sample containers will be obtained from the laboratory that will be conducting the analyses. Sample containers will be pre-preserved and certified as a precaution to prevent cross contamination of the sample containers during field preparation.

6.2 SAMPLE PACKAGING

All samples shipped off site for analysis will be packaged according to applicable regulations. Sampling containers will remain in their original packing in a cooler prior to filling. After filling, the containers will be placed in a chilled cooler. Ice will be placed in each sample cooler in double bagged zip top bags to prevent leakage, if punctured. If possible, highly contaminated samples (based on field screening) will be separated into a separate cooler from relatively unaffected samples. Trip blanks should be placed with the highly contaminated samples.

Soil and groundwater samples will be delivered by courier to Pace Analytical Services Inc. (Pace), located in Seattle, WA (or equivalent certified laboratory). Soil vapor and air samples will be delivered by courier to CH2M Hill Applied Sciences laboratory in Corvallis, OR (or equivalent certified laboratory).

6.3 SAMPLE DESIGNATION

Samples submitted for laboratory analysis will be assigned a unique sample location identifier. The identifier will typically include the name of the sample location such as MW-1 for Monitoring Well 1 and GP-1 for a Geoprobe location. Numbers assigned to new wells and new Geoprobe locations will be consecutive for all RI site investigations. Sample identifiers for soil samples will also include the depth of the sample, in feet bgs.

QA/QC samples (i.e., duplicates, trip blanks, and equipment rinsate blanks) will be assigned similar sample designations. Duplicate samples will be identified so that the laboratory will not be able to distinguish the QA/QC samples from actual samples.

6.4 REQUESTS FOR ANALYSIS

Sample custody will be tracked from point of origin through final analysis and disposal using a chain-of-custody document form. The chain-of-custody form will be completed with the appropriate sample/analytical information as soon as possible after samples are collected. For purposes of this work, custody will be defined as follows:

- In view of a PNG field representative.
- Inside a cooler which is in view of a PNG field representative.
- Inside any locked space such as an office, vehicle, or storage unit under the control of the PNG field representative.

Sample possession will be recorded on a chain-of-custody form. The following items will be recorded on the chain-of-custody document:

- Project name.
- Project number.
- PNG project manager.
- Sampler's name.
- Sample number, date and time collected, media, number of bottles submitted.
- Requested analyses for each sample.
- Shipment method.
- Type of data package required.
- Turnaround requirements.
- Signature, printed name, organization name, date, and time of transfer of all persons having custody of samples.
- Additional instructions or considerations that would affect analysis.

Persons in possession of the samples will be required to sign and date the chain-of-custody documentation whenever samples are transferred between individuals or organizations. The chain-of-custody document will be included in the shipping containers with the samples, and the containers will be sealed with a laboratory custody seal. The laboratory will implement its in-house custody procedures, which begin when sample custody is transferred to laboratory personnel.

In general, samples will be packed in shipping containers, and a custody seal will be placed on the container to reduce the potential for tampering. Proper shipping insurance will be requested and the top two copies of the chain-of-custody documentation will accompany the samples. The person shipping the samples will retain a third copy of the chain-of-custody document and shipping forms to allow sample tracking. The chain-of-custody documentation will accompany the samples from point of origin in the field to the laboratory.

6.5 ANALYTICAL METHODS

Chemical analysis of soil, groundwater, and air (soil gas) samples for target VOCs will utilize standard analytical methods. Soil and groundwater samples will be analyzed using EPA Method 8260B. Air samples will be analyzed using Modified EPA Method TO-15 SIM.

6.6 FIELD QUALITY ASSURANCE SAMPLES

Blanks and duplicate samples will be used for Quality Assurance (QA) evaluation during the investigation. The following types of QA samples will be used.

6.6.1 Trip Blanks

Trip blanks are water samples prepared by the laboratory by filling a water sample container with laboratory-grade, distilled, deionized water in the laboratory. Trip blanks will be prepared at the same time and location as the sample containers for a particular sampling event. Trip blanks will accompany the sample containers to and from the event, but at no time will they be opened or exposed to the atmosphere. One trip blank for VOCs will be included per VOC shipping event or two-day sampling event.

6.6.2 Equipment Rinsate Blanks

Equipment rinsate blanks are another type of field blank for water samples. They will be obtained after nondedicated sampling equipment is decontaminated, and will involve passing laboratory grade water (i.e., equivalent to trip blanks) through the sampling equipment and transferring the water into an appropriate sample container. Distilled water commonly obtained from a retail store will not be used for blanks without prior testing by the analytical laboratory.

Rinsate blanks will not be collected if single-use or dedicated equipment (e.g., bailers or tubing) is used for sampling. Rinsate blanks will be analyzed to determine whether decontamination of sampling equipment is adequate. One equipment rinsate blank will be collected for every 20 samples collected with nondedicated equipment, with at least one rinsate blank per each sampling event.

6.6.3 Field Duplicates

A duplicate water sample will be collected to assess the precision of groundwater sampling and analytical procedures. During each sampling event, at least one blind duplicate sample will be collected from a monitoring well at the same time as the regular sample. Duplicate samples will be obtained by alternately filling like sample bottles for the two sample sets (original and duplicate). One field duplicate sample will be collected for every 20 samples collected. with at least one field duplicate per each sampling event with less than 20 samples.

6.6.4 Laboratory Quality Control Samples

Matrix spike/spike duplicates (MS/MSD) consists of identifying selected samples for laboratory MS/MSD. MS/MSD samples will be identified at a rate of one per 20 samples or sample group per matrix, or as indicated by the analytical method.

TABLES

Table A-1
Proposed RI/FS Field Sampling Locations and Rationale
Former Milton's Dry Cleaners Facility
Vancouver, Washington

Sample Location ID	Approx. Completion Depth (feet bgs)	Intended Screening Zone	Approx. Screen Zone Elevation (feet bgs)	Location	Media	Analytical	Comments	Data Use
Deep Boring								
DSB-1	150	n/a	n/a	On-site	n/a	n/a	No chemical analyses	Deep stratigraphy
Shallow Aquifer Wells								
MW-1	23	Shallow groundwater	8-23	On-site	Water	Target VOCs	Existing Well	Shallow groundwater flow/plume characteristics
MW-2	23	Shallow groundwater	8-23	On-site	Water	Target VOCs	Existing Well	Shallow groundwater flow/plume characteristics
MW-3	23	Shallow groundwater	8-23	On-site	Water	Target VOCs	Existing Well	Shallow groundwater flow/plume characteristics
MW-4	23.5	Shallow groundwater	8.5-23.5	On-site	Water	Target VOCs	Existing Well	Shallow groundwater flow/plume characteristics
MW-5	25	Shallow groundwater	10-25	Off-site	Soil/Water	Target VOCs		Shallow groundwater flow/plume characteristics
MW-6	25	Shallow groundwater	10-25	Off-site	Soil/Water	Target VOCs		Shallow groundwater flow/plume characteristics
MW-7	25	Shallow groundwater	10-25	Off-site	Soil/Water	Target VOCs		Shallow groundwater flow/plume characteristics
MW-8	25	Shallow groundwater	10-25	Off-site	Soil/Water	Target VOCs		Shallow groundwater flow/plume characteristics
MW-9	25	Shallow groundwater	10-25	Off-site	Soil/Water	Target VOCs		Shallow groundwater flow/plume characteristics

Table A-1
Proposed RI/FS Field Sampling Locations and Rationale
Former Milton's Dry Cleaners Facility
Vancouver, Washington

Sample Location ID	Approx. Completion Depth (feet bgs)	Intended Screening Zone	Approx. Screen Zone Elevation (feet bgs)	Location	Media	Analytical	Comments	Data Use
Intermediate Wells								
MW-10	To be determined (estimated 40)	Intermediate groundwater	To be determined (estimated from the 25-40 ft zone)	On-site	Soil/water	Target VOCs		Latera/vertical hydrologic/plume characteristics
MW-11	To be determined (estimated 40)	Intermediate groundwater	To be determined (estimated from the 25-40 ft zone)	Kyocera Site Nest Kyocera's Well MW-3	Soil/water	Target VOCs		Latera/vertical hydrologic/plume characteristics
Geoprobe Investigation								
GP-1 to GP-71	To water table	Shallow water table [a]	Top of shallow water table [a]	Various locations	Soil/water	Target VOCs	One soil sample (with highest PID reading) submitted for each boring	Shallow soil/groundwater conditions
SG-1 to SG-21	6-8	Shallow soil [b]	6-8 [b]	Various locations	Air (soil gas)	Target VOCs		Extent of soil gas VOCs

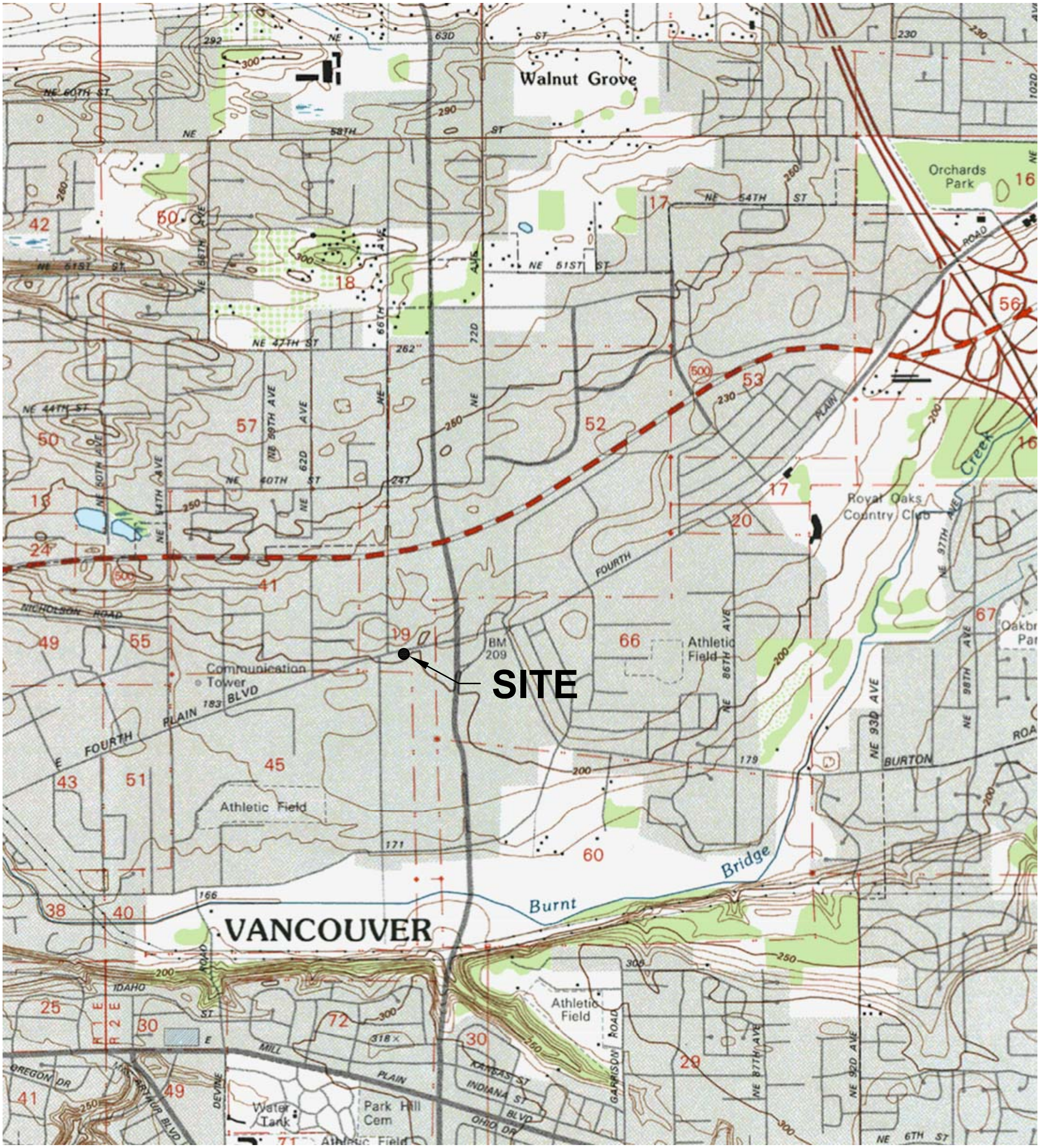
Notes:
[a]Grab sample collected at to of shallow water table
[b]Temporary soil gas probe screen
n/a = Not applicable
bgs = Below ground surface
VOCs = Volatile organic compounds by EPA Method 8260B Low Level (soil), EPA Method 8260B (groundwater), or Modified EPA Method TO-15SIM (air)

Table A-2
Sample Containers and Preservation Requirements
Milton's Dry Cleaners Site
Vancouver, Washington

Analytical Constituent	Sample Medium	Analytical Method	Containers	Preservation and Handling	Holding Time
Volatile Organic Compounds	Soil	EPA Method 8260B Low Level	4 ounce glass jar, Teflon-lined lid	Keep on ice (4°C), minimize headspace	14 days
	Groundwater	EPA Method 8260B or 8260SIM	40 ml glass vials, PTFE-lined silicon septum cap	HCL to pH <2, fill, leaving no air space, keep in dark on ice (4°C)	14 days
	Air (Soil Gas)	Modified EPA Method TO-15SIM	1 or 6 Liter Summa cannister[a]	None	30 days

Notes:
[a] Summa canister size will be determined by site-specific work plan
°C = Degrees Celsius
ml = milliliter

FIGURES



APPROXIMATE SCALE IN FEET

0 1000 2000 4000

NOTE: USGS, Orchards Quadrangle
Washington - Clark Co.
7.5 Minute Series (Topographic) 1990.
Base map provided by Map Tech.

PNG ENVIRONMENTAL, INC. 1339 Commerce Avenue, Suite 313 TEL (360) 414-0669 Longview, Washington 98632 FAX (360) 414-0663	DATE: 12-13-07 FILE NAME: 987-03 DRAWN BY: JJT APPROVED BY:	MILTON'S DRY CLEANERS 6721 E. FOURTH PLAIN BLVD. VANCOUVER, WASHINGTON	SITE LOCATION MAP	Project No. 987-03 Figure No. 1

APPENDIX SAP-1

STANDARD OPERATING PROCEDURES (SOPS)

STANDARD OPERATING PROCEDURE
LOGGING OF SOIL BOREHOLES
SOP 1

The following procedures are used for completing the Soil Boring Log Form (Figure 1-1). These procedures, which must be used for PNG projects where soil boring techniques are performed during field exploration, establish the minimum information that must be recorded in the field to adequately characterize soil boreholes.

These procedures are adapted from ASTM D-2488-84 (attached). Field staff is encouraged to examine ASTM D-2488-84 in its entirety. This standard operating procedure (SOP) has made minor modifications to emphasize environmental investigations as opposed to geotechnical investigations (for which the standards were written). Because environmental projects are each unique and because job requirements can vary widely, the minimum standards presented may need to be supplemented with additional technical descriptions or field test results. However, all soil boring field logs, regardless of special project circumstances, must include information addressed in this SOP to achieve the minimum acceptable standards required by PNG.

HEADING INFORMATION

- Project Number: Use the standard contract number.
- Client: Identify the name of the client and the project site location.
- Location: If stationing, coordinates, mileposts, or similar are applicable identify the location of the project. If this information is not available, identify the facility (i.e., 20 ft NE of Retort #1).
- Drilling Method: Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, cable tool) and the name of the drill rig (e.g., Mobil B 61, CME 55).
- Diameter: Provide the diameter of the borehole. If the borehole has variable diameters, provide the depth interval for each diameter.
- Sampling Method: Identify the type of sampler(s) used (e.g., standard split spoon, Dames & Moore sampler, grab).
- Drilling Contractor: Provide the name of the drilling contractor.
- PNG Staff: Enter the name(s) of PNG staff performing logging and sampling activities.
- Water Level Information: Provide the date, time, depth to static water, and casing depth. Generally, water levels should be taken each day before resuming drilling and at the completion of drilling. If water is not encountered in the boring, this information should be recorded.
- Boring Number: Provide the boring number. A numbering system should be developed prior to drilling that does not conflict with other site information, such as previous drilling or other sampling activities.
- Sheet: Number the sheets consecutively for each boring and continue the consecutive depth numbering.
- Drilling Start and Finish: Provide the drilling start and finish dates and times.

For consecutive sheets provide, at a minimum, the job number, the boring number, and the sheet number.

TECHNICAL DATA

- Sampler Type: Provide the sampler type (e.g., SS = split spoon, DM = Dames & Moore split spoon, G = grab).
- Depth of Casing: Enter the depth of the casing below ground surface immediately prior to sampling.
- Driven/Recovery: Provide the length that the sampler was driven and the length of sample recovered in the sampler. This column would not apply to grab samples.
- Sample Number/Sample Depth: Provide the sample number. The sample numbering scheme should be established prior to drilling. One method is to use the boring number and consecutive alphabetical letters. For instance, the first sample obtained from boring MW-4 would be identified as 4A and the second would be identified as 4B, and so on. Another method for sample identification is naming the boring number with the depth. For example, the sample from Boring 1 at 10 ft would be labeled B1-10'. The depth of the sample is the depth of the casing plus the length to the middle of the recovered sample to the nearest 0.1 ft. Typically, split spoon samplers are 18 in. long. Samples should be obtained from the middle of the recovered sample. The depth of the sample with the casing at 10 ft would then be 10.7 ft.
- Number of Blows: For standard split spoon samplers, record the number of blows for each 6 in. of sampler penetration. A typical blow count of 6, 12, and 14 is recorded as 6/12/14. Refusal is a penetration of less than 6 in. with a blow count of 50. A partial penetration of 50 blows for 4 in. is recorded as 50/4". For nonstandard split spoons (e.g., 5-ft tube used for continuous sampling), total blows will be recorded.
- Blank Columns: Two blank columns are provided. Project managers are encouraged to use these columns for site-specific information, usually related to the contaminants of concern. Examples for a hydrocarbon site would be sheen and PID readings of the samples.
- Depth: Use a depth scale that is appropriate for the complexity of the subsurface conditions. The boxes located to the right of the scale should be used to graphically indicate sample locations as shown in the example.
- Surface Conditions: Describe the surface conditions (e.g., paved, 4-in. concrete slab, grass, natural vegetation and surface soil, oil-stained gravel).
- Soil Description: The soil classification and definition of soil contacts should follow the format described in SOP-2, *Field Classification of Soil*.
- Comments: Include all pertinent observations. Drilling observations might include drilling chatter, rod-bounce (boulder), sudden differences in drilling speed, damaged samplers, and malfunctioning equipment. Information provided by the driller should be attributed to the driller. Information on contaminants might include odor, staining, color, and presence or absence of some indicator of contamination. Describe what it is that indicates contamination (e.g., fuel-like odor, oily sheen in drill cuttings, yellow water in drill cuttings).

Designation: D 2488 – 06

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids
D 1452 Practice for Soil Investigation and Sampling by Auger Borings
D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils
D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
D 2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Nov. 1, 2006. Published November 2006. Originally approved in 1966. Last previous edition approved in 2000 as D 2488 – 00.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

3.1.1 *clay*—soil passing a No. 200 (75-µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

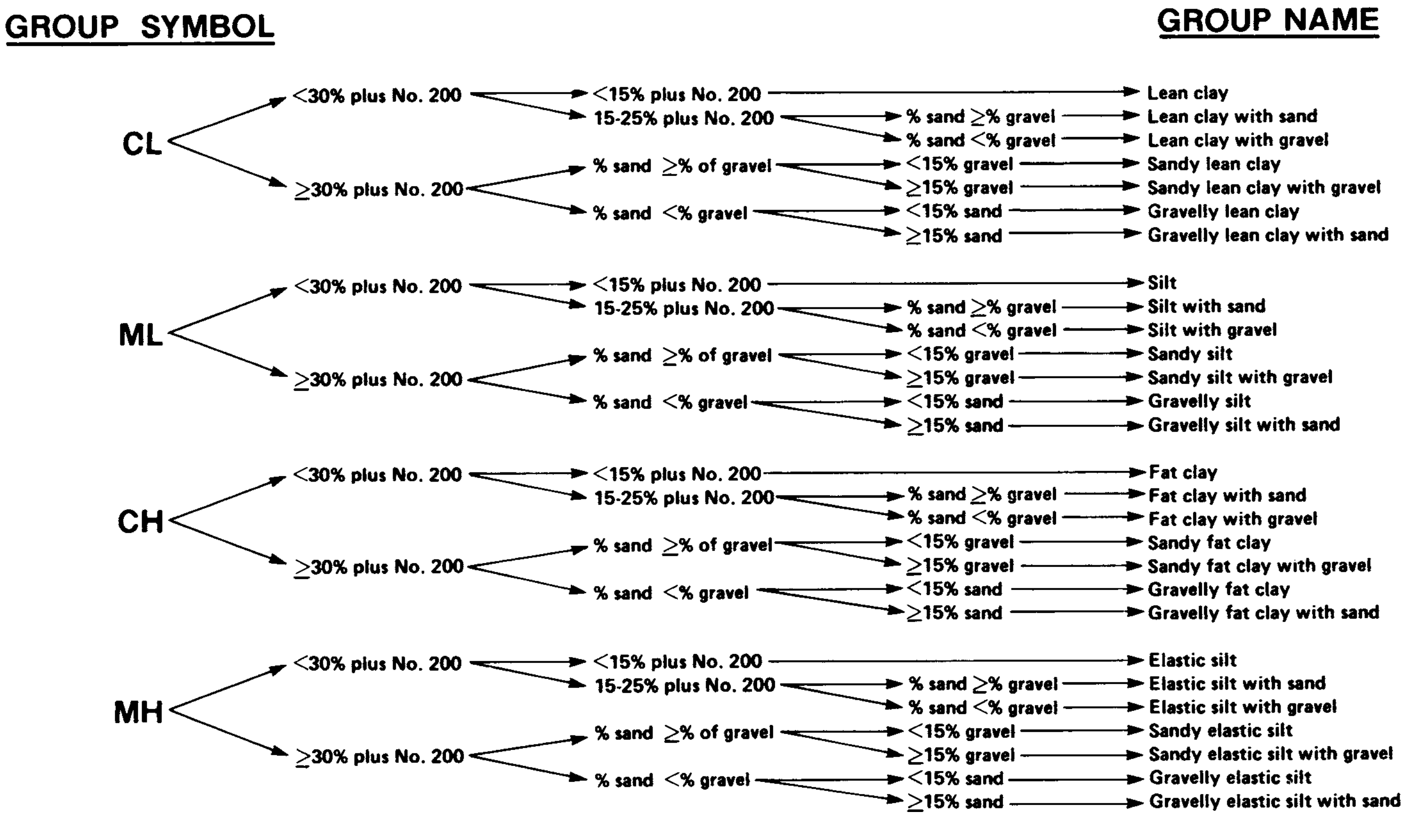
NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

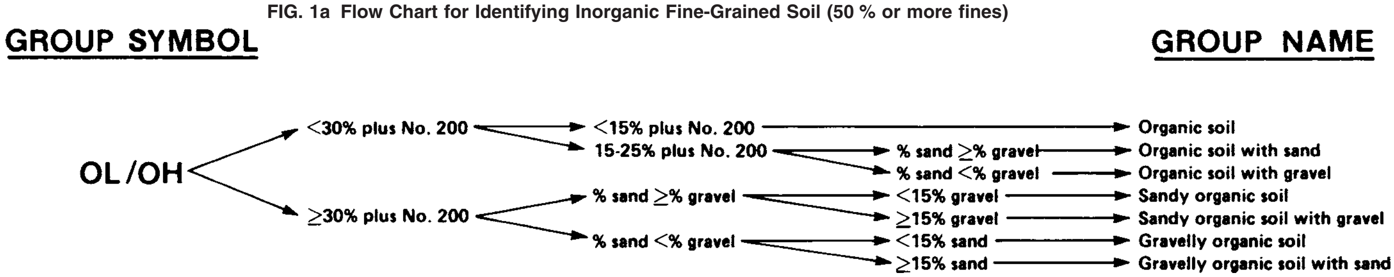
6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus*:



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

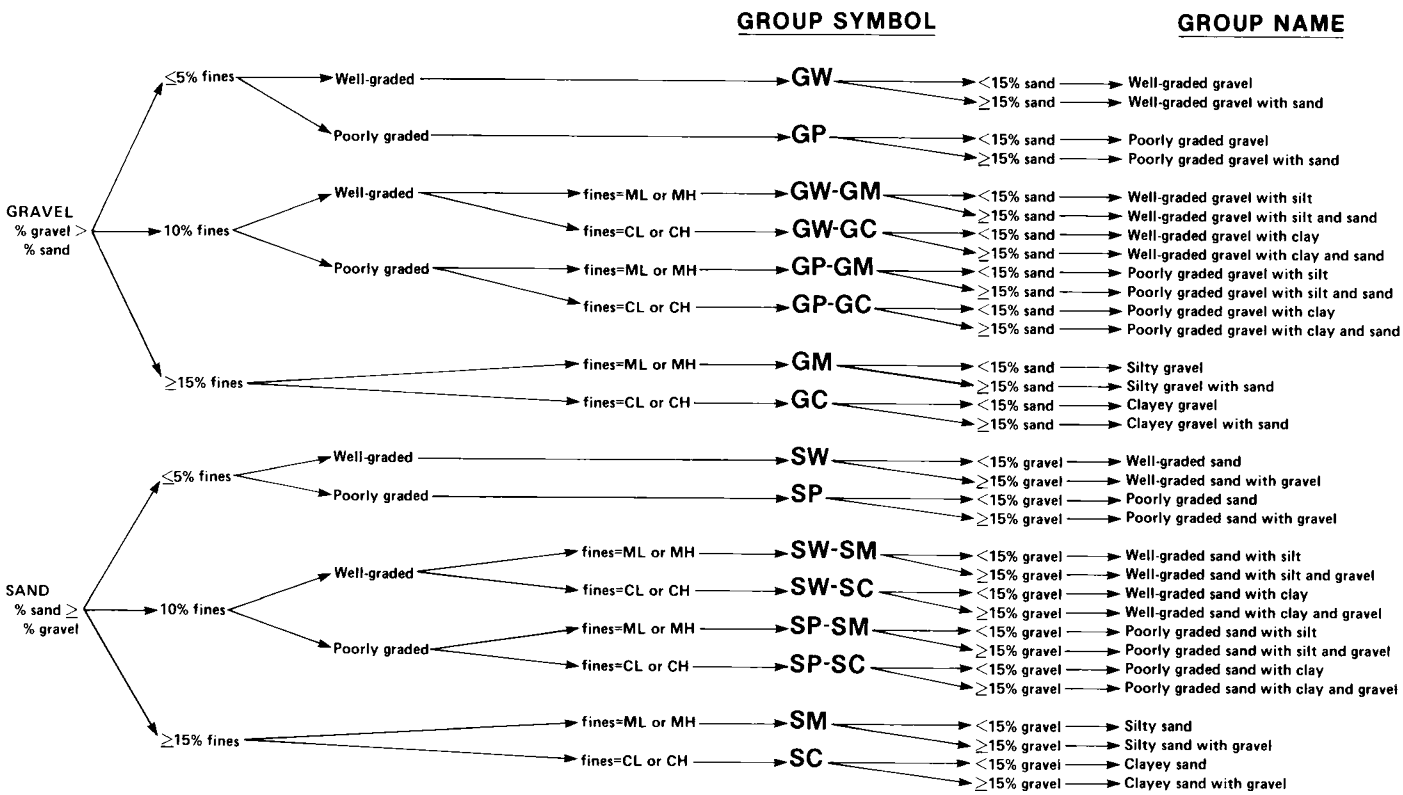
9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (3⁄8 in.)	200 g (0.5 lb)
19.0 mm (3⁄4 in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

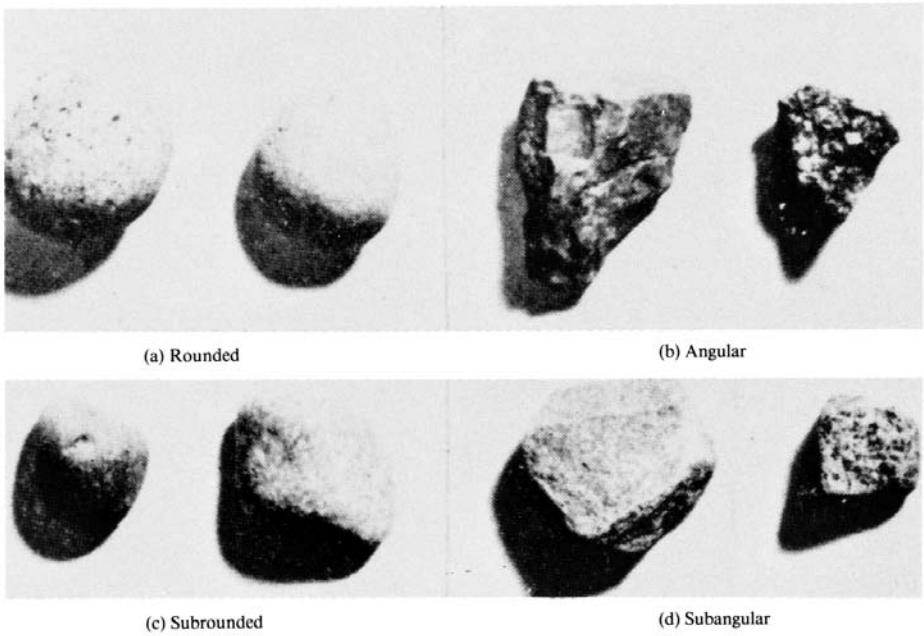


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

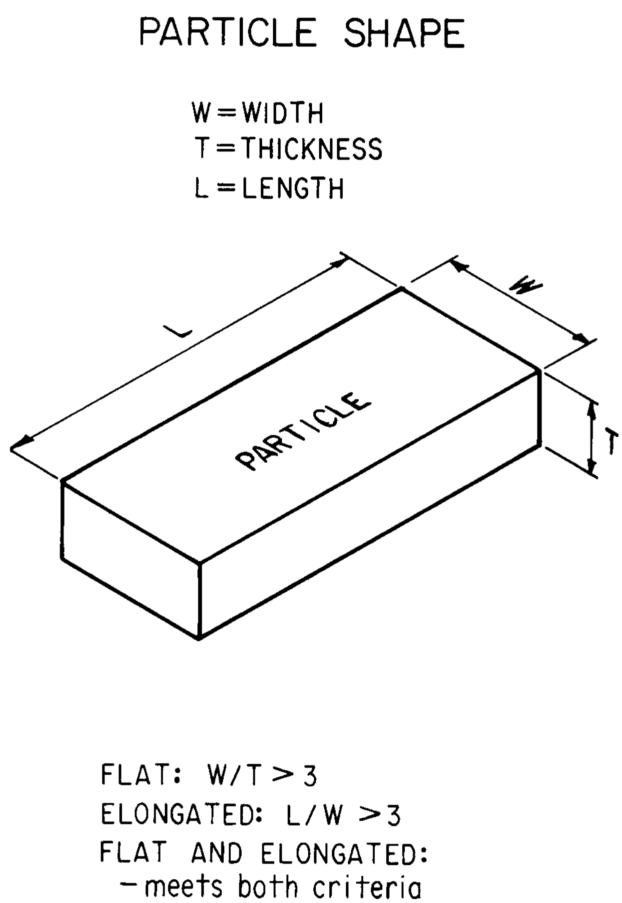


FIG. 4 Criteria for Particle Shape

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown.

X2.4.3 *Broken Shells*—About 60 % uniformly graded gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % nonplastic fines; "Poorly Graded Gravel with Silt and Sand (GP-GM)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (2000) that may impact the use of this standard.

(1) Revised footnote numbering in Reference Section.

(2) Revised classification example in X2.4.2 and X2.4.3.

STANDARD OPERATING PROCEDURE
FIELD CLASSIFICATION OF SOIL
SOP 2

This standard operating procedure (SOP) presents the field classification of soils to be used by PNG field staff. In general, PNG has adopted ASTM D-2488-84 (attached), *Standard Practice for Description and Identification of Soils* (Visual-Manual Procedures). ASTM D-2488-84 uses the Universal Soil Classification (USC) system for naming soils. Field personnel are encouraged to study these procedures.

Soil descriptions should be precise and comprehensive without being verbose. The overall impression of the soil should not be distorted by excessive emphasis on minor constituents. In general, the similarities of consecutive soil samples should be emphasized and minor differences de-emphasized. These descriptions will be used to interpret aquifer properties and other potential contaminant transport properties, rather than interpret the exact mineralogy or tectonic environment. We are primarily interested in engineering and geochemical properties of the soil.

Soil descriptions should be provided in the Soil Description column of the soil boring log (see SAP-48) for each sample collected. If there is no difference between consecutive soil samples, subsequent descriptions can be noted as “same as above” or minor changes such as “increasing sand” or “becomes dark brown” can be added.

The format and order of soil descriptions should be as follows:

1. Group symbol—The group symbol should be placed in the Unified Symbol column
2. USC group name—The USC name should be identical to the ASTM D-2488-84 Group Name with the appropriate modifiers
3. Minor components
4. Color
5. Moisture
6. Additional descriptions.

The minimum elements of the soil descriptions are discussed below.

DEFINITIONS OF SOIL TYPES

The USC is an engineering properties system that uses grain size to classify soils. The first major distinction is between fine-grained soils (more than 50 percent passing the No. 200 sieve (75 μm/0.029 in.]) and coarse-grained soils (more than 50 percent retained by the No. 200 sieve). PNG has small No. 200 sieves available for the field geologists. These are necessary to classify soils that are near the cutoff size.

Fine-grained soils are classified as either silts or clays. Field determinations of silts and clays are based on observations of dry strength, dilatancy, toughness, and plasticity. Field procedures for these tests are included in ASTM D-2488-84 (Exhibit 1). If these tests are used, the results should be included in the soil description. At least one complete round of field tests should be performed for a site if these materials are encountered, preferably at the beginning of the field investigation. The modifiers “fat” and “lean” are used by ASTM to describe soils of high and low plasticity. The soil group symbols (i.e., CL, MH) already indicate plasticity characteristics, and these modifiers are not necessary in the description. Soils with high plasticity can be emphasized by describing them as “silty CLAY with high plasticity.” Plasticity is an important descriptor because it is often used to interpret whether an ML soil is acting as either a leaky or a competent aquitard. For example, an ML soil can be dilatent/nonplastic and serve as a transport pathway, or it can be highly plastic and very impervious.

Coarse-grained soils are classified as either predominantly gravel or sand, with the No. 4 sieve (4.75 mm/0.19 in.) being the division. Modifiers are used to describe the relative amounts of fine-grained soil, as noted below:

Description	Percent Fines	Group Symbol
Gravel (sand)	<5 percent	GW, GP (SW, SP)
Gravel (sand) with silt (clay)	5–15 percent	Hyphenated names
Silty (clayey) gravel (sand)	>15 percent	GM, GC (SM, SC)

The gradation of a coarse-grained soil is included in the specific soil name (i.e., fine to medium SAND with silt). Estimating the percent of size ranges following the group name is encouraged for mixtures of silt sand and gravel. Use of the modifiers “poorly graded” or “well graded” is not necessary as they are indicated by the group symbol.

A borderline symbol is shown with a slash (GM/SM). This symbol should be used when the soil cannot be distinctly placed in either soil group. A borderline symbol should also be used when describing interbedded soils of two or more soil group names when the thickness of the beds are approximately equal, such as “interbedded lenses and layers of fine sand and silt.” The use of a borderline symbol should not be used indiscriminately. Every effort should be made to place the soil into a single group.

One very helpful addition to the soil log form description is the percentage of silt/sand/gravel. Even if the geologist did not have sufficient time to properly define the soil, this percentage breakdown allows classification at a later date.

MINOR COMPONENTS

Minor components, such as cobbles, roots, construction debris, and kitchen sinks, should be preceded by the appropriate adjective reflecting relative percentages: Trace (0–5 percent), few (5–10 percent), little (15–25 percent), and some (30–45 percent). The word “occasional” can be applied to random particles of a larger size than the general soil matrix (i.e., occasional cobbles, occasional brick fragments). The term “with” indicates definite characteristics regarding the percentage of secondary particle size in the soil name. It will not be used to describe minor components. If a non-soil component exceeds 50 percent of an interval, it should be stated in place of the group name.

COLOR

The basic color of a soil, such as brown, gray, or red, must be given. The color term can be modified by adjectives such as light, dark, or mottled. Especially note staining or mottling. This information may be useful to establish water table fluctuations or contamination. The Munsell soil color chart designation is the PNG color standard. These charts are readily available and offer a high degree of consistency in descriptions between geologists.

MOISTURE CONTENT

The degree of moisture present in the soil should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed in Table 3 of ASTM D-2488-84.

ADDITIONAL DESCRIPTION

Features such as discontinuities, inclusions, joints, fissures, slickensides, bedding, laminations, root holes, and major mineralogical components should be noted if they are observed. Anything unusual should be noted. Additional soil descriptions may be made at the discretion of the project manager or as the field conditions warrant. The Soil Boring Log Form lists some optional descriptions, as does Table 13 of the ASTM standard. The reader is referred to the ASTM standard for procedures of these descriptions.

CONTACTS BETWEEN SOIL TYPES

The contact between two soil types must be clearly marked on the soil boring log. The field geologist or engineer, who has the advantage of watching the drilling rate and cuttings removal and can converse with the driller in real-time has the best perspective for interpreting the interval. If the contact is obvious and sharp, draw it in with a straight line. If it is gradational, a slanted line over the interval is appropriate. In the case where it is unclear, a dashed line over the most likely interval is used. In the preparation of cross-sections, it is impossible to interpret boring logs where soil sample descriptions change over a five or ten foot sample interval and there is no indication where this change would likely occurred.

STANDARD OPERATING PROCEDURE
HYDROCARBON FIELD SCREENING FOR SOIL
SOP 3

This standard operating procedure (SOP) presents the qualitative field screening methods for hydrocarbons in soil. Field screening results are site-specific. The results may vary with soil type, soil moisture and organic content, ambient air temperature, and type of contaminant.

Field screening will be conducted on soil samples obtained from exploratory boreholes or excavations. Field screening results are used as a general guideline to delineate areas with potential residual hydrocarbons in soils. In addition, field screening results are used as a basis for selecting soil samples for chemical analysis. The field screening methods employed include 1) visual examination, 2) sheen testing, and 3) headspace vapor testing using an OVM 580B photoionization detector (PID) (or equivalent) calibrated to isobutylene. Sheen testing and headspace vapor testing are more sensitive screening methods that have been effective in detecting hydrocarbon concentrations below typical underground storage tank (UST) regulatory cleanup guidelines. The results of headspace and sheen screening should be included on the borehole logs or field notes.

VISUAL SCREENING

Visual screening consists of inspecting the soil for the presence of stains indicative of residual petroleum hydrocarbons. Visual screening is generally more effective in detecting the presence of heavier petroleum hydrocarbons, such as motor oil, or when hydrocarbon concentrations are high. Indications of the presence of hydrocarbons typically include a mottled appearance or dark discoloration of the soil.

SHEEN TESTING

Sheen testing involves immersion of the soil sample in water and observing the water surface for signs of sheen. A representative soil sample is placed into a clean stainless steel or plastic pan filled with clean water with as little disturbance as possible. Visual evidence of sheen forming on the surface of the water is classified as follows:

- No sheen (NS): No visible sheen on the water surface
- Colorless Sheen (CS) : Light, nearly colorless sheen; spread is irregular, not rapid; film dissipates rapidly (Note: light colorless sheens can be confused with sheens produced by organic content). Note that this sheen may or may not indicate the presence hydrocarbons.
- Heavy Sheen (HS): Light to heavy colorful film with iridescence; stringy, spread is rapid; sheen flows off the sample; most or all of water surface is covered with sheen

Following the sheen test, the pan must be decontaminated with methanol and distilled water prior to the next sampling event.

HEADSPACE VAPOR TESTING

Headspace vapor testing involves placing a small representative soil sample in a plastic sample bag. The sealed sample bag should be allowed to sit at ambient temperature for approximately ten minutes. The sample bag is then shaken slightly to promote volatilization to the air trapped in the bag. The probe of a PID equipped with a 10.6 eV bulb or equivalent, calibrated to isobutylene, is inserted into the bag to withdraw air from the bag. The instrument measures the concentration of organic vapors within the sample bag headspace in parts per million (ppm).

STANDARD OPERATING PROCEDURE
EQUIPMENT DECONTAMINATION FOR SOIL AND WATER SAMPLING
SOP 4

This standard operating procedure (SOP) describes procedures for decontamination of sampling equipment, drilling equipment and other tools that could come in to contact with contaminated media. Procedures were adopted from guidance documents and reports prepared by USEPA and include:

- Technical Enforcement Guidance Document (USEPA, November 1992).
- Compendium of Superfund Field Operations Methods (EPA, December 1987).
- Protocol for Ground-Water Evaluations (USEPA, September 1986).
- Technical Guidance Manual for Hydrogeologic Investigations and Ground Water Monitoring Programs (Ohio EPA, June, 1993).
- Field Sampling Procedures Manual (New Jersey DEP, July 1986).
- ASTM 5088-90 Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites (1992).

Personnel performing the decontamination procedures will wear protective clothing as specified in the site-specific Health and Safety Plan.

Benefits of an appropriately developed, executed, and documented equipment decontamination program are three-fold:

- Minimize the spread of contaminants within a study area or from site to site,
- Reduce the potential for worker exposure, and
- Improve data quality and reliability by eliminating the opportunity for cross-contamination

DECONTAMINATION REAGENTS

- Detergents shall be nonphosphate
- Acid rinses (inorganic constituents) shall be reagent grade nitric or hydrochloric acid
- Solvent rinses (organic constituents) shall be pesticide grade methanol, hexane, isopropopanol or acetone
- Deionized water rinse shall be organic free, reagent grade (generally provided by laboratory)
- Tap water rinse shall be either local tap water or distilled water available from retail stores. Note that this distilled water generally contains low levels of organic contaminants and can not be used for Deionized rinse or blanks.

INORGANIC CONTAMINATED SAMPLING EQUIPMENT

- Wash equipment with nonphosphate detergent, scrubbing off any residues
- Rinse generously with tap water
- Rinse equipment with Acid Rinse (0.1 N nitric or hydrochloric)
- Rinse with Reagent Water
- Allow to air dry

After decontaminating all sampling equipment, the gloves and other disposables will be placed in garbage bags. The wash and rinse will be containerized for proper disposal.

ORGANICALLY CONTAMINATED SAMPLING EQUIPMENT

- Wash equipment with nonphosphate detergent, scrubbing off any residues
- Rinse generously with tap water
- Rinse equipment with Solvent Rinse
- Rinse with Reagent Water
- Allow to air dry

After decontaminating all sampling equipment, the gloves and other disposables will be placed in garbage bags. The wash and rinse will be containerized for proper disposal.

DECONTAMINATION OF SAMPLING PUMPS

When pumps (e.g., submersible or bladder) are submerged below the water surface to collect water samples, they shall be thoroughly cleaned and flushed between uses. This cleaning process consists of an external detergent wash and high-pressure tap water rinse, or steam cleaning of pump casing, tubing, and cables, followed by a flush of potable water through the pump. This flushing can be accomplished by placing the pump in a newly purchased plastic garbage can filled with tap water and pumping multiple volumes through the pump. The procedure should be repeated first with detergent water and then with tap water. Blanks can be performed by pouring Reagent Water through the pump into the appropriate sample container.

STANDARD OPERATING PROCEDURE
SAMPLE PACKAGING AND SHIPPING
SOP 5

Specific requirements for sample packaging and shipping must be followed to ensure the proper transfer and documentation of environmental samples collected during field operations. Procedures for the careful and consistent transfer of samples from the field to the laboratory are outlined herein.

EQUIPMENT REQUIRED

Specific equipment or supplies necessary to properly pack and ship environmental samples include the following:

- Ice in sealed bags or blue ice
- Sealable airtight bags
- Plastic garbage bags
- Coolers
- Bubble wrap
- Fiber reinforced packing tape
- Scissors
- Chain-of-custody seals
- Airbills for overnight shipment
- Sample analysis request forms.

PROCEDURE

The following steps should be followed to ensure the proper transfer of samples from the field to the laboratories:

- Appropriately document all samples using the proper logbooks and tracking forms.
- Make sure all applicable laboratory quality control sample designations have been made on the sample analysis request forms. Samples that will be archived for future possible analysis should be clearly identified on the sample analysis request (chain-of-custody) form. Such samples should also be labeled on the sample analysis request form as "Do Not Analyze": Hold and archive for possible future analysis" because some laboratories interpret "archive" as meaning to continue holding the residual sample after analysis.
- Notify the laboratory contact and the project quality assurance/quality control (QA/QC) coordinator that samples will be shipped and the estimated arrival time. Send copies of all chain-of-custody, sample analysis request, and packing list forms to the laboratory *QAIQC* coordinator.
- Clean the outside of all dirty sample containers to remove any residual contamination.

- Check sample containers against the chain-of-custody forms to make sure all samples intended for shipment are accounted for.
- Store each sample container in a sealable bag that allows the sample label to be read. Volatile organic analyte (VOA) vials for a single sample must be encased in bubble wrap or foam rubber before being sealed in bags.
- Choose the appropriate size cooler (or coolers) and line with bubble wrap and a plastic garbage bag.
- Fill the cooler with the samples, separating glass containers with bubble wrap and allowing room for ice to keep the samples cold. Add enough ice or blue ice to keep the samples refrigerated overnight. Avoid separating the- samples from the ice with excess bubble wrap because it will insulate the containers from the ice. After all samples and ice have been added to the cooler, use bubble wrap to fill any empty space to keep the samples from shifting during transport.
- Remember to consolidate any VOA samples in a single cooler, and ship them with a trip blank, if the quality assurance project plan calls for one.
- Once all the samples are packed, close the plastic garbage bag and fasten it with a chain-of-custody seal.
- Store the signed chain-of-custody, sample analysis request, and packing list forms in a sealable bag and tape it to the inside of the cooler lid.
- Once the cooler is sufficiently packed to prevent shifting of the containers, close the lid and seal it shut using fiber reinforced packing tape. Also, if the cooler has a drain at the bottom, it should be taped shut.
- As security against unauthorized handling of the samples, apply one or two chain-of-custody seals across the opening of the cooler lid. Be sure the seals are properly affixed to the cooler so they are not removed during shipment.
- Label the cooler with destination and return addresses, and add other appropriate stickers, such as "This End Up," "Fragile," and "Handle With Care."
- If an overnight courier is used, fill out the airbill as required and fasten it to the top of the cooler. The identification number sticker should be taped to the lid, because tracking problems can occur if a sticker is removed during shipment.

STANDARD OPERATING PROCEDURE
GEOPROBE SOIL SAMPLING
SOP 6

Continuous or discrete soil samples can be collected using direct-push "GeoProbe"^{R} equipment and techniques. The GeoProbe equipment is mounted on a one-ton van or similar small truck. Borings are advanced by hydraulically pushing or hammering small-diameter steel rods into the subsurface. Sampling rods vary in outside diameter between two inches and 0.75 inches. Specialized tools are added to the base of the rod string in order to collect soil, groundwater, and/or vapor samples.

All soil samples are collected in new, dedicated clear acrylic liners placed inside the steel drive rods. Continuous soil sample cores can be collected as the rods are advanced. To collect discrete soil samples, the drive rods are advanced to the desired sampling depth with a disposable steel drive point blocking the sampler. A threaded pin locking the drive point can then be removed and soil then enters the sample rod/tube assembly as the rod string is advanced. Sample rods/tubes are typically four feet in length, and must be removed from the open hole to collect the sample. Sampling equipment is then decontaminated, a new drive point is locked into place, and the rod assembly is driven back into the open hole to the new desired sampling interval.

The following standard procedures are followed during sample collection:

- The recovered sample tube is opened on a clean surface using a decontaminated knife or specialized cutter. Representative soils are quickly transferred to appropriate sample containers and sample disturbance is minimized. Each sample container is immediately labeled and sealed.
- Representative portions of each soil sample are transferred from the sample tube to new zip-lock type plastic bags or polyethylene bags and sealed. Volatile head-space vapor readings are then measured as described in the SAP or SOP 3 (Hydrocarbon Field Screening for Soil). After head-space measurements have been recorded, a small volume of clean water is added to the soil. After agitation, the soil-water mixture is observed for visible sheen.
- Soil observed through the sample interval is then logged according to PNG's format described in the SOP.
- Following sample collection and logging, the sample rods and equipment are decontaminated in an isolated and dedicated area as follows.
  - All re-usable sampling equipment and down-hole equipment will be decontaminated using a hot pressure washer or in a solution of water and non-phosphatic detergent.
  - The sampling equipment will be rinsed with distilled or de-ionized water following washing.

STANDARD OPERATING PROCEDURE
SONIC DRILLING
SOP 7

This standard operating procedure (SOP) describes procedures for sonic drilling soil borings, soil sampling, and monitoring well installation. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present.

This SOP is intended as an overview and description of techniques for field personnel overseeing sonic drilling projects, and is not intended to guide subcontract drilling personnel in specific drilling techniques.

SONIC DRILLING OVERVIEW

Sonic drilling consists of a dual-cased system that uses high frequency mechanical vibration to collect intact, minimally disturbed continuous core soil samples, and to advance drill casing into the ground for well construction. The sonic drilling system may also utilize low speed rotational motion along with down-pressure to advance the drill bit. Sonic drilling is also referred to as Rotasonic, Rotosonic, Sonicore, Vibratory, and Resonantsonic drilling.

Advantage of using sonic drilling are that it provides a unique combination of low disturbance, large diameter continuous cores, high soil sample quality, and relatively fast drilling rates in deep gravel conditions. The outer casing prevents cross-contamination when drilling through contaminated zones or multiple aquifers. Sonic drilling also generates as much as 50% less investigation-derived waste soil cuttings compared to other common drilling methods.

The core barrel and drill rods are equipped with right hand threads and are rotated in a clockwise direction. The outer casing is equipped with left hand threads and is rotated in a counter-clockwise direction during drilling. In this manner, the core barrel and drill rods are not unscrewed as the outer casing is advanced.

Sonic Drilling Procedures

Down-hole drill tools and samplers will be steam-cleaned prior to arrival onsite and between each borehole location to minimize the potential for cross-contamination between borehole. Either a temporary decontamination pad will be constructed or a self-contained steam cleaning trailer will be used for steam cleaning the drilling tools and downhole equipment. All IDW generated during drilling, sampling, and decontamination will be containerized until characterized for disposal.

During drilling, the inner drill rods and core barrel may be advanced ahead of the outer casing to obtain a relatively undisturbed core sample. While drilling fluids (air or water) are occasionally used with sonic drilling, for environmental applications it is generally preferable not to add drilling fluids to the formation.

Soil samples are be collected and logged on a continuous basis during drilling as described below. Drill cuttings will be observed by the field geologist and each borehole will be logged in general accordance with ASTM D 2488, as described in the soil logging SOP (SOP 1).

In general, soil samples are recovered if possible using a ten-foot long, four-inch diameter core barrel advanced during drilling to yield a continuous core. The sample core may be extruded directly from the core barrel into a plastic sleeve, or onto a sampling table for observation. Samples may be collected with clear plastic or stainless steel liners placed inside the core barrel. Each ten-foot long core section will typically be subdivided into shorter sections placed in new clear plastic bags, and laid out in sequence for logging. A geologist will visually inspect all recovered samples, and perform any required field screening and sample collection.

Upon drilling completion, the boring will be abandoned by pumping full of bentonite grout, with an asphalt or concrete surface patch placed at the surface. Refer to the sampling and analysis plan (SAP) and Work Plan for details of the soil boring, including sample depth, boring total depth, and media analytical testing.

Telescoped Drilling

In order to isolate any potentially contaminated shallow groundwater, an oversized steel transmission casing can be installed from the ground surface, penetrating five to ten feet (or another appropriate distance) into the water table. A bentonite seal can be placed inside the base of the casing, and drilling continued using smaller-diameter steel casing. The temporary steel transmission casings can then be removed during monitoring well construction. This “telescoping” method is an industry standard protection for drilling through contaminated or potentially-contaminated aquifers. Once drilling reaches the desired depth, the drill bit is removed from the boring, the conductor casing backed out of the hole approximately two feet, and high density bentonite grout is placed in the bottom of the borehole and mechanically pushed into the borehole, forcing it laterally into the surrounding soil formation and outside the conductor casing annulus. Then a smaller diameter drill casing is used to drill the deeper borehole. As the monitoring well is constructed, the drill string is backed out of the hole and sealed above the well’s screened interval using pressurized bentonite grout below the water table. If no monitoring well is to be installed in the boring, the boring will be pumped full of bentonite grout as describe above.

Typical Well Installation Procedures

Wells are typically constructed as described below:

- Depending on the well location and depth, the sand filter pack will be installed by manually pouring sand from the ground surface as described below. The sand level will be measured with a stainless steel weighted tape during placement to detect bridging.
- The well casing will be surged and/or bailed with a clean surge block, stainless steel bailer, or submersible pump during placement of the sand pack and prior to the placement of bentonite in order to settle the sand pack. Sand pack settlement will be monitored by sounding until no further settlement is observed. Sand will be placed to one foot above the screen to prevent bentonite migration into the screen.
- After surging and confirming that the top of the sand pack reaches one foot above the top of the screen, bentonite will be installed to a depth of approximately one-foot below ground surface (bgs).
- The top of the well casing will be cut uniform and flat such that it is at a depth just below grade. A file will be used to cut a “reference mark” on the outside of the well casing.
- A protective monument will be installed flush to grade and the well casing will be furnished with a locking cap.
- Upon completion, the total depth of the well will be sounded such that construction details can be recorded to 0.01-foot accuracy. Total depth (length) of well, sump interval, screen intervals, and top of well below grade will be calculated and recorded. The top of the flush monument will represent ground datum unless a monument is set next to the well completion.

- Well logs and drilling reports will be furnished to the appropriate regulatory agency as required under state law.
- All information regarding soil conditions encountered in the boreholes and well construction details will be recorded on the Soil Borehole Log Form as described in SOP 1 (Logging of Soil Boreholes).

STANDARD OPERATING PROCEDURE
MEASUREMENT OF STATIC WATER LEVEL
AND PRODUCT LEVELS
SOP 10

This standard operating procedure (SOP) describes procedures for measuring water and light (floating) and dense (sinking) product levels in monitoring wells. Procedures outlined below are applicable to electronic interface probes, electronic water level meters, and product reactive paste.

FIELD PROCEDURES

- Open all well caps to be measured to allow equilibration of the water table to ambient barometric pressure. Always approach the well from the upwind direction and monitor the wellhead with health and safety equipment, as applicable for the site and outlined in the Site Health and Safety Plan.
- Check interface probe or electronic water level meter for proper operation following manufacturer's instructions. Clean probes and tapes at the end of each day of sampling. Note that the interface probes are susceptible to fouling and must be cleaned carefully. The interface probe is not to be used on wells that do not have high concentrations of contaminants based on field screening (PID readings or using a disposable bailer to check for presence of non-aqueous phase liquids [NAPLs]) or historical monitoring experience. Inexpensive, disposable bailers are always available for checking NAPLs in the case of unknown conditions.
- Clean probe and tape by washing with Alconox and water, rinsing with methanol or nitric (See SOP 4, Equipment Decontamination for Soil and Water Sampling) and rinsing with distilled, deionized water.
- If well depth is to be sounded to check accuracy of well completion documentation or to check for buildup of sediment in sump, the length of tape requiring additional cleaning is determined by the distance between top of casing and bottom of casing. If the fluid level probe is used for sounding the well, it must be fitted with a stainless steel weight and the distance from the bottom of weight to the tape markings calibrated into the measurements.
- Water level sounders will either have an audible alarm, indicator light, or needle gauge to indicate the water surface. Some brands of indicators are affected by NAPLs and provide false readings.
- Interface probes generally provide two tones or a constant tone and intermittent tone for indication of water and NAPL. If properly cleaned, the probes are effective for light non-aqueous phase liquids (LNAPLs). Be careful with dense non-aqueous phase liquids (DNAPLs), as many of the brands of probes are not accurate. A useful check it to slowly lower a disposable bailer into the well and let it sit for ten minutes before retrieval and direct measurement of the DNAPL layer.
- Product paste for petroleum LNAPLs is effective. Lower the coated tape quickly, and let sit for a period-of-time. A common problem with the paste is the smearing of petroleum on the lower end of the tape that fully penetrates the LNAPL layer. The tape section that is actually in the groundwater often turns color, providing an overestimate of the actual thickness. Repeated trials or use of a bailer to check the thickness is recommended.

FLOATING PRODUCT MEASUREMENTS

An interface probe which differentiates between floating product (e.g., aromatic hydrocarbons and water, is used to measure floating product thickness and depth to water. An alternate method involves using a stainless steel tape and hydrocarbon marking paste. The thickness of floating product and depth to the groundwater table are measured relative to the monitoring well top of casing (TOC), which should be clearly marked with a notch. This notch is the reference for the vertical survey of the well. The probe is lowered into the well and direct readings for the air/oil and oil/water interface are taken from the tape, which has graduated marks at 0.01 -ft intervals. For the steel tape method, the tape is held at a specific interval such that the marking paste overlaps the hydrocarbon interval. After 5 minutes, the past reacts and the two interfaces can be calculated from the graduated tape. The probe will be decontaminated with a methanol wash, trisodium phosphate wash, and distilled water rinse prior to use at each well. Where floating product is encountered, the true water table elevations will be calculated by adding the elevation of the measured water interface to a proportion of the hydrocarbon thickness that is based on the density of the hydrocarbon.

$$Z_{aw} = Z_{ow} + [P_{ro\,(}Z_{ao} - Z_{ow)]}$$

[True Level = Measured Water + (Density x Product Thickness)]

Where:

Z_{aw} = True elevation of air/water interface

Z_{ow} = Measured elevation of oil/water interface

Z_{aw} = Measured elevation of air/oil interface

P_{ro} = Specific gravity of the hydrocarbon

MAINTENANCE

- Carry spare batteries for the interface probe at all times. Check the circuitry in the field laboratory weekly during a sample run, by assembling the apparatus and dipping the end of the tape into a beaker of water.

Clean probes and tapes at the end of each day of sampling by washing with Alconox and water, rinsing with methanol, and rinsing with deionized water. In addition, clean tapes between wells at all time. Never use an interface probe on a "clean" well, as full decontamination is nearly impossible. When in doubt whether a well contains NAPL, use a disposable bailer to check for the presence of NAPL.

STANDARD OPERATING PROCEDURE
WELL DEVELOPMENT
SOP 12

BACKGROUND

This standard operating procedure (SOP) describes procedures for well development and completion which were adopted from regulatory guidance for well completion found in the Resource Conservation and Recovery Act (RCRA) Ground Water Monitoring Technical Enforcement Guidance Document (EPA, 1986), and the Environmental Protection Agency (EPA) Handbook (EPA, 1991).

All well drilling and installation procedures create a skin, or filter cake, on the borehole wall. During well development, the fine particulate matter is removed from the well or saturated formation near the screen. A secondary function of development is to settle the annular fill to a stable position.

The following factors influence the success of well development:

- The drilling method employed in the well construction.
- The design and completion of the well.
- The type and gradation of geologic material surrounding the screen.

Because of the small size of weathering products from the volcanic tuff, in some of the alluvial canyon aquifers in the region, it is virtually impossible to eliminate turbidity while developing the well.

Well Development Methods

There are various techniques that may be effective in developing wells depending on the hydrogeologic conditions encountered in the aquifer, drilling method used, and well design. Since hydrogeologic conditions may be complex and unpredictable, a single SOP cannot be developed that will apply to all possible situations. Rather, the methods discussed briefly below are intended to be used as alternatives or as a series of steps to achieve acceptable well development results. Refer to site-specific work plan for more information on the scope of work activities for determining the most appropriate method to be used for existing conditions.

- Wire-Brush Method - Running a tight-fitting wire brush up and down the interior of the well casing, screen, and sump serves to remove sediment and debris particles and clears the screen openings. Use of the wire-brush method followed by bailing is an effective primary development scheme preliminary to surging or pumping.
- Bailing Method - Bailing involves inserting and withdrawing of a bailer or length of pipe with an end cap on the bottom. Bailing serves to remove turbid water and exerts a surging action as the bailer passes the screen. After wire brushing of the well interior has been performed, the well is bailed to remove sediment and debris. The bailing method is also used as an alternative when the formation or

water-producing zone fails to supply water at sufficient rates to sustain development by pumping.

- Mechanical Surging - Surging involves raising and lowering a surge block inside the well to force water to flow into and out of a screen and through the filter pack. The seals on the surge block are the same diameter as the inside of the well casing or one-half inch smaller if surging is conducted inside the screened interval. Turbid water must frequently be bailed from the well so that fines are not forced into the formatting and to prevent sand from locking up the surge block.

- Swabbing Method - A swab is a mechanical surging device that is pulled upward through the water column in a well. Swabbing may be done with single- or double-swab flanges and with or without water-bypass vents. Water may be injected into the well to the formation through the swabbing tool. In this method, water flows into one part of the screen, through the filter pack and adjacent formation, and out in another part of the screen. Swabbing is an aggressive development method that may be suitable if the introduction of water is acceptable. Swabbing is not recommended for wells with plastic casing or screens.

- High-Velocity Jetting - Jetting, or forcing water through the screen from nozzles on a pipe assembly, can clear screen openings. The jetting method is not always advisable as it forces the fines back into the filter pack and formation and adds large volumes of water to the system.

- Overpumping - A simple method of removing fines from a water-bearing formation is by overpumping. This method involves alternately pumping the well at a rate that will force it to become dry and allowing it to recover. The overpumping method is not always effective, particularly in unconsolidated formations, and may result in a formation that is partially developed.

- Pump Development - Pump development is commonly used as the final phase of well development for ER Project monitor wells after wire brushing and bailing methods have been performed. A submersible pump and packer assembly, if applicable, is installed and pumping at a sustainable rate is conducted until the water attains acceptable criteria to complete well development.

PROCEDURE

Preoperation Activities

Decontaminate all equipment that will enter the well or come into contact with the development water before developing each well.

Well development may begin as soon as is practical after the well is installed, but typically no sooner than 24-hours after grouting is completed. Do not use any dispersing agents, acids, or disinfectants to enhance the development of the well unless otherwise specified.

Well Development Activities

Open the surface protective lid and remove the well cap (if applicable). Monitor air quality at the top of the casing and in the breathing zone using a PID or other suitable field monitoring instrument.

Measure and record depth to water and total depth of the well.

Begin bailing to remove turbid water from the well and sediment from the sump. Measure and record initial field chemical parameters (pH, electrical conductivity, and temperature) and turbidity. Periodically measure field parameters as specified in the site-specific work plan. Note and record volumes of water produced as bailing proceeds.

Begin pump-development procedures. For wells with multiple completions, each water-bearing zone is isolated using inflatable packers above and below the screen. The following general steps are taken to develop each screen individually and in succession:

- The drilling contractor installs a submersible pump-and-packer assembly across the first screen to be developed. Pumping is initiated at a sustainable rate that will not induce excessive drawdown.

- A transducer and/or a bubble piezometer may be installed in the well to measure water levels during the pump-development phase.

- When the pump has been turned on, collect a sample of the development water to measure and record initial field chemical parameters and turbidity. Note the initial color, clarity, and any obvious odor of the water. Periodically monitor water quality parameters throughout the pump-development phase as prescribed in the work plan. Likewise, note and record flow measurements (flow rate and volume produced) as indicated by an in-line flow meter. Continue to record measurements until the screen interval has been fully developed.

In general, well development procedures will continue for each screen interval until (1) the development water becomes free of suspended sediment, (2) an appropriate volume of water has been purged, and (3) field parameters have stabilized. Criteria for completing well development are described as follows:

- Turbidity Criteria - Well development shall continue until the turbidity readings stabilize or cannot be improved. If the well is not free of sediment after the required volume of water has been removed, continue pumping until twice that volume has been purged.

- Purge Volume Criteria - For wells where borehole drilling was conducted without the use of drilling fluid (water, mud, or additives), purge a minimum of five casing volumes of water before stopping well development. In situations where the groundwater flow from the screen interval is exceeded by the development pumping rate, the well may temporarily dry up.

- Field Parameter Criteria - This criterion for well development has been met when field parameters have stabilized over a series of monitoring measurements.

Documentation

Complete the appropriate data entry requirements on the Borehole/Well Completion information form to document well development.

STANDARD OPERATING PROCEDURES
GROUNDWATER SAMPLING WITH SUBMERSIBLE PUMP
SOP 13

This standard operating procedure (SOP) describes method for collecting groundwater samples including well purging and sample collection.

WELL PURGING

- Measure water level and well depth (if appropriate) according to SOP 10. Calculate casing storage volume.
- Lower decontaminated submersible pump or new tubing from surface mounted pump into borehole (disregard if well is equipped with a dedicated pump). Turn on pump.
- Pump at a maximum rate of one gallon per minute (gpm). Monitor the cumulative volume pumped using in-line meter or graduated container.
- After about two well volumes have been pumped, rinse a plastic beaker with flowing well water. Place the end of the pump discharge tube in the bottom of the beaker. Allow the water to fill and overflow the beaker.
- Measure field parameter (temperature, pH, and electrical conductivity) as described in SOP 11.
- When a minimum of three well volumes have been purged and water temperature, pH, and EC measurements have stabilized (i.e., 0.5^{o} C, 0.2 pH units, ten percent EC of the previous reading) sample collection can begin. Record field parameter measurements on *Groundwater Sampling Form*.
- Collect samples for analysis as described in the following section.

GROUNDWATER SAMPLING

- Reduce the purge rate from the pump to a maximum of 0.1 gpm and allow steady flow.
- If filtration is required, attach tubing to the in-line filter for filling into bottles that cap tightly.
- If a sample for volatile organic compound analysis was collected, recheck that the sample container does not contain headspace. If any air bubbles are present, the volatile organic compound sample must be retaken using a fresh sample container. All samples collected will be filled to the capacity required for analysis. Sample containers must not be rinsed with sample water before final filling in case of possible presence of floating products in the well, which can adhere to the sample container wall and bias analyses.
- Label the sample bottles with all necessary information. Record the information in the field logbook and complete all chain-of-custody documents and seals. Clean the exterior of the filled, sealed sample containers using a brush and soap and water mixture, and rinse with distilled water. Seal the sample container in a Ziploc bag and bubble pack to reduce the possibility of contaminating other samples if a sample bottle leaks or breaks.
- Place the properly labeled and sealed sample bottles on ice in a cooler for the duration of the sampling and transportation period. If collected, do not allow samples for volatile organic compound analysis to freeze. Note whether the sample type requires isolation from other sample types.

- If a submersible pump was used, clean the outside of the pump and tubing with clean tap water and Alconox or a high-pressure spray. Run water with Alconox through the pump followed by deionized water. Repeat. Collect decontamination water in appropriate containers.

STANDARD OPERATING PROCEDURE
GEOPROBE WATER SAMPLING
SOP 16

This standard operating procedure (SOP) describes water sampling using a Geoprobe.

GEOPROBE GROUNDWATER SAMPLING PROCEDURE

Prior to advancing a boring with a Geoprobe Unit, remove and inspect sample containers, sample forms, and Chain-of-Custody forms for consistency with sample location. Proceed with the following procedures after attaining the appropriate depth for collecting the desired groundwater sample.

- Slowly lower the disposable polyethylene tubing until it contacts the water surface, then slowly push the tubing into the water column allowing it to fill with a minimum of surface disturbance.
- Slowly raise the tubing to the ground surface. Avoid contact of the tubing with the well casing and/or ground.
- If sufficient water is present to permit purging and sampling, the first volume of water should be purged prior to sample collection. Purge water should be managed in 55-gallon drums or holding tanks, as appropriate, and temporarily stored on site pending off-site disposal and/or treatment.
- After purging has been completed, carefully fill each sample container, making an effort to minimize sample turbulence. As appropriate, sample containers will be filled in the following order: volatile organics, semi-volatile organics, specialty parameters, and inorganics (field-filtered). The volatile organic sample container should be inverted to ensure it contains no headspace or air bubbles. All other sample containers should be filled to the top. Containers that have preservatives added to them prior to sampling will not be overfilled. Repeat this step until a sufficient sample volume is acquired.
- Wipe off outside of sample containers and label sample containers with date and time of collection. Place sample into the appropriate cooler and preserve at 4°C.
- Record appropriate data and information into project log book.
- All Geoprobe rods and down-hole equipment should be decontaminated prior to sampling, between exploration points, and after all sampling is completed in a boring (see Geoprobe Decontamination Procedure).

STANDARD OPERATING PROCEDURE
LOW-FLOW PERISTALTIC PUMP GROUNDWATER SAMPLING
SOP 17

This standard operating procedure (SOP) is designed to assist the user in taking representative groundwater samples groundwater samples will be collected using low-flow (minimal drawdown) purging and sampling methods as discussed in U.S. EPA, Ground Water Issue, Publication Number EPA/540/S-95/504, April 1996 by Puls, R.W. and M.J. Barcelona - "Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures."

The field sampler's objective is to purge and sample the well so that the water that is discharged from the pump, and subsequently collected, is representative of the formation water from the aquifer's identified zone of interest.

This SOP is applied when the wells to be sampled are not equipped with dedicated down well equipment.

INITIAL PUMP FLOW TEST PROCEDURES

If possible, the optimum flow rate for each well will be established during well development/redevelopment or in advance of the actual sampling event. The monitoring well must be gauged for depth to water (SWL) prior to the installation of the disposable sampling tubing and before pumping of any water from the well. The measurement will be documented on a Field Data Sheet.

After tubing installation and confirmation that the SWL has returned to its original level (as determined prior to tubing installation), the peristaltic pump should be started at a discharge rate less than 0.5 liters per minute (0.13 gal/min) without any In-Line Flow Cell connected. The water level in the well casing must be monitored continuously for any change from the original measurement. If significant drawdown is observed, the pump's flow rate should be incrementally reduced until the SWL drawdown ceases and stabilizes. Total drawdown from the initial (static) water level should not exceed 25 percent of the distance between tubing inlet location and the top of the well screen (for example, if a well has a ten-foot screen zone and the tubing inlet is located mid-screen; the maximum drawdown should be 1.25 feet). In any case, the water level in the well should not be lowered below the top of the screen/intake zone of the well.

Once the specific well's optimum flow rate, without an In-Line Flow Cell connected, has been determined and documented, connect the In-Line Flow Cell system to be used to the well discharge and determine the control settings required to achieve the well's determined optimum flow rate with the In-Line Flow Cell connected (due to the system's back-pressure, the flow rate will be decreased by ten to 20 percent).

PURGE AND SAMPLING EVENTS

Prior to the initiation of purging a well, the Static Water Level will be measured and documented. The peristaltic pump will be started utilizing its documented control settings and its flow rate will be confirmed by volumetric discharge measurement with the In-Line Flow Cell connected. If necessary, any minor modifications to the control settings to achieve the well's optimum flow rate will be documented on the gauging sheet. When the optimum pump flow rate has been established, the SWL drawdown has stabilized within the required range, and at least one pump system volume (down well extraction tubing, pump head tubing, and discharge tubing volume) has been purged, begin taking field measurements for pH, temperature (T), conductivity (Ec), oxygen reduction potential (ORP), dissolved oxygen (DO), and turbidity (TU) using an in-line flow cell. All water chemistry field measurements will be documented on the gauging sheet. Measurements should be taken every three to five minutes until stabilization has been achieved. Stabilization is achieved after all parameters have stabilized for three consecutive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or dissolved oxygen. Three consecutive measurements indicating stability should be within:

Temperature	± 3 percent of reading (minimum of ± 0.2 C)
pH	± 0.1 units, minimum
Conductance	± 3 percent of reading
Dissolved Oxygen	± 10 percent of reading
Redox (ORP)	± 10 mV
Turbidity	± 10 percent NTU or < 10 NTU (Turbidity is not a water chemistry indicator parameter but is useful as an indicator of pumping stress on the formation)

When water quality parameters have stabilized, and there has been no change in the stabilized SWL (i.e., no continuous drawdown), sampling collection may begin.

EQUIPMENT LIST

The following equipment is needed to conduct low flow purging and sampling:

- Portable peristaltic pump equipped with a flow controller set to operate at the specific well's documented optimum flow rate.
- Disposable down well sampling tubing of sufficient length to intake groundwater at the target sampling depth for each well.
- In-Line Flow Cell and meter(s) with connection fittings and tubing to measure water quality.
- Water Level Probe or installed dedicated water level measurement system.
- Photoionization detector (PID).
- Sample containers appropriate for the analytical requirements.
- Field measurement documentation forms.
- 300 to 500 milliliter graduated cylinder or measuring cup.
- Five gallon bucket(s) for containerizing purge water.
- Wristwatch with second hand or stopwatch.
- Sufficient cleaning and decontamination supplies if portable Water Level Probe is utilized.

PROCEDURE

- Calibrate all field instruments at the start of each day's deployment per the instrument manufacturer's instructions. Record calibration data.
- Drive to the first well scheduled to be sampled (typically the least contaminated). Make notes in the field log book describing the well condition and activity in the vicinity of the well. Decontaminate the portable water gauging probe by washing with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Remove the wellhead cover and take a measurement of the well vapor space with a PID. Record the measurement on the gauging and sampling sheet.

- Measure the depth to water from the surveyed reference mark on the wellhead and record the measurement on the gauging and sampling sheet. Lock the water level meter in place so that the level can be monitored during purging and sampling. When placing the probe in the well, take precautions to not disturb or agitate the water.
- Insert a sufficient length of disposable sampling tubing into the well casing to insure that the tip of the tubing is located within the appropriate sampling depth within the well screen.
- Insert a new length of flexible silicone tubing into the peristaltic pump head fixture.
- Connect the down well sampling tubing to the silicone tubing in the peristaltic pump head fixture.
- Connect a new length of disposable pump discharge tubing to the silicone tubing in the peristaltic pump head fixture and secure to drain the flow-rate test purge water into the purge water collection container.
- Start the peristaltic pump. Set the pump controller settings to the documented settings for the specific well. Confirm the flow rate is equal to the well's established optimum flow rate. Modify as necessary (documenting any required modifications).
- Monitor the water level and confirm that the SWL drawdown has stabilized within the well's allowable limits.
- Remove the pump discharge tubing.
- Connect the pump discharge tubing to the In-Line flow cells "IN" fitting.
- Connect the Flow Cell's "OUT" line and secure to drain the purge water into the purge water collection container.
- After a single pump-system's volume (down well sampling tubing, pump head silicone tubing, and discharge tubing volume) has been adequately purged, read, and record water quality field measurements every three to five minutes until all parameters have stabilized within their allowable ranges for at least three consecutive measurements. When stabilization has been achieved, sample collection may begin.
- Disconnect the flow cell, and it's tubing, from the pump discharge line before collecting samples. Decrease the pump rate to 100 milliliters per minute or less by lowering the pump controller's setting prior to collecting samples for volatiles. Refer to the task instructions for the correct order and procedures for filling sample containers. Place the samples in a cooler with enough ice to keep them at 4 degrees Centigrade.
- Once samples for volatiles have been collected, re-establish pump flow rate to the original purge flow rate by inputting the documented controller settings for the well without the In-Line Flow Cell connected, and collect remaining samples.
- When all sample containers have been filled, make a final measurement of the well's Static Water Level and record the measurement on the gauging and sampling sheet. Measure the Total Depth of the well and record the measurement, as well.
- Measure and record total purge volume collected. Consolidate generated purge water.
- Remove and decontaminate the Portable Water Level Probe with phosphate-free detergent, rinsing with potable water and rinsing with deionized water.

- Disconnect and dispose of each length of down well sampling tubing, silicone pump head tubing, and pump discharge tubing.
- Secure the peristaltic pump in the portable pump carrying case.
- Secure the wellhead cover and secure with its lock. Move equipment to next well to be sampled.
- At the end of each day, post calibrate all field instruments and record the measurements.
- Clean and decontaminate the In-Line Flow Cell with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Photocopies of all completed forms should be made each day. The copies should be retained on site. The original forms will be kept in the PNG Environmental project file.

GROUNDWATER
SAMPLE COLLECTION FORM

Well ID no____________________________ Project name__________________________
Sample no.___________________________ Project no.____________________________
Date______/___/______________________ Collector_______________________________

Well Information

Monument condition ☐ Good ☐ Needs repair______________________________
Well cap condition ☐ Good ☐ Locked ☐ Replaced ☐ Needs replacement
Headspace reading ☐ Not measured _______ ppm ☐ Odor_____________
Elevation mark ☐ Yes ☐ Added ☐ Other ________________________
Well diameter ☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other ____________

Purge Data

Total well depth______________ft ☐ Clean bottom ☐ Muddy bottom ☐ Not measured
Depth to product_____________ft
Depth to water_______________ft
Casing volume ______________ft (H_2O) X ___________gpf = ________ X 3 = ______________
Casing volumes 3/4”=0.02 gpf 1”=0.04 gpf 2”=0.16 gpf 4”=0.65 gpf 6”= 1.47 gpf
Bladder Pumps: ¼” Tubing purge: 5.3mL/ft + 100mL; 3/8” Tubing purge: 9.5 mL/ft + 500mL

Purge Method

Pump type ☐ Peristaltic ☐ Bladder ☐ Submersible ☐ Other_____________
Purge tubing ☐ New LDPE ☐ New HDPE ☐ New Teflon ☐ New Tygon ☐ Other ______
Bailer type ☐ Disposable ☐ Teflon ☐ Stainless ☐ PVC ☐ Other ______
Purge start time______________Purge stop time______________Purge rate_________________
Refill Timer Setting______ Discharge Timer Setting ______ Pressure Setting______ Flow Rate _______

Field Parameters

Meter used ☐ HYDAC Ξ QED Flow Cell ☐ Hanna ☐ Other____________

Gallons / mL	pH	Temp (F)	Conductivity	ORP	DO mg/L	Turbidity	Comments

Sampling Device

Bailer ☐ Disposable ☐ Stainless ☐ Teflon ☐ Other __________________
Filter Type__________ Size________ (micron) Bailer cord used ☐ Monofillament

Bottles Filled Time_________

Number	Type			Preservative					Filtration	
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No

Comments:

Sampler’s Signature___________________________________Date_________/___/_________

STANDARD OPERATING PROCEDURE
LOW-FLOW GRUNDFOS REDI-FLO2 ENVIRONMENTAL PUMP GROUNDWATER SAMPLING METHOD
SOP 19

This standard operating procedure (SOP) is designed to assist the user in taking representative groundwater samples from wells. Groundwater samples will be collected using low-flow (minimal drawdown) purging and sampling methods as discussed in U.S. EPA, Ground Water Issue, Publication Number EPA/540/S-95/504, July 30, 1996 by Puls, R.W. and M.J. Barcelona - "Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells."

The field sampler's objective is to purge and sample the well so that the water that is discharged from the pump (and subsequently collected) is representative of the formation water from the aquifer's identified zone of interest.

This SOP is applied when the wells to be sampled are not equipped with dedicated down well equipment. The grundfos redi-flo2 environmental pump must be used in conjunction with the variable frequency drive (VFD) to perform low-flow sampling.

INITIAL PUMP FLOW TEST PROCEDURES

Measure and record the Static Water Level (SWL) on field data sheet following procedures outlined in SOP 10.

If possible, the optimum flow rate for each well will be established during well development/redevelopment or in advance of the actual sampling event. The appropriate tubing type (Teflon, HDPE, PVC, polyethylene, etc.) should be preselected based on the analytes of interest.

The mid-point of the saturated screen length is used by convention as the location of the pump intake (i.e. if total well depth is 30 feet below ground surface (bgs) and well is screened from 20-30 feet with a SWL of less than 20 feet. bgs, base of tubing should be lowered to 25 feet.). If the head within the well is within the screened interval tubing intake should be placed at ½ of the static well head (i.e. for previous example SWL is at 22 feet. bgs, tubing intake should be placed at 26 feet bgs: well depth [30 feet] minus SWL [22 feet] equals eight feet of head in well; 30 minus [8 x ½] equals 26 feet.).

Site specific work plans may change the pump intake depth in order to sample from the highest yielding zone within the screened interval. In wells with a fully saturated screen length over ten feet, testing should be performed if possible during development to determine highest water yielding zone within the screened interval.

After slowly lowering redi-flo2 pump with tubing pre-assembled to desired intake depth connect the pump to the VFD and power on. Slowly increase the pumping rate on the VFD such that pump discharge rate less than 0.5 liters per minute (L/min) (0.13 gal/min) without any In-Line Flow Cell connected. It is possible one may need to "prime the pump" during initial start up such that the flow rate is increased until discharge begins and then is immediately reduced to less than 0.5 L/min. The water level in the well casing must be monitored continuously for any change from the original measurement. If significant drawdown is observed, the pump's flow rate should be incrementally reduced until the SWL drawdown ceases and stabilizes. Total drawdown from the initial (static) water level should not exceed 0.3 feet. In any case, the water level in the well should not be lowered below the top of the screen/intake zone of the well.

Once the specific well's optimum flow rate, without an In-Line Flow Cell connected, has been determined and documented, connect the In-Line Flow Cell system to be used to the well discharge and determine the control settings required to achieve the well's determined optimum flow rate with the In-Line Flow Cell connected (due to the system's back-pressure, the flow rate may decreased slightly, however, this is less likely with the grundfos then with the peristaltic pump).

PURGE AND SAMPLING EVENTS

Prior to the initiation of purging a well, the Static Water Level will be measured and documented. The grundfos redi-flo2 pump will be started utilizing its documented control settings and its flow rate will be confirmed by volumetric discharge measurement with the In-Line Flow Cell connected. If necessary, any minor modifications to the control settings to achieve the well's optimum flow rate will be documented on the gauging sheet. When the optimum pump flow rate has been established, the SWL drawdown has stabilized within the required range, and at least one pump system volume (down well extraction tubing, pump head tubing, and discharge tubing volume) has been purged, begin taking field measurements for pH, temperature (T), conductivity (Ec), oxygen reduction potential (ORP), dissolved oxygen (DO), and turbidity (TU) using an in-line flow cell. All water chemistry field measurements will be documented on the gauging sheet. Measurements should be taken every three to five minutes until stabilization has been achieved. Stabilization is achieved after all parameters have stabilized for three consecutive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or dissolved oxygen. Three consecutive measurements indicating stability should be within:

Temperature	± 3 percent of reading (minimum of ± 0.2 C)
pH	± 0.1 units, minimum
Conductance	± 3 percent of reading
Dissolved Oxygen	± 10 percent of reading
Redox (ORP)	± 10 mV
Turbidity	± 10 percent Nephelometric Turbidity Units (NTU) or < 10 NTU (Turbidity is not a water chemistry indicator parameter but is useful as an indicator of pumping stress on the formation)

When water quality parameters have stabilized, and there has been no change in the stabilized SWL (i.e., no continuous drawdown), sampling collection may begin.

EQUIPMENT LIST

The following equipment is needed to conduct low flow purging and sampling:

- Grundfos redi-flo2 environmental pump equipped with a VFD to operate at the specific well's documented optimum flow rate.
- Extension cords to power pump and VFD.
- Generator if no a/c outlet is available on-site.
- Disposable down well sampling tubing of sufficient length to connect to pump and deliver groundwater to the surface for each well to be sampled.
- In-Line Flow Cell and meter(s) with connection fittings and tubing to measure water quality.
- Water Level Probe or installed dedicated water level measurement system.

- Photoionization detector (PID).
- Sample containers appropriate for the analytical requirements.
- Field measurement documentation forms.
- 300 to 500 milliliter graduated cylinder or measuring cup.
- Five gallon bucket(s) for containerizing purge water.
- Wristwatch with second hand or stopwatch.
- Sufficient cleaning and decontamination supplies for cleaning the grundfos redi-flo2 pump and water level probe.

PROCEDURE

- Calibrate all field instruments at the start of each day's deployment per the instrument manufacturer's instructions. Record calibration data.
- Drive to the first well scheduled to be sampled (typically the least contaminated). Make notes in the field log book describing the well condition and activity in the vicinity of the well. Decontaminate the portable water gauging probe by washing with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Remove the wellhead cover and take a measurement of the well vapor space with a PID. Record the measurement on the gauging and sampling sheet.
- Measure the depth to water from the surveyed reference mark on the wellhead and record the measurement on the gauging and sampling sheet. Lock the water level meter in place so that the level can be monitored during purging and sampling. When placing the probe in the well, take precautions to not disturb or agitate the water.
- Calculate the proper pump placement within the well screen using well construction log and water level measurements.
- Insert grundfos redi-flo2 pump into the well casing with sufficient tubing pre-attached to insure that the pump intake is located at the appropriate sampling depth within the well screen.
- Connect the grundfos redi-flo2 to the VFD and connect the VFD to wall outlet or generator.
- Secure tubing to bucket/drum to collect purge water into the purge water collection container.
- Start the grundfos pump using the VFD. Set the VFD controller settings to the documented settings for the specific well (if previously recorded). Confirm the flow rate is equal to the well's established optimum flow rate. Modify as necessary (documenting any required modifications).
- Monitor the water level and confirm that the SWL drawdown has stabilized within the well's allowable limits.
- Connect the pump discharge tubing to the In-Line flow cells "IN" fitting.
- Cut new tubing and connect to the Flow Cell's "OUT" line and secure to drain the purge water into the purge water collection container.

- After a single pump-system's volume (down well sampling tubing, pump head silicone tubing, and discharge tubing volume) has been adequately purged, read, and record water quality field measurements every three to five minutes until all parameters have stabilized within their allowable ranges for at least three consecutive measurements. When stabilization has been achieved, sample collection may begin.
- Disconnect the flow cell and it's tubing from the pump discharge line before collecting samples. Decrease the pump rate to approximately 100 milliliters per minute by lowering the VFD setting prior to collecting samples for volatiles. Refer to the task instructions for the correct order and procedures for filling sample containers. Place the samples in a cooler with enough ice to keep them at 4 degrees Centigrade.
- Once samples for volatiles have been collected, re-establish pump flow rate to the original purge flow rate by inputting the documented controller settings for the well without the In-Line Flow Cell connected, and collect remaining samples.
- When all sample containers have been filled, make a final measurement of the well's Static Water Level and record the measurement on the gauging and sampling sheet. Measure the Total Depth of the well and record the measurement.
- Measure and record total purge volume collected. Consolidate generated purge water.
- Remove and decontaminate the Portable Water Level Probe with phosphate-free detergent, rinsing with potable water and rinsing with deionized water.
- Remove pump and discharge tubing from well and place into deionized water with phosphate-free detergent, turn pump on and run detergent water through pump for approximately three to five minutes.
- In suspected or known heavily contaminated aquifers the following steps are needed after detergent water has been run through pump
    - If groundwater is known to be heavily contaminated with metals:
        - Place pump in diluted HCL solution (<10%) and run through pump for three to five minutes.
    - If groundwater is known to be heavily contaminated with organics:
        - Place pump in diluted isopropanol, acetone, methanol, or hexane, alone or if required in combination. Run solution through pump for three to five minutes.
- Move pump into deionized water only, turn pump on and run deionized water through pump for approximately three to five minutes. Dry thoroughly.
- The quality of pump decontamination between wells can be gauged using periodic trip blanks.
- Disconnect and dispose of each length of down well sampling tubing, silicone pump head tubing, and pump discharge tubing.
- Secure the grundfos pump in the portable reel hold.
- Secure the VFD and connection line in VFD case.

- Secure the wellhead cover and secure with its lock. Move equipment to next well to be sampled.
- At the end of each day, post calibrate all field instruments and record the measurements.
- Clean and decontaminate the In-Line Flow Cell with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Photocopies of all completed forms should be made each day. The copies should be retained on site. The original forms will be kept in the PNG Environmental project file.

GROUNDWATER SAMPLE COLLECTION FORM

Well ID no___________________________ Project name_________________________
Sample no.___________________________ Project no.___________________________
Date______/___/______________________ Collector_____________________________

Well Information

Monument condition ☐ Good ☐ Needs repair_______________________________
Well cap condition ☐ Good ☐ Locked ☐ Replaced ☐ Needs replacement
Headspace reading ☐ Not measured _______ ppm ☐ Odor_____________
Elevation mark ☐ Yes ☐ Added ☐ Other _________________________
Well diameter ☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other ____________

Purge Data

Total well depth_____________ft ☐ Clean bottom ☐ Muddy bottom ☐ Not measured
Depth to product_____________ft Pump/Tubing Intake Depth_______________ft
Depth to water_______________ft
Casing volume _____________ft (H_2O) X ___________gpf = _______ X 3 =____________
Casing volumes 3/4”=0.02 gpf 1”=0.04 gpf 2”=0.16 gpf 4”=0.65 gpf 6”= 1.47 gpf
Bladder Pumps: ¼” Tubing purge: 5.3mL/ft + 100mL; 3/8” Tubing purge: 9.5 mL/ft + 500mL

Purge Method

Pump type ☐ Peristaltic ☐ Bladder ☐ Submersible ☐ Other_____________
Purge tubing ☐ New LDPE ☐ New HDPE ☐ New Teflon ☐ New Tygon ☐ Other _____
Bailer type ☐ Disposable ☐ Teflon ☐ Stainless ☐ PVC ☐ Other _____
Purge start time_____________Purge stop time_____________Purge rate_________________

Field Parameters

Meter used ☐ HYDAC Ξ QED Flow Cell ☐ Hanna ☐ Other___________

Gallons / mL	pH	Temp (F)	Conductivity	ORP	DO mg/L	Turbidity	Comments

Sampling Device

Bailer ☐ Disposable ☐ Stainless ☐ Teflon ☐ Other __________________
Filter Type_________ Size________ (micron) Bailer cord used ☐ Monofillament

Bottles Filled Time_________

Number	Type			Preservative					Filtration	
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No
___	☐ VOA	☐ Amber	☐ Poly	☐ HCL	☐ Nitric	☐ Sulfuric	☐ None	☐ Other__	☐Yes	☐No

Comments:

Sampler’s Signature____________________________________Date_________/___/_________

STANDARD OPERATING PROCEDURE
SUB-SLAB VAPOR MONITORING AND SAMPLING
SOP 22

This standard operating procedure (SOP) describes procedures for performing sub-slab soil gas (vapor) monitoring and sampling. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present.

Personnel performing the soil gas monitoring and sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT

Coring/probe installation equipment which may be used includes the following: a rotary hammer (rotohammer) drill or truck-mounted Geoprobe rig, ½" to 1" diameter concrete coring drill bit (9/16" diameter recommended), cloth (for dust suppression during drilling), 0.25-inch outer diameter (OD) tubing (nylon, stainless steel, or Teflon®), granular bentonite grout or alternative, fine-grained (20-40) sand, cement. Aluminum foil covered one-hole rubber stoppers with stainless steel or brass tubes may also be utilized.

Leak check equipment using helium or other pre-approved non-reactive tracer gas may include: helium tank, piping, and valve, leak check enclosure (shroud), helium detector, paper towels or rags, and nitrile gloves.

Monitoring/sampling equipment which may be used includes the following: Summa canister (may be a one-liter or six-liter Summa canister with valve), certified flow controller, steel filter, T-fitting, PID, low flow vacuum pump (could be PID), vacuum gauge, barometer/thermometer/wind speed indicator.

CORING/PROBE INSTALLATION PROCEDURES

Concrete coring will be performed using a rotohammer, truck-mounted Geoprobe rig, or concrete corer. Prior to coring or drilling, an attempt will be made to locate utility lines and inside a building, to determine whether or not the building has an existing vapor barrier or a tensioned slab.

A minimum of one sample will be collected from beneath each building. In addition, one duplicate sample will be collected. If possible, the samples will be located in the central portion of the slab, away from the floor slab/perimeter foundation junction, where dilution is more likely to occur.

In each sample location, a small diameter (1/2" to 1") hole will be drilled in the foundation using a rotohammer or a truck-mounted Geoprobe rig. When drilling the hole, no water should be used, and care should be taken not to puncture the surface of soil underneath. If dust prevention is necessary, cover the location with a cloth or towel and drill through a pre-cut small hole in the cloth. During the course of work, it is important not to disturb the subslab region by applying significant pressures that might affect vapor concentrations by running of appliances or fans, slamming doors, or open doors or windows on a windy day. After coring, insert tubing with sampling point and add sand to cover tip with approximately 1 inch of sand. Grout to the surface with hydrated bentonite grout (if temporary installation) or cement (if permanent installation). Wait 30 minutes prior to sampling for bentonite or cement to congeal. VOC-free modeling clay may also be used to seal around the sample tubing to prevent vapor short-circuiting to the surface. An alternative to grouting around the tubing would be to utilize an aluminum foil-covered one-hole rubber stopper equipped with a stainless steel or brass vapor probe. This stopper would then be placed in the core hole, and tubing connected to it. Additional sealing of the stopper could be performed as previously described.

Procedures for leak checking, soil gas purging, and sampling are described in the section below.

Following the completion of sampling, patch the hole(s) in the building slab with cement and finish flush with the surface.

SYSTEM SETUP

Measure and record the initial vacuum of the laboratory-provided Summa canister.

The canister will then be fitted with the laboratory-provided steel filter. A 3-way valve will then be connected to the downhole tubing, with valves at each end of the 3-way valve.

The sampling train (steel-filter, flow-controller (if used), and Summa canister) will be attached to one of the closed valves (referred to as the sampling valve), and the vacuum pump (truck-mounted or otherwise) attached to the other closed valve (referred to as the purge valve).

LEAKING CHECKING - APPARATUS

After the sampling system is set up, make sure all valves are closed.

Open the purge valve (the valve connecting the purge pump to the apparatus), turn on the purge pump, and adjust to achieve a purge rate of approximately 100 to 200 milliliters per minute (ml/min).

Close the purge valve and check to verify that there is no loss of vacuum within the sampling apparatus over a one minute period of time. If there is a loss of vacuum, this indicates a leak in the purge/sample system that must be remedied. Close all valves.

If necessary, recheck the system to verify that there is no leakage as described above.

Document the date and time the leak check(s) were performed.

LEAKING CHECKING – PROBE POINT SURFACE SEAL

In addition checking for leaks in the apparatus, the probe point surface seal also needs to be checked for leakage. The preferred method uses helium gas as a tracer and permits checking for and correcting potential leaks in the field prior to sampling. Other tracer gases may be used but approval of their use should be verified prior to the start of the work.. The helium tracer gas method is listed in ITRC's "Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline" dated January 2007 (ITRC, 2007), and as described below.

Helium Leak Check Method

- Insert sample tubing through the leak check enclosure (also referred to as a shroud) and complete sample tubing connections to the other apparatus.
- Place the enclosure flush with the ground surface.
- Attach helium tubing from the helium tank regulator to the enclosure (the "helium in" tubing).

- Attach the exhaust tubing ("helium out") to the enclosure and locate the discharge end of the tubing as far as possible from the helium detector.
- Attach the helium detector on the exhaust line from the sample pump.
- Make sure the sample valve (from the sampling probe point) is closed.
- Open the helium tank valve and set the flow to approximately 200 milliliter per minute (ml/min); let it flow for about one minute to fill the leak check enclosure.
- Do an initial check to make sure the helium detector is not detecting any helium.
- Begin purging of soil gas as described in the section on purging below. During purging, continue monitoring helium detector, record readings. If helium is detected at over 10%, this indicates leakage; check/tighten all seals and fittings and repeat procedure.
- Close valves from the probe sampling point and purge pump lines, and turn pump off.
- If the helium detector reading is less than 10%, the system is considered leak free and sampling can be performed (see sampling section below).
- If the helium detector reading continues to be above 10%, leakage is indicated and the probe hole abandoned.
- Record helium monitoring measurements in field notes.

SOIL GAS PURGING PROCEDURES

Purging and sampling will be accomplished at a low flow rate (100 to 200 ml/min) to minimize the potential for inducing leakage.

Slowly open the vacuum pump purge valve and purge one to two tubing volumes of vapor from the line, then close the purge valve. Based on a volume of approximately 0.044 liters per foot of 0.25-inch ID tubing, and assuming 5 feet of tubing above ground, this would yield a purge volume of 0.44 liters for a 5-foot probe depth.

Care will be taken not to purge an excessive volume, or at an excessive rate, so as to minimize the chances of inducing leakage from the surface. In general, two tubing volumes will be the maximum volume purged prior to sampling. The pump will also be monitored for signs that it is laboring, a possible indication of a clogged probe or tubing.

During purging, check for leaks as described in the section on leak checks above.

SOIL GAS SAMPLE COLLECTION PROCEDURES - GRAB SAMPLING

Atmospheric conditions (barometric pressure, temperature, wind speed and direction) will be recorded prior to and after sampling. If atmospheric conditions cannot be directly measured, they will be obtained from the nearest weather station.

Procedures for sample container preparation, sampling, and shipment were provided by Air Toxics Ltd., however, any certified analytical laboratories should be able to provide similar material, as summarized below. The initial vacuum of the laboratory-provided certified Summa canister will be measured and recorded, and the canister then fitted with the laboratory-provided steel filter. A 3-way valve will then be connected to the downhole tubing, as described in the section on system set-up above.

After leak testing and soil gas purging, soil gas sampling may be performed.

After purging, the purge valve will be closed prior to opening the sampling valve. The sample valve will then be opened followed by slowly opening the Summa canister valve; and the canister's valve closed when the vacuum gauge showed a vacuum between –5 and –2 inches of mercury. The tubing sample valve should then be closed. At the completion of sampling the canister steel filter will then be removed and the fitting capped.

After removing and capping the canister fitting, a PID will be attached to the sample valve and the valve opened, with maximum and minimum PID measurements recorded for the next one minute.

Following PID measurement, the canister valve will be opened and the canister final vacuum recorded. The canister valve will then immediately be closed, the vacuum gauge removed, and the canister capped. The final vacuum reading from the canister should be recorded on the chain of custody and sample collection form.

Soil vapor samples will be shipped to a certified laboratory for analysis.

SAMPLING PROCEDURES USING A FLOW CONTROLLER SAMPLING

Procedures for sample container preparation, sampling, and shipment were provided by Air Toxics Ltd., however, any certified analytical laboratory should provide similar material. The sampling procedure is exactly the same as the sample procedure for grab sampling except that an in-line flow controller for a pre-specified sampling time (i.e. 30 minutes) will be used. The flow controller fits between the laboratory provided steel particulate filter and the Summa canister. The entire sample train (laboratory-provided steel particulate filter, flow-controller, and summa canister) should be pre-assembled prior to connecting to the sampling valve.

References: *Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline, Interstate Technology & Regulatory Council, dated January 2007 (ITRC, 2007)*

STANDARD OPERATING PROCEDURE
SOIL GAS (VAPOR) MONITORING AND SAMPLING
SOP 24

This standard operating procedure (SOP) describes procedures for performing soil gas (vapor) monitoring and sampling. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present.

Personnel performing the soil gas monitoring and sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT

Soil gas monitoring and sampling will be performed using direct push sampling equipment. The direct push probe will be advanced using either a truck- or track-mounted Geoprobe rig, or for limited access areas, using portable methods such as rotary hammer drill (rotohammer).

Coring/probe installation equipment which may be used includes the following a rotohammer or truck-mounted Geoprobe rig, ½" to 1" diameter concrete coring drill bit, cloth (for dust suppression during drilling), Geoprobe drill rods, 0.25-inch diameter tubing (nylon, stainless steel, or Teflon®), fine-grained (20-40) sand, granular bentonite grout or alternative, and possibly cement in cases where the formation has a very low permeability.

Leak check equipment using helium or other pre-approved non-reactive tracer gas may include: helium tank, piping, 3-way valve, leak check enclosure (shroud), helium detector, paper towels or rags, and nitrile gloves.

Monitoring/sampling equipment which may be used includes the following: Summa canister (may be a one-liter or six-liter Summa canister with valve), certified flow controller, steel filter, 3-way valve, extra miscellaneous valves, PID, low flow vacuum pump (could be PID), vacuum gauge, barometer/thermometer/wind speed indicator.

CORING/PROBE INSTALLATION PROCEDURES

Prior to drilling or coring, an attempt will be made to locate utility lines and if inside a building, to determine whether or not the building has an existing vapor barrier or a tensioned slab.

When samples are collected beneath buildings, a minimum of one sample will be collected from beneath each building. In addition, one duplicate sample will be collected. If possible, the samples will be located in the central portion of the slab, away from the floor slab/perimeter foundation junction, where dilution is more likely to occur.

In each sample location, a small diameter (1/2" to 1") hole will be drilled in the foundation using a rotohammer, truck-mounted Geoprobe rig, or concrete corer. When drilling the hole, no water should be used, and care should be taken not to puncture the surface of soil underneath. If dust prevention is necessary, cover the location with a cloth or towel and drill through a pre-cut small hole in the cloth.

The probes are typically advanced to a depth of 5 feet bgs, however, other site-specific depths may be targeted by the work plan. At target depth, the probe rod will be withdrawn approximately three inches to disengage the expendable probe tip and minimize the terminal void space volume. New, dedicated disposable nylon, stainless steel, or Teflon® tubing (nylon preferred) would then be fitted with a barbed steel end nut, pushed into the base of the probe rod, and threaded onto a downhole terminal fitting sealed with an o-ring to prevent vapor short-circuiting to the surface through the rod annulus.

The area immediately around the probe rods may be grouted in using hydrated bentonite grout (if temporary installation) or cement (if permanent installation). Wait 30 minutes prior to sampling for bentonite or cement to congeal. VOC-free modeling clay may also be used to seal around the probe rods to prevent vapor short-circuiting to the surface.

Procedures for leak checking, soil gas purging, and sampling are described in the section below.

Following the completion of sampling, the soil boreholes will be filled with hydrated granular or powdered bentonite grout. If a building slab or pavement is present, the hole(s) will be patched with cement and finished flush with the surface.

SYSTEM SETUP

Measure and record the initial vacuum of the laboratory-provided Summa canister.

The canister will then be fitted with the laboratory-provided steel filter. A 3-way valve will then be connected to the downhole tubing, with valves at each end of the 3-way valve.

The sampling train (steel-filter, flow-controller (if used), and Summa canister) will be attached to one of the closed valves (referred to as the sampling valve), and the vacuum pump (truck-mounted or otherwise) attached to the other closed valve (referred to as the purge valve).

LEAK CHECKING - APPARATUS

The method described below may be used to check for leaks in the lines and fittings of the above-ground sampling apparatus:

After the sampling system is set up, make sure all valves are closed.

Open the purge valve (the valve connecting the purge pump to the apparatus), turn on the purge pump, and adjust to achieve a purge rate of approximately 100 to 200 milliliters per minute (ml/min)..

Close the purge valve and check to verify that there is no loss of vacuum within the sampling apparatus over a one minute period of time. If there is a loss of vacuum, this indicates a leak in the system that must be remedied. Close all valves.

If necessary, recheck the system to verify that there is no leakage as described above.

Document the date and time the leak check(s) were performed.

LEAK CHECKING – PROBE POINT SURFACE SEAL

The preferred method for leak detection uses helium tracer gas; however, other pre-approved tracer gases may be used if required by the work plan. These methods permit checking for and correcting potential leaks in the field prior to sampling. The helium tracer method is discussed in ITRC's "Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline" dated January 2007 (ITRC, 2007), and is described below.

Helium Leak Check Method

- Insert sample tubing through the leak check enclosure (also referred to as a shroud) and complete sample tubing connections to the other apparatus.

- Place the enclosure flush with the ground surface.
- Attach helium tubing from the helium tank regulator to the enclosure (the "helium in" tubing).
- Attach the exhaust tubing ("helium out") to the enclosure and locate the discharge end of the tubing as far as possible from the helium detector.
- Attach the helium detector on the exhaust line from the sample pump.
- Make sure the sample valve (from the sampling probe point) is closed.
- Open the helium tank valve and set the flow to approximately 200 ml/minute; let it flow for about one minute to fill the leak check enclosure.
- Do an initial check to make sure the helium detector is not detecting any helium.
- Begin purging of soil gas as described in the section on purging below. During purging, continue monitoring helium detector, record readings. If helium is detected at over 10%, this indicates leakage; check/tighten all seals and fittings and repeat procedure.
- Close valves from the probe sampling point and purge pump lines, and turn pump off.
- If the helium detector reading is less than 10%, the system is considered leak free and sampling can be performed (see sampling section below).
- If the helium detector reading continues to be above 10%, leakage is indicated and the probe hole abandoned.
- Record helium monitoring measurements in field notes.

SOIL GAS PURGING PROCEDURES

Purging and sampling will be accomplished at a low flow rate (100 to 200 ml/minute) to minimize the potential for inducing leakage.

Slowly open the vacuum pump purge valve and purge one to two tubing volumes of vapor from the line, then close the purge valve. Based on a volume of approximately 0.044 liters per foot of 0.25-inch ID tubing, and assuming four feet of tubing above ground, this would yield a purge volume of 0.44 liters for a six-foot probe depth, and a purge volume of 0.53 liters for an 8-foot probe depth.

During purging, oxygen and carbons dioxide concentrations may be monitored in the soil gas stream if desired by the work plan.

SOIL GAS SAMPLING PROCEDURES

Atmospheric conditions (barometric pressure, temperature, wind speed and direction) will be recorded prior to and after sampling. If atmospheric conditions cannot be directly measured, they will be obtained from the nearest weather station.

Procedures for sample container preparation, sampling, and shipment are provided by Air Toxics Ltd., however, any certified analytical laboratory should provide similar material. These procedures are summarized as follows. The initial vacuum of the laboratory-provided Summa canister will be measured and recorded, and the canister then fitted with the laboratory-provided steel filter and flow-controller (if desired). A 3-way valve will then be connected to the downhole tubing, with valves at each end of the 3-way valve as described in the section on system set-up above.

After any leak testing and soil gas purging, soil gas sampling may be performed.

After purging, the purge valve will be closed prior to opening the sampling valve. The sample valve will then be opened followed by slowly opening the Summa canister valve; and the canister's valve closed when the vacuum gauge shows a vacuum between –5 and –2 inches of mercury. The tubing sample valve should then be closed. At the completion of sampling the canister steel filter will then be removed and the fitting capped.

After removing and capping the canister fitting, a PID will be attached to the sample valve and the valve opened, with maximum and minimum PID measurements recorded for the next one minute.

Following PID measurement, the canister valve will be opened and the canister final vacuum recorded. The canister valve will then immediately be closed, the vacuum gauge removed, and the canister capped. The final vacuum reading from the canister should be recorded on the chain of custody and sample collection form.

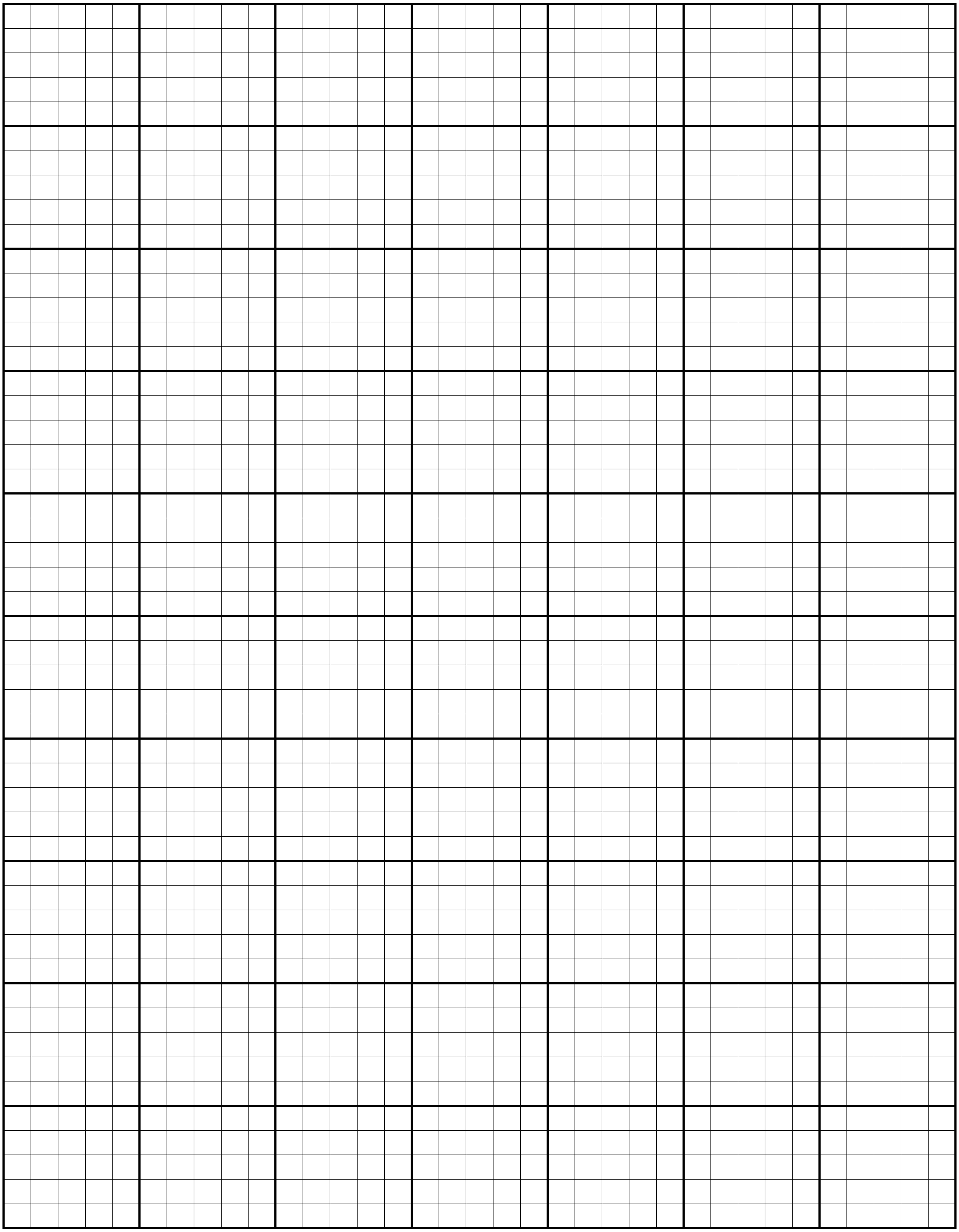
Soil vapor samples will be shipped to a certified laboratory for analysis.

References: *Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline, Interstate Technology & Regulatory Council, dated January 2007 (ITRC, 2007)*

APPENDIX SAP-2

FIELD FORMS

PNG Environmental, Inc 6665 SW Hampton St., Ste. 101 Tigard, Oregon 97223 PH (503) 620-2387 FAX (503) 620-2977	**FIELD REPORT**			Job Number:
	Project:			Date:
	Client:			Page: of
Prepared By:	Location:		Arrival:	Permit Number:
Purpose:	Weather:		Departure:	



DAILY AIR MONITORING RECORD

PNG Environmental, Inc.

Project ____ Project No. __________________________

Location _______________________________________ Date _______________ Day ___________

Weather: Temp: ____________ Conditions: ____

	Instrument	S/N	Calibration Date	Calibration Gas/Method	Calibration by
Organic vapors					
Parcticulates					
O_2					
Other					
Other					
Draeger					

Time	Location/Description	Organic Vapor (ppm)	Particulates mg/m3	O2 %	CG % LEL	Other

Notes: ____

____

____

Data collected by: ____

Print Name Signature

PNG ***Environmental, Inc.***

6665 SW Hampton Street, Suite 101
Tigard, Oregon 97223

(503) 620-2387 (503) 620-2977 FAX

BORING NUMBER
PROJECT
LOCATION
PROJECT NUMBER
LOGGED BY

North

SAMPLE INFORMATION							STRATA	DESCRIPTION	Well Diagram	BOREHOLE/WELL CONSTRUCTION DETAILS
Sample ID	Sample Type	Blow Counts	% Recov.	PID	Sheen	Depth (Feet)		USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.		
						--				**WELL CONSTRUCTION**
						--				DEPTHS (ft bgs)
						--				Borehole
						--				Sump
						5 --				Screen
						--				Casing
						--				Backfill
						--				Sand Pack
						--				Bentonite
						10 --				Concrete
						--				
						--				
						--				
						--				
						15 --				
						--				
						--				
						--				
						--				
						20 --				
						--				**MATERIALS**
						--				Monument:
						--				Well Cap:
						--				Concrete:
						25 --				Bentonite:
						--				Sand Pack:
						--				Casing:
						--				Well Screen:
						--				End Cap:
						30 --				Other:

DRILLING CONTRACTOR
DRILLING METHOD
BOREHOLE DIAMETER
SAMPLING EQUIPMENT
DRILLING DATE

COORDINATES
GROUND SURFACE ELEVATION
CASING ELEVATION
DATUM

WELL DEVELOPMENT FORM

Well ID #:______________________________ Project name:___________________________
Date:.__________________________________ Project #:_______________________________
Time:__________________________________ Engineer:_________________________________

WELL INFORMATION

Monument condition o Good o Needs repair______________________________
Well cap condition o Good o Locked o Replaced o Needs replacement
Headspace reading o Not measured _______ ppm
Elevation mark o Yes o Added o Other ____________________________
Well diameter o 2-inch o 4-inch o 6-inch o Other ______________
o Odor ______________ o Comments____

PURGE DATA

Total well depth______________ft o Clean bottom o Muddy bottom o Not measured
Depth to product_____________ft
Depth to water_______________ft
Casing volume ______________ft (H_2O) X ___________gpf = ________
Casing volumes 2”=0.16 gpf 4”=0.65 gpf 6”= 1.47 gpf

PURGE METHOD

Pump type o Peristaltic o Centrifugal o Submersible o Other______________
Purge tubing o New LDPE o New HDPE o New Teflon o New Tygon o Other ______
Bailer type o Disposable o Teflon o Stainless o PVC o Other ______
Bailer cord used o Monofillament o Other ____________________
Purge start time______________Purge stop time______________Purge rate__________________
Total Volume Purged (gallons) ______________

FIELD PARAMETERS

Meter used o HYDAC o pH2Tester o Hach o Other______________
Gallons pH Temp. Conductivity Turbidity Comments

____
____
____
____
____

Dissolved Oxygen _____________ **Carbon Dioxide** ______________

NOTES/COMMENTS

____
____
____

Engineer’s Signature______________________________________Date________________________

GROUNDWATER
SAMPLE COLLECTION FORM

Well ID no MW-______________________ Project name__________________________
Sample no. MW-______________________ Project no.____________________________
Date________/____/__________________ Collector_____________________________

Well Information

Monument condition ☐ Good ☐ Needs repair________________________________
Well cap condition ☐ Good ☐ Locked ☐ Replaced ☐ Needs replacement
Headspace reading ☐ Not measured _______ ppm ☐ Odor_____________
Elevation mark ☐ Yes ☐ Added ☐ Other ___________________
Well diameter ☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other ____________
Comments____

Purge Data

Total well depth_____________ft ☐ Clean bottom ☐ Muddy bottom ☐ Not measured
Depth to product_____________ft Top of Screen________ft bgs Water above Screen Y / N
Depth to water______________ft Pump/Tubing Intake Depth_______________ft
Casing volume _____________ft (H_2O) X ___________gpf = ________ X 3 = _____________
Casing volumes 3/4”=0.02 gpf 1”=0.04 gpf 2”=0.16 gpf 4”=0.65 gpf 6”= 1.47 gpf

Purge Method

Pump type ☐ Peristaltic ☐ Centrifugal ☐ Submersible ☐ Other_____________
Purge tubing ☐ New LDPE ☐ New HDPE ☐ New Teflon ☐ New Tygon ☐ Other ______
Bailer type ☐ Disposable ☐ Teflon ☐ Stainless ☐ PVC ☐ Other ______
Purge start time_____________Purge stop time_____________Purge rate__________________

Field Parameters

Meter used ☐ HYDAC ☐ pH2Tester ☐ Hanna ☐ Other____________

Gallons	pH	Temperature	Conductivity	Comments

Dissolved Oxygen ____________ **Oxidation Reduction Potential** ____________

Sampling Device

Bailer ☐ Disposable ☐ Stainless ☐ Teflon ☐ Other ___________________
Filter Type__________ Size________ (micron) ☐ Other ___________________
Bailer cord used ☐ Monofillament ☐ Other ___________________

Bottles Filled Time_________

Number	Type	Preservative	Filtration
____	☐ VOA ☐ Amber ☐ Poly	☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__	☐Yes ☐No
____	☐ VOA ☐ Amber ☐ Poly	☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__	☐Yes ☐No
____	☐ VOA ☐ Amber ☐ Poly	☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__	☐Yes ☐No
____	☐ VOA ☐ Amber ☐ Poly	☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__	☐Yes ☐No
____	☐ VOA ☐ Amber ☐ Poly	☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__	☐Yes ☐No

Comments:

Sampler’s Signature___________________________________Date____/____/_______

PNG Environmental, Inc.

6665 SW Hampton Street, Suite 101
Tigard, Oregon 97223 USA
Phone: (503) 620-2387
Fax: (503) 620-2977

CHAIN OF CUSTODY FORM

Laboratory: ______________________

Address: ______________________

____

Project Name: ______________________

Page: _____ of _____

PNG Project Number: ______________________

PNG Sample Collector: ______________________

PNG Project Manager: ______________________

Laboratory Identification Number	**Laboratory Instructions:** / Sample ID	Sample Collection Date	Sample Collection Time	Sample Matrix: Soil	Water	Other	Number of Containers	Requested Laboratory Analyses: NWTPH-HCID	NWTPH-Gx	NWTPH-Dx	EPA 8020M (BTEX)	EPA 8260 (VOCs)	EPA 8010/8020 (VOCs)	EPA 8270 SIMS (PAHs)	EPA 6010/200.7 (Dissolved Lead)	EPA 8082 (PCBs)					Requested TAT (N / R

For Laboratory Use Only

Total Number of Containers:

COC Seal Intact (Y / N / NA)

Samples Received Intact: (Y / N)

Samples Received Cold: (Y / N)

Report Turnaround Time: (Rush / Normal)

Report Distribution: (Phone / Fax / E-Mail)

1	2	3
Relinquished - Date/Time: ______	Relinquished - Date/Time: ______	Relinquished - Date/Time: ______
Signature: ______	Signature: ______	Signature: ______
Printed Name: ______	Printed Name: ______	Printed Name: ______
Company: ______	Company: ______	Company: ______
Recieved - Date/Time: ______	Recieved - Date/Time: ______	Recieved - Date/Time: ______
Signature: ______	Signature: ______	Signature: ______
Printed Name: ______	Printed Name: ______	Printed Name: ______
Company: ______	Company: ______	Company: ______

COMMENTS

PNG Environmental, Inc 6665 SW Hampton St. Tigard, Oregon 97223 PH (503) 620-2387 FAX (503) 620-2977	**Photo Log**	Job Number:
	Project:	Date:
	Client:	Page: of
Prepared By:	Purpose: Field Documentation	

Photo Number	Time/Date	Description	Photographer
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APPENDIX B

QAPP

APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

Tier 1 and Tier 2 Vapor Intrusion Assessment
Milton's Dry Cleaners
Vancouver, Washington

Ecology Facility Site ID: 19779

Prepared for:

BODYFELT, MOUNT, STOUP, & CHAMBERLAIN
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Prepared by:

PNG ENVIRONMENTAL, INC.

987-03
March 10, 2010

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Table B-1 – Data Quality Objectives for Soil Gas and Air Samples
Table B-2 – Sample Containers and Preservation Requirements

1 INTRODUCTION

This quality assurance project plan (QAPP) presents the organization, objectives, and specific quality assurance (QA) and quality control (QC) associated with a Tier I and Tier II Vapor Intrusion Assessment at the Milton's Dry Cleaner (Milton's) site located in Vancouver, Washington. Specific objectives for this phase of work are described in the accompanying Work Plan. This work is being conducted as part of Remedial Investigation/Risk Assessment/Feasibility Study (RI/RA/FS) performed under Agreed Order No. DE4239 07/4-TC-S between Ms. Lila Rears/Mr. Pat Milton and the Washington Department of Ecology (Ecology).

1.1 SITE DESCRIPTION AND BACKGROUND

Milton's operated as a dry cleaners facility from 1969 to 2001. In 1994, the sewer backed up at Milton's prompting an inspection of the septic tank. Tetrachloroethene (PCE) was detected in the tank during the inspection prompting several environmental investigations to assess the nature and extent of PCE at the site (discussed in detail in the Work Plan).

In 2001, the septic system and 1,839.49 tons of PCE impacted soil was removed from the site under the Voluntary Cleanup Program (VCP). Ecology issued a "soils only" No Further Action (NFA) determination for site after the successful completion of soil remediation. Post remediation groundwater monitoring indicated that PCE concentrations remained above the Model Toxics Control Act (MTCA) Method A Cleanup Level in two of the site monitoring wells. Groundwater remedial action in the form of injection of hydrogen release compounds (HRC) was performed on two occasions to enhance the biodegradation of PCE. Quarterly groundwater monitoring continued at the site until April 2005 when the fourth consecutive quarterly sampling event demonstrated that the concentration of PCE in all four site monitoring wells remained below the MTCA Method A Cleanup Level. A request was made for an NFA determination from Ecology.

Ecology requested that sampling of soil and groundwater be performed on adjacent properties before an NFA would be considered. Access to the adjacent properties was pursued through legal channels but was unsuccessful resulting in no further work being performed on the project. Due to this lack of activity, Ecology removed the site from the VCP.

In 2005, an Environmental Site Assessment (ESA) was performed at the Kyocera International (Kyocera) site as part of a due diligence effort related to a real estate transaction. PCE was discovered in groundwater and prompted further investigation. Kyocera concluded that the PCE was from an upgradient offsite source with Milton's being the most likely source. In 2007, Ecology determined that further investigation was warranted.

The most recent phase of RI work for the Milton's project began in July 2008. Work was performed at the Milton's site and offsite to evaluate the down gradient extent of the contaminant plume. Tasks included on- and off-site soil borings; installation of shallow- and intermediate-zone monitoring wells; collection of soil gas samples; laboratory analysis of soil, water, and soil gas/air samples; interpretation of data; and preparation of technical reports presenting the results of the RI work. As part of this RI work, soil gas samples were collected from six temporary borings drilled on properties owned by

Vancouver School District #37. The results of this work indicated the detection of six chlorinated compounds: PCE, trichloroethene (TCE) cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), 1,1-dichloroethene (1,1-DCE), and vinyl chloride. Based on these findings, additional vapor intrusion sampling was recommended, as described in the accompanying Work Plan.

1.2 QUALITY ASSURANCE PROJECT PLAN OBJECTIVES

The quality assurance project objectives are addressed in terms of the data quality objectives (DQOs). The DQOs are based on the specific objectives of the project and data collection program as presented in the Work Plan. DQOs are selected to ensure that the data collected during the project are of adequate quality to assure that project objectives are met. Additional considerations for DQOs are proven performance of analytical methods and procedures and indirect requirements, such as regulatory agency mandates. Specific objectives for this project are:

- Data collected are high quality, representative, and verifiable.
- Data are usable by the client and the Ecology to support objectives stated in the Work Plan and Agreed Order.

This document includes descriptions of procedures for sampling quality assurance/quality control (QA/QC) and data validation and data entry QA/QC for laboratory data. The QAPP provides a consistent set of QA/QC procedures that will be used throughout the project.

2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The field activities associated with this investigation will be performed by PNG Environmental, Inc. (PNG). CH2M Hill's Applied Science Laboratory (CH2M) in Corvallis, Oregon, will perform laboratory analysis of the soil gas/air samples.

PNG's Project Manager, will be responsible for verifying that the procedures and guidelines described in the QAPP are followed. PNG and CH2M personnel responsibilities for quality assurance activities are summarized below.

Project Manager – Responsibilities

- Oversee project performance to ensure compliance.
- Implement necessary action and adjustments to accomplish program objectives.
- Monitor field investigations.
- Coordinate field and laboratory sample tracking.
- Review all data and prepare reports and other project-related documents.
- Act as liaison between Milton's and Ecology.

Project QA Coordinators – Responsibilities

- Conduct field operations.
- Provide technical QA assistance.
- Arrange for other external procurement packages for QA needs.
- Coordinate corrective actions.
- Review analytical data and data validation reports.

Analytical QA Officer – Responsibilities

- Assure that laboratory instruments are calibrated and maintained as specified.
- Assure internal quality control measures and analytical methods are performed.
- Assure corrective action is taken and project QA coordinator is notified when problems occur.
- Assure that laboratory evaluation is complete and reported in the required deliverables.

3 DATA QUALITY OBJECTIVES

The overall DQOs are to collect acceptable data of known and usable quality. This objective will be achieved and documented using the procedures and criteria set forth in the QAPP. For each measurement made to obtain quantitative data, a set of quality objectives will be used to aid in collecting usable data. This section identifies the known and potential contaminants of potential concern (COPCs) as identified by the Ecology, followed by the measurements that will be used to assess DQOs.

3.1 CHEMICALS OF POTENTIAL CONCERN

Table B-1 lists the constituents and analytical methods for soil gas/air samples to be analyzed for this project. Known and potential COPCs will be analyzed by the following test method:

- Volatile Organic Compounds (VOCs) by Modified Method TO-15 SIM.

Table B-1 compares method reporting limits (MRLs) for analytes by the selected analytical methods to vapor intrusion screening levels and EPA Region 9 Preliminary Remediation Goals (PRGs). Although these criteria or standards may not necessarily be applicable to the project location, they are used to compare achievable MRLs to generally conservative criteria.

3.2 DATA QUALITY OBJECTIVE MEASUREMENTS

The following sections discuss what measurements will be used to assess DQOs, specifically precision, accuracy, representativeness, completeness, and comparability.

Precision, accuracy, and completeness criteria used for field measurements are not generally well defined in guidelines and literature. These parameters have been defined using the best available guidelines to establish field measurement QA objectives and will be followed as closely as possible.

3.2.1 Precision

Data precision will be determined by examining replicate samples for degree of variance and determining if sampling error has occurred. Precision is generally assessed by duplicate measurements of a subset of samples (laboratory or field duplicate samples). The chemical analysis methods define the proportion of the samples being analyzed for which precision must be assessed. This proportion is defined in the laboratory's quality assurance manuals. The precision of physical measurements, such as water level measurements and of field measurements (such as pH and specific conductance) will be based on the general body of data for the instruments and methods, but will not be calculated specifically.

Precision will be expressed as a relative percent difference (RPD). When detected concentrations in either a sample or a duplicate are least than five times the method reporting limit (MRL) or method detection limit (MDL), data quality objectives for precision suggest that sample and duplicate results should be within plus or minus the MRL of each other. When detected concentrations in the sample and duplicate are both greater than five times the MRL, data quality objectives for precision suggest that the RPDs between the results should be less than or equal to 20 percent.

The RPD is calculated as follows:

$$RPD = 100x \frac{|c_1 - c_2|}{(c_1 + c_2)/2}$$

where:

RPD = relative percent difference
c_1 = concentration of an analyte in a sample
c_2 = concentration of an analyte in a duplicate sample

3.2.2 Accuracy

Accuracy measures the level of bias exhibited by an analytical method or measurement. To measure accuracy, a substance with a known value is analyzed or measured, and the result is compared with the known value. Only laboratory accuracy will be assessed. The accuracy of field measurements is inherent in the instrument and procedure used.

The accuracy of laboratory analysis is assessed by measuring standard reference materials (instrument calibration) and spiked samples (surrogate recoveries, matrix spikes, and laboratory control samples). Standard reference materials are used to calibrate laboratory instruments. The analytical method specifies the frequency and accuracy required for a spiked sample analysis.

Spike recovery is determined by splitting a sample into two portions, spiking one portion with a known quantity of a constituent of interest, and analyzing both portions. Spike recovery is expressed as percent recovery:

$$\textit{Percent Recovery} = \frac{(MC - KC) \times 100}{KC}$$

where:

KC = known concentration of an analyte
MC = measured concentration of an analyte

3.2.3 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic of the population, the natural variation at a sampling point, or an environmental condition. There is no standard method or formula to evaluate representativeness. Sampling and analysis plans (SAPs) are designed to allow collection of representative samples. Representativeness is achieved by selecting sampling locations that are appropriate for the objective of the specific sampling task, and by collecting an adequate number of samples. The representativeness of the data will be evaluated and used to identify data gaps that can be addressed during or following completion of the specific investigation.

3.2.4 Completeness

Completeness is generally expressed as a percentage of measurements that are valid and usable relative to the total number of related measurements. Completeness criteria between 80 to 85 percent are identified in EPA guidance (EPA 1987); however, Ecology has specified a completeness criteria of at least 90% be used to determine the adequacy of the results (Ecology 2010). The percent completeness is defined by the following equation.

$$\textit{Percent completeness} = \frac{N \times 100}{N_t}$$

where:

N = Number of samples that meet data quality goals
N_t = Total number of samples analyzed

3.2.5 Comparability

Comparability is an expression of the confidence with which one data set can be compared with another. The use of standard techniques for both sample collection and laboratory analysis should make the data collected comparable to both internal and other data generated.

4 SAMPLING PROCEDURES

Sampling procedures for soil gas/air samples are presented in the Work Plan and the SAP. These procedures are designed such that samples are collected in a manner which will ensure that the project objectives are met.

QA samples will be collected in the field, as specified in the SAP. QA samples will consist of field duplicates. QA samples will be blind labeled and preserved as if they were typical samples. QA samples will be clearly identified on the field sampling data sheets (see SAP). Analytical results from blanks and duplicates will facilitate data QC checks. Field duplicates indicate overall precision in both field and laboratory procedures. Results will be evaluated by applying the parameters discussed in previous section, and the evaluation will be discussed in the data validation report.

Field Duplicates - Duplicate soil gas/air samples will be collected to assess the precision of sampling and analytical procedures. Duplicate soil gas/air samples will be collected and tested for VOCs at an interval of one duplicate per 20 samples collected. Field duplicates will be collected immediately after the initial sample of the duplicate pair.

Laboratory Quality Control Samples - Matrix spike/spike duplicates (MS/MSD) consist of identifying selected samples for laboratory quality control measures. MS/MSD samples will be identified at a rate of one per 20 samples or sample group per matrix, or as indicated by the analytical method.

4.1 SAMPLE PRESERVATION

Sample containers and methods of preservation for each analysis are listed in Table B-2. Sample containers will be supplied by the laboratory for each sampling event, and in general air analysis does not require preservatives.

4.2 SAMPLE PACKAGING AND SHIPPING

To insure that the laboratory has ample time to complete all analyses within holding time requirements and to reduce the potential for field degradation of samples, the samples will be shipped from the field to CH2M Hill at a minimum of every two days. Holding times for specific analytical methods are included in Table B-2. Sampling canisters will be stored and shipped in the boxes provided by the laboratory, and shipped with a custody seal affixed to the analytical laboratory. The sample containers do not need to be kept cold.

5 SAMPLE CUSTODY PROCEDURES

Samples will be handled, preserved, and stored using procedures that help ensure quality objectives are met.

5.1 FIELD SAMPLE CUSTODY

Sample custody will be tracked from point of origin through final analysis and disposal using a chain-of-custody form (see SAP), which will be filled out with the appropriate sample/analytical information as soon as possible after samples are collected. For purposes of this work, custody will be defined as follows:

- In view of a PNG field representative.
- Inside a cooler which is in view of a PNG field representative.
- Inside any locked space such as an office, vehicle, or storage unit under the control of the PNG field representative.

Sample possession will be recorded on a chain-of-custody form. The following items will be recorded on the chain of custody form:

- Project name.
- Project number.
- PNG project manager.
- Sampler's name.
- Sample number, date and time collected, media, and number of containers submitted.
- Requested analyses for each sample.
- Turnaround requirements.
- Signature, printed name, organization name, date, and time of transfer of all persons having custody of samples.
- Additional instructions or considerations that would affect analysis.

Persons in possession of the samples will be required to sign and date the chain-of-custody form whenever samples are transferred between individuals or organizations. The chain-of-custody will be included in the shipping containers with the samples and the containers will be sealed with a laboratory custody seal. The laboratory will implement its in-house custody procedures which begin when sample custody is transferred to laboratory personnel.

If samples are shipped via air or ground transportation by a third party, the procedures in SOP 10 (see SAP) will be followed. In general, samples will be packed in shipping containers, and a custody seal will be placed on the container to reduce the potential for tampering. Proper shipping insurance will be requested and the top two copies of the chain-of-custody form will accompany the samples. The person shipping the samples will retain a third copy of the chain-of-custody and shipping forms to allow sample tracking. The chain-of-custody form will accompany the samples from point of origin in the field to the laboratory.

CH2M Hill, a designated sample custodian will accept custody of the received samples, and will verify that the chain-of-custody form matches the samples received. The shipping container or set of containers is given a laboratory identification number, and each sample is assigned a unique sequential identification number that includes the original container identification number.

5.2 SAMPLE LABELING

Sample container labels will clearly indicate:

- Sample location.
- Sample number.
- Date and time of sample collection.
- Sampler's initials.
- Any pertinent comments such as specifics of filtration or preservation.

Labels will be filled out at the time of sampling. Sample labeling information will also be recorded on appropriate field data sheets such as groundwater sampling forms, borehole logs, and daily field reports as indicated in the SAP.

6 EQUIPMENT CALIBRATION AND MAINTENANCE PROCEDURES

All instruments and equipment used during field sampling and analysis will be operated, calibrated, and maintained according to manufacturer's guidelines and recommendations. Operation, calibration, and maintenance will be performed by personnel properly trained in these procedures.

6.1 FIELD INSTRUMENTATION

Field instruments will be used during the investigation and may include the following:

- Photo-ionization detector (PID).
- Combustible gas indicator (CGI).
- If used, the PID will require calibration before use and periodically during sampling activities.

Field instrument calibration and preventive maintenance will follow the manufacturer’s guidelines, and any deviation from the established guidelines will be documented. Generally, field instruments will be calibrated daily before work begins. Field personnel may decide to calibrate more than once a day if inconsistent or unusual readings occur or if conditions warrant more-frequent calibration. Calibration activities will be recorded in field logbooks.

6.1.1 Field Calibration

Calibration procedures, calibration frequency, and standards for measurement will be conducted according to manufacturer's guidelines. To assure that field instruments are properly calibrated and remain operable, the following procedures will be used, at a minimum:

- Operation, maintenance, and calibration will be performed in accordance with the instrument manufacturer’s specifications.
- All standards used to calibrate field instruments will meet the minimum requirements for source and purity recommended in the equipment operation manual. Standards will be used before any expiration dates that may be printed on the container.
- Acceptable criteria for calibration will be based on the limits set in the operations manual.
- All users of the equipment will be trained in the proper calibration and operation of the instrument.
- Operation and maintenance manuals for each field instrument will be brought to the site.
- Field instruments will be inspected before they are taken to the site.
- If used, field instruments will be calibrated at the start and end of each work period. Meters will be recalibrated, as necessary, during the work period.
- Calibration procedures (including time, standards used, and calibration results) will be recorded in a field logbook. Although not reviewed during routine QA/QC checks, the data will be available if problems are encountered.

6.1.2 Preventive Maintenance

Preventative maintenance of field instruments and equipment will follow the operations manuals. A schedule of preventive maintenance activities will be followed to minimize downtime and ensure the accuracy of measurement systems. Maintenance will be documented in the field logbook.

6.2 LABORATORY INSTRUMENTATION

Specific laboratory instrument calibration procedures, frequency of calibration, and preparation of calibration standards will be according to the method requirements as developed by the EPA, following procedures presented in SW-846.

7 ANALYTICAL PROCEDURES

The analytical methods and references for analyses that may be used during project implementation are summarized in Table B-1 and discussed in Section 3.

In accordance with the QA/QC requirements set forth in this QAPP, CH2M Hill will perform the analyses of soil gas/air samples using EPA methods, with modifications noted in Section 3. Samples will be analyzed by CH2M Hill, which is qualified to perform the analyses using standard, documented laboratory procedures. CH2M Hill has QA/QC plans and standard operation procedures that provide data quality procedures according to the protocols for the analytical method and cleanup steps. The data quality procedures are at a level sufficient to meet the sampling program's data quality objectives. CH2M Hill will perform, document, and report laboratory procedures, as described in their quality assurance manuals.

8 DATA REDUCTION, VALIDATION, AND REPORTING

The laboratory performing sample analyses will be required to submit analytical data supported by sufficient QA information to permit independent and conclusive determination of data quality. Data quality will be evaluated by PNG using the data validation procedures described in this section. The results of the PNG evaluation will be used to determine if the project data quality objectives have been met.

8.1 LABORATORY EVALUATION

Initial data reduction, evaluation, and reporting at CH2M Hill will be carried out as described in EPA SW-846 manuals for organic and inorganic analyses, as appropriate. Additional data qualifiers may be defined and reported to further explain the laboratory's quality control concerns about a particular sample result. All additional data qualifiers will be defined in the laboratory's case narrative report associated with each laboratory report.

8.2 DATA EVALUATION

8.2.1 Validation

After PNG receives the analytical data, the data will be validated under the supervision of the project QA coordinator. PNG will examine the data for precision, completeness, accuracy, and adherence to standard operating procedures. PNG will validate laboratory analytical data as described in the following sections. QC checks will be performed on laboratory information using the sample log-in reports faxed to PNG after samples are entered into the laboratory information management system. The reports will be assessed early in the process, which will allow QC checks to begin before sample holding times have expired or before errors are incorporated in the laboratory reports.

VALIDATION PROCEDURES

Laboratory analytical data will be reported in a CH2M Hill standard format to facilitate data validation. The items reported by the laboratory include those listed below:

- Dates samples were collected, received by the laboratory, and analyzed.
- On each laboratory sample data sheet: method of detection (e.g., GC, HPLC, AA, ICP).
- On each laboratory sample data sheet: a tabulation of MDLs or MRLs, or a master sheet of MDLs or MRLs with detection limit multiplication factors (due to dilutions or dry weights) specified.
- Constituent concentrations reported in micrograms per cubic meter of air (ug/m^3) or ppbv (parts per billion vapor) for air, micrograms or milligrams per liter (µg/L or mg/L) for water, and milligrams per kilogram (mg/Kg) for soil (dry weight basis).
- Volumes analyzed and dilution factors, if any.
- Ancillary information, including percent moisture in soil sample.
- Method blank data associated with each sample.

- Results for matrix spike analyses, concentrations added, and percent recovery.
- Results of laboratory duplicate or laboratory control sample analyses for each constituent, as applicable to the method.
- A statement in the cover letter describing how standard calibration curves were generated and applied to the samples for quantitation (and access to laboratory records of standard calibration curves and all other pertinent data for possible inspection), if this varies from the method specified in SW-846.
- A statement in the cover letter describing any significant problems in any aspect of sample analysis, deviation from prescribed QA/QC criteria, or other relevant information. A statement in the cover letter describing any changes or deviations from the required methods, the reason for the change(s), and a description of the deviations that were used for sample analysis.
- A copy of the chain-of-custody form for each batch of samples reported.

PNG will review data and assign data qualifiers to sample results, following portions of the EPA procedures. Data qualifiers are used to classify sample data as to its conformance to QC requirements. The most common qualifiers are listed below:

- A – Acceptable.
- J – Estimate, qualitatively correct but quantitatively suspect.
- R – Reject, data not suitable for any purpose.
- U – Not detected at a specified detection limit.

Poor surrogate, blank contamination, or calibration problems, among other things, can cause the sample data to be qualified. Whenever sample data is qualified, the reasons for the qualification will be stated in the data validation report.

For inorganic and organic analyses, the following information will be reviewed during data validation:

- Sampling locations and blind sample numbers.
- Sampling dates.
- Requested analysis.
- Laboratory service request number(s).
- Chain-of-custody documentation.
- Sample preservation.
- Holding times.
- Method blanks.
- Surrogate recoveries (organic analyses only).
- MS results (inorganics analyses only).
- MS/MSD analyses (organic analyses only).
- Laboratory duplicates (inorganic analyses only).
- Field duplicates (if submitted).
- Laboratory control samples (organic analyses only).
- MRLs above requested levels.
- Any additional comments or difficulties reported by the laboratory.
- Overall assessment.

The results of the data validation review will be summarized for each batch of samples. Data qualifiers will be assigned to sample results as per EPA guidelines. The data validation reports will summarize the precision and accuracy for the samples. The quality of the analytical data, as defined by precision and accuracy, will be assessed and compared to data quality objectives for the project.

The laboratory will routinely archive raw laboratory data, including initial and continuing calibration data, chromatograms, quantitation reports, blank sheets, and sampling logs, and will provide these data in addition to the deliverables listed above, if requested.

8.2.2 Reduction

Following data validation and assignment of data qualifiers, if any, the analytical data will be tabulated. The tabulation of analytical and field data, with the appropriate data qualifiers, will be stored on computer disk. Data will be further reduced and managed using the following computer software applications:

- Excel™ (spreadsheet).
- Word™ (word processing).
- Surfer™ (geostatistical contouring).
- Statistical applications using appropriate methods.

Data will be reduced to summarize particular data sets. In addition, statistical techniques may be applied to test results. These techniques will help assess the representativeness, comparability, precision, and completeness of the data sets. Reduced data sets will be used in reporting the overall accuracy of the assessment.

8.2.3 Reporting

After completing data collection, validation, and reduction, the data will be used in reports. Copies of the reports will be kept in the main project file, submitted to the client for review, and then submitted to the Ecology. The original copy of any document that PNG produces will remain in the main project file.

9 INTERNAL QUALITY CONTROL AND QUALITY ASSURANCE

9.1 BASIC QUALITY CONTROL

QC data will involve the collection of field sample duplicates and blanks, laboratory analysis of the samples, and evaluation of the data.

Daily internal QC checks will he performed for field activities. Checks will consist of reviewing field notes and field activity memoranda to determine whether the specified measurements, calibrations, and procedures are being followed. The need for and content of corrective action will be assessed on an ongoing basis, in consultation with the project manager.

Field sample blanks and duplicates will be collected and submitted to the laboratory for analysis as necessary to determine if any sampling contamination was caused by field sampling equipment and to check data precision.

The laboratory will document the completion and evaluation of internal QC checks and any corrective actions or reanalysis completed.

Data reduction QC checks will be performed on all entered, calculated, and graphic data produced by PNG. Data entry will be compared with data generated during field activities and recorded in notebooks or on field data forms. Analytical data entry will be reviewed against laboratory reports and data validation reports.

9.2 PERFORMANCE AND SYSTEM AUDITS

PNG's project manager will monitor the performance of the field and laboratory quality assurance program. Proper communication between field staff, project management, and the laboratory will be maintained so that consistent and appropriate methods and techniques are used throughout the project.

9.2.1 Field Performance

Field performance will be monitored through daily review of documentation, sample handling records (i.e., chain-of-custody forms), field measurements, and periodic field inspections. All field and sampling will be checked for compliance with relevant work plans.

9.2.2 Laboratory Performance and System Audits

The laboratory will audit in-house performance and systems under their in-house QA/QC guidelines. Such audits will be made available for review on request. While samples for this investigation are analyzed, the project QA coordinator will be in contact with the analytical laboratory to assess progress toward obtaining the data quality objectives, and to make corrective measures as problems arise.

9.3 PREVENTITIVE MAINTENANCE

Field equipment will be checked daily to detect any malfunctions. Steps will be taken to repair or replace any piece of equipment that appears unreliable. Repairs will be made according to the manufacturers' guidelines, or by qualified repair technicians.

Equipment will also be periodically serviced, according to the manufacturers' recommendations.

Preventive maintenance of analytical equipment is discussed in Section 6 and described in CH2M Hill's quality assurance manual.

9.4 DATA ASSESSMENT PROCEDURES

Procedures to assess data precision, accuracy, and completeness will be completed routinely, through data validation reports. Precision and accuracy will be based on laboratory documentation. Completeness will be based on the usability of the data collected, relative to the data needs of an investigative task or the amount of data scheduled for collection. Completeness will be quantified when appropriate, but will be qualitatively evaluated with respect to the representativeness of the data when detection or lack thereof, is the objective.

The Quality Assurance Program for CH2M Hill outlines the precision and accuracy limits for each laboratory analytical method and parameter. The laboratory is responsible for assuring that these precision limits are consistently met or exceeded.

9.5 CORRECTIVE ACTION

The need for corrective action will be evaluated on an ongoing basis, depending on the results of internal and laboratory QC checks. In the event that quality assurance is not met, corrective actions will be taken.

During field operation and sampling procedures, field personnel will be responsible for reporting any changes to specified sampling procedures. A description of any such change will be entered in appropriate field sheets.

If quality control audits result in detection of unacceptable conditions or data, the project manager, in conjunction with the project quality assurance coordinator, will be responsible for implementing corrective action. Specific corrective actions are outlined in each SW-846 method, or in CH2M Hill's quality assurance manuals, and include, but are not limited to:

- Identifying the source of the unacceptable condition.
- Reanalyzing samples if holding time criteria permit.
- Resampling and reanalyzing.
- Evaluating and amending sampling and analytical procedures.
- Accepting data and flagging to indicate the level of uncertainty.

Ecology will be notified of each significant field, laboratory, or project corrective action, if taken.

9.6 QUALITY ASSURANCE REPORTS

No separate QA report for this project is anticipated. The Vapor Intrusion Assessment report will contain a separate QA section that will summarize the overall quality of the chemical results in terms of the specific data quality goals identified in this QAPP, and will identify chemical results qualified by PNG.

Reports will be maintained in the project files and will include results of performance and system audits; periodic assessment of measurement data accuracy, precision, and completeness; significant QA/QC problems and recommended solutions; and resolutions of previously identified problems.

10 REFERENCES

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EPA. 1987. *Data Quality Objectives for Remedial Response Activities, Development Process*. U.S. Environmental Protection Agency

EPA. 1994a (February). *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*. U.S. Environmental Protection Agency Office of Emergency and Remedial Response, EPA 540/R-94/013.

EPA. 1994b (February). *Contract Laboratory Program National Functional Guidelines for Organic Data Review.* U.S. Environmental Protection Agency Office of Emergency and Remedial Response, EPA 540/R-94/012.

EPA. 1998 (May 1). *Memorandum from Stanford J. Smucker, Ph.D., Regional Toxicologist of USEPA Region IX, to PRG table mailing list regarding Region 9 Preliminary Remediation Goals (PRGs).* U.S. Environmental Protection Agency.

EPA. 1999 (January). *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition.* U.S. Environmental Protection Agency Office of Research and Development, EPA/625/R-96/010b.

EPA. 2000. *Preliminary Remediation Goals*, EPA Region 9. U.S. Environmental Protection Agency (revised October 2004).

TABLES

Table B-1
Data Quality Objectives For Soil Gas and Air Samples (ug/m^3)
Former Milton's Dry Cleaners
Vancouver, Washington

Analyte	Method Reporting Limit	MTCA Indoor Air SLVs[a]	MTCA Subslab SLVs[a]	MTCA Soil Gas < 15 feet SLVs[a]	MTCA Soil Gas > 15 feet SLVs[a]	Ecology Reference (Milton's Specific)
Tetrachloroethene	0.1356	0.42	4.2	4.2	42	42
Trichloroethene	0.1075	0.1	1	1	10	10
Chloroethane	0.0270	NV	NV	NV	NV	NV
1,1-Dichloroethane	0.0820	320	3,200	3,200	32,000	NA
1,1-Dichloroethene	0.0793	91	910	910	9100	NA
1,2-Dichloroethane	0.0820	2.2	22	22	220	NA
1,2-Dichloroethene (trans)	0.0793	32	320	320	3200	NA
1,2-Dichloroethene (cis)	0.0785	16	160	160	1600	NA
1,1,1-Trichloroethane	0.1110	4,800	48,000	4,800	480,000	NA
Vinyl chloride	0.0511	0.28	2.8	2.8	28	NA

NOTES:

[a] Model Toxics Control Act (MTCA) Method B Soil gas screening level values (SLVs) provided by Ecology in October 2009 Draft Guidance and Milton's work plan comment letter dated May 21, 2008

ug/m^3 = micrograms per cubic meter of air

NA = Not Applicable

Table B-2
Sample Containers and Preservation Requirements
Former Milton's Dry Cleaners
Vancouver, Washington

Analytical Constituent	Sample Medium	Analytical Method	Containers	Preservation and Handling	Holding Time
Volatile Organic Compounds	Soil Gas/Air	Modified EPA Method TO-15SIM	1 or 6 Liter Summa cannister	None	30 days