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Letter of Transmittal

To:	WA Department of Ecology-NWRO 3190 - 160th Avenue S.E. Bellevue, WA 98008-5452	**From:**	Kate Snider
		Date:	April 15, 2008
Attn:	John Keeling	**Project No:**	COS-GWSA T.6010

Re: **Gas Works Park Northeast Corner Investigation Data Report**

We are sending the following items:

Date	Copies	Description
April 15, 2008	2	Gas Works Park Northeast Corner Investigation Data Report

Remarks:

On behalf of the City of Seattle, enclosed for your review is the Northeast Corner Investigation Data Report for City-led investigation activities conducted at Gas Works Park in September, 2007. Field activities were conducted in accordance with the *Gas Works Park Northeast Corner Investigation Sampling and Analysis Plan—Ecology Review Draft* submitted to Ecology August 14, 2007, and approved via email by Ecology on August 22, 2007. Reporting of investigation activities directed by PSE and conducted in coordination with this event will be submitted separately by PSE.

Copies to:

Grant Yang, Washington State Department of Ecology (1)

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Gas Works Park
Northeast Corner Investigation

Data Report

Prepared for

City of Seattle

Seattle
Public
Utilities

Prepared by

FLOYD | SNIDER

April 15, 2008

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List of Abbreviations and Acronyms

Abbreviation/ Acronym	**Definition**
ARSLID	Aromatic-Specific Laser Ionization Detector
bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, xylene
DNAPL	Dense non-aqueous phase liquid
DOT	Department of Transportation
EPRI	Electric Power Research Institute
GPS	Global positioning system
GVP	Gas vapor probe
GWS–ESA	Gas Works Sediment–Eastern Study Area
GWS–WSA	Gas Works Sediment–Western Study Area
HAS	Hollow stem auger
IDW	Investigation-derived waste
LNAPL	Light non-aqueous phase liquid
NAPL	Non-aqueous phase liquid
NE	Northeast
PAH	Polycyclic aromatic hydrocarbon
PID	Photoionization detector
PSE	Puget Sound Energy
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
USGS	United States Geological Survey
UV	Ultraviolet
VOC	Volatile organic compound
YAG	Yttrium aluminum garnet

1.0 Introduction

Floyd|Snider has prepared this Northeast (NE) Corner Data Report on behalf of the City of Seattle (City). The data report describes field and analytical procedures and results of the investigation completed at Gas Works Park in September 2007. A separate, but associated data report is being prepared by Puget Sound Energy (PSE) and describes additional field and analytical procedures completed during the NE Corner Investigation with focus on the eastern shoreline.

The NE Corner Investigation at Gas Works Park consisted of two coordinated field events implemented by the City and PSE with the objective of characterizing the presence of subsurface dense non-aqueous phase liquid (DNAPL) and/or tar in the NE Corner Investigation area and shoreline. Information and data collected during these investigations will aid in the following:

- Evaluating sediment area remedial actions currently being conducted under an Agreed Order between PSE, the City, and the Washington State Department of Ecology.
- Providing information to the City Parks Department for their continued maintenance and management of tar exposures in the park.

All sampling and analysis activities completed by the City were performed according to the procedures specified in the NE Corner Investigation Sampling and Analysis Plan (SAP; Floyd|Snider 2007), and are consistent with those previously specified in the Gas Works Sediment–Western Study Area (GWS-WSA) Remedial Investigation/Feasibility Study (RI/FS) Quality Assurance Project Plan and site-specific Health and Safety Plan for the GWS-WSA in the Current Situation Report and RI/FS Work Plan (Appendices C and D, respectively, of the GWS-WSA RI/FS Work Plan; Floyd|Snider 2005).

1.2 SITE CONDITIONS

Gas Works Park is located approximately 4.6 miles north of downtown Seattle, in an area of mixed residential and commercial/industrial properties. The park is situated on the north shore of Lake Union (Figure 1.1). The study area for the NE Corner Investigation area consists of a tract of land along the eastern shoreline of Gas Works Park and the meadow area located north of the play barn structures and picnic area (refer to Figure 1.2). Ground cover at the park consists of grasses, trees, shrubs, asphalt parking areas, recreational trails, and concrete driveways.

1.2.1 Tar and Dense Non-aqueous Phase Liquid Occurrence

Tar is a mixture of hydrocarbon compounds; therefore its physical state can vary from a relatively high viscosity DNAPL to a plastic solid. Consequently, tar in a particular soil sample may be present as a heterogeneous material with variable viscosity and potential for migration. The physical state of the tar at any given location is a function of its temperature, weathering history, and source. Some tars produced from historical manufactured gas plant (MGP) processes have densities near 1 g/cm^3 and therefore can exhibit mobility during warmer seasons, and behave more as a semi-solid material during colder seasons. In this report, the term DNAPL is used to describe dense non-aqueous phase liquids, and the term tar is used to describe a DNAPL that appears more semi-solid. Both can exist with a range of physical properties.

The extent of DNAPL and tar has been investigated in sediments in the GWS Eastern Study Area (GWS-ESA); however, prior to this investigation, there was insufficient data to define the extent and relationship of these occurrences related to the uplands, and along the northeastern shoreline and bank. Tar bodies (relatively pure tar masses as opposed to DNAPL occurring in the interstitial spaces of soil/sediment) have been observed along the eastern bank area and in the adjacent shallow sediments. Two additional areas of tar, beyond those mapped in the draft GWS-ESA RI/FS (RETEC 2006), were identified during warmer summer temperatures in August 2006 by the Seattle Parks Department. These tar bodies were removed by the Seattle Parks Department from the partially seasonally submerged areas along the eastern shoreline in January 2007 when they were less pliable and easier to excavate. Another occurrence was more recently observed in May 2007 in the northeastern area of the uplands along the dirt foot path. This occurrence was partially removed by the Parks Department, then covered with a geotextile fabric before clean backfill material was placed in the excavated area. Removal and maintenance activities are conducted by the Parks Department in accordance with the Consent Decree and associated Cleanup Action Plan in place for the Gas Works Park Uplands (Ecology 1999). Figure 1.2 identifies the locations of recently exposed tar in the NE corner of the park.

1.3 INVESTIGATION OBJECTIVES

The NE Corner Investigation was completed to assess the occurrence of tar and DNAPL and the potential migration of DNAPL from the uplands to sediments, and to provide sufficient data to inform future remedy maintenance planning for the Gas Works Park Uplands in regards to surface tar occurrences. This was done by completing the investigation objectives discussed below.

The main objective of the NE Corner Investigation was to delineate the lateral and vertical extents of subsurface tar and/or DNAPL in the NE corner of the Park. The investigation phases conducted by the City included an initial soil gas survey, followed by a soil boring investigation in the meadow area to accomplish the following:

- Assess the nature and extent of soil gas in the shoreline and meadow area to provide screening level data regarding the potential presence of subsurface tar and/or DNAPL.
- Visually delineate the presence of tar and/or DNAPL by advancing soil borings in the meadow area with limited existing data coverage. The soil boring data will assist in evaluating the potential for ongoing DNAPL migration to the shoreline and sediments.
- Characterize petrophysical properties of the tar and/or DNAPL-impacted media collected during the field event in order to evaluate its potential mobility in soils and fill.

- Evaluate the geologic conditions and physical properties of soil material in the meadow area with limited existing data coverage, including thickness and elevations of fill and glacial units.

2.0 Soil Gas Survey

2.1 SCOPE OF SOIL GAS SURVEY

On August 28 and 29, 2007 a soil gas survey was conducted as a screening method to identify locations where total aromatics measured in the subsurface soil may be associated with the presence of shallow subsurface tar and/or DNAPL. The soil gas survey assisted in selecting locations for hollow stem auger (HSA) drilling. A real-time instrument, the Aromatic-Specific Laser Ionization Detector (ARSLID) manufactured by Dakota Technologies of Fargo, ND and a Gas Vapor Probe (GVP) Kit with a Retract-A-Tip® manufactured by AMS, Inc. of America Falls, Idaho was used for the survey.

Soil gas samples were collected from an established 30-foot center grid throughout the NE corner meadow area, and along the eastern shoreline east of the meadow and play barn structures. GPS coordinates were collected at each soil gas sample location using a handheld GPS unit with sub-meter accuracy. The GPS coordinates were integrated with the ARSLID data to construct a 2D contour map of the total aromatics measured in the subsurface soil assumed to be associated with subsurface tar masses and/or DNAPL and are presented in Table 2.1 and on Figure 2.1. Figure 2.1 was used by the City and PSE to guide their locations and extent of soil boring advancement in the meadow area, and along the eastern shoreline. The following sections describe the equipment and methods used for soil gas sample collection and the interpretation of the results.

2.2 SOIL GAS SURVEY EQUPMENT AND METHODS

2.2.1 Equipment

The soil gas survey was completed using a GVP Kit with a Retract-A-Tip®. The 5/8-inch diameter probe was driven approximately 18 inches into the ground and sample tubing was connected to the portable ARSLID. The ARSLID is based on resonance-enhanced laser ionization, increasing its specificity and sensitivity for aromatic compounds relative to photoionization detectors (PIDs). As the air stream is drawn into the ARSLID, it is ionized and an electrical current is generated as the ions are drawn to electrodes via a potential bias. The 266 nanometers (nm) frequency quadrupled YAG micro laser (constructed of Yttrium aluminum garnet, a synthetic crystalline material) excites naphthalene more efficiently than the other aromatic hydrocarbon compounds, as this is the peak resonance wavelength for naphthalene. Therefore, the ARSLID is particularly sensitive to naphthalene and other polycyclic aromatic hydrocarbons (PAHs) with a similar structure, and less sensitive to single aromatic compounds such as benzene, toluene, ethylbenzene, and xylene (BTEX). ARSLID output data are total aromatic hydrocarbons, labeled as Naphthalene Equivalents in micrograms per cubic meter ($\mu g/m^3$), but all aromatic compounds of interest, (i.e., those potentially associated with tar and/or DNAPL) if present, are detected at some level, and included in the total aromatic hydrocarbon concentration.

The ARSLID was connected via ethernet cable to a laptop equipped with the ARSLID monitoring software that recorded real-time data produced by the ARSLID. Following completion of the survey, this data was downloaded, and evaluated, with the highest detected concentration at each sampling location recorded. Table 2.1 presents a summary of the soil gas survey results.

2.2.2 Sampling Methods

The soil gas probe was driven to approximately 18 inches below ground surface (bgs) using a slide hammer or electric drill. Once driven to depth, the probe was pulled back a few inches to expose the Retract-A-Tip® screened sampling port. Teflon tubing extending from the GVP sample tip was then connected to the sample inlet internal pump of the ARSLID with a Swagelok, drawing vapor through the tubing and sample port of the ARSLID for analysis of the soil gas.

Once the probe was driven to depth, the ARSLID signal was allowed to stabilize (on average, approximately 3 to 4 minutes) and recorded. A few locations responded in a different manner, taking as long as 20 minutes for the soil gas concentrations to peak and return to a baseline concentration. These included locations SG-04, SG-14, and SG-17 (Figure 2.1). Upon completion of sample collection at each location, the GVP and sampling tip was removed either by hand or by a retrieval jack and the ARSLID signal was allowed to return to baseline prior to collection of the next sample at a new sample location. The sampling tip and screen were decontaminated with deionized water and Alconox solution between sampling locations.

2.2.3 Equipment Calibration

The ARSLID requires calibration once every 1 to 2 weeks. To maintain a high quality of data, the ARSLID was calibrated before and after the 2-day sampling event. A two-point calibration was performed with a gas standards generator, which includes a permeation tube containing naphthalene crystals. The two point calibration was conducted by flushing through the ARSLID monitor a zero gas (no naphthalene present), and a carrier gas with a concentration of approximately 2000 $\mu g/m^3$ naphthalene. The permeation tube was heated to 100 degrees Celsius and ultra high purity nitrogen gas was used as the carrier gas to flush the naphthalene vapors from the permeation tube into the ARSLID monitor. Once the calibration was completed the ARSLID was allowed to return to baseline (i.e., approximately 0 $\mu g/m^3$) prior to sampling.

2.3 FIELD OBSERVATIONS

The City proposed that soil gas measurements be collected at a total of 54 probe locations throughout the NE corner meadow area and along the shoreline. However, due to malfunctioning equipment, difficult drilling conditions, and refusal in some locations, soil gas samples were collected from a total of 36 probe locations.

2.3.1 Refusal and Shallow Groundwater

In general, refusal occurred in the northern portion of the meadow area near SG-02, SG-03, and SG-04 at approximately 10 to 15 inches bgs. Soil Gas Probe SG-02 hit refusal twice before achieving the maximum depth of 18 inches. Locations along the western portion of the meadow also hit refusal at approximately 16 inches including SG-16 and SG-17. If refusal occurred, a second or third attempt was made to advance the probe in close proximity to the original sample location. Based on the condition of the sampling tip, it was suspected that refusal occurred due to the potential presence of a subsurface concrete foundation. In some cases where tree roots or rocks were encountered, the probe was moved a few inches next to the original location and advanced until 18 inches could be achieved.

In the central meadow area near locations SG-09 to SG-15 and SG-18 to SG-22, drilling conditions were very difficult as the ground was very hard and almost impenetrable, however a total depth of 18 inches was achieved with the use of a drill hammer for probe advancement.

In some cases the total depth of 18 inches could not be achieved due to the shallow water table along the NE shoreline area. SG-08 could only be sampled to approximately 12 inches bgs due to the shallow water table. SG-40 was initially advanced to 12 inches along the shoreline when the shallow water table was encountered. The sample was relocated a couple of feet up bank to get a more representative soil vapor sample. Due to the shallow groundwater table, a soil gas sample was not collected at location SG-45, and instead visual observations were made of the subsurface. These observations are detailed in the following section.

Of all of the probe locations, the shoreline area had the most apparent observed odor and/or sheen, and tar and/or DNAPL present in the soil and on the GVP, sampling tip, and hand auger.

2.3.2 Observations of Impacted Media

Soil cuttings taken from the drill hammer and sampling tip screen provide information regarding the shallow subsurface soils, which are located beneath the vegetated topsoil extending to a maximum depth of 18” bgs. At locations SG-14, SG-17, and SG-27 in the central meadow area, a faint to strong odor was observed and cuttings taken from the drill hammer and sampling tip screen at these locations generated a sheen during sheen testing. SG-14 had a slight sheen and strong naphthalene odor and the soil appeared to contain brick fragments. SG-17, located approximately 40 feet to the south of SG-14, also had a faint naphthalene odor. SG-27, located in the south-central portion of the meadow, had a faint odor on the sampling tip and screen. Field observations also noted that the shallow subsurface soil (beneath the topsoil to a depth of approximately 18 inches bgs) in these eastern and central portions of the meadow consisted of a black, soot-like material.

The samples with faint to strong naphthalene or hydrocarbon odor and/or sheen generated from sheen testing cuttings and soil from the sampling tip screen included sample locations SG-08, SG-23, SG-40, and SG-45. Hand augers were advanced at SG-08 to assess subsurface soil conditions along the shoreline. Significant naphthalene odors were observed in the soil. Sheen was present in water observed in the hand auger when the soil was agitated. At location SG-23, the presence of tar and/or DNAPL was encountered in the top 18 inches of the soil column and observed on the GVP, sampling tip, and hand auger. This occurrence was the most significant and was documented in the field log book along with indications of DNAPL/tar thickness and odors. This location (refer to Figure 2.1) is in the “Tar Mound” area near the birch tree where tar occurrences have previously been observed, and hardened tar is visible at the ground surface. The surface conditions in this area include a few inches of leaf debris, gravel, and brambles, and tar and/or DNAPL is present within inches of the ground surface.

Three hand augers were advanced in close proximity to SG-40. A faint hydrocarbon odor and no sheen were observed in the auger locations. SG-45, located approximately 40 feet south of SG-40 along the shoreline, was also hand augered to obtain visual observation of subsurface conditions, as a soil gas sample could not be collected due to the shallow water table. Moderate hydrocarbon sheen and a faint naphthalene odor were observed at location SG-45.

In the areas along the shoreline with strong naphthalene odor and/or sheen present, the ARSLID did not always return back to baseline immediately. If the ARSLID did not return to baseline, additional time was allowed for the ARSLID to stabilize and new screens and tubing were used prior to collection at the next sample location.

2.4 SOIL GAS SURVEY RESULTS

Detected total aromatic hydrocarbon concentrations from the NE corner meadow area and eastern shoreline soil gas survey ranged from 6 to 8,349 µg/m^3. Figure 2.1 presents the results of the soil gas survey, and the peak concentration recorded from each sample location is summarized in Table 2.1. The highest concentration was detected at point SG-23 (8,348 µg/m^3), located adjacent to the NE shoreline birch tree and in the vicinity of the recent May 2007 tar seep. Elevated concentrations were also detected in the southern portion of the meadow at SG-27 (586 µg/m^3) and in the southeast shoreline across from the play barn structures at location SG-48 (514 µg/m^3). These three highest detected soil gas concentrations were selected as areas requiring further investigation as part of the soil boring investigation.

As part of the drilling phase of the investigation, borings were advanced in the vicinity of each of these soil gas probe locations with elevated concentrations. SB-4 installed by the City team was placed near soil gas probe location SG-27. The PSE team advanced Geoprobe borings near locations SG-23 and SG-48, and will report findings and observations in their data reporting package. Soil borings installed in these three areas encountered subsurface tar and/or DNAPL and/or anthropogenic solids in the shallow subsurface indicating a likely connection between the soil gas survey results and the presence of these contaminants and industrial solids in the shallow subsurface. Even though there was a potential correlation between the soil gas survey results and shallow contamination and industrial solids, the soil gas survey results were not good indicators of deeper subsurface impacts, especially when the contamination and/or industrial solids were observed in moist or wet media, or associated with the water table. This is because the moisture content of these deeper soils impacts the ability of the volatile compounds to off-gas in the soils and be detected by the ARSLID monitor.

3.0 Soil Boring Installation and Sample Collection

A total of 16 soil borings were advanced at 13 locations under the direction of the City team in the NE Corner meadow area between September 17 and 20, 2007. The original scope of work presented in the SAP was completed ahead of schedule and six additional borings were advanced at other locations to provide increased data density and coverage throughout the NE Corner Investigation area. The following sections detail the drilling and sample collection methods and observations recorded by field oversight staff.

3.1 SCOPE OF FIELD INVESTIGATION

Thirteen soil borings (plus an additional three re-drilled borings completed for laboratory sample collection) were advanced in the NE corner meadow area to evaluate the extent of tar and/or DNAPL and to collect information relative to the geotechnical characteristics of the individual geologic units that were encountered in the borings.

The soil borings were generally advanced through varying thicknesses of fill to depths where glacial deposits were encountered. The glacial deposits were distinct and characterized by the gray, slightly silty to silty sand matrix with rounded gravel, and the absence of debris. The depths of the soil borings ranged from approximately 15 to 20 feet bgs. Select soil borings were sampled for petrophysical analyses when contamination was encountered in sufficient volumes to warrant laboratory testing. Figure 3.1 presents the locations of the NE corner meadow area soil borings. Boring locations in state plane coordinates are included on each individual boring log, presented in Appendix A.

The original scope of the City-led investigation was for the advancement of seven soil boring locations (SB-1 through SB-7) located in the NE corner meadow area north of the play barn structures. Completion of these borings occurred ahead of schedule, allowing for the completion of six additional soil borings (SB-8 through SB-13) in the NE corner meadow area. The locations of the additional borings were selected in coordination with PSE and guided by field observations recorded from the original boring locations. Other criteria for boring location selection included results from the soil gas survey, and field observations recorded by PSE in boring locations along the eastern side of the meadow area and along the eastern shoreline.

3.2 DRILLING METHODS

Soil borings were advanced by Cascade Drilling Incorporated of Woodinville, Washington between September 17 and September 20, 2007 using a track-mounted limited access HSA drill rig. The HSA drill rig employed 8-inch outside diameter continuous flight HSAs and was operated by a licensed driller at all times.

3.3 SOIL SAMPLE COLLECTION METHODS

Soil samples were collected at 2.5-foot intervals at each boring location by driving a Dames and Moore split spoon sampler through the bottom of the auger. Table 3.1 presents a summary of all soil samples collected from the meadow area, and includes observations regarding the types of contamination and industrial solids encountered at each location. Blow counts to drive the sampler through each sampling interval were recorded by the logging geologist. Following collection of a sample, augers were advanced to the top of the next sampling interval and the process was repeated. Where substantial contamination was encountered, an attempt was made to collect a representative sample for petrophysical laboratory analysis. Samples for petrophysical laboratory analysis were collected from the boring by placing three 0.5-foot long brass liners end to end inside the Dames and Moore split spoon sampler and driving the sampler through the next interval to collect the sample. The brass sample liners were then removed from the sampler and if sufficient material that appeared to contain contamination was captured inside the liner, it was then capped, sealed, and placed on dry ice. Samples were kept frozen and were shipped to PTS Laboratories in Santa Fe Springs, California for geotechnical and petrophysical testing. Additionally, physical testing (i.e., grain size distribution and bulk density) was performed on select soil samples to complement petrophysical analyses completed on tar and/or DNAPL impacted samples.

All soil boring locations were logged by a registered licensed geologist in accordance with standard geologic practices for the environmental industry. Boring logs are attached in Appendix A and include detailed descriptions of materials encountered during drilling. Logs include the Unified Soil Classification System (ASTM D-2488-93) classification and description, blow counts for each sample interval, moisture content, color, and the presence of any anthropogenic materials (i.e., debris), odors, sheens, and oily (DNAPL) or tarry substances. The extent of DNAPL and/or tar within the materials encountered at each location is also documented. The material encountered at each location was recorded on a boring log and photo-documented. Select photographs from the investigation are included in Appendix B.

3.4 FIELD OBSERVATIONS

The lithology encountered in these subsurface explorations was relatively consistent throughout the NE corner meadow area and is described as follows:

- **Topsoil.** Light brown, slightly gravelly, silty sand with organics.
- **Gas Works Fill $_1$.** Gray to black variable matrix of sand, silt and gravel with scattered amounts of wood debris, with some brick debris, and asphalt pieces. This unit was generally encountered in the western portion of the meadow area, and extended from within a few feet of the ground surface, to the glacial deposits between 10- to 15-feet deep.
- **Gas Works Fill $_2$.** Light to dark brown to black, primarily sand and gravel matrix with slag, brick fragments, and vesicular debris. This unit was generally encountered in borings along the eastern side of the meadow area extending to the glacial deposits approximately 15 to 20 feet bgs.
- **Glacial Deposits.** Light gray, silty sand and sandy silt with variable amounts of rounded gravels.

The major geologic units underlying the site that were encountered during the NE Corner Investigation are consistent with the geologic units described in previous investigations at the site. Determination of the original geologic framework for the Gas Works Park Uplands was recorded by the USGS (Sabol et al. 1988; Turney and Goerlitz 1989, 1990) and was refined by subsurface explorations completed by the Electric Power Research Institute (EPRI) and RETEC (EPRI 1998). In this data report, the unit previously identified as Gas Works Fill has been divided for distinction into two subunits (as described above as Gas Works Fill $_1$ and Gas Works Fill $_2$) as the composition of these two fill types was unique, but they are still both encompassed by the previous identification and description of the Gas Works Fill unit.

The Gas Works Fill $_1$ unit was encountered along the western side of the meadow area between the shallow topsoil, and the glacial deposits. The unit was composed of various fill materials as stated above, and did not contain the vesicular debris, or slag material identified in the Gas Works Fill $_2$. Gas Works Fill $_1$ was encountered in borings SB-1, SB-2, SB-8, SB-11, SB-12 and SB-12A.

The Gas Works Fill $_2$, which is primarily a gravel or coarse sand composed of multicolored (grey, white, brown, black), angular, vesicular byproduct, was observed from within a few feet of the surface to the contact with the glacial deposits (which occurred at approximately 15 feet bgs). The industrial debris identified in the Gas Works Fill $_2$ was important to segregate from the general Gas Works Fill unit, as these industrial debris materials may be associated with PAHs. The Gas Works Fill $_2$ unit was encountered in eastern meadow borings SB-3, SB-4, SB-5, SB-6, SB-7, SB-9, SB-10, and SB-13.

Refusal was encountered in one boring location in the NW corner of the meadow area. SB-12 was advanced to 3.5 feet bgs. The driller identified the material as potentially metal, or a large rock. The boring was located over the footprint of a former tank structure. The boring location was abandoned and relocated approximately 20 feet to the northeast, outside of the former tank structure footprint. Shallow refusal was not encountered in the second boring identified as Boring SB-12A.

In two boring locations, SB-2 and SB-3 (Figure 3.1) DNAPL contamination was encountered, and an attempt was made to collect a brass sample liner for laboratory analysis. A sample was successfully collected from boring SB-2 but not from SB-3. At both locations, a second boring was advanced within 5 feet of the initial location to the depth of contamination identified in the initial boring so that a lined sample could be collected for laboratory analysis. These secondary borings were identified as Borings SB-2A and SB-3A.

Groundwater was typically encountered between 7- to 8-feet bgs, and was identified by saturated soils in the borings. The presence of NAPL associated with the groundwater table was observed in some meadow borings including SB-1, SB-2, and SB-2A. Contamination indicators including staining and odors were also observed at the contact between the Gas Works Fill units and glacial deposits, and well into the glacial deposits in multiple locations. Cross-section Figures 3.2 and 3.3, and plan view Figure 3.4 present the extents of contamination and industrial solids identified in the meadow area borings.

Impacted media were observed as shallow as 1.0 to 3.0 feet bgs in Borings SB-2, SB-6, SB-11; however, no new near surface tar occurrences were observed in the meadow area. A wide range of contamination types and industrial solids were observed in the soil boring cores throughout the meadow. Sheens, LNAPL, DNAPL, tar and anthropogenic solids, such as soot, ash, black carbon, or lampblack, coal, or charcoal, and slag were observed in numerous borings. The following paragraphs describe the contaminant types and industrial solids identified in boring locations located in the NE corner meadow area.

Tar-like Material Occurrences. Plastic, highly viscous tar-like material was encountered in Soil Boring SB-12A in all four samples collected from the interval between 5 feet bgs and the bottom of the boring at approximately 10 feet bgs. Fragments of the tar-like material in a sandy gravel matrix were observed within a 5- to 9-foot depth interval, where a more solid layer of tar-like material was encountered at 10 feet bgs. A sample of this tar-like material was collected and is shown in Field Photograph 1 in Appendix B. The drill rig was unable to penetrate deeper than 11 feet bgs at this location, and was unable to collect a sample at the borings total depth. It was assumed that the refusal was associated with the dense, viscous properties of the tar-like material causing the drill rig to seize up while attempting to drill into the material. This plastic tar-like material was also encountered in Soil Boring SB-6 southwest of the tar mound at a depth of approximately 3 feet bgs and was observed to be entrained in a sandy gravel matrix in that location. Tar-like material was not encountered in any other meadow area boring locations, or at depths shallower than 3 feet bgs.

NAPL Occurrences. NAPL was encountered in the western portion of the meadow in Borings SB-2 and SB-2A in samples collected at the water table. The product appeared to be reddish-brown and coated the outside of the sampling apparatus. Visible sheen was observed in the bowl used for the sheen test and NAPL coated the soil matrix. Field Photographs 2 and 3 in Appendix B show the NAPL encountered in SB-2 and SB-2A during sheen testing, and on the sample core. Some separate phase liquid was also detected in Boring SB-1 (south of SB-2) in a sample collected at the water table. This product was slightly visible on the soil particles, and formed small, light reddish-brown globules of product on the water surface during sheen testing. Black-colored separate phase product (NAPL) was observed coating soil particles from a sample collected from SB-3 at the water table in the meadow area, and sheen testing of soils sampled at the contact with glacial materials (15.5’ bgs) also observed small blebs of NAPL on some portions of the sample.

Black Staining and Soot-like Material Occurrences. All soil borings advanced in the eastern portion of the meadow area (SB-3 through SB-7, SB-9, and SB-10) and SB-13 in the southwestern portion of the meadow encountered the Gas Works Fill $_2$ within depths ranging from approximately 2 to 15 feet bgs. At two of these locations (See SB-7 and SB-9), some samples of the matrix of the Gas Works Fill $_2$ was observed to be stained or coated black with a soot-like material that clouded the water during sheen testing and stained sampling equipment and gloves. Field Photograph 4 in Appendix B is an example of the Gas Works Fill $_2$ coated with this black material. Sheen in the soil was not always associated with this material. In Soil Boring SB-13, located in the southwestern corner of the meadow area, a similar black soot-like material was encountered at approximately 2.5 to 4 feet bgs as small particles and as larger charcoal-like pieces. This material did not generate sheen during sheen testing. Field Photograph 5 in Appendix B shows this charcoal-like material.

Slag and Vesicular Debris Occurrences. As discussed in the lithology description of the Gas Works Fill $_2$, slag and vesicular debris were encountered in borings along the eastern side of the meadow, and in SB-13 in the southwest corner of the meadow. This material was often encountered in combination with the black staining and soot-like material discussed in the previous paragraph. This material is identified throughout this report as Gas Works Fill $_2$. Fill material that did not contain these slag and vesicular debris materials are distinguished as Gas Works Fill $_1$.

Figure 3.4 visually presents the type and depth interval of the various contaminant types encountered in the meadow area borings. Figures 3.2 and 3.3 present cross-sectional depictions of the subsurface cutting west to east through the center of the meadow area, and north to south through the western side of the meadow respectively.

3.5 PERIMETER NOISE AND AIR MONITORING

In accordance with the SAP, noise monitoring and perimeter air monitoring were conducted along the perimeter of the drilling exclusion zone during drilling activities. Measurements were collected on a frequency of once every 2 hours during intrusive drilling activities. The following sections describe the results of the noise and air monitoring.

3.5.1 Noise Monitoring Methods and Results

The City team was responsible for noise monitoring on September 17 through 19, while the PSE team was responsible for noise monitoring on September 20 through 21. Since both investigations were conducted within a common exclusion zone, each monitoring event was conducted by one team on behalf of the entire NE Corner Investigation event. The following paragraphs summarize the results of monitoring activities conducted by the City team September 17 through 19, 2007.

Noise level measurements were collected using a handheld self-calibrating decibel monitor at six locations along the exclusion zone fence line every 2 hours during drilling operations (Figure 1.2). At each location, measurements were collected continuously for approximately 30 seconds, and the maximum level detected was recorded by the field staff. Noise levels were then compared to the allowable noise level dictated by Chapter 173-60 WAC and Seattle Municipal Code Chapter 25.08.

Noise levels at the exclusion zone perimeter did not reach or exceed the maximum permissible sound level (MPSL) for auger drilling in a residential area of 80 decibels. Noise levels measured at the exclusion zone read between 55 and 77 decibels.

3.5.2 Air Monitoring Methods and Results

Air monitoring was conducted by the City and PSE teams concurrent with noise monitoring discussed above, every 2 hours during drilling operations. Measurements were collected using a Mini-Rae 2000 benzene-specific PID calibrated to measure total volatile organic compounds (VOCs). At each monitoring point, a measurement was collected for at least 1 minute, and the highest detected concentration recorded by field staff.

VOC concentrations were measured in parts per million, and throughout the drilling event, total VOC concentrations were not detected during any monitoring events at the exclusion zone perimeter.

4.0 Laboratory Testing and Results

From September 17 to September 20, 2007, seven soil samples were collected in 0.5-foot long 2-inch outside-diameter brass samplers placed inside a Dames and Moore split spoon sampler and driven into the subsurface by limited access HSA. Tar- and/or DNAPL-impacted media samples were submitted via Federal Express to PTS laboratories in Santa Fe Springs, California under chain-of-custody procedures. All collected samples were submitted for Ultraviolet (UV) and ambient light photography to identify samples with elevated hydrocarbon fluorescence. A subset of the samples submitted for UV light photography were then selected for petrophysical testing based on the results of the UV light photography. Petrophysical testing included product saturation and mobility analysis as well as geotechnical properties testing (i.e., moisture content, porosity, bulk density, grain density, and grain size). The samples were shipped frozen on dry ice and arrived at the laboratory in a frozen state. The following sections describe the laboratory methods and results of the sample analyses conducted for the NE corner meadow area.

4.1 ULTRAVIOLET LIGHT PHOTOGRAPHY

Seven samples were collected from the NE Corner meadow area borings and submitted to PTS laboratories for UV light photography. Each sample was photographed by PTS in ambient white and UV light, which allows hydrocarbon contamination to fluoresce. The photographs were used to facilitate selection of samples for petrophysical analyses based on the contaminant type and saturation shown by the UV light photographs.

4.1.1 Photography Methods

Each brass-lined sample core submitted to the laboratory was cut open while remaining frozen and photographed under a UV and white light source. Different wavelengths of UV light can be used to stimulate hydrocarbon fluorescence. In general, the longer the UV light wavelength, the wider the range of products that will fluoresce. Shorter wavelength lights generally have an increased response from the mineral components of a soil sample that can interfere with the chemical response. For this reason, PTS laboratories uses a longer wavelength tube of 365 nanometers, which is industry standard, to avoid interference from mineral deposits in the samples.

The core UV fluorescent response is a qualitative characteristic and can change from core to core or over time within the same core. The UV response may be affected by the amount of NAPL saturation (there is a threshold that must be overcome before some NAPLs will fluoresce), water content or washing, lithology, biodegradation, weathering, and NAPL type. Fainter color can also indicate less NAPL saturation whereas brighter is more representative of heavier NAPL saturation in some instances. On the color spectrum, lighter UV colors are representative of lighter hydrocarbons and darker UV colors are representative of heavier hydrocarbons (i.e., bluish white versus dark gold or brown fluorescence).

In general, the UV light photography characteristics described above can be applied to the NE Corner samples as follows:

- Lighter hydrocarbons will have light UV colors.
- Heavier hydrocarbons will have darker UV colors.
- Fainter fluorescence may be indicative of less NAPL saturation, or a thinner smearing or coating of NAPL over the soil matrix where brighter fluorescence may be indicative of a thicker smearing of NAPL, or a more saturated matrix.
- The longer the hydrocarbon chain, the higher the fluorescence.
- Unrefined products such as crude oils are more responsive to UV light than refined products, such as alcohols.

In addition, when hydrocarbon products fluoresce under UV light, various hydrocarbon types typically fluoresce according to the following color scheme:

- Gasoline-range, light end hydrocarbons will be bright, white to bluish and white to greenish.
- Diesel-range, mid range hydrocarbons will be heavier (darker) bluish white with no green.
- Heavy oil-range hydrocarbons will be yellow to gold.
- DNAPLs will be dark gold to orange to reddish to brown to dark brown.

4.1.2 Results

The descriptions below were developed through discussions with PTS Laboratory staff experienced with the methods, and an understanding of existing site conditions. The descriptions below summarize the results for the seven meadow area samples analyzed by UV light photography. UV and ambient light photographs are included in Appendix C.

SB-2-S4: The image is dark gold and appears to be heavy oil-range hydrocarbon. The blue specks are interference from the UV apparatus, and could also be from the duct tape used to secure each end of the sampler and are not part of the sample.

SB-2A-S1: The image appears to be the same hydrocarbon type as SB-2-S4. The top section is a bluish gold and most likely a thinner smear of the same product type over the soil matrix, resulting in the bluish tint.

SB-3A: The image appears to be the same hydrocarbon type as SB-2-S4 and SB-2A-S1, although it may be a thinner layer due to the slightly different color than the other two.

SB-5-S5 & SB-8-S5: The small bluish specks in the image are likely a thin smearing of product. There was not enough information to determine if this could be a lighter range hydrocarbon given the lighter bluish color.

SB-12A-S4: The image is orange, reddish-brown, and indicative of a DNAPL range. The fairly bright color is not a smear of contamination.

SB-12A-S6: The image is the same orange, reddish-brown as SB-12A-S4 and indicative of a DNAPL range with less intensity.

The UV photographs were used to determine what samples and sample intervals should be analyzed for petrophysical properties based on the observed NAPL presence and saturation. All samples except SB-5-S5 and SB-8-S5 were selected for further analysis. These two samples did not appear to contain sufficient volumes of NAPL to warrant further testing. Table 4.1 presents sample information, and, where applicable, the sample depth ranges selected from each sample core for further petrophysical analyses.

4.2 PETROPHYSICAL TESTING

Based on the results of the UV Light Photography and field observations, five of the seven samples (SB2-S4, SB-2A-S1, SB-3A, SB12A-S4 and SB12A-S6) submitted to PTS Laboratories for photographing were selected for additional analyses. Each of the selected samples was analyzed for pore fluid saturation by Method API RP40 and NAPL mobility by ASTM Method D425M/API RP40. Tables 4.2, 4.3, and 4.4 present a summary of analytical results, and laboratory reports are attached in Appendix D. The following sections describe the analytical methods and results of the petrophysical analysis.

NAPL viscosity and specific gravity analyses by Methods ASTM D445 and ASTM D1481 stated in the SAP were not performed on samples as sufficient volume of NAPL was not collected at any of the boring locations to effectively complete the analyses.

4.2.1 Physical Properties Testing Analytical Methods and Results

In addition to the petrophysical analyses, each of the five samples submitted to PTS Laboratories was analyzed for grain size distribution by Method ASTM D422/D4464M. Results of the grain size distribution analysis are summarized in Table 4.2, and the full laboratory report is attached in Appendix D. Grain density and bulk density, along with total porosity were analyzed as part of both the free product mobility testing, and the pore fluid saturation testing, for the sample intervals selected for each analysis. Additionally, as part of the pore fluid saturation analysis, moisture content was analyzed by Method ASTM D2216, and air-filled porosity was analyzed as part of the API RP 40 analysis for the sample intervals selected for pore fluid saturation analysis. The results of these analyses are presented in Tables 4.3 and 4.4.

4.2.2 Pore Fluid Saturation Testing Methods and Results

To assess the pore fluid saturation of the selected samples, testing was conducted according to Method API RP40. Laboratory Standard Operating Procedures are attached in Appendix D. Pore fluid saturation is determined using a solvent distillation to remove pore fluids from the sample, then conducting a material balance to determine the percent volumes or weights of each fluid present. Of the samples analyzed from the meadow area, fluid saturation as a percent of pore volume ranged from 4.5 percent NAPL to 89.3 percent NAPL. The sample containing 89.3 percent of the pore volume saturated with NAPL was the tar sample collected from Boring SB-12A near the picnic platform along the Northern edge of the meadow area. The elevated NAPL saturation observed in the tar sample from SB-12A is greater than those saturations typically observed in field soils impacted by NAPL or DNAPL. Results of the pore fluid saturation testing are presented in Table 4.3.

4.2.3 Free Product Mobility Testing Methods and Results

The purpose of free product mobility testing is to determine if NAPL present in a soil sample is mobile, and if so, determine what the resulting residual saturation is of the soils after all mobile NAPL has been removed. Samples were analyzed by the ASTM Method D425. According to this method, each sample is centrifuged for 1 hour at 1000-times the force of gravity. This length of time and force has been determined to provide a conservative value for driving a sample to residual saturation. Measurements of water and NAPL saturations in the sample before and after centrifuging are compared to provide information regarding the volume of NAPL forced from the sample at 1000-times gravity. Sample segments are cut vertically (parallel to the core axis) for testing. Results of this testing provide a qualitative type result of whether or not NAPL present in a sample exists at saturations high enough to provide a potential for migration. These data provide information on the percent of tar and/or DNAPL present in the soil as well as identify the minimum tar and/or DNAPL saturation required before the tar and/or DNAPL potentially becomes mobile. Tar and/or DNAPL saturations less than the residual saturation should represent residual tar and/or DNAPL.

All but one of the samples submitted to PTS from the meadow area were collected from above the groundwater table. Given the typical groundwater table fluctuation at the site, and the location of sample collection below grade it was determined that the samples collected from the unsaturated zone are likely unsaturated year round. Based on this, laboratory testing of these samples was conducted by centrifuging the samples in air. Sample SB12A-S6 collected at a depth of 10.35 to 10.5 feet bgs was collected from below the groundwater table. Due to this, SB12A-S6 was centrifuged under water to more accurately represent saturated conditions. A groundwater sample was collected from Monitoring Well MW-3, located west of the meadow area in the northern central portion of the Park, for use in the testing to aid in more accurately representing site conditions.

Of the five samples analyzed from the meadow area, two of the samples (SB-12A S6 and SB-3A) produced NAPL during the centrifuging process. The remaining three samples analyzed did not produce measurable volumes of NAPL during the centrifuging process. However, the relatively low initial NAPL saturations of these three samples, prior to centrifuging (6.7 to 13 percent) would not be expected to result in a measurable change in NAPL saturation following centrifugation (i.e., NAPL mobility resulting from the test). (Information obtained through personal communications with a professional at PTS Laboratories) The results of the saturation analysis and mobility testing are dependent upon the small sub-sample used for testing. A section of the sample core approximately 2-inches thick is selected from the sample, and tested for NAPL saturation and mobility. Since this analyzed sample volume is only a fraction of the collected sample volume, results may not provide representative data if the sub-section of sample selected for testing does not adequately capture the most saturated portion of the sample. The initial NAPL saturation measured in the SB-12A tar sample prior to centrifugation was much higher than NAPL saturations commonly observed in NAPL impacted soil samples. Following the centrifuging process, the resulting residual saturation was also much higher than commonly observed. Interpretation of this result is attributed to the multi-phase matrix of the sample with the additional presence of tar and black carbon, influencing the behavior of the NAPL within the tar sample. Table 4.4 presents the results of the free product mobility testing.

5.0 Waste Management

5.1 WASTE CHARACTERIZATION

Investigation-derived waste (IDW) generated during the City team and PSE-led field investigations were combined in 55-gallon Department of Transportation (DOT) approved steel drums for on-site storage pending results of chemical analyses for waste profiling. Water generated during decontamination and cleaning of drilling equipment and auger flights was also containerized in DOT approved 55-gallon steel drums for on-site storage pending analytical results.

Three composite soil samples and two composite decontamination water samples were collected from the drums, and analyzed for gasoline and diesel-range petroleum hydrocarbons, BTEX, metals, and semivolatile organic compounds. Due to the elevated levels of benzene detected in one of the soil samples, all containerized soil was transported from the site as a hazardous solid. Decontamination water samples did not contain elevated levels of benzene contamination; however the concentrations of diesel and heavy oil-range hydrocarbons were substantial and a visible sheen was present on the water in addition to visible turbidity. Due to the analytical results and observed water quality, decontamination water was not discharged to the sanitary sewer as described in the SAP and was profiled and transported from the site for disposal at a licensed waste management facility. Decontamination water was transported from the site as a non-hazardous, DOT non-regulated liquid. Laboratory results for waste profiling chemical analyses are included in Appendix E.

5.2 WASTE DISPOSAL

A total of 10 drums containing soil and 5 drums containing water were removed from the site by Clean Harbors Inc. on September 21 and September 26, 2007. All drums were properly secured and labeled as either a hazardous solid or non-hazardous, DOT non-regulated liquid. IDW removed from the site by Clean Harbors included all IDW generated by both City team activities in the NE corner meadow area and PSE-led activities along the eastern shoreline area between September 17 and September 26, 2007. Appendix F contains waste profile forms, and disposal certifications for all containerized waste removed from the site.

6.0 References

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Gas Works Park
Northeast Corner Investigation

Data Report

Tables

Table 2.1
Soil Gas Survey Results Summary

Soil Gas Sample Location	Sample Date/Time	Easting^3	Northing^3	Surface Soil Description	Total Aromatic Concentration (ug/m3)	Total Aromatic Concentration^1 (µg/m3)	Noticeable Odors and Observed tar/DNAPL	Comments
SG-01	8/28/2007 15:13	1270608.7	239483.2	Sparse grass/topsoil	28.4	18.4	None	
SG-02	8/28/2007 15:44	1270635.8	239484.0	Grass/topsoil	41.3	31.3	Moderate hydrocarbon odor	Initially encountered refusal, third attempt resulted in probe depth and sample collection.
SG-03	8/28/2007 16:05	1270665.6	239485.2	Grass/topsoil	32.9	22.9	None	Initially encountered refusal at approx. 1 foot, white, concrete/rock like material on tip of probe.
SG-04	8/29/2007 19:47	1270695.1	239484.0	Grass/topsoil	227.4	212.4	Moderate napthalene/hydrocarbon odor from soils on probe	
SG-05	NA	1270728.5	239480.6	NA	NA	NA	NA	Not Sampled
SG-06	NA	1270755	239484	NA	NA	NA	NA	Not Sampled
SG-07	NA	1270785.0	239485.9	NA	NA	NA	NA	Not Sampled
SG-08	8/28/2007 18:03	1270815.9	239463.7	Shoreline sand/gravel	NA1	NA^2	Significant hydrocarbon and bitter odor	Augered near boring, conducted sheen test on soil cuttings. Moderate iridescent sheen observed.
SG-09	8/28/2007 17:35	1270785.5	239454.3	Dirt path/topsoil	20.9	9.9	None	
SG-10	8/28/2007 17:21	1270755	239454	Grass/topsoil	78.8	68.8	None	
SG-11	8/28/2007 16:58	1270724.4	239451.1	Grass/topsoil	46.3	35.3	None	
SG-12	8/28/2007 16:38	1270695.6	239454.2	Grass/topsoil	32.6	20.6	None	
SG-13	8/28/2007 16:18	1270664.0	239454.4	Grass/topsoil	45.2	33.2	Faint hydrocarbon odor on soil adhered to screen	
SG-14	8/29/2007 18:30	1270635.5	239454.2	Grass/topsoil	130.9	120.9	Strong hydrocarbon odor on soil cuttings from auger and probe	Refusal at 10 inches with probe. Drilled auger to 12 inches, then drove probe to full 18 inches. Conducted sheen test. Slight fragmented sheen observed.
SG-15	8/28/2007 15:03	1270605.1	239454.2	Grass/topsoil	90.1	80.1	None	
SG-16	8/28/2007 14:41	1270597.6	239425.0	Grass/topsoil	235.5	225.5	Faint hydrocarbon odor at 16 inches	Due to refusal the soil gas sample was collected at 17 inches bgs
SG-17	8/29/2007 17:49	1270631.7	239421.5	Grass/topsoil	196.0	187.0	Very faint hydrocarbon on soils on screen	Due to refusal the soil gas sample was collected at 10 inches bgs
SG-18	8/29/2007 17:00	1270665.4	239424.7	Grass/topsoil	24.3	10.3	None	
SG-19	8/29/2007 16:33	1270695.3	239407.8	Grass/topsoil	68.1	57.1	None	
SG-20	8/29/2007 16:10	1270725.3	239416.9	Grass/topsoil	82.3	69.3	None	
SG-21	NA	1270757.7	239423.5	NA	NA	NA	NA	Encountered refusal at approx. 6 to 8 inches in depth at six locations within 10 ft of the target location. White material on tip of auger and probe.
SG-22	8/29/2007 19:11	1270784.3	239426.5	Dirt path/topsoil	9.8	6.8	None	
SG-23	8/29/2007 8:55	1270814.9	239426.6	Leaf debris, blackberry brambles, topsoil	8,353.3	8,349.3	Very strong naphthalene/hydrocarbon odor, Tar/DNAPL on probe screen and adjacent	
SG-24	8/28/2007 19:45	1270816.6	239393.7	Leaf debris, blackberry brambles, topsoil	35.3	30.3	None	
SG-25	8/28/2007 19:30	1270785.8	239395.2	Grass/topsoil	40.3	37.3	None	
SG-26	NA	1270754.8	239394.2	NA	NA	NA	NA	Not Sampled
SG-27	8/29/2007 18:46	1270725.6	239394.1	Grass/topsoil	593.8	585.8	Very faint hydrocarbon on soils on screen	
SG-28	NA	1270695.9	239394.1	NA	NA	NA	NA	Not Sampled
SG-29	NA	1270666.5	239394.4	NA	NA	NA	NA	Not Sampled
SG-30	8/28/2007 13:02	1270635.0	239394.4	Grass/topsoil	58.1	58.1	None	Sample location in shade.
SG-31	8/28/2007 14:24	1270603.9	239399.7	Grass/topsoil	78.3	70.3	None	
SG-32	NA	1270601.3	239376.6	NA	NA	NA	NA	Not Sampled

Soil Gas Sample Location	Sample Date/Time	Easting[3]	Northing[3]	Surface Soil Description	Total Aromatic Concentration (ug/m3)	Total Aromatic Concentration[1] (µg/m3)	Noticeable Odors and Observed tar/DNAPL	Comments
SG-33	NA	1270635.8	239374.4	Grass/topsoil	NA	NA	NA	Probing attempted several times within a 3-foot radius of target location. Refusal at all locations.
SG-34	8/28/2007 11:42	1270664.7	239364.3	Grass/topsoil	19.0	19.0	None	Sample location in shade. Moist tip noted upon retrieval.
SG-35	NA	1270696.3	239365.0	NA	NA	NA	NA	Not Sampled
SG-36	8/29/2007 19:16	1270725.9	239364.7	Grass/topsoil	32.1	22.1	NA	
SG-37	NA	1270758.0	239350.8	NA	NA	NA	NA	Not Sampled
SG-38	8/29/2007 10:06	1270785.7	239364.2	Sparse grass/topsoil	17.3	6.3	None	
SG-39	8/29/2007 10:01	1270818.5	239363.8	Grass/topsoil	18.9	7.9	None	
SG-40	NA	1270846.2	239334.6	Shoreline sand/gravel	NA1	NA[2]	Moderate naphthalene/hydrocarbon odor prior to probing	Augered at three locations surrounding target and conducted sheen test. No sheens were observed.
SG-41	8/29/2007 10:35	1270830.6	239334.4	Bark over topsoil	20.2	10.2	None	
SG-42	8/29/2007 10:18	1270786.7	239333.0	Grass/topsoil	19.5	10.5	None	
SG-43	NA	1270753.0	239341.2	NA	NA	NA	NA	Not Sampled
SG-44	8/29/2007 12:20	1270822.4	239303.8	Grass/topsoil	37.0	23.0	None	
SG-45	NA	1270846.5	239304.2	Shoreline sand/gravel	NA	NA	Faint hydrocarbon odor in auger hole.	Did not attempt soil gas sample collection. Augered at target location. Moderate sheen observed in standing water of auger hole.
SG-46	NA	1270845.0	239275.6	NA	NA	NA	NA	Not Sampled
SG-47	8/29/2007 12:46	1270822.2	239273.2	Grass/topsoil	43.4	32.4	None	
SG-48	8/29/2007 12:59	1270821.7	239244.5	Grass/topsoil	558.4	514.4	None	
SG-49	8/29/2007 13:43	1270815.6	239214.0	Grass/topsoil	213.0	193.0	None	
SG-50	8/29/2007 14:08	1270815.8	239184.2	Grass/topsoil	57.3	38.3	None	
SG-51	8/29/2007 14:32	1270808.7	239154.2	Grass/topsoil	47.9	29.9	None	
SG-52	NA	1270799.3	239113.5	NA	NA	NA	NA	Not Sampled
SG-53	8/29/2007 15:18	1270789.8	239124.9	Grass/topsoil	93.1	83.1	None	
SG-54	NA	1270789.5	239094.8	NA	NA	NA	NA	Not Sampled

Notes:

1 Total aromatic concentration as presented, reflects the maximum aromatic concentration minus the ARSLID baseline concentration for each sample location during the sampling period.

2 Soil gas samples were not able to be collected as water entered Teflon tubing and prevented sample collection.

3 Soil Gas Survey location coordinates provided in NAD 83 Horizontal Datum, Washington State Plane Coordinate system, North Zone, units of feet.

4 Information provided for locations where sample collection was attempted, including refusal locations.

Table 3.1
Soil Boring Sample Information Summary

			Observed Indicators of Contamination					
Soil Boring	Sample ID	Depth range	Petrophysical Sample Collected[1]	Solids[2]	Light to moderate sheen	Moderate to heavy sheen	NAPL	Tar
SB-1	SB1-S1	0-1	-	-	-	-	-	-
	SB1-S2	2.5-4.0	-	-	-	-	-	-
	SB1-S3	5.0-6.5	-	-	-	-	-	-
	SB1-S4	7.5-9.0	-	-	-	X	X	-
	SB1-S5	10-10.5	-	-	-	X	X	-
	SB1-S6	12.5-12.9	-	-	X	-	-	-
	SB1-S7	15-15.2	-	-	-	-	-	-
SB-2	SB2-S1	0-1	-	-	-	-	-	-
	SB2-S2	2.5-4	-	-	-	-	-	-
	SB2-S3	5-6.5	-	-	-	-	-	-
	SB2-S4	6.5-8	X	-	-	X	-	-
	SB2-S5	8-9.5	-	-	-	X	X	-
	SB2-S6	10-10.1	-	-	X	-	-	-
	SB2-S7	12.5-12.7	-	-	X	-	-	-
SB-2A	SB2A-S1	8-9.5	X	-	-	X	X	-
SB-3	SB3-S1	0-1.0	-	-	-	-	-	-
	SB3-S2	2.5-4.0	-	-	-	-	-	-
	SB3-S3	5.0-6.5	-	X	X	-	-	-
	SB3-S4	7.5-9.0	-	X	X	-	-	-
	SB3-S5	10.0-11.5	-	X	-	X	X	-
	SB3-S6	12.5-13.0	-	-	X	-	-	-
	SB3-S7	15.0-15.5	-	-	-	X	X	-
SB-3A	SB3A-1	9.0-10.5	X	-	-	-	X	-
SB-4	SB4-S1	0-1.0	-	-	-	-	-	-
	SB4-S2	2.5-4.0	-	X	-	-	-	-
	SB4-S3	5.0-6.5	-	X	X	-	-	-
	SB4-S4	7.5-9.0	-	X	-	X	-	-
	SB4-S5	10.0-11.5	-	X	X	-	-	-
	SB4-S6	12.5-13.0	-	-	-	-	-	-
	SB4-S7	15.0-15.3	-	-	X	-	-	-
SB-5	SB5-S1	0-1.0	-	-	-	-	-	-
	SB5-S2	1.0-2.0	-	X	X	-	-	-
	SB5-S3	2.5-4.0	-	X	X	-	-	-
	SB5-S4	5.0-6.5	-	X	X	-	-	-
	SB5-S5	7.5-9.0	X	X	-	X	-	-
	SB5-S6	10.0-10.4	-	-	-	-	-	-
	SB5-S7	12.0-12.4	-	-	-	-	-	-
SB-6	SB6-S1	0-1.0	-	X	-	-	-	-
	SB6-S2	1.0-2.0	-	-	-	-	-	X
	SB6-S3	2.5-4.0	-	X	X	-	X	-
	SB6-S4	5.0-6.5	-	X	X	-	-	-
	SB6-S5	7.5-9.0	-	X	-	X	-	-
	SB6-S6	10.0-11.5	-	-	-	X	-	-
	SB6-S7	12.5-14.0	-	-	-	X	-	-
	SB6-S8	15.0-15.7	-	-	X	-	-	-
	SB6-S9	17.5-18.0	-	-	-	-	-	-

Soil Boring	Sample ID	Depth range	Observed Indicators of Contamination Petrophysical Sample Collected[1]	Solids[2]	Light to moderate sheen	Moderate to heavy sheen	NAPL	Tar
SB-7	SB7-S1	0-1.0	-	-	-	-	-	-
	SB7-S2	2.5-4.0	-	X	-	-	-	-
	SB7-S3	5.0-6.5	-	X	X	-	-	-
	SB7-S4	7.5-9.0	-	X	-	X	-	-
	SB7-S5	10.0-11.5	-	X	-	X	-	-
	SB7-S6	12.5-13.0	-	-	X	-	-	-
	SB7-S7	15.0-15.5	-	-	-	-	-	-
SB-8	SB8-S1	0-1.0	-	-	-	-	-	-
	SB8-S2	1.0-4.5	-	-	-	-	-	-
	SB8-S3	5.0-6.5	-	-	-	-	-	-
	SB8-S4	7.5-9.0	-	-	X	-	-	-
	SB8-S5	9.0-10.5	X	-	-	X	-	-
	SB8-S6	10.5-11.0	-	-	X	-	-	-
	SB8-S7	12.5-12.7	-	-	X	-	-	-
SB-9	SB9-S1	0-1.0	-	-	-	-	-	-
	SB9-S2	2.5-4.0	-	X	-	-	-	-
	SB9-S3	5.0-6.5	-	X	X	-	-	-
	SB9-S4	7.5-9.0	-	X	X	-	-	-
	SB9-S5	10.0-11.0	-	X	-	X	-	-
SB-10	SB10-S1	0-1.0	-	X	-	-	-	-
	SB10-S2	2.5-4.0	-	-	-	-	-	-
	SB10-S3	5.0-6.5	-	X	X	-	-	-
	SB10-S4	7.5-9.0	-	X	-	X	-	-
	SB10-S5	10.0-11.5	-	X	X	-	-	-
	SB10-S6	12.5-14.0	-	X	-	X	-	-
	SB10-S7	15.0-15.5	-	X	-	X	X	-
	SB10-S8	17.5-17.9	-	-	-	X	-	-
	SB10-S9	20.0-20.4	-	-	X	-	-	-
SB-11	SB11-S1	0-1.0	-	-	-	-	-	-
	SB11-S2	2.5-3.0	-	-	-	X	-	-
	SB11-S3	5.0-6.5	-	-	-	X	-	-
	SB11-S4	7.5-9.0	-	-	X	-	-	-
	SB11-S5	10.0-10.4	-	-	-	-	-	-
	SB11-S6	12.5-12.7	-	-	-	-	-	-
	SB11-S7	15.0-15.3	-	-	-	-	-	-
SB-12	SB12-S1	0-1.0	-	-	-	-	-	-
	SB12-S2	2.5-3.0	-	-	X	-	-	-
SB-12A	SB12A-S1	0-1.0	-	-	-	-	-	-
	SB12A-S2	2.5-2.8	-	-	-	-	-	-
	SB12A-S3	5.0-6.5	-	-	-	X	-	X
	SB12A-S4	6.5-8.0	X	-	-	X	X	X
	SB12A-S5	8.0-9.0	-	-	-	X	-	X
	SB12A-S6	10.0-10.2	X	-	-	-	-	X
SB-13	SB13-S1	0-1.0	-	-	-	-	-	-
	SB13-S2	2.5-4.0	-	X	-	-	-	-
	SB13-S3	5.0-6.5	-	X	-	-	-	-
	SB13-S4	7.5-9.0	-	-	-	-	-	-
	SB13-S5	10.0-11.5	-	-	-	-	-	-
	SB13-S6	12.5-13.0	-	-	-	-	-	-
	SB13-S7	15.0-15.4	-	-	-	-	-	-

Notes:

▨ Gray shaded cells indicate sample intervals were contamination was observed.

1 Column indicates all samples collected for UV light photography, and potential petrophysical testing (Table 4.1).

2 Solids includes the presence of black carbon (lampblack), soot, coal, charcoal, and slag.

Table 4.1
UV Light and Petrophysical Sample Summary

								Sample Interval Selected for Petrophysical Analyses (feet)			
									Free Product Mobility		
Sample ID	Sample Depth (feet)	Collection Date	USC Description	Qualitative Field Observations	PID Reading (ppm)	Observed Water Table Depth (feet bgs)	UV Light Photographed	Pore Fluid Saturation Package	Under Air (ASTM D425M)	Under Water (ASTM D425M)	Grain Size Analyses (Grab)
SB2-S4	**6.5-8.0**	9/17/2007	SM	Heavy, colored sheen observed in sample. Sheen on sampler. Heavy hydrocarbon odor. Wood debris present.	NA	9	**Y**	**6.65-6.8**	**6.5-6.65**	**--**	**6.85**
SB2A-S1	**8.0-9.5**	9/17/2007	SM / SC	Heavy product in sample. Yellow and orange sheen observed in sheen test bowl. Heavy odor. Product consistent with that observed in SB2-S4 at 8-foot depth.	NA	9 (assumed)	**Y**	**8.0-8.15**	**8.3-8.4**	**--**	**8.45**
SB 3A	**9.0-10.5**	9/19/2007	SM (inferred)	Product at bottom of sampler retained for petro testing. No sheen. Heavy odor. Product stains gloves yellow.	0	10	**Y**	**9.15-9.3**	**9.0-9.15**	**--**	**9.2**
SB5-S5	**7.5-9.0**	9/18/2007	SM	Heavy sheen. Slight odor. Potential slag and debris present.	1.8	7	**Y**	**--**	**--**	**--**	**NA**
SB8-S5	**9.5-10.0**	9/18/2007	SM	Heavy sheen on sampler. Hydrocarbon odor. Wood debris present.	88.7	9	**Y**	**--**	**--**	**--**	**--**
SB12A-S4	**6.5-8.0**	9/20/2007	CL (inferred)	Heavy sheen on sampler. Product in sample. Heavy naphthalene odor.	NA	8	**Y**	**6.65-6.8**	**6.5-6.65**	**--**	**6.85**
SB12A-S6	**10.0-10.2**	9/20/2007	NA	Tar-like substance on plug at 10 feet from previous drive. DNAPL / Tar captured in sampler.	58.4	8	**Y**	**10.2-10.35**	**--**	**10.35-10.5**	**10.15**

Notes:
UV Light photographs presented in Appendix C.
Laboratory results for petrophysical analyses presented in Appendix D.
bgs below ground surface

Table 4.2
Grain Size Analysis Results Summary

Sample ID	Depth (feet)	Mean Grain Size Description	Median Grain Size (mm)	Particle Size Distribution (% by weight)						
				Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Silt & Clay
SB2-S4	6.85	Fine sand	0.29	11.3	3.8	19.7	49.9	(2)	(2)	15.3
SB2A-S1	8.45	Medium sand	0.72	7.6	17.9	36.4	27.4	(2)	(2)	10.8
SB3A	9.3	Medium sand	0.45	0.0	14.3	37.2	35.6	(2)	(2)	12.8
SB12A-S4	6.85	Medium sand	0.51	21.8	10.2	22.0	31.7	(2)	(2)	14.3
SB12A-S6	10.15	Silt	0.01	0	0	0	0	54.8	45.2	100

Notes:

1 Samples Analyzed by Method ASTM D422/D4464M.

2 Mechanical sieve used, does not differentiate between silt and clay fractions.

Table 4.3
Pore Fluid Saturation Analysis Results Summary

Test Method			API RP 40 / ASTM D2216	API RP 40		API RP 40		API RP 40	
								Pore Fluid Saturation	
Sample ID	Depth (feet)	Sample Orientation[1]	Moisture Content (% weight)	Bulk Density (g/cc)	Grain Density (g/cc)	Total Porosity[2] (% Vb)	Air Filled Porosity[2] (% Vb)	Water[3] (% Pv)	NAPL[3] (% Pv)
SB2-S4	6.65-6.8	V	19.2	1.59	2.64	39.7	9.0	72.7	4.5
SB2A-S1	8.0-8.15	V	15.0	1.42	2.65	46.4	25.1	41.0	4.9
SB 3A	9.15-9.3	V	41.1	1.09	2.26	51.8	6.4	74.5	13.2
SB12A-S4	6.65-6.8	V	18.8	1.64	2.64	37.8	6.9	76.0	5.8
SB12A-S6	10.2-10.35	V	152.8	0.44	1.55	71.4	0.6	9.9	89.3

Notes:

1 Sample Orientation: V = vertical

2 Total Porosity = no pore fluids in place; all interconnected pore channels; Air Filled = pore channels not occupied by pore fluids

3 Water = 0.9996 g/cc, Hydrocarbon = 0.9600 g/cc

Vb Bulk volume

Pv Pore volume

Table 4.4
Free Product Mobility Testing Results

						Pore Fluid Saturations[3]				
						Initial Fluid Saturations		After Centrifuge at 1000xG		
Sample ID	**Sample Depth (feet)**	**Sample Orientation[1]**	**Bulk Density[2] (g/cc)**	**Grain Density[2] (g/cc)**	**Total Porosity[2] (% Vb)**	**Water Saturation (% Pv)**	**NAPL Saturation (% Pv)**	**Water Saturation (% Pv)**	**NAPL Saturation (% Pv)**	**Notes**
SB2-S4	6.5-6.65	V	1.65	2.59	36.1	61.9	6.7	39.4	6.7	No visible NAPL produced. Produced water clear with no hydrocarbon odor.
SB2A-S1	8.3-8.4	V	1.84	2.69	31.8	62.1	7.0	31.4	7.0	No visible NAPL produced. Produced water clear with no hydrocarbon odor.
SB 3A	9.0-9.15	V	1.21	2.45	50.7	57.4	17.6	22.6	16.1	Dark brown LNAPL produced. Produced water clear.
SB12A-S4	6.5-6.65	V	1.73	2.62	34.0	83.4	13.0	53.0	13.0	No visible NAPL produced. Produced water clear with faint hydrocarbon odor.
SB12A-S6[4]	10.35-10.5	V	0.54	1.61	66.76	9.93	88.74	8.10	87.81	NAPL produced from top and bottom of sample. Produced water clear. Sample compressed slightly during centrifuging.

Notes:

1 Sample Orientation V = Vertical
2 Testing performed using Method API RP 40
3 Testing performed using Method ASTM D425M, Dean-Stark
4 Sample analyzed for pore fluid saturation under water, due to collection of sample from below the water table.
NAPL Non-aqueous phase liquid
Pv Pore volume
Vb Bulk volume
Water = 0.9996 g/cc
NAPL = 0.9600 g/cc

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Figures

Map created using TOPO!® software.
©2003 National Geographic
(www.nationalgeographic.com/topo)

FLOYD | SNIDER strategy ▪ science ▪ engineering	**NE Corner Investigation Data Report Gas Works Park City of Seattle**	Figure 1.1 Site Vicinity Map

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Date: 1/9/2008

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Figure 1.2
NE Corner Investigation Area Extents
And Tar Occurrence Locations

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Figure 2 (NE Corner Investigation Area Extents).mxd
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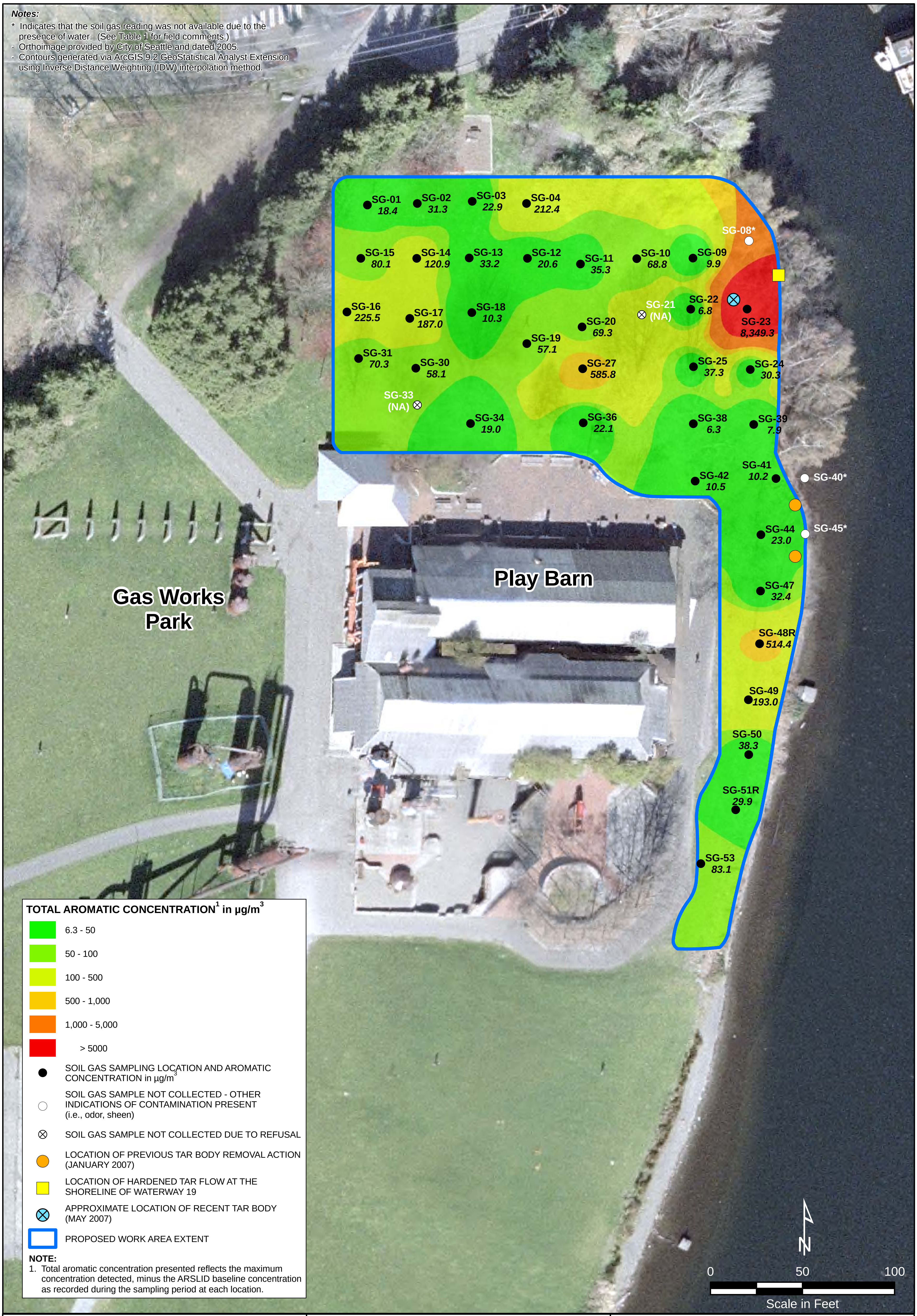

Notes:
- * Indicates that the soil gas reading was not available due to the presence of water. (See Table 1 for field comments.)
- Orthoimage provided by City of Seattle and dated 2005.
- Contours generated via ArcGIS 9.2 GeoStatistical Analyst Extension using Inverse Distance Weighting (IDW) interpolation method.

TOTAL AROMATIC CONCENTRATION[1] in µg/m^3

🟩	6.3 - 50
🟩	50 - 100
🟨	100 - 500
🟨	500 - 1,000
🟧	1,000 - 5,000
🟥	> 5000
●	SOIL GAS SAMPLING LOCATION AND AROMATIC CONCENTRATION in µg/m^3
○	SOIL GAS SAMPLE NOT COLLECTED - OTHER INDICATIONS OF CONTAMINATION PRESENT (i.e., odor, sheen)
⊗	SOIL GAS SAMPLE NOT COLLECTED DUE TO REFUSAL
●	LOCATION OF PREVIOUS TAR BODY REMOVAL ACTION (JANUARY 2007)
🟨	LOCATION OF HARDENED TAR FLOW AT THE SHORELINE OF WATERWAY 19
⊗	APPROXIMATE LOCATION OF RECENT TAR BODY (MAY 2007)
▭	PROPOSED WORK AREA EXTENT

NOTE:
1. Total aromatic concentration presented reflects the maximum concentration detected, minus the ARSLID baseline concentration as recorded during the sampling period at each location.

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Figure 2.1
Soil Gas Concentration Contours

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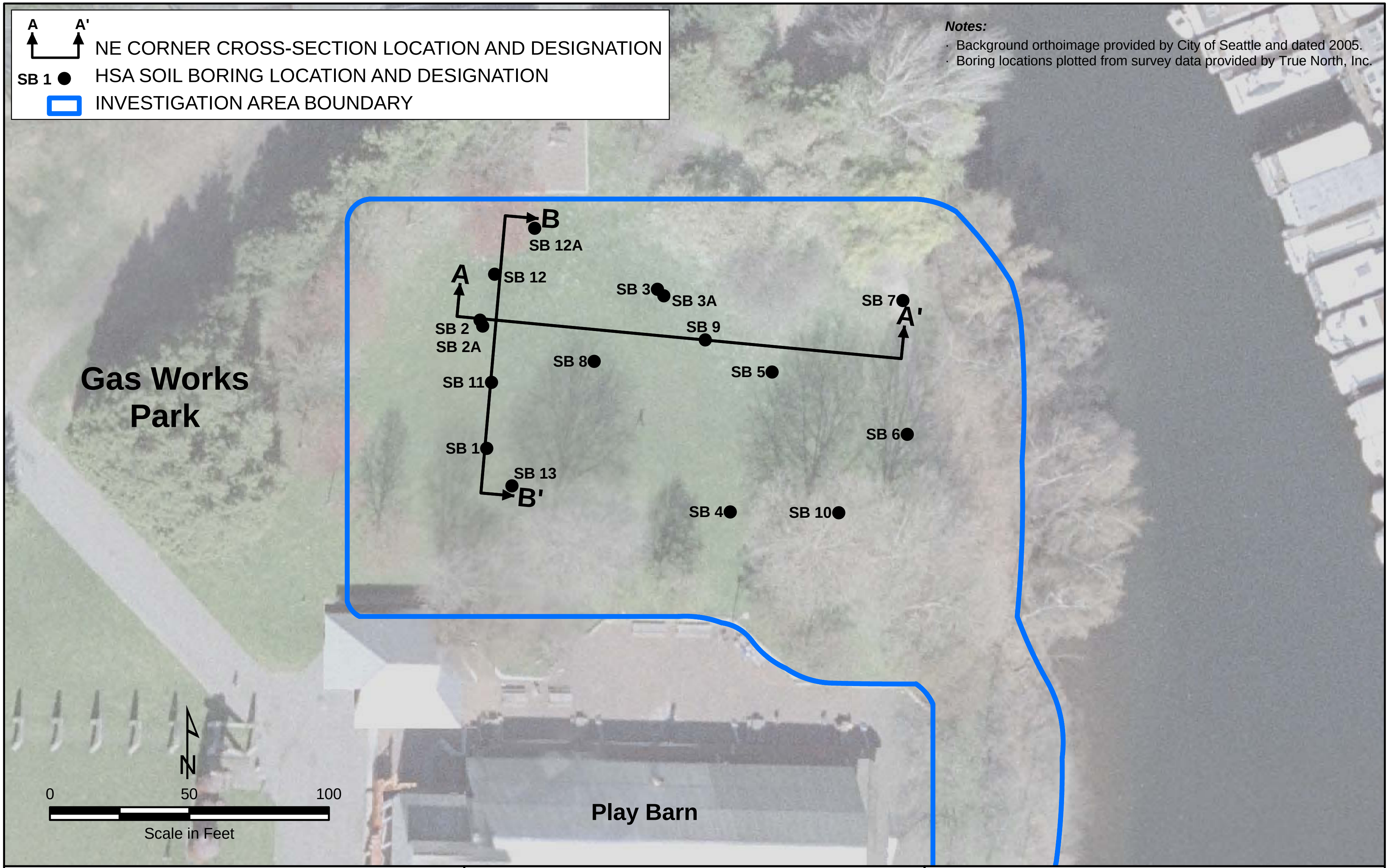

Notes:

- Background orthoimage provided by City of Seattle and dated 2005.
- Boring locations plotted from survey data provided by True North, Inc.

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Figure 3.1
Soil Boring and Lithologic
Cross-Section Locations

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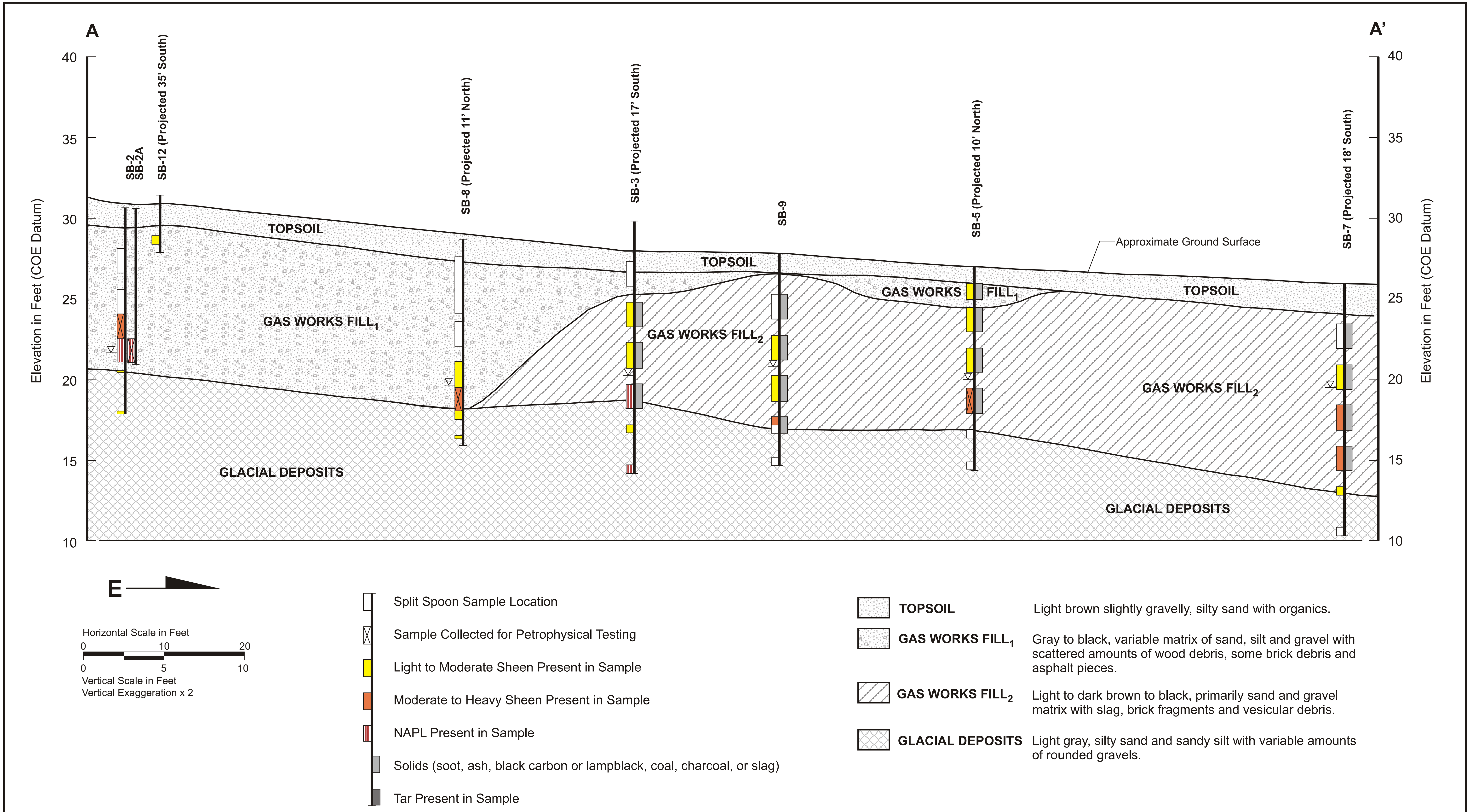

Split Spoon Sample Location

Sample Collected for Petrophysical Testing

Light to Moderate Sheen Present in Sample

Moderate to Heavy Sheen Present in Sample

NAPL Present in Sample

Solids (soot, ash, black carbon or lampblack, coal, charcoal, or slag)

Tar Present in Sample

▨	**TOPSOIL**	Light brown slightly gravelly, silty sand with organics.
▨	**GAS WORKS FILL$_1$**	Gray to black, variable matrix of sand, silt and gravel with scattered amounts of wood debris, some brick debris and asphalt pieces.
▨	**GAS WORKS FILL$_2$**	Light to dark brown to black, primarily sand and gravel matrix with slag, brick fragments and vesicular debris.
▨	**GLACIAL DEPOSITS**	Light gray, silty sand and sandy silt with variable amounts of rounded gravels.

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Figure 3.2
Cross Section A-A'

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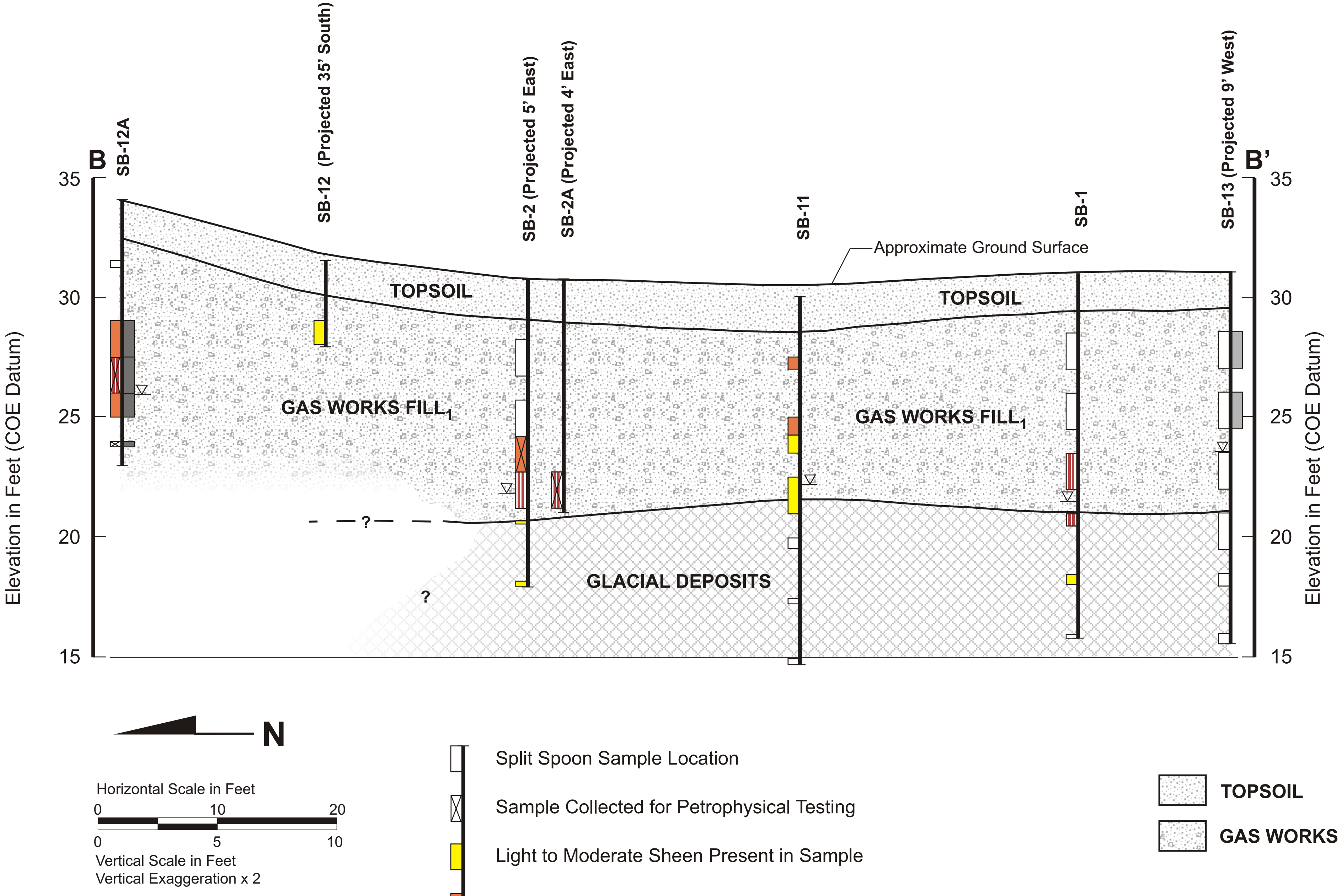

▯ Split Spoon Sample Location

☒ Sample Collected for Petrophysical Testing

🟨 Light to Moderate Sheen Present in Sample

🟧 Moderate to Heavy Sheen Present in Sample

▥ NAPL Present in Sample

▯ Solids (soot, ash, black carbon or lampblack, coal, charcoal, or slag) Present in Sample

▮ Tar Present in Sample

▒	**TOPSOIL**	Light brown slightly gravelly, silty sand with organics.
▒	**GAS WORKS FILL$_1$**	Gray to black, variable matrix of sand, silt and gravel with scattered amounts of wood debris, some brick debris and asphalt pieces.
▨	**GLACIAL DEPOSITS**	Light gray, silty sand and sandy silt with variable amounts of rounded gravels.

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Figure 3.3
Cross Section B-B'

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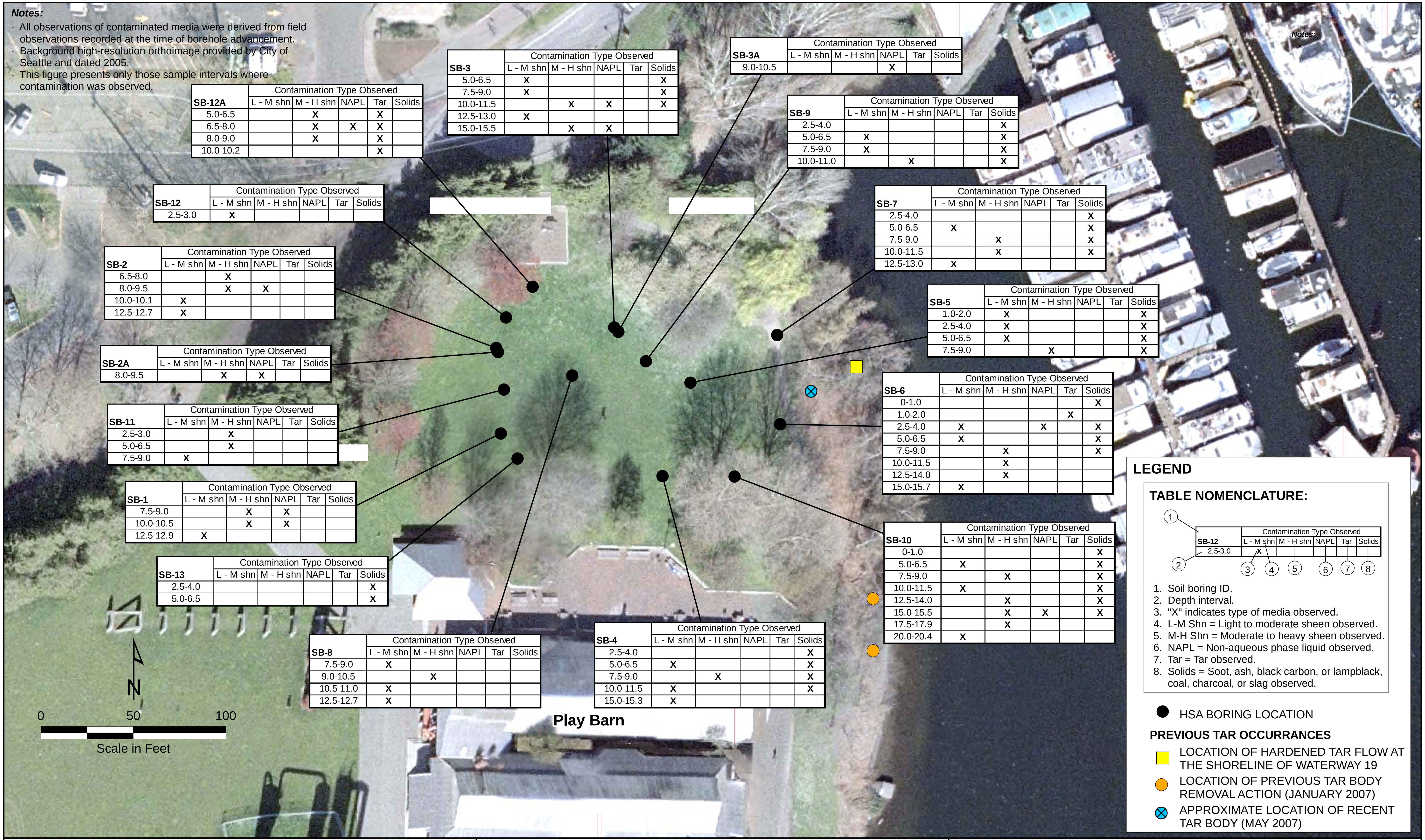

Notes:
- All observations of contaminated media were derived from field observations recorded at the time of borehole advancement.
- Background high-resolution orthoimage provided by City of Seattle and dated 2005.
- This figure presents only those sample intervals where contamination was observed.

SB-12A	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
5.0-6.5		X		X	
6.5-8.0		X	X	X	
8.0-9.0		X		X	
10.0-10.2				X	

SB-3	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
5.0-6.5	X				X
7.5-9.0	X				X
10.0-11.5		X	X		X
12.5-13.0	X				
15.0-15.5		X	X		

SB-3A	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
9.0-10.5			X		

SB-9	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
2.5-4.0					X
5.0-6.5	X				X
7.5-9.0	X				X
10.0-11.0		X			X

SB-12	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
2.5-3.0	X				

SB-7	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
2.5-4.0					X
5.0-6.5	X				X
7.5-9.0		X			X
10.0-11.5		X			X
12.5-13.0	X				

SB-2	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
6.5-8.0		X			
8.0-9.5		X	X		
10.0-10.1	X				
12.5-12.7	X				

SB-5	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
1.0-2.0	X				X
2.5-4.0	X				X
5.0-6.5	X				X
7.5-9.0		X			X

SB-2A	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
8.0-9.5		X	X		

SB-6	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
0-1.0					X
1.0-2.0				X	
2.5-4.0	X		X		X
5.0-6.5	X				X
7.5-9.0		X			X
10.0-11.5		X			
12.5-14.0		X			
15.0-15.7	X				

SB-11	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
2.5-3.0		X			
5.0-6.5		X			
7.5-9.0	X				

SB-1	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
7.5-9.0		X	X		
10.0-10.5		X	X		
12.5-12.9	X				

SB-10	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
0-1.0					X
5.0-6.5	X				X
7.5-9.0		X			X
10.0-11.5	X				X
12.5-14.0		X			X
15.0-15.5		X	X		X
17.5-17.9		X			
20.0-20.4	X				

SB-13	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
2.5-4.0					X
5.0-6.5					X

SB-4	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
2.5-4.0					X
5.0-6.5	X				X
7.5-9.0		X			X
10.0-11.5	X				X
15.0-15.3	X				

SB-8	Contamination Type Observed				
	L - M shn	M - H shn	NAPL	Tar	Solids
7.5-9.0	X				
9.0-10.5		X			
10.5-11.0	X				
12.5-12.7	X				

LEGEND

TABLE NOMENCLATURE:

SB-12 ①	Contamination Type Observed				
	L - M shn ④	M - H shn ⑤	NAPL ⑥	Tar ⑦	Solids ⑧
2.5-3.0 ②	X ③				

1. Soil boring ID.
2. Depth interval.
3. "X" indicates type of media observed.
4. L-M Shn = Light to moderate sheen observed.
5. M-H Shn = Moderate to heavy sheen observed.
6. NAPL = Non-aqueous phase liquid observed.
7. Tar = Tar observed.
8. Solids = Soot, ash, black carbon, or lampblack, coal, charcoal, or slag observed.

● HSA BORING LOCATION

PREVIOUS TAR OCCURRENCES

🟨 LOCATION OF HARDENED TAR FLOW AT THE SHORELINE OF WATERWAY 19

● LOCATION OF PREVIOUS TAR BODY REMOVAL ACTION (JANUARY 2007)

⊗ APPROXIMATE LOCATION OF RECENT TAR BODY (MAY 2007)

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Figure 3.4
Distribution of Field-Observed
Contaminated Media and
Industrial Solids

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Appendix A
Boring Logs

Log of Soil Boring SB-1

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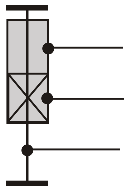
Boring SB-1 Date 9/17/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Cloudy, 60 degrees, Light Rain
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30" Drop
Bottom of Boring 15.2' BGS ATD Water Level Depth 9.5'
Ground Surface Elevation 31.0' (COE Datum)

Obs. Well Install. Yes ~~No~~

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB1-S1 (Grab Sample)	NA	0.0	0.0'	1.0'		None	SM	Black, (loose), damp to moist, slightly gravelly silty SAND to sandy SILT with organics. No odor. (Topsoil)
SB1-S2	67	0.6	2.5'	4.0'		None	ML	Olive green to gray, stiff to very stiff, moist, slightly sandy, slightly clayey SILT with rounded gravels. No odor. (Gas Works Fill$_1$)
SB1-S3	11	0.3	5.0'	6.5'		None	SW-SM	Light gray, medium dense, moist, slightly clayey, slightly silty SAND with rounded and angular gravels, organics, wood debris @5.5' and hydrocarbon odor near bottom. (Gas Works Fill$_1$)
SB1-S4	20	161	7.5'	9.0'		Heavy sheen at bottom	ML-SM	Gray to brown, medium stiff, moist, sandy SILT with organics and product (LNAPL?) saturated wood debris. Grades to (medium dense), moist to wet SAND with strong hydrocarbon odor and scattered wood and brick debris. (Gas Works Fill$_1$)
SB1-S5	50/6"	0.2	10.0'	10.5'		Heavy sheen with color and blebs	SW	Gray, very dense, wet SAND with angular and rounded gravel and trace organics. Naphthalene odor. (Glacial Deposits)
SB1-S6	50/4"	1.8	12.5'	12.9'		Light sheen	SW	Gray, very dense, moist, slightly silty to silty SAND with rounded gravels and slight hydrocarbon odor. (Glacial Deposits)
SB1-S7	50/2"	0.3	15.0'	15.2'		None	SW	Gray, very dense, moist, slightly silty to silty SAND with rounded gravels and slight odor. Silt content increases at bottom. (Glacial Deposits)
								Bottom of Boring at 15.2 feet BGS.



▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,409 ft
E: 1,270,640 ft

Log of Soil Boring SB-2

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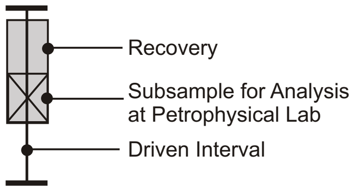
Boring SB-2 Date 9/17/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Cloudy, 60 degrees, Light Rain
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30" Drop
Bottom of Boring 12.7' BGS ATD Water Level Depth 9.0'
Ground Surface Elevation 30.7' (COE Datum)

Obs. Well Install. ☐ Yes ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB2-S1 (Grab Sample)	NA	0.0	0.0'	1.0'	▨	None		SM	Light to dark brown, (loose), moist, silty SAND to sandy SILT with organics. (Topsoil)
SB2-S2	32	9.0	2.5'	4.0'	▨	None		SM	Gray to black, medium dense, moist, silty, gravelly SAND with abundant wood debris and small chunks asphalt (?) Light to moderate hydrocarbon odor. (Gas Works Fill$_1$)
SB2-S3	8	NA	5.0'	6.5'					Soft drive - no recovery Put ring in sampler and sample @ 6.5ft to 8.0 ft BGS
SB2-S4	11	NA	6.5'	8.0'	☒	Heavy sheen w/ colors		SW	Black, medium dense, moist to wet, slightly silty SAND with small gravels between wood debris. Heavy hydrocarbon odor and sheen on sampler. Grade to (medium dense), wet, gray to light brown, silty, clayey SAND. (Gas Works Fill$_1$)
SB2-S5	27	137	8.0'	9.5'	▨	Very heavy sheen	∇	SM-SC	Black SILT over gray/brown, silty, gravelly SAND. Heavy hydrocarbon odor and product (LNAPL?) in sample. Orange, heavy stain on bowl. (Gas Works Fill$_1$)
SB2-S6	50/1"	17.3	10.0'	10.1'	▨	Light sheen		SW	Gray, very dense, wet, well-graded SAND with light hydrocarbon odor. Carry down? (Glacial Deposits)
SB2-S7	50/2"	NA	12.5'	12.7'	▨	Light sheen		SW	Gray, very dense, moist, slightly silty to silty SAND with scattered gravel and light hydrocarbon odor. Carry down? (Glacial Deposits)
									Bottom of Boring at 12.7 feet BGS.



∇ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,455 ft
E: 1,270,638 ft

Log of Soil Boring SB-2A

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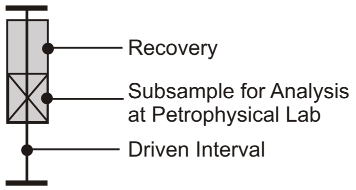
Obs. Well Install. ☐ Yes ☒ No

Boring SB-2A
Date 9/17/07
Sheet 1 of 1
Job Gas Works NE Corner Investigation
Job No. COS-GWSA (6010)
Logged By Matt Woltman
Weather 65 degrees, Raining
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30” Drop
Bottom of Boring 9.5’ BGS
ATD Water Level Depth NA
Ground Surface Elevation 30.6' (COE Datum)

SAMPLE ID	Blow Count	PID (ppm)	DEPTH		SAMPLE RECOVERY (FT)	SHEEN TEST		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
			From	To					
							0		
							1		
							2		
							3		
							4		Boring located adjacent to SB-2. Auger to 8ft BGS and obtain ring sample.
							5		
							6		
							7		
							8		
SB2A-S1	37	NA	8.0'	9.5'	☒	Very heavy sheen consistent with SB-2	9	SM-SC	Gray to light brown, medium dense, moist to wet, silty, gravelly SAND with heavy hydrocarbon odor and product (LNAPL?) in sample. Orange, heavy, stain on bowl. (Gas Works Fill$_1$)
							10		Bottom of Boring at 9.5 feet BGS.
							11		
							12		
							13		
							14		
							15		
							16		
							17		
							18		
							19		
							20		



▽ Groundwater Observed
At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,453 ft
E: 1,270,639 ft

Log of Soil Boring SB-3

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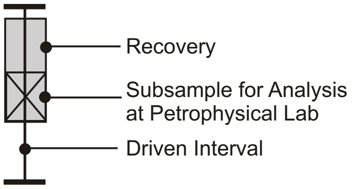
Boring SB-3 Date 9/19/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Cloudy, 60 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30" Drop
Bottom of Boring 15.5' BGS ATD Water Level Depth 9.5'
Ground Surface Elevation 29.8' (COE Datum)

Obs. Well Install. ☐ Yes ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB3-S1 (Grab Sample)	NA	0.0	0.0'	1.0'		NA	SM-ML	Light brown, (loose), dry to moist, silty SAND to sandy SILT with scattered gravels and organics. (Topsoil)
SB3-S2	63	0.0	2.5'	4.0'		None	ML	Light brown to gray, stiff to very stiff, dry to moist, sandy SILT with rounded gravels and oxidized orange material. (Gas Works Fill$_2$)
SB3-S3	10	0.0	5.0'	6.5'		Light sheen	SM	Light to dark brown and black, loose, moist, slightly silty to silty SAND with debris (slag, brick fragments, vesicular pieces, angular gravels) and shiny/glassy pieces scattered throughout. (Gas Works Fill$_2$)
SB3-S4	5	0.0	7.5'	9.0'		Light to moderate sheen	SM	Same as above. (Gas Works Fill$_2$)
SB3-S5	14	14.0	10.0'	11.5'		Heavy sheen	SM	Same as above. (Gas Works Fill$_2$) Black product (DNAPL?) coats sand and debris with strong hydrocarbon odor and visible sheen. Grades to light gray, wet, slightly silty SAND with gravels.
SB3-S6	50/6"	1.8	12.5'	13.0'		Very light broken sheen	SP	Light gray, very dense, wet, fine SAND with trace gravels. (Glacial Deposits) Slight hydrocarbon odor. (carry down?)
SB3-S7	50/5"	1.1	15.0'	15.5'		Moderate to heavy sheen	SP-SW	Same as above. (Glacial Deposits) Abundant gravels at bottom of sample. Slight to moderate odor. Discontinuous sheen blobs (DNAPL?) on small portions of sample.
								Bottom of Boring at 15.5 feet BGS.



∇ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,466 ft
E: 1,270,701 ft

Log of Soil Boring SB-3A

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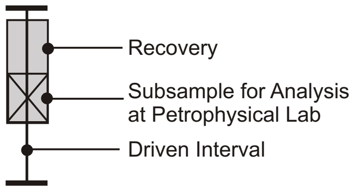
Boring SB-3A Date 9/19/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Cloudy, 60 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30” Drop
Bottom of Boring 10.5’ BGS ATD Water Level Depth ~10'
Ground Surface Elevation 29.4' (COE Datum)

Obs. Well Install. ☐ Yes ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH		SAMPLE RECOVERY (FT)	SHEEN TEST		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
			From	To					
							0		
							1		
							2		
							3		
							4		Boring located adjacent to SB-3. Auger to 9ft BGS and obtain ring sample.
							5		
							6		
							7		
							8		
SB3A-S1	20	NA	9.0'	10.5'	☒	NA	9		Black, medium dense, moist to wet, slightly silty SAND with debris (Gas Works $Fill_2$). Black product (DNAPL?) at bottom of lower ring. Heavy hydrocarbon odor.
							10 ▽		
							11		Bottom of Boring at 10.5 feet BGS.
							12		
							13		
							14		
							15		
							16		
							17		
							18		
							19		
							20		



▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,464 ft
E: 1,270,704 ft

Log of Soil Boring SB-4

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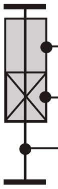
Boring	SB-4
Date	9/19/07
Sheet	1 of 1
Job	Gas Works NE Corner Investigation
Job No.	COS-GWSA (6010)
Logged By	Matt Woltman
Weather	Cloudy, 60 degrees
Drilled By	Cascade Drilling, Curtis
Drill Type/Method	HSA, Limited Access Rig
Sampling Method	Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30" Drop
Bottom of Boring	15.3' BGS
ATD Water Level Depth	7'
Ground Surface Elevation	29.0' (COE Datum)
Obs. Well Install.	Yes ~~No~~

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB4-S1 (Grab Sample)	NA	0.0	0.0'	1.0'		None	SM-ML	Light brown, (loose), dry to moist, sandy SILT to silty SAND with some gravels and organics. No odor. (Topsoil)
SB4-S2	50	0.0	2.5'	4.0'		None	SM	Light to dark brown to black, medium dense to dense, wet, silty SAND with silt nodules and charred black cinder (lampblack?) and organics. No odor. Chunk of slag in bottom of sample. (Gas Works Fill$_1$)
SB4-S3	12	0.0	5.0'	6.5'		Light sheen	SM-ML	Light brown to gray, loose to medium dense, wet grading to moist, silty to very silty SAND with black soot, charred pieces, small brick fragments and occasional gravels. (Gas Works Fill$_1$)
SB4-S4	13	1.0	7.5'	9.0'		Moderate sheen	SW	Dark brown to black, medium dense, wet, slightly silty SAND with debris - brick fragments, slag pieces. Sandier at top of sample, dark staining at middle and bottom. Moderate hydrocarbon odor at middle to bottom of sample. (Gas Works Fill$_2$)
SB4-S5	28	6.7	10.0'	11.5'		Light sheen above and below contact	SM-ML	Same as above with increasing silt content. (Gas Works Fill$_2$) Light gray, stiff, moist to wet, sandy SILT with charred pieces and rounded gravels. (Glacial Deposits) Slight hydrocarbon odor throughout.
SB4-S6	50/5"	NA	12.5'	13.0'		NA		No recovery.
SB4-S7	50/4"	0.8	15.0'	15.3'		Light Sheen	SW-SP	Light gray, very dense, wet, fine SAND with rounded small gravels and trace silt. Slight hydrocarbon odor. Bottom of Boring at 15.3 feet BGS.



▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,386 ft
E: 1,270,727 ft

Log of Soil Boring SB-5

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Boring SB-5 Date 9/18/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Cloudy, 60 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30” Drop
Bottom of Boring 12.4’ BGS ATD Water Level Depth 7’
Ground Surface Elevation 27.0' (COE Datum)

Obs. Well Install. ☐ Yes ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB5-S1 (Grab Sample)	NA	0.0	0.0’	1.0’	▨	None	SM-ML	Light brown, (loose), dry to damp, silty SAND to sandy SILT with organics (Topsoil) and scattered gravels.
SB5-S2 (Grab Sample)	NA	0.0	1.0'	2.0'	▨	Light sheen	SM-ML	Dark brown to black, loose, dry to moist, silty SAND to sandy SILT with gravels and reflective pieces. No odor. (Gas Works Fill$_1$) Turns water black in sheen test.
SB5-S3	11	0.0	2.5'	4.0’	▨	Light to moderate sheen	SM	Light brown to black, loose, moist, slightly silty fine SAND with lots of debris, brick pieces, coal pieces? and asphalt. (Gas Works Fill$_2$)
SB5-S4	6	0.0	5.0’	6.5’	▨	Light sheen	SM	Same as above. (Gas Works Fill$_2$)
SB5-S5	20	1.8	7.5'	9.0’	☒	Heavy sheen	SM	Black, loose to medium dense, wet, slightly silty SAND with debris fragments and slag? Black staining. (Gas Works Fill$_2$) Slight hydrocarbon odor.
SB5-S6	50/4"	9.2	10.0'	10.4’	▨	None	SW	Light gray to light brown, very dense, moist to wet, gravelly SAND with some staining at top of sample (carry down?). (Glacial Deposits)
SB5-S7	50/4”	1.4	12.0’	12.4’	▨	None	SW	Gray, very dense, moist to wet, silty SAND with large rounded gravels. (Glacial Deposits) Bottom of Boring at 12.4 feet BGS.

▨ Recovery
☒ Subsample for Analysis at Petrophysical Lab
┼ Driven Interval

▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,436 ft
E: 1,270,742 ft

Log of Soil Boring SB-6

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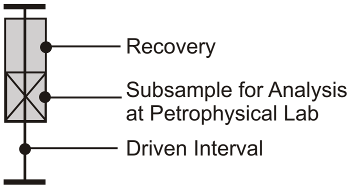
Boring SB-6 Date 9/18/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Sunny, 65 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30” Drop
Bottom of Boring 18.0’ BGS ATD Water Level Depth 7’
Ground Surface Elevation 27.9' (COE Datum)

Obs. Well Install. ☐ Yes ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB6-S1 (Grab Sample)	NA	0.0	0.0’	1.0’		NA	0 1	SM-ML	Light brown, (loose), dry to damp, silty SAND to sandy SILT with organics and loose piece of slag. No odor. (Topsoil)
SB6-S2 (Grab Sample)	NA	0.5	1.0'	2.0'		NA	2	GP	~cobbles and gravels in drill cuttings. Napthalene odor. Tar-like material in cuttings. (Gas Works Fill$_1$)
SB6-S3	28	1.4	2.5'	4.0’		Light to moderate sheen	3 4	SM	Light to dark brown, medium dense, moist, slightly silty SAND with debris (slag, brick, etc.) (Gas Works Fill$_2$) Slight hydrocarbon odor. DNAPL-like product at 3ft BGS.
SB6-S4	12	1.1	5.0’	6.5’		Light to moderate sheen	5 6	SM	Same as above. (Gas Works Fill$_2$)
SB6-S5	8	1.2	7.5'	9.0’		Heavy sheen	7 ▽ 8 9	SM	Same as above. (Gas Works Fill$_2$)
SB6-S6	6	3.1	10.0'	11.5'		Heavy sheen	10 11	SP	Dark brown to black, loose, wet, fine SAND with trace silt. Possible shell fragments. Moderate hydrocarbon odor. Sheen on sample tube. (Gas Works Fill$_2$)
SB6-S7	6	1.4	12.5'	14.0'		Moderate sheen	12 13 14	SM	Dark brown to black with orange nodules, (loose), wet, slightly silty fine SAND with various debris pieces. Slight hydrocarbon odor. (Gas Works Fill$_2$)
SB6-S8	50/3"	0.0	15.0'	15.7'		Light sheen	15 16 17	SM-SM	Light gray, very dense, wet to moist, silty SAND to sandy SILT with rounded gravels. Moderate hydrocarbon odor at contact. (Glacial Deposits)
SB6-S9	50/6"	NA	17.5'	18.0'		NA	18		Bottom of Boring at 18.0 feet BGS.
							19 20		



▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,414 ft
E: 1,270,791 ft

Log of Soil Boring SB-7

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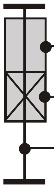
Obs. Well Install. Yes ☐ No ☒

Boring SB-7 Date 9/18/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Sunny, 65 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30” Drop
Bottom of Boring 15.5’ BGS ATD Water Level Depth 6.5’
Ground Surface Elevation 26.0' (COE Datum)

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SHEEN TEST	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB7-S1 (Grab Sample)	NA	0.0	0.0’	1.0’	NA	SM-ML	Light brown, (loose), dry, silty SAND to sandy SILT with organics. (Topsoil)
SB7-S2	12	0.0	2.5'	4.0’	NA	SM	Brown to black, medium dense, dry to moist, silty SAND with brick fragments, asphalt, slag. No odor. (Gas Works Fill$_2$)
SB7-S3	7	0.1	5.0’	6.5’	Light sheen with color	SM	Same as above, with black staining on lower portion of sample. (Gas Works Fill$_2$)
SB7-S4	7	1.8	7.5'	9.0’	Heavy sheen	SM	Same as above. (Gas Works Fill$_2$)
SB7-S5	9	2.6	10.0'	11.5'	Heavy sheen	SM	Same as above. (Gas Works Fill$_2$)
SB7-S6	50/5"	10.8	12.5'	13.0'	Light to moderate sheen		Visible sheen on sample tube.
						ML	Light gray, very dense, wet, clayey SILT with large, rounded gravels. (Glacial Deposits)
SB7-S7	50/6"	3.3	15.0'	15.5'	None	SP	Light gray, very dense, wet, slightly silty SAND with rounded gravels. (Glacial Deposits)
							Bottom of Boring at 15.5 feet BGS.



Recovery

Subsample for Analysis at Petrophysical Lab

Driven Interval

▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,462 ft
E: 1,270,789 ft

Log of Soil Boring SB-8

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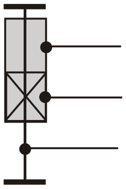
Boring SB-8 Date 9/18/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Sunny, 65 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30" Drop
Bottom of Boring 12.7' BGS ATD Water Level Depth 9.0'
Ground Surface Elevation 28.7' (COE Datum)

Obs. Well Install. Yes [✓ No]

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST
SB8-S1 (Grab Sample)	NA	0.0	0.0'	1.0'		NA
SB8-S2 (Grab Sample)	NA	0.0	1.0'	4.5'		None
SB8-S3	27	0.0	5.0'	6.5'		None
SB8-S4	12	6.8	7.5'	9.0'		Light to moderate sheen
SB8-S5	80	10.7 88.7	9.0'	10.5'		Heavy sheen at bottom
SB8-S6	50/6"	2.4	10.5'	11.0'		Very light sheen (carry down?)
SB8-S7	50/3"	1.3	12.5'	12.7'		Very light sheen (carry down?)

USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SM-ML	Light to dark brown, (loose), dry to damp, slightly sandy to sandy SILT with scattered gravels and organics. No odor. (Topsoil)
GW	Rough drilling to ~4.5ft BGS, gravels and cobbles in cuttings. Sand and silt in matrix. Little to no debris. No odor. (Gas Works Fill$_1$)
ML	Light gray to dark brown, medium stiff, moist, sandy, clayey SILT with rounded gravels and organics. No odor. (Gas Works Fill$_1$)
SM	Gray to brown, medium dense, moist, slightly silty SAND with gravels. No odor. (Gas Works Fill$_1$)
SM-CL-ML	Gray to light brown, medium dense, moist to wet, slightly silty SAND with rounded gravels and hydrocarbon odor over Brown, medium stiff, moist, silty CLAY to clayey SILT with wood debris and gravels. Hydrocarbon odor. Abundant wood with hydrocarbon odor at bottom.
SM	Black, very dense, wet, silty, gravelly SAND with wood debris and heavy sheen on sampler. (Gas Works Fill$_2$)
SW	Gray, very dense, wet, slightly silty, gravelly SAND. Slight hydrocarbon odor (carry down?). (Glacial Deposits)
SP	Same as above. (Glacial Deposits)
	Bottom of Boring at 12.7 feet BGS.



▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,440 ft
E: 1,270,679 ft

Log of Soil Boring SB-9

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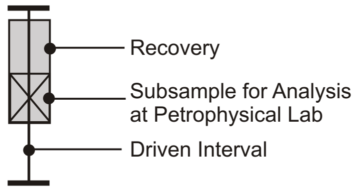
Boring SB-9 Date 9/19/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Cloudy, 60 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30" Drop
Bottom of Boring 13.0' BGS ATD Water Level Depth 7.0'
Ground Surface Elevation 27.8' (COE Datum)

Obs. Well Install. Yes ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST	Depth (ft)	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB9-S1 (Grab Sample)	NA	0.0	0.0'	1.0'		NA	0	SM-ML	Light brown, (loose), dry to moist, silty SAND to sandy SILT with trace gravels and organics. No odor. (Topsoil)
SB9-S2	14	0.0	2.5'	4.0'		No sheen	3	SM	Light to dark brown to black, loose to medium dense, dry to moist, slightly silty SAND with debris (slag, brick fragments, shiny pieces, vesicular debris, etc.) No odor. (Gas Works Fill$_2$)
SB9-S3	8	0.0	5.0'	6.5'		Light sheen	5	SM	Same material as above (Gas Works Fill$_2$) with more shiny pieces. Large piece of slag at bottom of sampler.
							7 ∇		
SB9-S4	24	0.0	7.5'	9.0'		Light to moderate sheen	8	SM	Same material as above.(Gas Works Fill$_2$) Poor recovery. Light sheen on sampler water. Samples stained black. Slight hydrocarbon odor.
SB9-S5	50/6"	1.4	10.0'	11.0'		Moderate sheet at top sample	10	SM	Same as above - Gas Works Fill$_2$ (stained black) over ~2", light brown, medium dense, wet, silty SAND with organics.
		0.0				No sheen in RSD	11	SP	Light gray, very dense, wet, slightly silty SAND with rounded gravels. Slight sheen at top of sampler. Moderate hydrocarbon odor throughout. (Glacial Deposits)
SB9-S6	50/6"	0.0	12.5'	13.0'		No sheen	12.5	SP-GP	Light gray, very dense, wet, fine SAND with gravel becoming very gravelly at bottom of sample. (Glacial Deposits)
							13		Bottom of Boring at 13.0 feet BGS.



∇ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,448 ft
E: 1,270,718 ft

Log of Soil Boring SB-10

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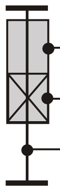
Boring SB-10 Date 9/20/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Sunny, 60 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30” Drop
Bottom of Boring 20.4’ BGS ATD Water Level Depth 9.0’
Ground Surface Elevation 31.0' (COE Datum)

Obs. Well Install. ☐ Yes ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB10-S1 (Grab Sample)	NA	0.0	0.0’	1.0’		NA	0 1 2	SM-ML	Light brown, (loose), dry to moist, silty SAND to sandy SILT with scattered gravels and organics, piece of slag and shiny black rock. No odor. (Topsoil)
SB10-S2	50	0.0	2.5’	4.0’		None	3 4	SM-ML	Light brown to gray, very dense, dry to moist, silty SAND to sandy SILT with organics. Angular gravels throughout becoming gravelly. Organic reduced odor. (Compact Topsoil)
SB10-S3	12	0.0	5.0’	6.5’		Light sheen	5 6 7	SM	Dark brown to black, loose to medium dense, moist, slightly silty to silty SAND with debris (slag pieces, brick fragments, shiny pieces, angular gravels. (Gas Works Fill$_2$) Slight hydrocarbon odor at bottom sample.
SB10-S4	13	0.0	7.5’	9.0’		Moderate sheen	8 9 ∇	SM	Same as above. (Gas Works Fill$_2$) Poor recovery.
SB10-S5	9	0.3	10.0’	11.5’		Light to moderate sheen	10 11	SM	Same as above. (Gas Works Fill$_2$) Moderate hydrocarbon odor at bottom of sample.
SB10-S6	7	9.5	12.5’	14.0’		Heavy sheen	12 13 14	SP-SM	Same as above. (Gas Works Fill$_2$) Debris not as abundant as S4 and S5. Strong hydrocarbon odor. Sheen visible on sampler.
SB10-S7	50/5"	7.8	15.0'	15.5'		Heavy sheen	15 16	SM	Same as above. (Gas Works Fill$_2$) Debris becomes more abundant with depth. Strong hydrocarbon odor. Product (DNAPL?) at top of sample.
SB10-S8	50/5"	0.9	17.5'	17.9'		Moderate to heavy sheen	17 18 19	SM	Light to dark gray, very dense, wet, slightly silty to silty SAND with abundant rounded gravels (Glacial Deposits). Slight to moderate hydrocarbon odor. Slight broken staining (colored) visible in sand matrix.
SB10-S9	50/5"	2.3	20.0'	20.4'		Light sheen	20	JP	Light gray, very dense, wet, fine SAND with small rounded gravels and trace silt. (Glacial Deposits) Slight hydrocarbon odor at top of sample. (carry down?)
									Bottom of Boring at 20.4 feet BGS.



∇ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,386 ft
E: 1,270,766 ft

Log of Soil Boring SB-11

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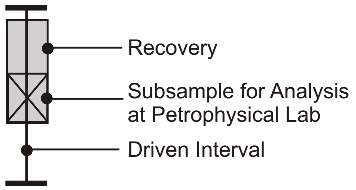
Obs. Well Install. ☐ Yes ☒ No

Boring SB-11 Date 9/20/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Cloudy, 60 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30" Drop
Bottom of Boring 15.3' BGS ATD Water Level Depth 8.0'
Ground Surface Elevation 30.2' (COE Datum)

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB11-S1 (Grab Sample)	NA	0.0	0.0'	1.0'			SM-ML	Dark brown to black, (loose), dry to moist, silty SAND to sandy SILT with organics. No odor. (Topsoil)
SB11-S2	50/6"	0.0	2.5'	3.0'		Heavy sheen	SM	Light gray to black, (very dense), moist, silty to very silty SAND with gravels. Very strong hydrocarbon odor at bottom of sample. Shiny pieces. (Gas Works Fill$_1$)
SB11-S3	14	3.0	5.0'	6.5'		Top sample- heavy sheen Bottom sample- light sheen	SM	Light brown to gray, medium dense, moist, silty to very silty SAND with scattered gravels and organics. Moderate hydrocarbon odor in top ½ sample grading to slight odor at bottom. Becoming more silty at bottom of sample. (Gas Works Fill$_1$)
SB11-S4	40	14.2	7.5'	9.0'		Slight to moderate at top and bottom	SP	Light gray, dense, wet, slightly silty SAND with rounded gravels. (Glacial Deposits) Moderate hydrocarbon odor at contact.
SB11-S5	50/5"	0.0	10.0'	10.4'		None	SP-SM	Light gray to dark gray/black, very dense, wet, slightly silty fine SAND with scattered organics? Slight hydrocarbon odor. Rounded gravels at bottom of sample. (Glacial Deposits)
SB11-S6	50/3"	0.0	12.5'	12.7'		None	SP-SM	Light gray, very dense, moist to wet, slightly silty to silty SAND with rounded gravels. (Glacial Deposits)
SB11-S7	50/3"	0.0	15.0'	15.3'		None	SP-SM	Same as above. (Glacial Deposits) Bottom of Boring at 15.3 feet BGS.



▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,433 ft
E: 1,270,642 ft

Log of Soil Boring SB-12

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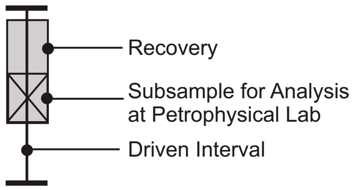
Boring SB-12 Date 9/20/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Cloudy, 60 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30” Drop
Bottom of Boring 3.5’ BGS ATD Water Level Depth NA
Ground Surface Elevation 31.6' (COE Datum)

Obs. Well Install. ☐ Yes ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST		USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB12-S1 (Grab Sample)	NA	0.1	0.0’	1.0’	▨		0 1	SM-ML	Light brown, (loose), dry to moist, silty SAND to sandy SILT with organics and scattered gravels. No odor. (Topsoil)
SB12-S2	50/6"	78.2	2.5’	3.0’	▨	Light sheen	2 3	SM	Light brown to black, very dense, moist, slightly gravelly, silty, SAND with trace organics, plastic pieces, and debris. Heavy naphthalene odor on sample. Very hard drilling. (Gas Works Fill$_1$)
							4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20		Bottom of Boring at 3.5 feet BGS. Refusal at 3.5ft BGS. Driller indicates auger is on steel or rock.



▽ Groundwater Observed
At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,472 ft
E: 1,270,643 ft

Log of Soil Boring SB-12A

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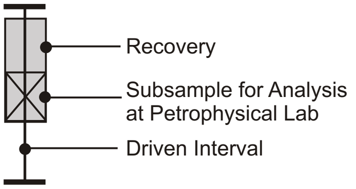
Boring SB-12A Date 9/20/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Cloudy, 60 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30” Drop
Bottom of Boring 11.0’ BGS ATD Water Level Depth 8.0’
Ground Surface Elevation 33.9' (COE Datum)

Obs. Well Install. Yes ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST	Depth (ft)	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB12A-S1 (Grab Sample)	NA	0.0	0.0’	1.0’	▨	NA	0–1	SM-ML	Light brown to gray, (loose), dry to moist, silty SAND to sandy SILT with angular gravels, concrete debris and organics. No odor. Very hard drilling. (Topsoil)
SB12A-S2	50/4"	NA	2.5’	2.8'	▨	NA	2–3		No recovery-rock in sampler. No sample taken. Very hard drilling.
SB12A-S3	17	82.1	5.0’	6.5’	▨	Heavy sheen	5–6	CL	Light to dark gray, medium stiff to stiff, moist, silty CLAY with brick fragments and soft pilable tar in sample. Strong to very strong naphthalene odor on sample. (Gas Works Fill$_1$)
SB12A-S4	17	NA	6.5'	8.0'	☒	Heavy sheen	6–7		Same as above. Heavy naphthalene odor-product in sample. Heavy sheen on sampler.
SB12A-S5	50/6"	NA	8.0'	9.0'	▨	Moderate sheen	8 ▽–9	ML	Dark gray to black, very stiff to very dense, wet, clayey sandy SILT to clayey silty SAND with rounded gravels. Strong naphthalene odor, tar on auger plug at 10ft BGS. (Gas Works Fill$_1$)
SB12A-S6	50/3"	58.4 10.6	10.0'	10.2'	☒		10		10.0 to 10.3ft BGS: Tar sample in ring.
							11		Bottom of Boring at 11.0 feet BGS. Attempt to drive SPT sample at 11.0ft BGS - refusal
							12–20		



▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,488 ft
E: 1,270,657 ft

Log of Soil Boring SB-13

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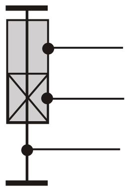
Boring SB-13 Date 9/20/07 Sheet 1 of 1
Job Gas Works NE Corner Investigation Job No. COS-GWSA (6010)
Logged By Matt Woltman Weather Sunny, 65 degrees
Drilled By Cascade Drilling, Curtis
Drill Type/Method HSA, Limited Access Rig
Sampling Method Dames and Moore Split Spoon Sampler, 140 lb Hammer, 30” Drop
Bottom of Boring 15.4’ BGS ATD Water Level Depth 7.5’
Ground Surface Elevation 31.1' (COE Datum)

Obs. Well Install. Yes ☐ ☒ No

SAMPLE ID	Blow Count	PID (ppm)	DEPTH From	DEPTH To	SAMPLE RECOVERY (FT)	SHEEN TEST	USCS Symbol	DESCRIPTION: color, texture, moisture MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.
SB13-S1 (Grab Sample)	NA	0.0	0.0’	1.0’		NA	SM-ML	Dark brown to black, (loose), dry to moist, silty SAND to sandy SILT with organics and scattered gravel. No odor. (Topsoil)
SB13-S2	37	0.0	2.5’	4.0’		None	SP	Dark brown to black, medium dense to dense, dry to moist, slightly silty SAND with scattered debris (brick fragments, vesicular pieces, slag). No odor. Piece of coal at ~2.7ft BGS? (Gas Works Fill$_1$)
SB13-S3	36	0.0	5.0’	6.5’		None	SM	Same as above. (Gas Works Fill$_1$)
SB13-S4	25	0.0	7.5’	9.0’		None	▽ SC-SM	Dark brown to light gray, medium dense, wet, silty to very silty SAND with organics and rounded gravels (4") over light gray, medium dense, wet, slightly clayey, silty SAND with trace gravels and scattered organics. Larger sand grains at bottom sample. (Gas Works Fill$_1$)
SB13-S5	75	0.0	10.0’	11.5’		None	SM SP	Same as above. (Gas Works Fill$_1$) Light gray, very dense, wet, fine SAND, with rounded gravels and trace silt. (Glacial Deposits) Slight hydrocarbon odor.
SB13-S6	50/6"	0.0	12.5’	13.0’		None	SP	Same as above. (Glacial Deposits)
SB13-S7	50/5”	0.0	15.0’	15.4’		None	SP	Same as above. (Glacial Deposits) Bottom of Boring at 15.4 feet BGS.



▽ Groundwater Observed At Time of Drilling

Boring Location in NAD 83 Datum
Washington State Plane (North)

N: 239,396 ft
E: 1,270,649 ft

Gas Works Park
Northeast Corner Investigation

Data Report

Appendix B
Field Photographs

Field Photograph 1. Tar-like material observed in Boring SB-12A. Petrophysical sample.

Field Photograph 2. NAPL encountered in Boring SB-2 at the groundwater table.

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Northeast Corner Investigation
Data Report
Gas Works Park
City of Seattle

Appendix B
Field Photographs 1 and 2

Field Photograph 3. NAPL encountered in SB-2A at a depth of 8.0 to 9.5 feet below ground surface.

Field Photograph 4. Black staining of the Gas Works Fill Unit observed in Boring SB-9.

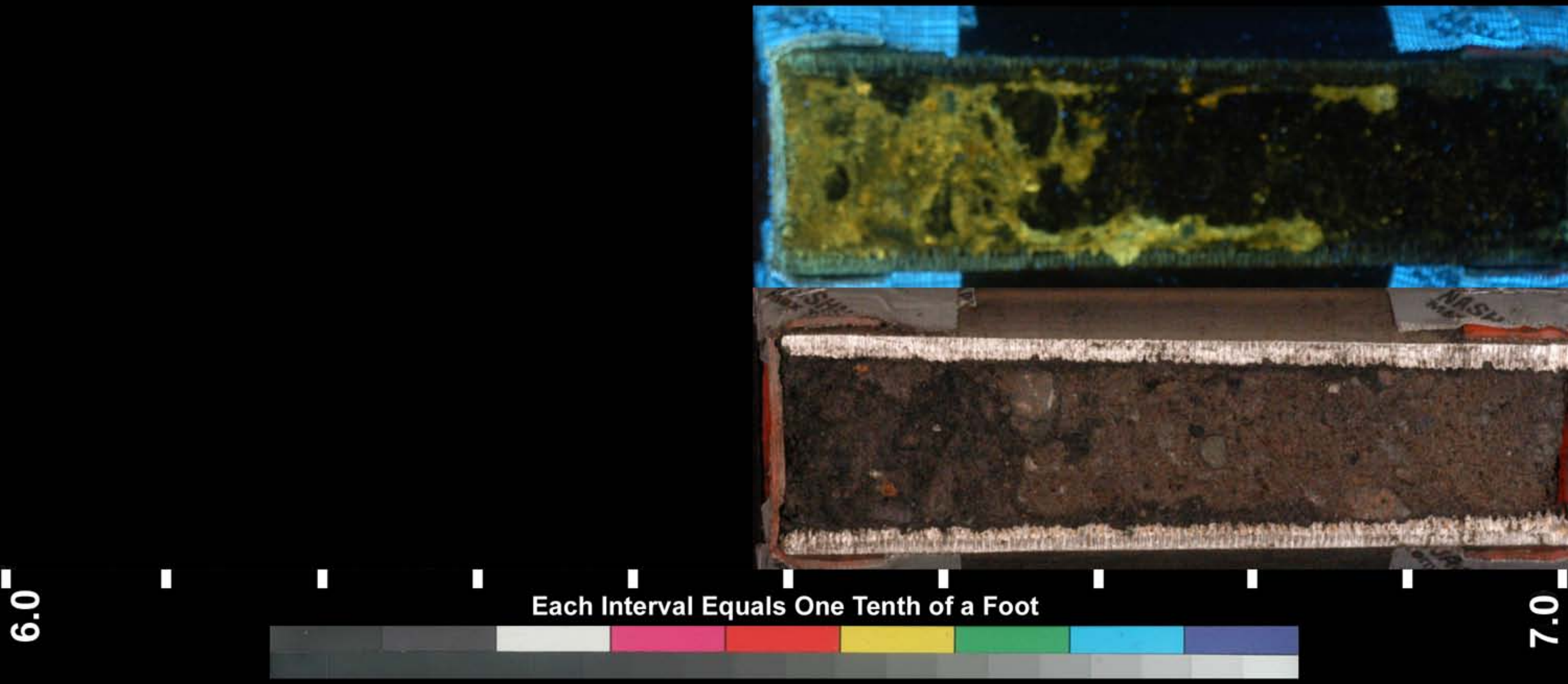
Field Photograph 5. Black charcoal, dust-like material encountered in Boring SB-13.

Gas Works Park
Northeast Corner Investigation

Data Report

Appendix C
Laboratory UV Light Photographs

PTS Laboratories
ENVIRONMENTAL SERVICES
PTS File No.: 37801



Project: Gas Works NE Corner Boring ID: SB2-S4
Project No.: T6010 COS-GWSA

PTS Laboratories
ENVIRONMENTAL SERVICES
PTS File No.: 37801

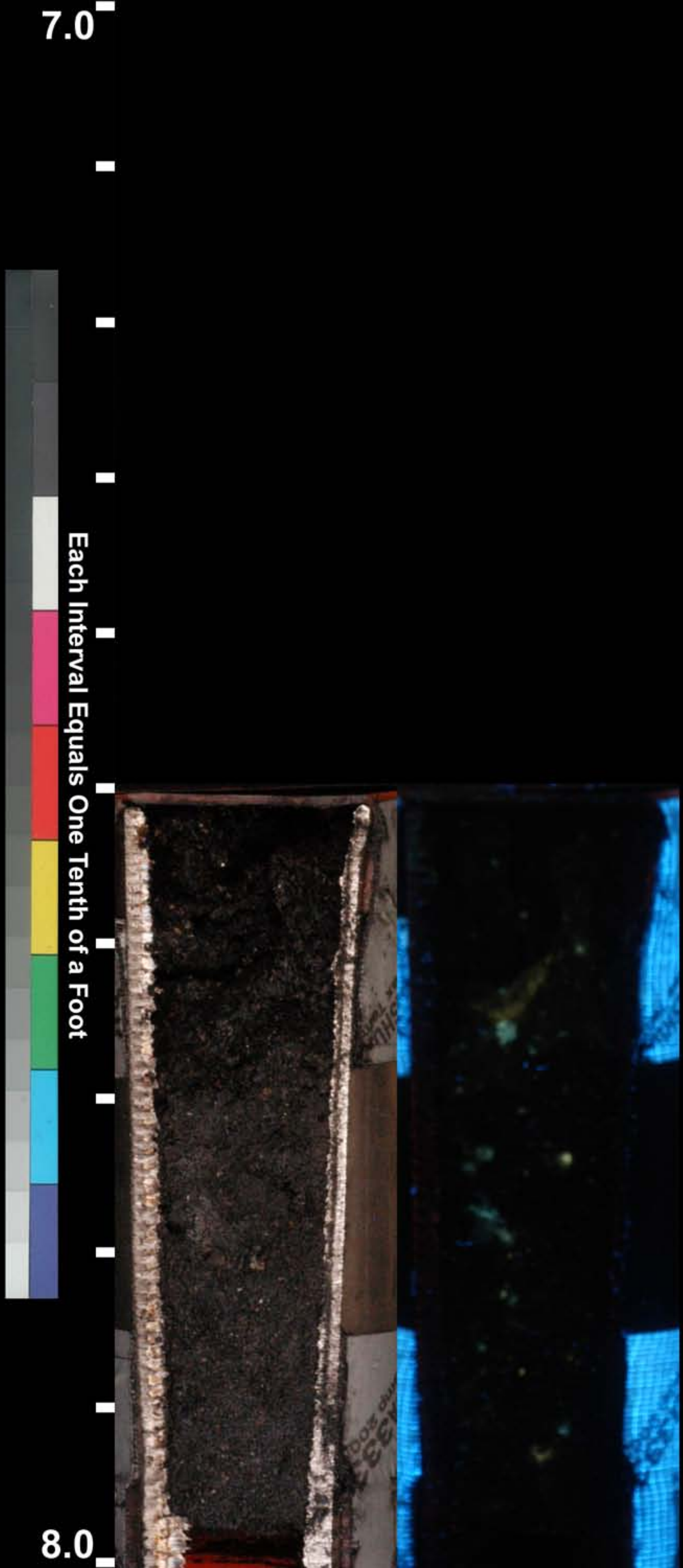
Project: Gas Works NE Corner   Boring ID: SB2A-S1
Project No.: T6010 COS-GWSA

PTS Laboratories
ENVIRONMENTAL SERVICES
PTS File No.: 37801

Project: Gas Works NE Corner   Boring ID: SB 3A
Project No.: T6010 COS-GWSA

Project: Gas Works NE Corner   Boring ID: SB5-S5

Project No.: T6010 COS-GWSA



PTS Laboratories
ENVIRONMENTAL SERVICES

PTS File No.: 37801

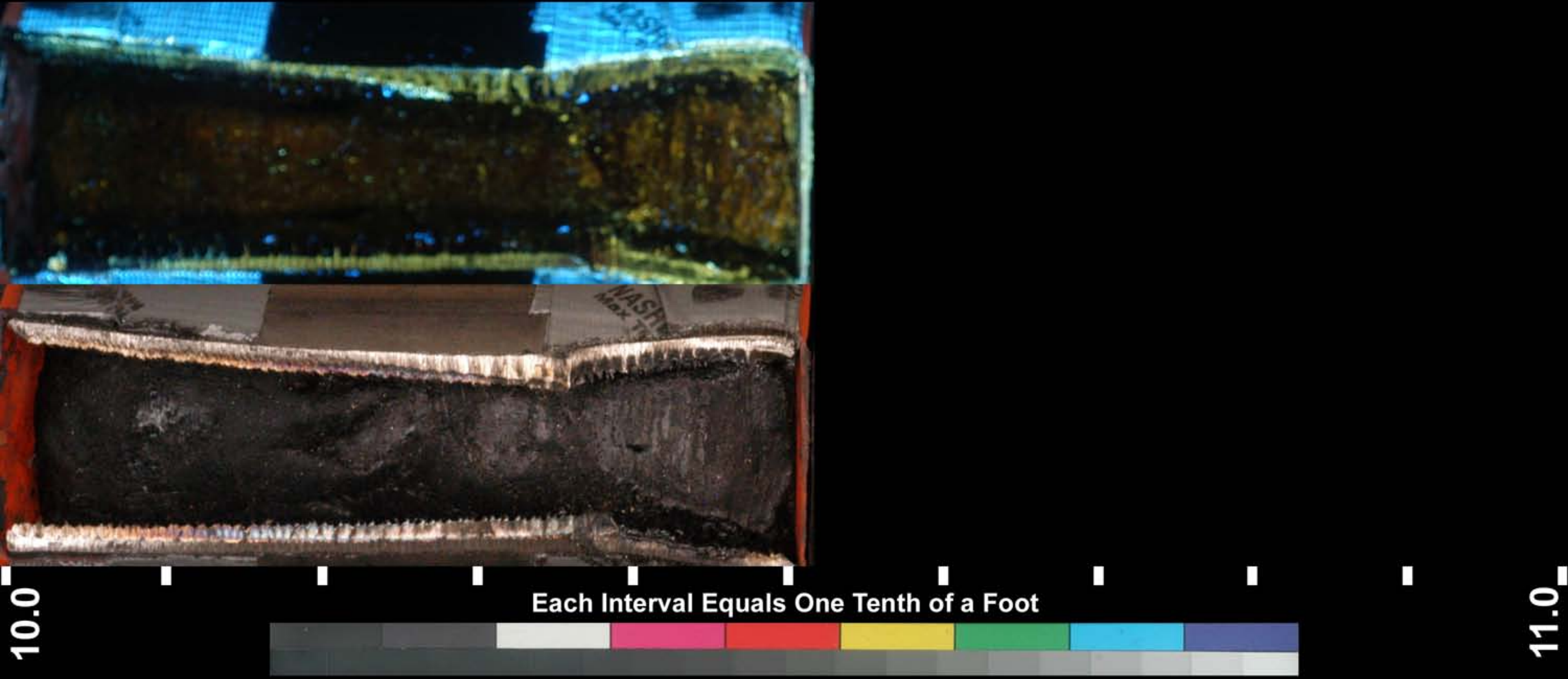
PTS Laboratories
ENVIRONMENTAL SERVICES
PTS File No.: 37801

Project: Gas Works NE Corner   Boring ID: SB8-S5
Project No.: T6010 COS-GWSA

PTS Laboratories
ENVIRONMENTAL SERVICES
PTS File No.: 37801

Project: Gas Works NE Corner   Boring ID: SB12A-S4
Project No.: T6010 COS-GWSA

PTS Laboratories
ENVIRONMENTAL SERVICES
PTS File No.: 37801



Each Interval Equals One Tenth of a Foot

Project: Gas Works NE Corner Boring ID: SB12A-S6
Project No.: T6010 COS-GWSA

Gas Works Park
Northeast Corner Investigation

Data Report

Appendix D
PTS Laboratory Reports and COC Documents

PARTICLE SIZE SUMMARY

(METHODOLOGY: ASTM D422/D4464M)

PROJECT NAME: Gas Works NE Corner
PROJECT NO: T6010 COS-GWSA

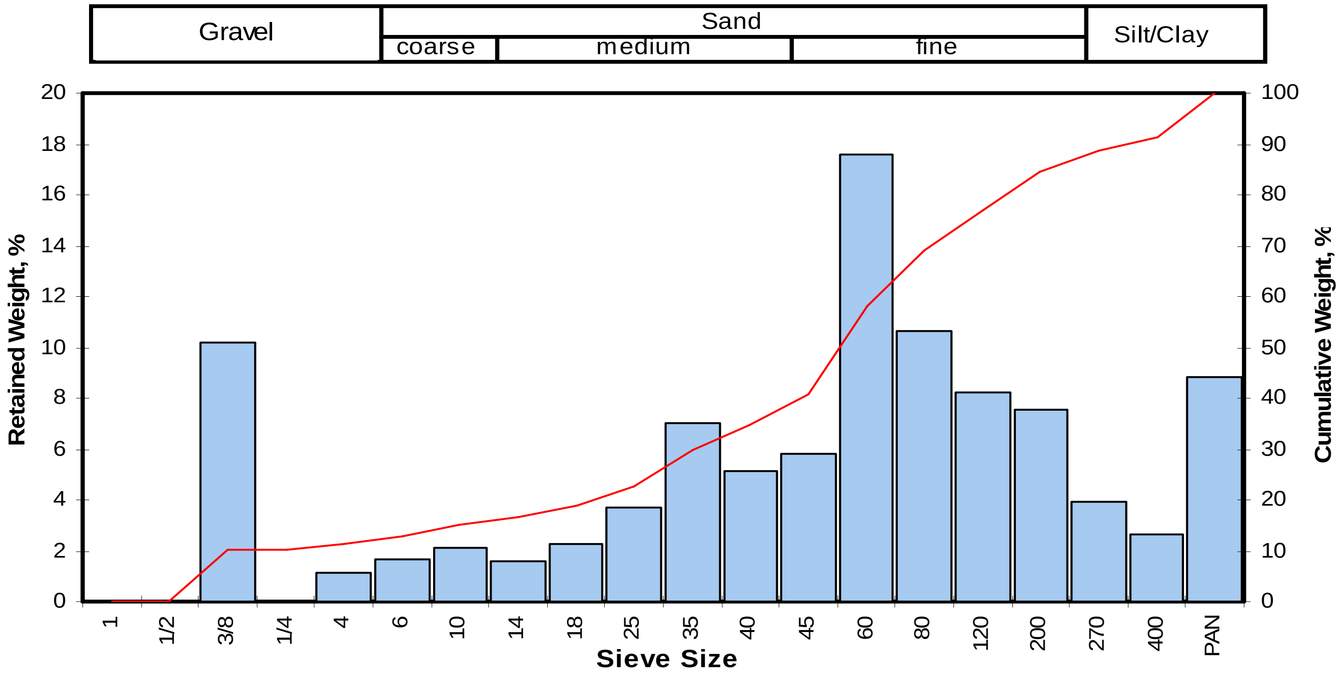
Sample ID	Depth, ft.	Mean Grain Size Description (1)	Median Grain Size mm	Particle Size Distribution, wt. percent						Silt & Clay
					Sand Size					
				Gravel	Coarse	Medium	Fine	Silt	Clay	
SB2-S4	6.85	Fine sand	0.294	11.33	3.78	19.70	49.86	(2)	(2)	15.34
SB2A-S1	8.45	Medium sand	0.725	7.56	17.86	36.43	27.38	(2)	(2)	10.76
SB3A	9.3	Medium sand	0.449	0.00	14.32	37.24	35.63	(2)	(2)	12.81
SB12A-S4	6.85	Medium sand	0.507	21.83	10.17	22.03	31.66	(2)	(2)	14.31
SB12A-S6	10.15	Silt	0.006	0.00	0.00	0.00	0.00	54.85	45.15	100.00

(1) Based on Mean from Trask
(2) Mechanical sieve does not differentiate silt/clay fractions.

PTS Laboratories, Inc.

Particle Size Analysis - ASTM D422M

Client:	Floyd Snider	**PTS File No:**	37801
Project:	Gas Works NE Corner	**Sample ID:**	SB2-S4
Project No:	T6010 COS-GWSA	**Depth, ft:**	6.85



Opening Inches	Opening Millimeters	Phi of Screen	U.S. Sieve No.	Sample Weight grams	Incremental Weight, percent	Cumulative Weight, percent
0.9844	25.002	-4.64	1	0.00	0.00	0.00
0.4922	12.501	-3.64	1/2	0.00	0.00	0.00
0.3740	9.500	-3.25	3/8	2.60	10.22	10.22
0.2500	6.351	-2.67	1/4	0.00	0.00	10.22
0.1873	4.757	-2.25	4	0.28	1.10	11.33
0.1324	3.364	-1.75	6	0.42	1.65	12.98
0.0787	2.000	-1.00	10	0.54	2.12	15.10
0.0557	1.414	-0.50	14	0.41	1.61	16.71
0.0394	1.000	0.00	18	0.57	2.24	18.95
0.0278	0.707	0.50	25	0.94	3.70	22.65
0.0197	0.500	1.00	35	1.79	7.04	29.69
0.0166	0.420	1.25	40	1.30	5.11	34.80
0.0139	0.354	1.50	45	1.48	5.82	40.62
0.0098	0.250	2.00	60	4.48	17.62	58.24
0.0070	0.177	2.50	80	2.71	10.66	68.90
0.0049	0.125	3.00	120	2.10	8.26	77.15
0.0029	0.074	3.75	200	1.91	7.51	84.66
0.0021	0.053	4.25	270	0.99	3.89	88.56
0.0015	0.037	4.75	400	0.67	2.63	91.19
			PAN	2.24	8.81	100.00
TOTALS				25.43	100.00	100.00

Cumulative Weight Percent greater than

Weight percent	Phi Value	Particle Size Inches	Particle Size Millimeters
5	-3.17	0.3534	8.977
10	-2.69	0.2538	6.446
16	-0.72	0.0649	1.648
25	0.67	0.0248	0.630
40	1.47	0.0142	0.360
50	1.77	0.0116	0.294
60	2.08	0.0093	0.236
75	2.87	0.0054	0.137
84	3.68	0.0031	0.078
90	4.52	0.0017	0.043
95	2.70	0.0061	0.154

Measure	Trask	Inman	Folk-Ward
Median, phi	1.77	1.77	1.77
Median, in.	0.0116	0.0116	0.0116
Median, mm	0.294	0.294	0.294
Mean, phi	1.38	1.48	1.58
Mean, in.	0.0151	0.0141	0.0132
Mean, mm	0.383	0.358	0.335
Sorting	2.146	2.202	1.989
Skewness	0.999	-0.129	-0.406
Kurtosis	0.039	0.331	1.091

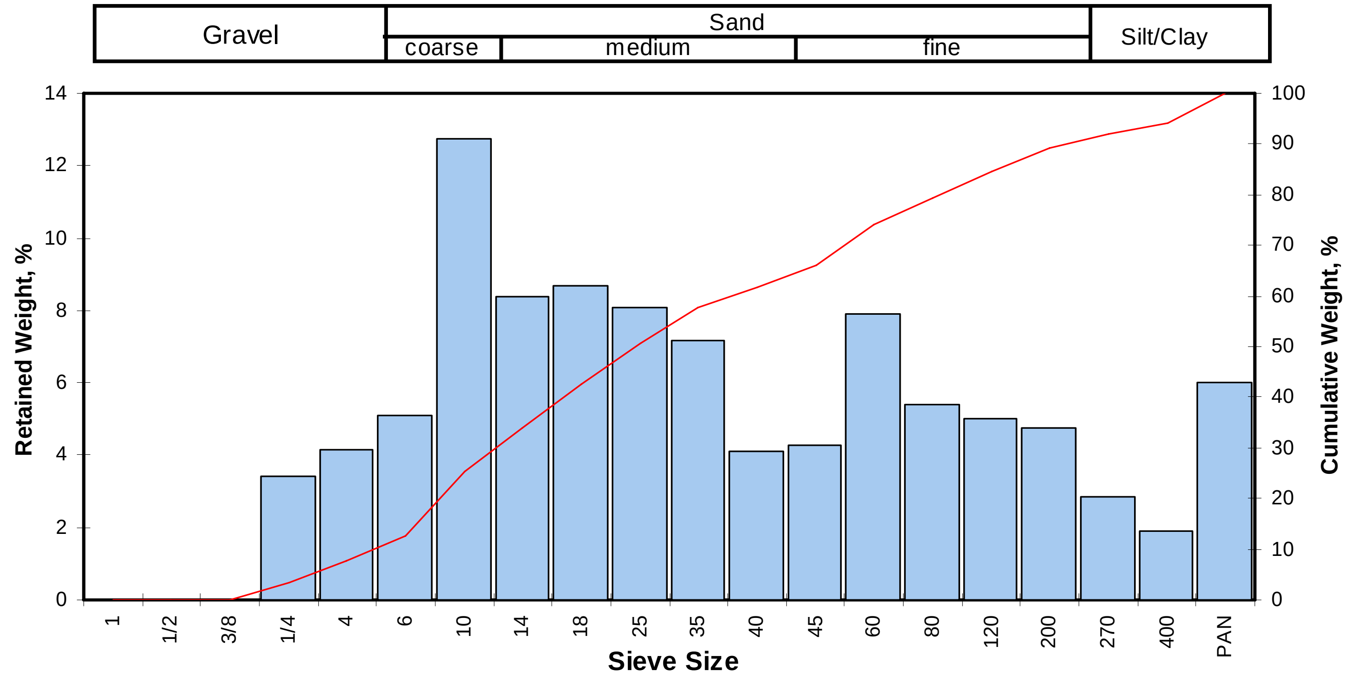
Grain Size Description (ASTM-USCS Scale)	Fine sand (based on Mean from Trask)

Description	Retained on Sieve #	Weight Percent
Gravel	4	11.33
Coarse Sand	10	3.78
Medium Sand	40	19.70
Fine Sand	200	49.86
Silt/Clay	<200	15.34
	Total	100

PTS Laboratories, Inc.

Particle Size Analysis - ASTM D422M

Client:	Floyd Snider	**PTS File No:**	37801
Project:	Gas Works NE Corner	**Sample ID:**	SB2A-S1
Project No:	T6010 COS-GWSA	**Depth, ft:**	8.45



Opening		**Phi of Screen**	**U.S. Sieve No.**	**Sample Weight grams**	**Incremental Weight, percent**	**Cumulative Weight, percent**
Inches	**Millimeters**					
0.9844	25.002	-4.64	1	0.00	0.00	0.00
0.4922	12.501	-3.64	1/2	0.00	0.00	0.00
0.3740	9.500	-3.25	3/8	0.00	0.00	0.00
0.2500	6.351	-2.67	1/4	0.96	3.41	3.41
0.1873	4.757	-2.25	4	1.17	4.15	7.56
0.1324	3.364	-1.75	6	1.44	5.11	12.68
0.0787	2.000	-1.00	10	3.59	12.75	25.43
0.0557	1.414	-0.50	14	2.36	8.38	33.81
0.0394	1.000	0.00	18	2.45	8.70	42.51
0.0278	0.707	0.50	25	2.27	8.06	50.57
0.0197	0.500	1.00	35	2.02	7.17	57.74
0.0166	0.420	1.25	40	1.16	4.12	61.86
0.0139	0.354	1.50	45	1.21	4.30	66.16
0.0098	0.250	2.00	60	2.23	7.92	74.08
0.0070	0.177	2.50	80	1.52	5.40	79.47
0.0049	0.125	3.00	120	1.41	5.01	84.48
0.0029	0.074	3.75	200	1.34	4.76	89.24
0.0021	0.053	4.25	270	0.80	2.84	92.08
0.0015	0.037	4.75	400	0.54	1.92	94.00
			PAN	1.69	6.00	100.00
TOTALS				28.16	100.00	100.00

Cumulative Weight Percent greater than

Weight percent	**Phi Value**	**Particle Size**	
		Inches	**Millimeters**
5	-2.51	0.2238	5.686
10	-2.01	0.1588	4.033
16	-1.55	0.1156	2.937
25	-1.03	0.0801	2.035
40	-0.14	0.0435	1.105
50	0.46	0.0285	0.725
60	1.14	0.0179	0.455
75	2.09	0.0093	0.236
84	2.95	0.0051	0.129
90	3.88	0.0027	0.068
95	3.96	0.0025	0.064

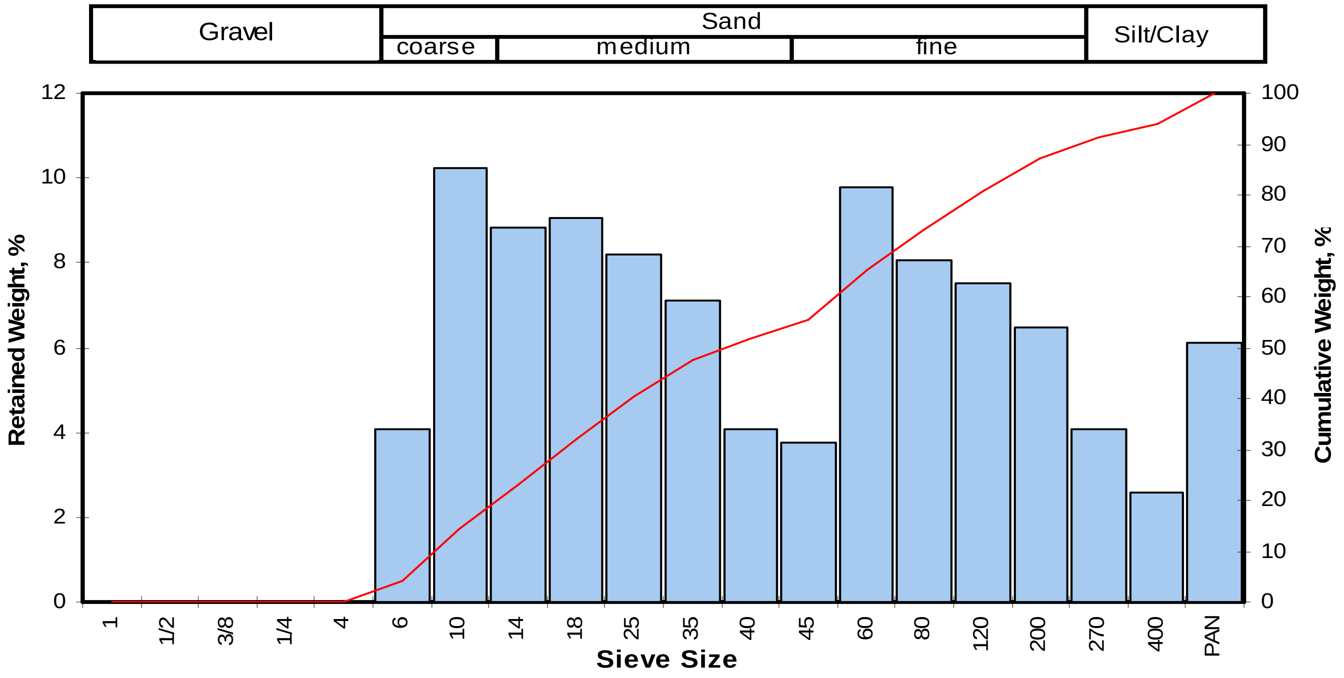
Measure	**Trask**	**Inman**	**Folk-Ward**
Median, phi	0.46	0.46	0.46
Median, in.	0.0285	0.0285	0.0285
Median, mm	0.725	0.725	0.725
Mean, phi	-0.18	0.70	0.62
Mean, in.	0.0447	0.0243	0.0256
Mean, mm	1.135	0.616	0.650
Sorting	2.939	2.253	2.106
Skewness	0.956	0.104	0.092
Kurtosis	0.227	0.435	0.852

Grain Size Description (ASTM-USCS Scale)	Medium sand (based on Mean from Trask)

Description	**Retained on Sieve #**	**Weight Percent**
Gravel	4	7.56
Coarse Sand	10	17.86
Medium Sand	40	36.43
Fine Sand	200	27.38
Silt/Clay	<200	10.76
	Total	100

Particle Size Analysis - ASTM D422M

Client:	Floyd Snider	**PTS File No:**	37801
Project:	Gas Works NE Corner	**Sample ID:**	SB3A
Project No:	T6010 COS-GWSA	**Depth, ft:**	9.3



Opening		Phi of	U.S. Sieve	Sample Weight	Incremental Weight,	Cumulative Weight,
Inches	Millimeters	Screen	No.	grams	percent	percent
0.9844	25.002	-4.64	1	0.00	0.00	0.00
0.4922	12.501	-3.64	1/2	0.00	0.00	0.00
0.3740	9.500	-3.25	3/8	0.00	0.00	0.00
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00
0.1873	4.757	-2.25	4	0.00	0.00	0.00
0.1324	3.364	-1.75	6	0.38	4.09	4.09
0.0787	2.000	-1.00	10	0.95	10.23	14.32
0.0557	1.414	-0.50	14	0.82	8.83	23.14
0.0394	1.000	0.00	18	0.84	9.04	32.19
0.0278	0.707	0.50	25	0.76	8.18	40.37
0.0197	0.500	1.00	35	0.66	7.10	47.47
0.0166	0.420	1.25	40	0.38	4.09	51.56
0.0139	0.354	1.50	45	0.35	3.77	55.33
0.0098	0.250	2.00	60	0.91	9.80	65.12
0.0070	0.177	2.50	80	0.75	8.07	73.20
0.0049	0.125	3.00	120	0.70	7.53	80.73
0.0029	0.074	3.75	200	0.60	6.46	87.19
0.0021	0.053	4.25	270	0.38	4.09	91.28
0.0015	0.037	4.75	400	0.24	2.58	93.86
			PAN	0.57	6.14	100.00
TOTALS				9.29	100.00	100.00

Cumulative Weight Percent greater than

Weight	Phi	Particle Size	
percent	Value	Inches	Millimeters
5	-1.68	0.1264	3.212
10	-1.32	0.0981	2.491
16	-0.90	0.0737	1.872
25	-0.40	0.0519	1.317
40	0.48	0.0283	0.718
50	1.15	0.0177	0.449
60	1.74	0.0118	0.300
75	2.62	0.0064	0.163
84	3.38	0.0038	0.096
90	4.09	0.0023	0.059
95	3.87	0.0027	0.068

Measure	Trask	Inman	Folk-Ward
Median, phi	1.15	1.15	1.15
Median, in.	0.0177	0.0177	0.0177
Median, mm	0.449	0.449	0.449
Mean, phi	0.43	1.24	1.21
Mean, in.	0.0291	0.0167	0.0170
Mean, mm	0.740	0.424	0.432
Sorting	2.845	2.142	1.913
Skewness	1.031	0.039	0.008
Kurtosis	0.237	0.296	0.754

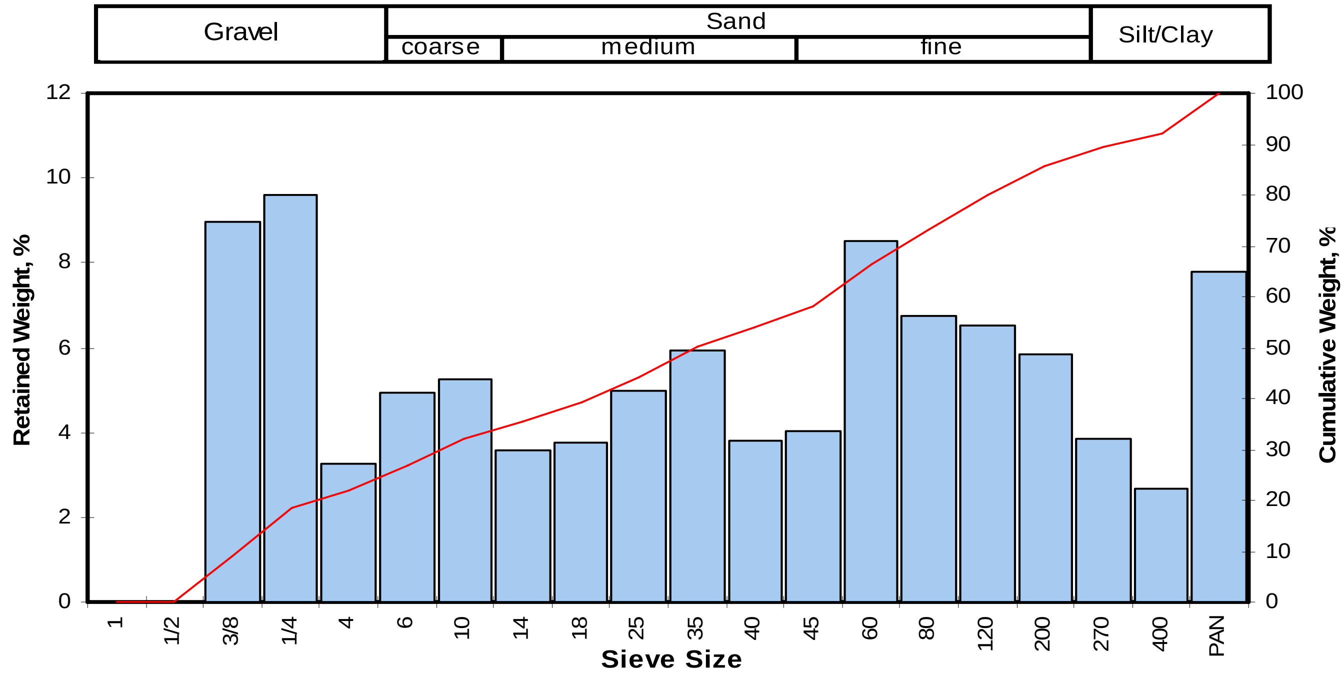
Grain Size Description (ASTM-USCS Scale)	Medium sand (based on Mean from Trask)

Description	Retained on Sieve #	Weight Percent
Gravel	4	0.00
Coarse Sand	10	14.32
Medium Sand	40	37.24
Fine Sand	200	35.63
Silt/Clay	<200	12.81
	Total	100

PTS Laboratories, Inc.

Particle Size Analysis - ASTM D422M

Client:	Floyd Snider	**PTS File No:**	37801
Project:	Gas Works NE Corner	**Sample ID:**	SB12A-S4
Project No:	T6010 COS-GWSA	**Depth, ft:**	6.85



Opening		Phi of Screen	U.S. Sieve No.	Sample Weight grams	Incremental Weight, percent	Cumulative Weight, percent
Inches	Millimeters					
0.9844	25.002	-4.64	1	0.00	0.00	0.00
0.4922	12.501	-3.64	1/2	0.00	0.00	0.00
0.3740	9.500	-3.25	3/8	1.80	8.97	8.97
0.2500	6.351	-2.67	1/4	1.93	9.62	18.59
0.1873	4.757	-2.25	4	0.65	3.24	21.83
0.1324	3.364	-1.75	6	0.99	4.94	26.77
0.0787	2.000	-1.00	10	1.05	5.23	32.00
0.0557	1.414	-0.50	14	0.72	3.59	35.59
0.0394	1.000	0.00	18	0.75	3.74	39.33
0.0278	0.707	0.50	25	1.00	4.99	44.32
0.0197	0.500	1.00	35	1.19	5.93	50.25
0.0166	0.420	1.25	40	0.76	3.79	54.04
0.0139	0.354	1.50	45	0.81	4.04	58.08
0.0098	0.250	2.00	60	1.71	8.52	66.60
0.0070	0.177	2.50	80	1.35	6.73	73.33
0.0049	0.125	3.00	120	1.31	6.53	79.86
0.0029	0.074	3.75	200	1.17	5.83	85.69
0.0021	0.053	4.25	270	0.77	3.84	89.53
0.0015	0.037	4.75	400	0.54	2.69	92.22
			PAN	1.56	7.78	100.00
TOTALS				20.06	100.00	100.00

Cumulative Weight Percent greater than

Weight percent	Phi Value	Particle Size	
		Inches	Millimeters
5	-3.42	0.4224	10.728
10	-3.19	0.3583	9.101
16	-2.82	0.2787	7.080
25	-1.93	0.1499	3.809
40	0.07	0.0376	0.955
50	0.98	0.0200	0.507
60	1.61	0.0129	0.327
75	2.63	0.0064	0.162
84	3.53	0.0034	0.086
90	4.34	0.0019	0.049
95	3.05	0.0047	0.120

Measure	Trask	Inman	Folk-Ward
Median, phi	0.98	0.98	0.98
Median, in.	0.0200	0.0200	0.0200
Median, mm	0.507	0.507	0.507
Mean, phi	-0.99	0.35	0.56
Mean, in.	0.0782	0.0308	0.0267
Mean, mm	1.985	0.782	0.677
Sorting	4.852	3.178	2.570
Skewness	1.547	-0.197	-0.278
Kurtosis	0.201	0.019	0.583

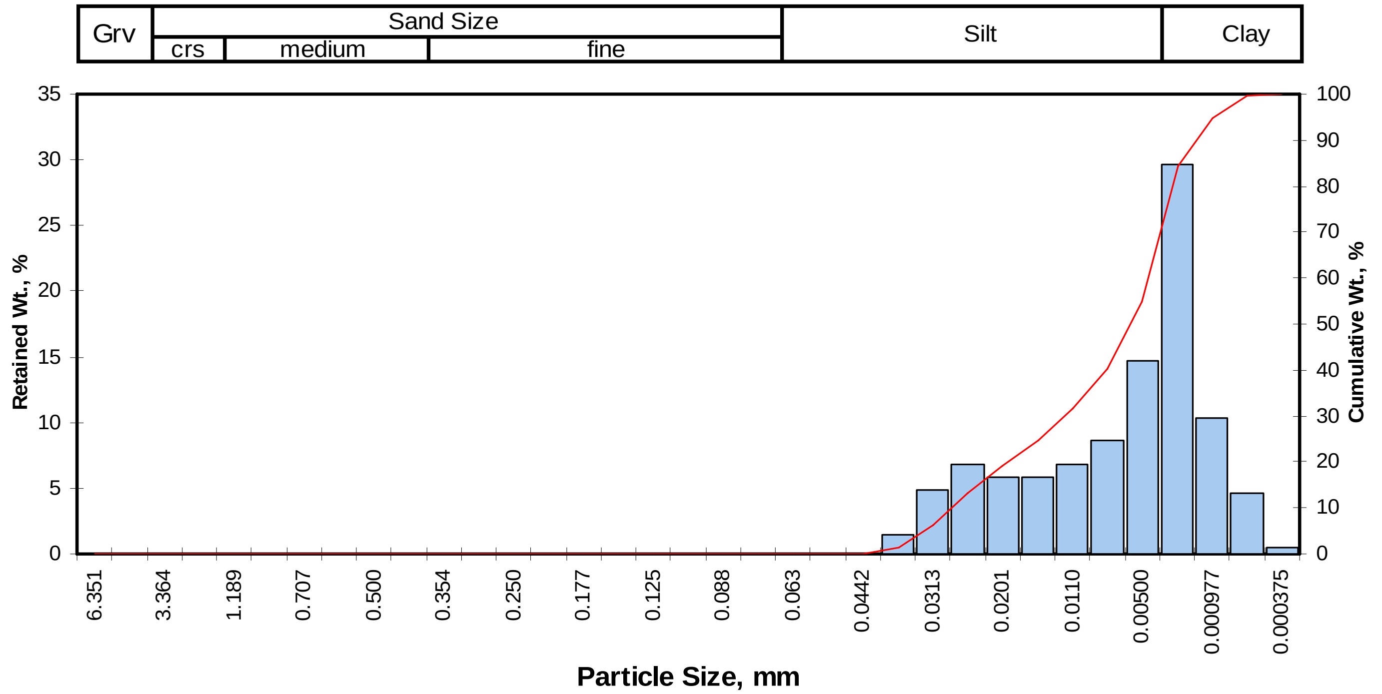
Grain Size Description (ASTM-USCS Scale)	Medium sand (based on Mean from Trask)

Description	Retained on Sieve #	Weight Percent
Gravel	4	21.83
Coarse Sand	10	10.17
Medium Sand	40	22.03
Fine Sand	200	31.66
Silt/Clay	<200	14.31
	Total	100

PTS Laboratories, Inc.

Particle Size Analysis - ASTM D4464M

Client:	Floyd Snider	**PTS File No:**	37801
Project:	Gas Works NE Corner	**Sample ID:**	SB12A-S6
Project No:	T6010 COS-GWSA	**Depth, ft:**	10.15



Opening		Phi of Screen	U.S. No.	Sample Weight, grams	Increment Weight, percent	Cumulative Weight, percent
Inches	**Millimeters**					
0.2500	6.351	-2.67	1/4	0.00	0.00	0.00
0.1873	4.757	-2.25	4	0.00	0.00	0.00
0.1324	3.364	-1.75	6	0.00	0.00	0.00
0.0787	2.000	-1.00	10	0.00	0.00	0.00
0.0468	1.189	-0.25	16	0.00	0.00	0.00
0.0331	0.841	0.25	20	0.00	0.00	0.00
0.0278	0.707	0.50	25	0.00	0.00	0.00
0.0234	0.595	0.75	30	0.00	0.00	0.00
0.0197	0.500	1.00	35	0.00	0.00	0.00
0.0166	0.420	1.25	40	0.00	0.00	0.00
0.0139	0.354	1.50	45	0.00	0.00	0.00
0.0117	0.297	1.75	50	0.00	0.00	0.00
0.0098	0.250	2.00	60	0.00	0.00	0.00
0.0083	0.210	2.25	70	0.00	0.00	0.00
0.0070	0.177	2.50	80	0.00	0.00	0.00
0.0059	0.149	2.75	100	0.00	0.00	0.00
0.0049	0.125	3.00	120	0.00	0.00	0.00
0.0041	0.105	3.25	140	0.00	0.00	0.00
0.0035	0.088	3.50	170	0.00	0.00	0.00
0.0029	0.074	3.75	200	0.00	0.00	0.00
0.0025	0.063	4.00	230	0.00	0.00	0.00
0.0021	0.053	4.25	270	0.00	0.00	0.00
0.00174	0.0442	4.50	325	0.03	0.03	0.03
0.00146	0.0372	4.75	400	1.47	1.47	1.50
0.00123	0.0313	5.00	450	4.91	4.91	6.41
0.000986	0.0250	5.32	500	6.79	6.79	13.20
0.000790	0.0201	5.64	635	5.83	5.83	19.03
0.000615	0.0156	6.00		5.80	5.80	24.83
0.000435	0.0110	6.50		6.75	6.75	31.57
0.000308	0.00781	7.00		8.58	8.58	40.15
0.000197	0.00500	7.65		14.70	14.70	54.85
0.000077	0.00195	9.00		29.70	29.69	84.54
0.000038	0.000977	10.00		10.30	10.30	94.83
0.000019	0.000488	11.00		4.67	4.67	99.50
0.000015	0.000375	11.38		0.50	0.50	100.00
TOTALS				**100.00**	**100.00**	**100.00**

Cumulative Weight Percent greater than			
Weight percent	**Phi Value**	**Particle Size**	
		Inches	**Millimeters**
5	4.93	0.0013	0.033
10	5.17	0.0011	0.028
16	5.47	0.0009	0.023
25	6.01	0.0006	0.015
40	6.99	0.0003	0.008
50	7.43	0.0002	0.006
60	7.88	0.0002	0.004
75	8.56	0.0001	0.003
84	8.98	0.0001	0.002
90	9.53	0.0001	0.001
95	10.04	0.0000	0.001

Measure	Trask	Inman	Folk-Ward
Median, phi	7.43	7.43	7.43
Median, in.	0.0002	0.0002	0.0002
Median, mm	0.006	0.006	0.006
Mean, phi	6.79	7.22	7.29
Mean, in.	0.0004	0.0003	0.0003
Mean, mm	0.009	0.007	0.006
Sorting	2.422	1.751	1.649
Skewness	1.105	-0.119	-0.050
Kurtosis	0.243	0.459	0.820

Grain Size Description (ASTM-USCS Scale)	Silt (based on Mean from Trask)

Description	Retained on Sieve #	Weight Percent
Gravel	4	0.00
Coarse Sand	10	0.00
Medium Sand	40	0.00
Fine Sand	200	0.00
Silt	>0.005 mm	54.85
Clay	<0.005 mm	45.15
	Total	**100**

PTS File No: 37801
Client: Floyd Snider

PTS Laboratories

PHYSICAL PROPERTIES DATA - PORE FLUID SATURATIONS

PROJECT NAME: Gas Works NE Corner
PROJECT NO: T6010 COS-GWSA

		METHODS:	API RP 40 / ASTM D2216	API RP 40		API RP 40		API RP 40	
		SAMPLE	MOISTURE	DENSITY		POROSITY, %Vb (2)		PORE FLUID SATURATIONS, % Pv (3)	
SAMPLE ID.	DEPTH, ft.	ORIENTATION (1)	CONTENT, % weight	BULK, g/cc	GRAIN, g/cc	TOTAL	AIR FILLED	WATER	NAPL
SB2-S4	6.65-6.8	V	19.2	1.59	2.64	39.7	9.0	72.7	4.5
SB2A-S1	8.0-8.15	V	15.0	1.42	2.65	46.4	25.1	41.0	4.9
SB 3A	9.15-9.3	V	41.1	1.09	2.26	51.8	6.4	74.5	13.2
SB12A-S4	6.65-6.8	V	18.8	1.64	2.64	37.8	6.9	76.0	5.8
SB12A-S6	10.2-10.35	V	152.8	0.44	1.55	71.4	0.6	9.9	89.3

(1) Sample Orientation: H = horizontal; V = vertical (2) Total Porosity = no pore fluids in place; all interconnected pore channels; Air Filled = pore channels not occupied by pore fluids (3) Water = 0.9996 g/cc, Hydrocarbon = 0.9600 g/cc; Vb = Bulk Volume, cc; Pv = Pore Volume, cc; ND = Not Detected

PTS File No: 37801
Client: Floyd Snider

PTS Laboratories

FREE PRODUCT MOBILITY: INITIAL AND RESIDUAL SATURATIONS

PROJECT NAME: Gas Works NE Corner
PROJECT NO: T6010 COS-GWSA

		METHODS:	**API RP 40**		**API RP 40**	**ASTM D425M, DEAN-STARK**			
						PORE FLUID SATURATIONS, % Pv			
		SAMPLE	DENSITY		TOTAL	Initial Fluid Saturations		After Centrifuge at 1000xG	
SAMPLE ID.	DEPTH, ft.	ORIENTATION (1)	BULK, g/cc	GRAIN, g/cc	POROSITY, %Vb	WATER (Swi) SATURATION	NAPL (Soi) SATURATION	WATER (Srw) SATURATION	NAPL (Sor) SATURATION
SB2-S4	6.5-6.65	V	1.65	2.59	36.1	61.9	6.7	39.4	6.7
	NOTE:	**No visible NAPL produced. Produced water clear with no hydrocarbon odor.**							
SB2A-S1	8.3-8.4	V	1.84	2.69	31.8	62.1	7.0	31.4	7.0
	NOTE:	**No visible NAPL produced. Produced water clear with no hydrocarbon odor.**							
SB 3A	9.0-9.15	V	1.21	2.45	50.7	57.4	17.6	22.6	16.1
	NOTE:	**Dark brown LNAPL produced. Produced water clear.**							
SB12A-S4	6.5-6.65	V	1.73	2.62	34.0	83.4	13.0	53.0	13.0
	NOTE:	**No visible NAPL produced. Produced water clear with faint hydrocarbon odor.**							

N/A = Not Analyzed. Vb = Bulk Volume, Pv = Pore Volume. (1) H = horizontal, V = vertical
Soi = Initial NAPL Saturation as received prior to centrifuging at 1000xG, Swi = Initial Water Saturation as received prior to centrifuging at 1000xG
Sor = Residual NAPL Saturation after centrifuging at 1000xG, Srw = Residual Water Saturation after centrifuging at 1000xG
Water =0.9996 g/cc, NAPL = 0.9600 g/cc.

PTS File No: 37801
Client: Floyd Snider

FREE PRODUCT MOBILITY: INITIAL AND RESIDUAL SATURATIONS

(Samples spun under water.)

PROJECT NAME: Gas Works NE Corner
PROJECT NO: T6010 COS-GWSA

		METHODS:	**API RP 40**		**API RP 40**	**ASTM D425M, DEAN-STARK**			
						PORE FLUID SATURATIONS, % Pv			
			DENSITY			Initial Fluid Saturations		After Centrifuge at 1000xG	
SAMPLE ID.	DEPTH, ft.	SAMPLE ORIENTATION (1)	BULK, g/cc	GRAIN, g/cc	TOTAL POROSITY, %Vb	WATER (Swi) SATURATION	NAPL (Soi) SATURATION	WATER (Srw) SATURATION	NAPL (Sor) SATURATION
SB12A-S6	10.35-10.5	V	0.54	1.61	66.8	9.9	88.7	8.1	87.8

NOTE: NAPL produced from top and bottom of sample. Produced water clear. Sample compressed slightly during centrifuging.

N/A = Not Analyzed. Vb = Bulk Volume, Pv = Pore Volume. (1) H = horizontal, V = vertica
Soi = Initial NAPL Saturation as received prior to centrifuging at 1000xG, Swi = Initial Water Saturation as received prior to centrifuging at 1000xG
Sor = Residual NAPL Saturation after centrifuging at 1000xG, Srw = Residual Water Saturation after centrifuging at 1000xG
Water =0.9996 g/cc, NAPL = 0.9600 g/cc.

DATE **PTS FILE#** 37801 **CHAIN OF CUSTODY RECORD** **PAGE** 1 **OF** 1

COMPANY
FLOYD SNIDER

ADDRESS
601 UNION ST. STE 600, SEATTLE, WA 98101

PROJECT MANAGER
KATE SNIDER / MEGAN KING

PROJECT NAME
GAS WORKS NE CORNER

PHONE NUMBER
206-292-2078

PROJECT NUMBER
T 6010 COS-GWSA

FAX NUMBER

SITE LOCATION
GAS WORKS PARK, SEATTLE WA

SAMPLER SIGNATURE

PO#

SPECIAL HANDLING
24 HOURS
72 HOURS
5 DAYS [✓ NORMAL]
OTHER

SAMPLE CONDITIONS
RECEIVED ON ICE YES/NO
SEALED YES/NO
OTHER YES/NO

ANALYSIS REQUEST

SAMPLE ID NUMBER	DATE	TIME	DEPTH, FT	PHYSICAL PROPERTIES PACKAGE, API RP40	MOISTURE CONTENT, ASTM D2216	POROSITY, API RP40	GRAIN DENSITY, API RP40	BULK DENSITY, API RP40	AIR PERMEABILITY, API RP40	SPECIFIC RETENTION/YIELD ASTM D425	CAPILLARY PRESSURE, ASTM D425M	SOIL pH, EPA 9045	GRAIN SIZE: DRY; 400 MESH	GRAIN SIZE: SIEVE & LASER	GRAIN SIZE: LASER; 1 MICRON	HYDRAULIC CONDUCTIVITY, EPA 9100, API RP40	TOC: WALKLEY-BLACK	HYDRAULIC CONDUCTIVITY PACKAGE	ATTERBERG LIMITS, ASTM D4318	TNRCC PROPERTIES PACKAGE	White light + UV Photography	Digital imaging - CDs	PORE FLUID SATURATION PACKAGE		NUMBER OF SAMPLES
SB2-S4	9/17/07	-	6.5-8.0		✓		✓	✓													✓		✓		
SB2A-S1	9/17/07	-	8.0-9.5		✓		✓	✓													✓		✓		
SB 3A	9/19/07	-	9.0-10.5		✓		✓	✓													✓		✓		
SB5-S5	9/18/07	-	7.5-9.0		✓		✓	✓													✓		✓		
SB8-S5	9/18/07	-	9.5-10.0		✓		✓	✓													✓		✓		
SB12A-S4	9/20/07	-	6.5-8.0		✓		✓	✓													✓		✓		
SB12A-S6	9/20/07	-	10.0-10.2		✓		✓	✓													✓		✓		

COMMENTS
HOLD PORE
FLUID SAT. PKG
+ PHYSICAL
PROPERTIES
PENDING
RESULTS OF
UV + WHITE LT.
PHOTOGRAPHY

1. RELINQUISHED BY	2. RECEIVED BY	3. RELINQUISHED BY	4. RECEIVED BY
COMPANY FLOYD SNIDER	COMPANY PTS Labs	COMPANY	COMPANY
DATE 9/24/07 TIME 3:00 PM	DATE 9/25/07 TIME 1310	DATE TIME	DATE TIME

Digital Core Photography of Cryogenically Preserved Core

(Method: ASTM D5079, API RP 40)

Purpose

Cryogenic preservation and processing of subsurface core sample combined with digital core photography allows the capturing of both visible and ultra-violet (UV) imaging for both print and digital images. These core photographs (Core PhotoLogs™) provide some of the most important engineering and geologic data generated from a subsurface investigation. The images obtained are high-detail engineering documents that provide ease of study and a permanent defensible record of the subsurface.

Method Summary

Cores are preserved and handled cryogenically, then cut open (slabbed) on specially designed core processing equipment. Frozen core is cut open using a horizontal bandsaw with a diamond-segmented blade. After cutting, the slabbed core is cleaned and prepared for photography. Most core is slabbed into ¼-¾ sections providing enough bulk rock for lithologic description and plenty of material for the analytical work.

Core Preservation

The cores may be preserved using either liquid nitrogen (LN2) or dry ice methods. Liquid nitrogen is the fastest way to freeze core and preserve fluid saturations. Use this method when maintaining fluid saturations is the most critical parameter and to preserve volatile and semivolatile hydrocarbons. LN2 freezing will also keep fluids from migrating in high-permeance materials. Negative aspects are possible frost heaving and core/acetate cracking due to rapid freezing.

Freezing core using dry ice is the second fastest way to freeze core and preserve fluid saturations. It is best for most applications and the longer freeze time results in little alteration of core physical properties. Use this method when maintaining fluid saturations and core physical properties are of equal importance. Dry ice preservation will also preserve volatile and semivolatile hydrocarbons and keep fluids from migrating in high-permeance materials.

Liquid Nitrogen Core Preservation

1. After labeling and attaching end caps, the core is wrapped with several layers of plastic wrap.
2. Plastic wrap helps liquid nitrogen to evenly cool the core, resulting in less cracking of core or liner.
3. Place plastic wrapped core into a cryogenic freeze box.
4. Pour LN2 evenly over the core.
5. Completely fill the cryogenic freeze box with liquid nitrogen.
6. Five to ten minutes of submersion in LN2 will completely freeze a core.
7. The core can now be stored on dry ice for transport to laboratory.

Dry Ice Core Preservation

1. Large marine ice chests used for freezing and transporting core.
    a. Up to 72 quart coolers used for smaller core.
    b. Large marine coolers (94 quarts and greater) used for core over two feet long.
2. Place approximately 50 to 75 pounds of dry ice in the bottom of the ice chest.
3. After labeling the core and attaching end caps, place core in ice chest.
    a. Close lid and core will freeze solid in 30 minutes.
    b. Each ice chest freezes up to 22.5 feet of core using 75 pounds of dry ice.
4. Caution - Do not put dry ice in an unventilated or enclosed space due to risk of death by asphyxiation!
5. Continue adding core and dry ice as necessary.
6. The frozen core is now ready for transport to laboratory.

Digital Core Photography of Cryogenically Preserved Core

(Method: ASTM D5079, API RP 40)

Transporting Frozen Core

1. Caution - Do not transport dry ice in passenger compartments due to risk of death by asphyxiation!
2. Large ice chests are used for transporting frozen core.
3. Place a layer of foam, bubble wrap, or "Styrofoam peanuts" in the bottom of ice chest to absorb shock during transport
4. Place one layer of core on top of packing material.
5. Place a layer of dry ice over the core.
    a. Dry ice pellets can be used as a "packing material" to secure the core and fill any voids between cores.
    b. Block dry ice can also be used by breaking into smaller pieces and packing around core.
    c. Styrofoam peanuts can be added to the core layers to cushion the core during transport.
6. Continue alternating layers of core, packing materials and dry ice. Do not exceed three layers of core.
7. Fill remaining space with dry ice.
8. Put Chain of Custody in a zip lock bag and tape inside lid.
9. Close lid and seal with tape to keep cold.
10. Attach Dry Ice Placards to ice chest.
11. Contact Overnight Courier for shipment to laboratory for next day delivery.
12. Arrange shipment so core does not sit in hot warehouse or truck for days.

Core Preparation

The core is cut while cryogenically frozen into 1/4:3/4 sections (slab:bulk). This leaves the bulk amount of core available for testing.

1. Place frozen core into horizontal diamond segmented band saw.
2. Adjust blade height to cut core either 1/4:3/4 or 1/3:2/3 depending upon project requirements.
3. Use liquid nitrogen blade coolant/lubricant.
5. Cut the entire core length with one continuous cut.
6. Stop horizontal band saw and remove slabbed core from carriage.
7. Prepare core surface by removing saw smear with core scraper tool.
8. Keep core frozen at all time during core processing.

Core Photography

The digital core images are captured while the core remains cryogenically frozen. Depending upon core size diameter either the ¼ slab or 3/4 bulk sections may be photographed. The core images are captured in both visible (white light) and ultra-violet (UV) light. Extreme care is taken to color match the actual core with the prints.

1. Prepare core surface by removing saw smear with core scraper tool.
2. Allow prepared core surface to come to optimum core image capture temperature while maintaining bulk of core cryogenically frozen.
3. Place prepared frozen core into core photography copy stand.
4. Make sure digital camera has appropriate lens, filters, and settings for white light conditions.
5. Verify camera is in focus.
6. Capture white light image
7. Make sure digital camera has appropriate lens, filters, and settings for UV light conditions.
8. A 365 nm Longwave ultraviolet tube is used to provide UV source light.
9. Verify camera is in focus.
10. Capture white light image.

Digital Core Photography of Cryogenically Preserved Core

(Method: ASTM D5079, API RP 40)

Core Photography cont.

11. Advance core one foot and continue capturing white light and UV images.
12. After all core depths have been photographed assemble images into one foot white light/UV composite images.
13. Assemble one foot composite images into strip format.
14. Use high resolution digital photographic printer to print 8”x10” prints of one-foot core images.

Reporting

Digital images can be provided in multiple formats including photographic prints, web site ready files, CDs, and cross-platform formats (PC, Mac and UNIX). The digital images are provided in multiple resolutions and continuous strip format where applicable. Photographic data can be placed in reports along with tabular data. PTS can also provide a record of your core photographs as digital images in a Core Image Archive delivered on a CD-ROM for wider distribution or placement on your corporate intranet. Prints may be provided in full-scale, half-scale or continuous strip format.

PARTICLE SIZE BY DRY SIEVE PROCEDURE

(Method: ASTM D422-63 Reapproved 1998)

Scope

Particle size distribution of sediments is determined by sieving which consists of using a set of standard square-mesh, woven-wire cloth sieves that conform to ASTM E-11 in conjunction with a Ro-Tap mechanical shaker unit.

Weighed particles can range from 0.25 to 0.0012 inches and are determined as the fraction of each sample is collected and weighed in each standard sieve. The complete set of sieves is:

U.S. Sieve Number	Opening, Inches	Opening, mm	Phi of Screen
1	0.9844	25.002	-4.64
1/2	0.4922	12.501	-3.64
3/8	0.3740	9.500	-3.25
1/4	0.2500	6.351	-2.67
4	0.1873	4.757	-2.25
6	0.1324	3.364	-1.75
10	0.0787	2.000	-1.00
14	0.0557	1.414	-0.50
18	0.0394	1.000	0.00
25	0.0278	0.707	0.50
35	0.0197	0.500	1.00
40	0.0166	0.420	1.25
45	0.0139	0.354	1.50
60	0.0098	0.250	2.00
80	0.0070	0.177	2.50
120	0.0049	0.125	3.00
200	0.0029	0.074	3.75
270	0.0021	0.053	4.25
400	0.0015	0.037	4.75

Method Summary

The soil sample is dried and gently disaggregated using a wooden mortar and pestle. Samples that contain heavy concentrations of hydrocarbons are extracted by Dean-Stark distillation (API RP40) using either toluene or a chloroform-methanol azeotrope as the solvent prior to disaggregation. A representative portion of the sample, 50-1000 grams, is introduced into a stack of sieves beginning with U.S. Standard Sieve number 1/4 and is continuously shaken on the Ro-Tap shaker unit for a period of no less than 20 minutes and no greater than 30 minutes. Weights of the sample retained on each standard sieve number are recorded.

Quality Control

Calibration is determined by standards created by PTS Laboratories, Inc. by multiple size separation runs. Each screen is inspected prior to use for signs of excessive wear, distortion of the wire cloth or other aberrations. Sieves suspected of having a flaw are replaced and given to the laboratory supervisor for microscopic inspection, after which they are tested with standards, repaired or discarded. Duplicate samples are run for each batch of twenty samples and blind mixes of standards are run weekly. Duplicate sample acceptance ranges are 80-120 %, blind sample acceptance ranges are 90-110%.

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PARTICLE SIZE BY DRY SIEVE PROCEDURE

(Method: ASTM D422-63 Reapproved 1998)

Reporting

Data is reported in tabular and graphical formats corresponding to the ASTM/USCS Classification system and can be presented in an EDD format. Statistical data of mean, median, standard deviation, sorting, skewness and kurtosis are included.

SAMPLE PREPARATION FOR PARTICLE SIZE ANALYSIS PROCEDURE

(ASTM D421/422M Method)

Sampling

1. Sub-sample approximately 20-30 grams of representative material at the requested interval.
2. Break up aggregations using a wood or rubber-covered pestle.
3. Dry sample at room temperature until weight is stable.
    a. If RUSH turnaround time is required, dry sample at 150°F until weight is stable.
    b. If sample is contaminated with petroleum hydrocarbons, sample must be cleaned.
        i. Package sample in thimble or cellulose envelope for Dean-Stark or Soxhlet extraction.
        ii. Extract for 4-8 hours or until sample is clean.
        iii. Dry sample at 150°F in vacuum oven until weight is stable.
4. For LPSA analysis, material passing a No. 10 (2.00-mm) sieve is required.
5. **Note:** For non-sediment (soil) samples, contact client to develop procedure.

ATTACHMENTS

ASTM D422 Method

PTS Laboratories
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PARTICLE SIZE BY LASER LIGHT SCATTERING PROCEDURE

(Method: ASTM D4464M-85)

Scope

Particle size distribution of sediments is determined by using laser light diffraction to measure the amount and patterns of light scattered by a particle's surface. This is done using laser light with a 750 nm wavelength, a Fourier lens focusing system and an array of 126 detectors. Light is diffracted around a particle at angles inversely proportional to the size of the particle; the smaller the particle the larger the angle of diffraction.

Measured particles can range from 0.4-2000 µm and are determined as the sample, dispersed in a transport fluid, is circulated through the analyzer. Extended range analyses, 0.4 - >2000 µm is accomplished by combining the >2000 µm fraction from screen sieving with the <2000 µm fraction from light scattering.

The procedure is a modification of ASTM D4464-85 (reapproved in 2000) to measure the particle size of catalytic material. The modification is that the procedure has been extended to include the measurement of unconsolidated soils and sediments. The procedure is in current use by the USGS, City of Los Angeles, University of Florida and major petroleum companies. Local, state and federal regulatory agencies have recognized the method as an alternative to ASTM D422 (hydrometer) and the pipette method.

Method Summary

For soils the sample is dried and gently disaggregated using a wooden mortar and pestle. Samples that contain heavy hydrocarbons are extracted by Dean-Stark distillation (API RP40) using either toluene or a chloroform-methanol azeotrope as the solvent prior to disaggregation. A representative portion of the sample, 5-10 grams, is introduced into the fluid module of the analyzer and is continuously circulated through the laser beam. Water samples are introduced directly into the fluid module. The circulation fluid is filtered to 0.2 µm and contains a dispersant to prevent coagulation along with an internal sonification unit to further separate the particles.

The laser beam passes through the sample cell where the suspended particles scatter the incident light. Fourier optics collect the diffracted light and focus it on to three sets of detectors, one for low-angle scattering, the second for mid-angle scattering and the third for high-angle scattering. The composite, time-averaged diffraction pattern is measured by 126 detectors placed at angles to ~35° from the optical axis. Sizes are computed by the Fraunhofer Model for Light Scattering and summed into normal ASTM, USCS or Wentworth distribution classifications for 0.4-2000 µm.

Quality Control

Calibration is determined by the optical design. Therefore, no calibration is required. All necessary adjustments are made by measuring electrical offsets and aligning the laser beam. Quality control samples of traceable diameter are run at regular intervals or as required on a project basis. Repeatability is <1% about the mean size (repeat runs of the same sample).

Reporting

Data is reported in tabular and graphical formats corresponding to the ASTM/USCS Classification system and can be presented in an EDD format. Statistical data of mean, median, standard deviation, sorting, skewness and kurtosis are included.

SAMPLE PREPARATION FOR PARTICLE SIZE ANALYSIS PROCEDURE

(ASTM D421/422M Method)

Sampling

1. Sub-sample approximately 20-30 grams of representative material at the requested interval.
2. Break up aggregations using a wood or rubber-covered pestle.
3. Dry sample at room temperature until weight is stable.
    a. If RUSH turnaround time is required, dry sample at 150°F until weight is stable.
    b. If sample is contaminated with petroleum hydrocarbons, sample must be cleaned.
        i. Package sample in thimble or cellulose envelope for Dean-Stark or Soxhlet extraction.
        ii. Extract for 4-8 hours or until sample is clean.
        iii. Dry sample at 150°F in vacuum oven until weight is stable.
4. For LPSA analysis, material passing a No. 10 (2.00-mm) sieve is required.
5. **Note:** For non-sediment (soil) samples, contact client to develop procedure.

LPSA Sample Preparation

1. Disaggregate sample material to grain size using wood or rubber-covered pestle being careful not to break individual grains.
2. Separate test sample by sieving with a No. 10 (2-mm) sieve.
    a. Record weight of any retained material and passing material weight.
3. By use of a micro sample splitter, select a portion of sample suitable for occlusion (8-12 percent occlusion) of the Laser Particle Size Analyzer (LPSA).
4. Place the sample in a 250-mL beaker and cover with 125 mL of sodium hexametaphosphate solution.
    a. A solution of sodium hexametaphosphate is prepared at a rate of 40 grams of sodium hexametaphosphate per liter of distilled or demineralized water.
    b. Stir or agitate until the soil is thoroughly wetted.
    c. Allow to soak for at least 16 hours.
5. Following soaking period, disperse sample prior to introduction into Laser Particle Size Analyzer.
6. Stir with stainless steel or glass stirrer or use sonicator.
7. **Note:** For non-sediment (soil) samples, contact client to develop procedure.

LPSA Analysis

1. Wash sample into LPSA fluid module using distilled or demineralized water making sure all sample is washed from beaker.
2. Allow to circulate for at least 20 seconds or until the sample is completely dispersed before measuring.
3. Measure sample particle size distribution per Method ASTM D4464M.

Test results are presented in tabular and graphical formats.

PARTICLE SIZE ANALYSIS PROCEDURE

(ASTM D421/422M Method, ASTM D4464M)

Additional

Dry Sieve data may be mathematically combined with Laser Diffraction data to create a combination report presenting grain size distribution from 1” to 0.375um.

ATTACHMENTS

ASTM D4464M Method

Designation: D 422 – 63 (Reapproved 1998)

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428

Standard Test Method for Particle-Size Analysis of Soils[1]

1. Scope

1.1 This test method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 µm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75 µm is determined by a sedimentation process, using a hydrometer to secure the necessary data (Note 1 and Note 2).

NOTE 1—Separation may be made on the No. 4 (4.75-mm), No. 40 (425-µm), or No. 200 (75-µm) sieve instead of the No. 10. For whatever sieve used, the size shall be indicated in the report.

NOTE 2—Two types of dispersion devices are provided: (*1*) a high-speed mechanical stirrer, and (*2*) air dispersion. Extensive investigations indicate that air-dispersion devices produce a more positive dispersion of plastic soils below the 20-µm size and appreciably less degradation on all sizes when used with sandy soils. Because of the definite advantages favoring air dispersion, its use is recommended. The results from the two types of devices differ in magnitude, depending upon soil type, leading to marked differences in particle size distribution, especially for sizes finer than 20 µm.

2. Referenced Documents

2.1 *ASTM Standards:*

D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[3]

E 100 Specification for ASTM Hydrometers[4]

3. Apparatus

3.1 *Balances*—A balance sensitive to 0.01 g for weighing the material passing a No. 10 (2.00-mm) sieve, and a balance sensitive to 0.1 % of the mass of the sample to be weighed for weighing the material retained on a No. 10 sieve.

3.2 *Stirring Apparatus*—Either apparatus A or B may be used.

3.2.1 Apparatus A shall consist of a mechanically operated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10 000 rpm without load. The shaft shall be equipped with a replaceable stirring paddle made of metal, plastic, or hard rubber, as shown in Fig. 1. The shaft shall be of such length that the stirring paddle will operate not less than ¾ in. (19.0 mm) nor more than 1½ in. (38.1 mm) above the bottom of the dispersion cup. A special dispersion cup conforming to either of the designs shown in Fig. 2 shall be provided to hold the sample while it is being dispersed.

3.2.2 Apparatus B shall consist of an air-jet dispersion cup[5] (Note 3) conforming to the general details shown in Fig. 3 (Note 4 and Note 5).

NOTE 3—The amount of air required by an air-jet dispersion cup is of the order of 2 ft^3/min; some small air compressors are not capable of supplying sufficient air to operate a cup.

NOTE 4—Another air-type dispersion device, known as a dispersion tube, developed by Chu and Davidson at Iowa State College, has been shown to give results equivalent to those secured by the air-jet dispersion cups. When it is used, soaking of the sample can be done in the sedimentation cylinder, thus eliminating the need for transferring the slurry. When the air-dispersion tube is used, it shall be so indicated in the report.

NOTE 5—Water may condense in air lines when not in use. This water must be removed, either by using a water trap on the air line, or by blowing the water out of the line before using any of the air for dispersion purposes.

3.3 *Hydrometer*—An ASTM hydrometer, graduated to read in either specific gravity of the suspension or grams per litre of suspension, and conforming to the requirements for hydrometers 151H or 152H in Specifications E 100. Dimensions of both hydrometers are the same, the scale being the only item of difference.

3.4 *Sedimentation Cylinder*—A glass cylinder essentially 18 in. (457 mm) in height and 2½ in. (63.5 mm) in diameter, and marked for a volume of 1000 mL. The inside diameter shall be such that the 1000-mL mark is 36 ± 2 cm from the bottom on the inside.

3.5 *Thermometer*—A thermometer accurate to 1°F (0.5°C).

3.6 *Sieves*—A series of sieves, of square-mesh woven-wire cloth, conforming to the requirements of Specification E 11. A full set of sieves includes the following (Note 6):

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

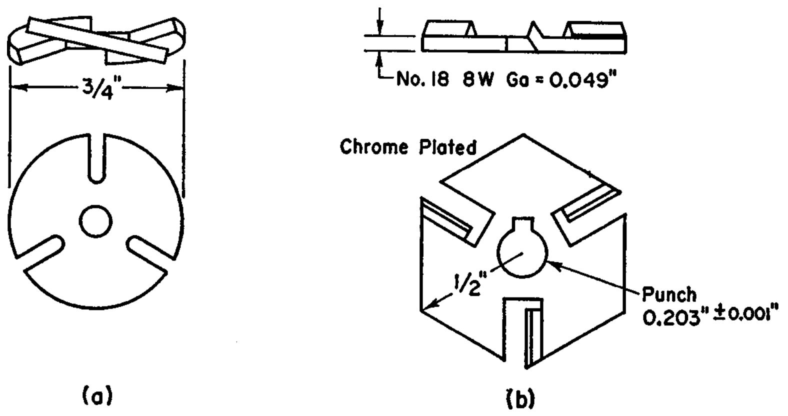
Current edition approved Nov. 21, 1963. Originally published 1935. Replaces D 422 – 62.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] *Annual Book of ASTM Standards*, Vol 14.03.

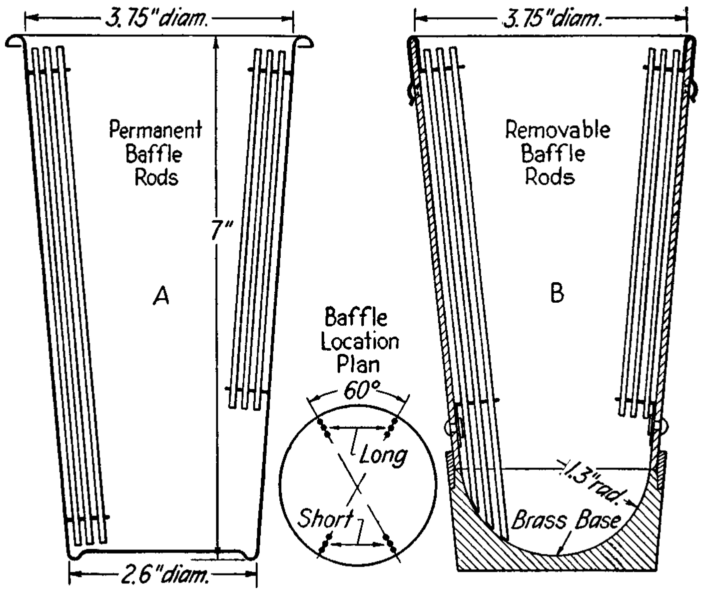
[5] Detailed working drawings for this cup are available at a nominal cost from the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103. Order Adjunct No. 12-404220-00.



Metric Equivalents

in.	0.001	0.049	0.203	½	¾
mm	0.03	1.24	5.16	12.7	19.0

FIG. 1 Detail of Stirring Paddles



Metric Equivalents

in.	1.3	2.6	3.75
mm	33	66	95.2

FIG. 2 Dispersion Cups of Apparatus

3-in. (75-mm)
2-in. (50-mm)
1½-in. (37.5-mm)
1-in. (25.0-mm)
¾-in. (19.0-mm)
⅜-in. (9.5-mm)
No. 4 (4.75-mm)
No. 10 (2.00-mm)
No. 20 (850-µm)
No. 40 (425-µm)
No. 60 (250-µm)
No. 140 (106-µm)
No. 200 (75-µm)

NOTE 6—A set of sieves giving uniform spacing of points for the graph, as required in Section 17, may be used if desired. This set consists of the following sieves:

3-in. (75-mm)
1½-in. (37.5-mm)
¾-in. (19.0-mm)
⅜-in. (9.5-mm)
No. 4 (4.75-mm)
No. 8 (2.36-mm)
No. 16 (1.18-mm)
No. 30 (600-µm)
No. 50 (300-µm)
No. 100 (150-µm)
No. 200 (75-µm)

3.7 *Water Bath or Constant-Temperature Room*—A water bath or constant-temperature room for maintaining the soil suspension at a constant temperature during the hydrometer analysis. A satisfactory water tank is an insulated tank that maintains the temperature of the suspension at a convenient constant temperature at or near 68°F (20°C). Such a device is illustrated in Fig. 4. In cases where the work is performed in a room at an automatically controlled constant temperature, the water bath is not necessary.

3.8 *Beaker*—A beaker of 250-mL capacity.

3.9 *Timing Device*—A watch or clock with a second hand.

4. Dispersing Agent

4.1 A solution of sodium hexametaphosphate (sometimes called sodium metaphosphate) shall be used in distilled or demineralized water, at the rate of 40 g of sodium hexametaphosphate/litre of solution (Note 7).

NOTE 7—Solutions of this salt, if acidic, slowly revert or hydrolyze back to the orthophosphate form with a resultant decrease in dispersive action. Solutions should be prepared frequently (at least once a month) or adjusted to pH of 8 or 9 by means of sodium carbonate. Bottles containing solutions should have the date of preparation marked on them.

4.2 All water used shall be either distilled or demineralized water. The water for a hydrometer test shall be brought to the temperature that is expected to prevail during the hydrometer test. For example, if the sedimentation cylinder is to be placed in the water bath, the distilled or demineralized water to be used shall be brought to the temperature of the controlled water bath; or, if the sedimentation cylinder is used in a room with controlled temperature, the water for the test shall be at the temperature of the room. The basic temperature for the hydrometer test is 68°F (20°C). Small variations of temperature do not introduce differences that are of practical significance and do not prevent the use of corrections derived as prescribed.

5. Test Sample

5.1 Prepare the test sample for mechanical analysis as outlined in Practice D 421. During the preparation procedure

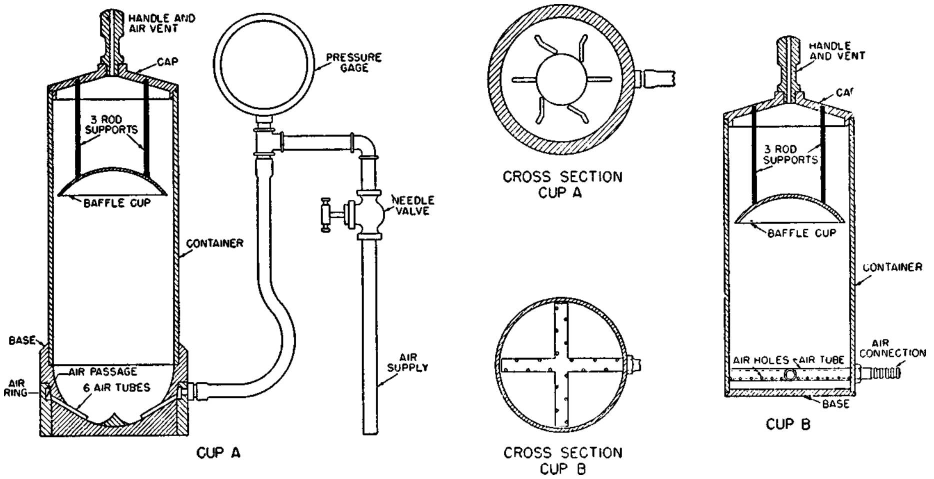
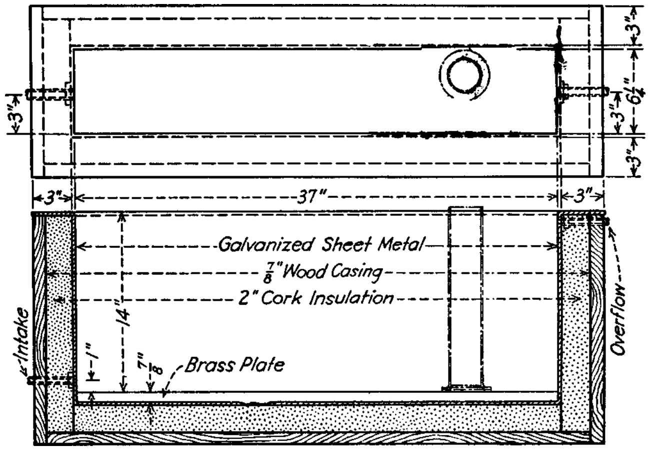


FIG. 3 Air-Jet Dispersion Cups of Apparatus B



Metric Equivalents

in.	⅞	1	3	6¼	14	37
mm	22.2	25.4	76.2	158.2	356	940

FIG. 4 Insulated Water Bath

the sample is divided into two portions. One portion contains only particles retained on the No. 10 (2.00-mm) sieve while the other portion contains only particles passing the No. 10 sieve. The mass of air-dried soil selected for purpose of tests, as prescribed in Practice D 421, shall be sufficient to yield quantities for mechanical analysis as follows:

5.1.1 The size of the portion retained on the No. 10 sieve shall depend on the maximum size of particle, according to the following schedule:

Nominal Diameter of Largest Particles, in. (mm)	Approximate Minimum Mass of Portion, g
⅜ (9.5)	500
¾ (19.0)	1000
1 (25.4)	2000
1½ (38.1)	3000
2 (50.8)	4000
3 (76.2)	5000

5.1.2 The size of the portion passing the No. 10 sieve shall be approximately 115 g for sandy soils and approximately 65 g for silt and clay soils.

5.2 Provision is made in Section 5 of Practice D 421 for weighing of the air-dry soil selected for purpose of tests, the separation of the soil on the No. 10 sieve by dry-sieving and washing, and the weighing of the washed and dried fraction retained on the No. 10 sieve. From these two masses the percentages retained and passing the No. 10 sieve can be calculated in accordance with 12.1.

NOTE 8—A check on the mass values and the thoroughness of pulverization of the clods may be secured by weighing the portion passing the No. 10 sieve and adding this value to the mass of the washed and oven-dried portion retained on the No. 10 sieve.

SIEVE ANALYSIS OF PORTION RETAINED ON NO. 10 (2.00-mm) SIEVE

6. Procedure

6.1 Separate the portion retained on the No. 10 (2.00-mm) sieve into a series of fractions using the 3-in. (75-mm), 2-in.

(50-mm), 1½-in. (37.5-mm), 1-in. (25.0-mm), ¾-in. (19.0-mm), ⅜-in. (9.5-mm), No. 4 (4.75-mm), and No. 10 sieves, or as many as may be needed depending on the sample, or upon the specifications for the material under test.

6.2 Conduct the sieving operation by means of a lateral and vertical motion of the sieve, accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve. In no case turn or manipulate fragments in the sample through the sieve by hand. Continue sieving until not more than 1 mass % of the residue on a sieve passes that sieve during 1 min of sieving. When mechanical sieving is used, test the thoroughness of sieving by using the hand method of sieving as described above.

6.3 Determine the mass of each fraction on a balance conforming to the requirements of 3.1. At the end of weighing, the sum of the masses retained on all the sieves used should equal closely the original mass of the quantity sieved.

HYDROMETER AND SIEVE ANALYSIS OF PORTION PASSING THE NO. 10 (2.00-mm) SIEVE

7. Determination of Composite Correction for Hydrometer Reading

7.1 Equations for percentages of soil remaining in suspension, as given in 14.3, are based on the use of distilled or demineralized water. A dispersing agent is used in the water, however, and the specific gravity of the resulting liquid is appreciably greater than that of distilled or demineralized water.

7.1.1 Both soil hydrometers are calibrated at 68°F (20°C), and variations in temperature from this standard temperature produce inaccuracies in the actual hydrometer readings. The amount of the inaccuracy increases as the variation from the standard temperature increases.

7.1.2 Hydrometers are graduated by the manufacturer to be read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to secure readings of soil suspensions at the bottom of the meniscus, readings must be taken at the top and a correction applied.

7.1.3 The net amount of the corrections for the three items enumerated is designated as the composite correction, and may be determined experimentally.

7.2 For convenience, a graph or table of composite corrections for a series of 1° temperature differences for the range of expected test temperatures may be prepared and used as needed. Measurement of the composite corrections may be made at two temperatures spanning the range of expected test temperatures, and corrections for the intermediate temperatures calculated assuming a straight-line relationship between the two observed values.

7.3 Prepare 1000 mL of liquid composed of distilled or demineralized water and dispersing agent in the same proportion as will prevail in the sedimentation (hydrometer) test. Place the liquid in a sedimentation cylinder and the cylinder in the constant-temperature water bath, set for one of the two temperatures to be used. When the temperature of the liquid becomes constant, insert the hydrometer, and, after a short interval to permit the hydrometer to come to the temperature of the liquid, read the hydrometer at the top of the meniscus formed on the stem. For hydrometer 151H the composite correction is the difference between this reading and one; for hydrometer 152H it is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

8. Hygroscopic Moisture

8.1 When the sample is weighed for the hydrometer test, weigh out an auxiliary portion of from 10 to 15 g in a small metal or glass container, dry the sample to a constant mass in an oven at 230 ± 9°F (110 ± 5°C), and weigh again. Record the masses.

9. Dispersion of Soil Sample

9.1 When the soil is mostly of the clay and silt sizes, weigh out a sample of air-dry soil of approximately 50 g. When the soil is mostly sand the sample should be approximately 100 g.

9.2 Place the sample in the 250-mL beaker and cover with 125 mL of sodium hexametaphosphate solution (40 g/L). Stir until the soil is thoroughly wetted. Allow to soak for at least 16 h.

9.3 At the end of the soaking period, disperse the sample further, using either stirring apparatus A or B. If stirring apparatus A is used, transfer the soil-water slurry from the beaker into the special dispersion cup shown in Fig. 2, washing any residue from the beaker into the cup with distilled or demineralized water (Note 9). Add distilled or demineralized water, if necessary, so that the cup is more than half full. Stir for a period of 1 min.

NOTE 9—A large size syringe is a convenient device for handling the water in the washing operation. Other devices include the wash-water bottle and a hose with nozzle connected to a pressurized distilled water tank.

9.4 If stirring apparatus B (Fig. 3) is used, remove the cover cap and connect the cup to a compressed air supply by means of a rubber hose. A air gage must be on the line between the cup and the control valve. Open the control valve so that the gage indicates 1 psi (7 kPa) pressure (Note 10). Transfer the soil-water slurry from the beaker to the air-jet dispersion cup by washing with distilled or demineralized water. Add distilled or demineralized water, if necessary, so that the total volume in the cup is 250 mL, but no more.

NOTE 10—The initial air pressure of 1 psi is required to prevent the soil-water mixture from entering the air-jet chamber when the mixture is transferred to the dispersion cup.

9.5 Place the cover cap on the cup and open the air control valve until the gage pressure is 20 psi (140 kPa). Disperse the soil according to the following schedule:

Plasticity Index	Dispersion Period, min
Under 5	5
6 to 20	10
Over 20	15

Soils containing large percentages of mica need be dispersed for only 1 min. After the dispersion period, reduce the gage pressure to 1 psi preparatory to transfer of soil-water slurry to the sedimentation cylinder.

10. Hydrometer Test

10.1 Immediately after dispersion, transfer the soil-water slurry to the glass sedimentation cylinder, and add distilled or demineralized water until the total volume is 1000 mL.

10.2 Using the palm of the hand over the open end of the cylinder (or a rubber stopper in the open end), turn the cylinder upside down and back for a period of 1 min to complete the agitation of the slurry (Note 11). At the end of 1 min set the cylinder in a convenient location and take hydrometer readings at the following intervals of time (measured from the beginning of sedimentation), or as many as may be needed, depending on the sample or the specification for the material under test: 2, 5, 15, 30, 60, 250, and 1440 min. If the controlled water bath is used, the sedimentation cylinder should be placed in the bath between the 2- and 5-min readings.

NOTE 11—The number of turns during this minute should be approximately 60, counting the turn upside down and back as two turns. Any soil remaining in the bottom of the cylinder during the first few turns should be loosened by vigorous shaking of the cylinder while it is in the inverted position.

10.3 When it is desired to take a hydrometer reading, carefully insert the hydrometer about 20 to 25 s before the reading is due to approximately the depth it will have when the reading is taken. As soon as the reading is taken, carefully remove the hydrometer and place it with a spinning motion in a graduate of clean distilled or demineralized water.

NOTE 12—It is important to remove the hydrometer immediately after each reading. Readings shall be taken at the top of the meniscus formed by the suspension around the stem, since it is not possible to secure readings at the bottom of the meniscus.

10.4 After each reading, take the temperature of the suspension by inserting the thermometer into the suspension.

11. Sieve Analysis

11.1 After taking the final hydrometer reading, transfer the suspension to a No. 200 (75-µm) sieve and wash with tap water until the wash water is clear. Transfer the material on the No. 200 sieve to a suitable container, dry in an oven at 230 ± 9°F (110 ± 5°C) and make a sieve analysis of the portion retained, using as many sieves as desired, or required for the material, or upon the specification of the material under test.

CALCULATIONS AND REPORT

12. Sieve Analysis Values for the Portion Coarser than the No. 10 (2.00-mm) Sieve

12.1 Calculate the percentage passing the No. 10 sieve by dividing the mass passing the No. 10 sieve by the mass of soil originally split on the No. 10 sieve, and multiplying the result by 100. To obtain the mass passing the No. 10 sieve, subtract the mass retained on the No. 10 sieve from the original mass.

12.2 To secure the total mass of soil passing the No. 4 (4.75-mm) sieve, add to the mass of the material passing the No. 10 sieve the mass of the fraction passing the No. 4 sieve and retained on the No. 10 sieve. To secure the total mass of soil passing the ⅜-in. (9.5-mm) sieve, add to the total mass of soil passing the No. 4 sieve, the mass of the fraction passing the ⅜-in. sieve and retained on the No. 4 sieve. For the remaining sieves, continue the calculations in the same manner.

12.3 To determine the total percentage passing for each sieve, divide the total mass passing (see 12.2) by the total mass of sample and multiply the result by 100.

13. Hygroscopic Moisture Correction Factor

13.1 The hydroscopic moisture correction factor is the ratio between the mass of the oven-dried sample and the air-dry mass before drying. It is a number less than one, except when there is no hygroscopic moisture.

14. Percentages of Soil in Suspension

14.1 Calculate the oven-dry mass of soil used in the hydrometer analysis by multiplying the air-dry mass by the hygroscopic moisture correction factor.

14.2 Calculate the mass of a total sample represented by the mass of soil used in the hydrometer test, by dividing the oven-dry mass used by the percentage passing the No. 10 (2.00-mm) sieve, and multiplying the result by 100. This value is the weight W in the equation for percentage remaining in suspension.

14.3 The percentage of soil remaining in suspension at the level at which the hydrometer is measuring the density of the suspension may be calculated as follows (Note 13): For hydrometer 151H:

$$P = [(100\,000/W) \times G/(G - G_1)](R - G_1) \tag{1}$$

NOTE 13—The bracketed portion of the equation for hydrometer 151H is constant for a series of readings and may be calculated first and then multiplied by the portion in the parentheses.

For hydrometer 152H:

$$P = (Ra/W) \times 100 \tag{2}$$

where:

a = correction faction to be applied to the reading of hydrometer 152H. (Values shown on the scale are computed using a specific gravity of 2.65. Correction factors are given in Table 1),

P = percentage of soil remaining in suspension at the level at which the hydrometer measures the density of the suspension,

R = hydrometer reading with composite correction applied (Section 7),

W = oven-dry mass of soil in a total test sample represented by mass of soil dispersed (see 14.2), g,

G = specific gravity of the soil particles, and

G_1 = specific gravity of the liquid in which soil particles are suspended. Use numerical value of one in both instances in the equation. In the first instance any possible variation produces no significant effect, and in the second instance, the composite correction for R is based on a value of one for G_1.

15. Diameter of Soil Particles

15.1 The diameter of a particle corresponding to the percentage indicated by a given hydrometer reading shall be calculated according to Stokes' law (Note 14), on the basis that a particle of this diameter was at the surface of the suspension at the beginning of sedimentation and had settled to the level at which the hydrometer is measuring the density of the suspension. According to Stokes' law: see Table 2

TABLE 1 Values of Correction Factor, α, for Different Specific Gravities of Soil Particles[A]

Specific Gravity	Correction Factor[A]
2.95	0.94
2.90	0.95
2.85	0.96
2.80	0.97
2.75	0.98
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.03
2.45	1.05

[A] For use in equation for percentage of soil remaining in suspension when using Hydrometer 152H.

$$D = \sqrt{[30n/980(G - G_1)] \times L/T} \quad (3)$$

where:

D = diameter of particle, mm,

n = coefficient of viscosity of the suspending medium (in this case water) in poises (varies with changes in temperature of the suspending medium),

L = distance from the surface of the suspension to the level at which the density of the suspension is being measured, cm. (For a given hydrometer and sedimentation cylinder, values vary according to the hydrometer readings. This distance is known as effective depth (see Table 2)),

T = interval of time from beginning of sedimentation to the taking of the reading, min,

G = specific gravity of soil particles, and

G_1 = specific gravity (relative density) of suspending medium (value may be used as 1.000 for all practical purposes).

NOTE 14—Since Stokes' law considers the terminal velocity of a single sphere falling in an infinity of liquid, the sizes calculated represent the diameter of spheres that would fall at the same rate as the soil particles.

15.2 For convenience in calculations the above equation may be written as follows: see Table 3

$$D = K\sqrt{L/T} \quad (4)$$

where:

K = constant depending on the temperature of the suspension and the specific gravity of the soil particles. Values of K for a range of temperatures and specific gravities are given in Table 3. The value of K does not change for a series of readings constituting a test, while values of L and T do vary.

15.3 Values of D may be computed with sufficient accuracy, using an ordinary 10-in. slide rule.

NOTE 15—The value of L is divided by T using the *A*- and *B*-scales, the square root being indicated on the *D*-scale. Without ascertaining the value of the square root it may be multiplied by K, using either the *C*- or *CI*-scale.

16. Sieve Analysis Values for Portion Finer than No. 10 (2.00-mm) Sieve

16.1 Calculation of percentages passing the various sieves used in sieving the portion of the sample from the hydrometer test involves several steps. The first step is to calculate the mass of the fraction that would have been retained on the No. 10 sieve had it not been removed. This mass is equal to the total percentage retained on the No. 10 sieve (100 minus total

TABLE 2 Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes[A]

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, *L*, cm	Actual Hydrometer Reading	Effective Depth, *L*, cm	Actual Hydrometer Reading	Effective Depth, *L*, cm
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5		
1.006	14.7	6	15.3	36	10.4
1.007	14.4	7	15.2	37	10.2
1.008	14.2	8	15.0	38	10.1
1.009	13.9	9	14.8	39	9.9
1.010	13.7	10	14.7	40	9.7
1.011	13.4	11	14.5	41	9.6
1.012	13.1	12	14.3	42	9.4
1.013	12.9	13	14.2	43	9.2
1.014	12.6	14	14.0	44	9.1
1.015	12.3	15	13.8	45	8.9
1.016	12.1	16	13.7	46	8.8
1.017	11.8	17	13.5	47	8.6
1.018	11.5	18	13.3	48	8.4
1.019	11.3	19	13.2	49	8.3
1.020	11.0	20	13.0	50	8.1
1.021	10.7	21	12.9	51	7.9
1.022	10.5	22	12.7	52	7.8
1.023	10.2	23	12.5	53	7.6
1.024	10.0	24	12.4	54	7.4
1.025	9.7	25	12.2	55	7.3
1.026	9.4	26	12.0	56	7.1
1.027	9.2	27	11.9	57	7.0
1.028	8.9	28	11.7	58	6.8
1.029	8.6	29	11.5	59	6.6
1.030	8.4	30	11.4	60	6.5
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				

[A] Values of effective depth are calculated from the equation:

$$L = L_1 + 1/2\,[L_2 - (V_B/A)] \quad (5)$$

where:

L = effective depth, cm,

L_1 = distance along the stem of the hydrometer from the top of the bulb to the mark for a hydrometer reading, cm,

L_2 = overall length of the hydrometer bulb, cm,

V_B = volume of hydrometer bulb, cm^3, and

A = cross-sectional area of sedimentation cylinder, cm^2

Values used in calculating the values in Table 2 are as follows:
For both hydrometers, 151H and 152H:

L_2 = 14.0 cm
V_B = 67.0 cm^3
A = 27.8 cm^2

For hydrometer 151H:
L_1 = 10.5 cm for a reading of 1.000
= 2.3 cm for a reading of 1.031

For hydrometer 152H:
L_1 = 10.5 cm for a reading of 0 g/litre
= 2.3 cm for a reading of 50 g/litre

TABLE 3 Values of K for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

Temperature,° C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.1323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01255	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149

percentage passing) times the mass of the total sample represented by the mass of soil used (as calculated in 14.2), and the result divided by 100.

16.2 Calculate next the total mass passing the No. 200 sieve. Add together the fractional masses retained on all the sieves, including the No. 10 sieve, and subtract this sum from the mass of the total sample (as calculated in 14.2).

16.3 Calculate next the total masses passing each of the other sieves, in a manner similar to that given in 12.2.

16.4 Calculate last the total percentages passing by dividing the total mass passing (as calculated in 16.3) by the total mass of sample (as calculated in 14.2), and multiply the result by 100.

17. Graph

17.1 When the hydrometer analysis is performed, a graph of the test results shall be made, plotting the diameters of the particles on a logarithmic scale as the abscissa and the percentages smaller than the corresponding diameters to an arithmetic scale as the ordinate. When the hydrometer analysis is not made on a portion of the soil, the preparation of the graph is optional, since values may be secured directly from tabulated data.

18. Report

18.1 The report shall include the following:

18.1.1 Maximum size of particles,

18.1.2 Percentage passing (or retained on) each sieve, which may be tabulated or presented by plotting on a graph (Note 16),

18.1.3 Description of sand and gravel particles:

18.1.3.1 Shape—rounded or angular,

18.1.3.2 Hardness—hard and durable, soft, or weathered and friable,

18.1.4 Specific gravity, if unusually high or low,

18.1.5 Any difficulty in dispersing the fraction passing the No. 10 (2.00-mm) sieve, indicating any change in type and amount of dispersing agent, and

18.1.6 The dispersion device used and the length of the dispersion period.

NOTE 16—This tabulation of graph represents the gradation of the sample tested. If particles larger than those contained in the sample were removed before testing, the report shall so state giving the amount and maximum size.

18.2 For materials tested for compliance with definite specifications, the fractions called for in such specifications shall be reported. The fractions smaller than the No. 10 sieve shall be read from the graph.

18.3 For materials for which compliance with definite specifications is not indicated and when the soil is composed almost entirely of particles passing the No. 4 (4.75-mm) sieve, the results read from the graph may be reported as follows:

(*1*) Gravel, passing 3-in. and retained on No. 4 sieve ..... %
(*2*) Sand, passing No. 4 sieve and retained on No. 200 sieve ..... %
  (*a*) Coarse sand, passing No. 4 sieve and retained on No. 10 sieve ..... %
  (*b*) Medium sand, passing No. 10 sieve and retained on No. 40 sieve ..... %
  (*c*) Fine sand, passing No. 40 sieve and retained on No. 200 sieve ..... %
(*3*) Silt size, 0.074 to 0.005 mm ..... %
(*4*) Clay size, smaller than 0.005 mm ..... %
  Colloids, smaller than 0.001 mm ..... %

18.4 For materials for which compliance with definite specifications is not indicated and when the soil contains material retained on the No. 4 sieve sufficient to require a sieve analysis on that portion, the results may be reported as follows (Note 17):

SIEVE ANALYSIS

Sieve Size	Percentage Passing
3-in.	....
2-in.	....
1½-in.	....
1-in.	....
¾-in.	....
⅜-in.	....
No. 4 (4.75-mm)	....
No. 10 (2.00-mm)	....
No. 40 (425-µm)	....
No. 200 (75-µm)	....

HYDROMETER ANALYSIS

0.074 mm	....
0.005 mm	....
0.001 mm	....

NOTE 17—No. 8 (2.36-mm) and No. 50 (300-µm) sieves may be substituted for No. 10 and No. 40 sieves.

19. Keywords

19.1 grain-size; hydrometer analysis; hygroscopic moisture; particle-size; sieve analysis

Designation: D 4464 – 00

Standard Test Method for
Particle Size Distribution of Catalytic Material by Laser Light Scattering[1]

This standard is issued under the fixed designation D 4464; 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.

1. Scope

1.1 This test method covers the determination of the particle size distribution of catalyst and catalyst carrier particles and is one of several found valuable for the measurement of particle size. The range of particle sizes investigated was 30 to 300 µm equivalent spherical diameter. The technique is capable of measuring particles above and below this range. The angle and intensity of laser light scattered by the particles are selectively measured to permit calculation of a volume distribution using light-scattering techniques.

1.2 *This standard does not purport to address all of the safety concerns, 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 3766 Terminology Relating to Catalysts and Catalysis[2]

E 105 Practice for Probability Sampling of Materials[3]

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[3]

E 456 Terminology Relating to Quality and Statistics[3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[3]

E 1617 Practice for Reporting Particle Size Characterization Data[3]

3. Terminology

3.1 Definitions and recommended nomenclature pertaining to catalysts and to materials used in their manufacture can be found in Terminology D 3766.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *background*—extraneous scattering of light by material present in the dispersion fluid other than the particles to be measured. It includes scattering by contamination in the measurement path.

3.2.2 *Fraunhofer Diffraction*—the optical theory that describes the low-angle scattering of light by particles that are large compared to the wavelength of the incident light.

3.2.3 *Mie Scattering*—the complex electromagnetic theory that describes the scattering of light by spherical particles. It is usually applied to particles with diameters that are close to the wavelength of the incident light. The real and imaginary indices of light refraction of the particles are needed.

3.2.4 *multiple scattering*—the re-scattering of light by a particle in the path of light scattered by another particle. This usually occurs in heavy concentrations of a particle dispersion.

4. Summary of Test Method

4.1 A prepared sample of particulate material is dispersed in water or a compatible organic liquid and is circulated through the path of a laser light beam or some other suitable source of light. The particles pass through the light beam and scatter it. Photodetector arrays collect the scattered light which is converted to electrical signals to be analyzed using Fraunhofer Diffraction, or Mie Scattering, or both. Scattering information, typically, is analyzed assuming a spherical geometry for the particles. Calculated particle sizes are, therefore, presented as equivalent spherical diameters.

5. Significance and Use

5.1 It is important to recognize that the results obtained by this test method or any other method for particle size determination utilizing different physical principles may disagree. The results are strongly influenced by physical principles employed by each method of particle size analysis. The results of any particle sizing method should be used only in a relative sense and should not be regarded as absolute when comparing results obtained by other methods.

5.2 Light scattering theories (Fraunhofer Diffraction[4] and Mie Scattering[5]) that are used for determination of particle size has been available for many years. Several manufacturers of testing equipment now have units based on these principles. Although each type of testing equipment utilizes the same basic principles for light scattering as a function of particle size, different assumptions pertinent to application of the theory and different models for converting light measurements

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[1] This test method is under the jurisdiction of ASTM Committee D32 on Catalysts and is the direct responsibility of Subcommittee D32.02 on Physical-Mechanical Properties.

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[2] *Annual Book of ASTM Standards*, Vol 05.05.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] Born, M., and Wolf, E., *Principles of Optics*, Chptr 8, Pergamon Press, Oxford, 1957.

[5] van Hulst, H.C., *Light Scattering by Small Particles*, Chptr 9, John Wiley & Sons, New York, 1908.

to particle size, may lead to different results for each instrument. Furthermore, any particles which are outside the size measurement range of the instrument will be ignored, causing an increase in the reported percentages within the detectable range. A particle size distribution which ends abruptly at the detection limit of the instrument may indicate that particles outside the range are present. Therefore, use of this test method cannot guarantee directly comparable results from different types of instruments.

5.3 This test method can be used to determine particle size distributions of catalysts and supports for materials specifications, manufacturing control, and research and development work.

6. Interferences

6.1 Air bubbles entrained in the circulating fluid will scatter light and then be reported as particles. Circulating fluids, typically, do not require degassing, but should be bubble-free on visual inspections.

6.2 Contaminants, such as non-aqueous solvents, oil or other organic coatings on the sample may emulsify in an aqueous carrier, scatter light, and be reported as part of the particle size distribution. Samples containing such contaminants may be analyzed in a non-aqueous carrier solvent to dissolve the contaminants or washed free of the contaminant with a compatible aqueous solvent.

6.3 Reagglomeration or settling of particles during analysis will cause erroneous results. Dispersions shall be prepared so a stable dispersion is maintained throughout the analysis.

6.4 Insufficient sample loading may cause electrical noise interference and poor data reproducibility. High sample loading may cause excessive light attenuation and multiple scattering, resulting in erroneous particle size distributions.

7. Apparatus

7.1 *Particle Size Analyzer*, based on Fraunhofer Diffraction or Mie Scattering, or both, light scattering analysis techniques. Ensure that the analyzer system or subsystem is optimum for the range of the powder being tested.

7.2 *Micro Sample Splitter*, used in accordance with MNL 32.[6] to obtain the test portion of sample.

7.3 *Ultrasonic Probe or Bath*, if needed, to ensure dispersion of agglomerates prior to analysis.

8. Reagents and Materials

8.1 The selected liquid carrier shall:

8.1.1 Be compatible with the construction materials of the sample delivery system.

8.1.2 Not cause dissolution or clumping of the particles.

8.1.3 Be sufficiently clean to achieve acceptable background levels.

8.2 The use of surfactant(s) is often recommended by equipment manufacturers. However, agents such as surfactants, antifoams, and viscosity modifiers should be used with caution. An interlaboratory study of this test method showed that the use of different types and concentrations of surfactant can significantly affect the results. In calculating the precision of this test method, results obtained using surfactants were excluded because they contributed disproportionately to the scatter in results. Comparisons between laboratories should be performed with liquid carriers which are identical in all respects.

9. Sampling and Sample Size

9.1 A representative test sample shall be obtained according to Practice E 105. The test portion shall be extracted from the test sample using a micro sample splitter according to Manual 32. Quartering shall not be used.

9.2 Refer to the equipment manufacturer's recommendation to ensure that the amount of the test portion is acceptable to achieve optimum light scattering conditions. A wide range of sample portions is acceptable depending upon median particle size, particle density, and the sample delivery system.

9.3 For liquid dispersed materials, redisperse as necessary to ensure representative samples.

10. Preparation of Apparatus

10.1 Allow the instrument to warm up according to the manufacturer's recommendations.

10.2 Install and fill the desired sample delivery system and select applicable instrument range as indicated by the instrument manufacturer's instructions.

10.3 Establish correct optical alignment and calibration at a frequency in accordance with the manufacturer's requirements.

11. Calibration and Standardization

11.1 Performance of the instrument is defined by the geometry of the optical components. (Refer to the manufacturer's instruction manual.)

11.2 Spherical particle standards are available. Diagnostic powders are available from some equipment manufacturers to ensure consistent instrument function. (Some instruments may permit the use of reticles for calibration.)

NOTE 1—A partial list of standards, powders, and reticles can be found in the D32 research report for this test method.

12. Procedure

12.1 Measure the background in the mode in which the analysis will be carried out. Be sure that the carrier is flowing through the light path while measuring the background. Background values shall not exceed the manufacturer's specifications. If background values exceed manufacturer's recommendations, perform the necessary procedures as specified by the manufacturer to bring the background values within acceptable limits.

12.2 Obtain representative sample according to Section 9.

12.3 Select appropriate run time for the sample. This procedure is very specific to the application and is generally gauged by the run-to-run repeatability.

12.4 Select the desired output parameters according to the requirements set forth by the instrument manufacturer.

12.5 Transfer a representative aliquot to the sample delivery system and allow it to circulate for at least 20 s or until the solid is uniformly dispersed before measuring. (Determine that

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[6] *ASTM Manual Series: MNL 32*, "Manual on Test Sieving Methods," Pope, L.R. and Ward, C.W., eds., 4th ed, 1998.

the sample is not settling out in the circulation system. This can be checked by repeated runs at higher circulation rates.)

12.6 Perform the sample analysis according to the manufacturer's instructions.

12.7 Drain and fill the sample dispersion system in preparation for the next sample analysis. Drain and clean, as necessary, to avoid contamination of the subsequent sample.

13. Report

13.1 Information shall be reported as agreed between supplier and user, in accordance with Practice E 1617. The basis of the reported results is percent volume distribution calculated as equivalent spherical diameter. If all particles have the same density, this is the same as percent weight distribution.

14. Precision and Bias [7]

14.1 *Test Program*—An interlaboratory study was conducted in which particle size was measured as three points in seven separate laboratories on three materials. Each laboratory conducted a single determination on each of three subsamples of each material. Practice E 691, modified for nonuniform data sets, was followed for the data reduction.

14.2 *Precision*—Pairs of test results obtained by a procedure similar to that described in the study are expected to differ in absolute value by less than the 95 % probability interval, which is equal to 2.772*S, where S is the estimate of standard deviation.

14.3 *Summary of Precision Results*—The test results are shown in micrometres as Fraction Smaller Than (FST) at the indicated diameter at three selected points on the cumulative particle size distribution. Repeatability is the within laboratory agreement and reproducibility is the agreement between laboratories, expressed both in micrometres and as percent of consensus mean. See Table 1.

14.4 *Bias*—The test method is without known bias.

15. Keywords

15.1 catalyst; Fraunhofer Diffraction; light scattering; Mie Scattering

TABLE 1 Precision

Fraction Smaller Than (FST)	Consensus Median Diameter, µm	Repeatability	Reproducibility
D3295001			
10 volume %	37.11	0.61 (1.65 %)	4.66 (12.5 %)
50 volume %	68.04	1.18 (1.74 %)	2.85 (4.19 %)
90 volume %	120.6	3.59 (2.98 %)	9.66 (8.01 %)
D3291003			
10 volume %	39.71	1.91 (4.81 %)	8.59 (21.6 %)
50 volume %	83.28	3.13 (3.76 %)	7.49 (8.99 %)
90 volume %	153.2	6.82 (4.45 %)	16.31 (10.7 %)
D3295003			
10 volume %	57.78	5.53 (9.57 %)	12.30 (21.3 %)
50 volume %	140.4	9.70 (6.91 %)	16.38 (11.7 %)
90 volume %	254.6	17.53 (6.88 %)	53.82 (21.1 %)

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[7] Use of the terms repeatability, reproducibility, precision and bias is in accordance with Terminology E 456 and Practice E 177. Supporting data are available from ASTM Headquarters. Request RR: D32-1013.

PORE FLUID SATURATIONS - DISTILLATION EXTRACTION PROCEDURE

(Method: Dean Stark, API RP 40)

Scope

Pore fluid saturations of plug samples drilled, cut, or formed from whole cores are determined using a solvent boiling flask, thimble, calibrated sidearm, and condenser. The samples may contain naturally occurring hydrocarbons, be contaminated with refined hydrocarbons (LNAPL's or DNAPL's) from leaks or spills, or hydrocarbons from other processes. The method uses solvent distillation to remove pore fluids (hydrocarbons and water) from the plug samples and material balance (gravimetric and volumetric methods) to summarize the fluids. Sample basic properties (pore volume, bulk volume) must be determined separately in order to report the fluid saturations as percent pore space or bulk volume.

Method Summary

Refer to API RP 40 Section 4.3 and Yeung et al, 1994 for method description.

Quality Control

Refer to API RP 40 Section 4.3 and Yeung et al, 1994 for limitations and accuracy/precision.

Reporting

Data is reported in tabular format and can be presented in an EDD format.

Laboratory Procedure

1. Weigh native sample to 0.01gm.
2. Place sample in dried cellulose extraction thimble.
3. Place thimble in distillation flask.
4. Fill boiling flask 2/3 full with toluene.
5. Assemble system.
6. Turn on heater and monitor water distilled into the water trap.
7. When water production stabilizes continue extraction for 1 hr.
8. Turn off heater and allow system to cool to room temperature.
9. Read extracted water volume to 0.01ml.
10. Remove thimble from distillation flask.
11. Dry to a stable weight at 150°F in a vacuum oven.
12. Record sample weight at ambient temperature to 0.01gm.
13. Calculate water weight:

    Wt. water = (volume of water x density of water)

14. Calculate hydrocarbon weight:

    Wt. Hydrocarbon = ((sample initial weight - sample dry weight) - water weight)

Blank Acceptance Range: 0.01gm
Standard Acceptance Range: 80-120%

Optional: Convert extracted weights to volumes and express as percentage of pore space saturation. Requires Porosity measurement.

PORE FLUID SATURATIONS - DRYING PROCEDURE

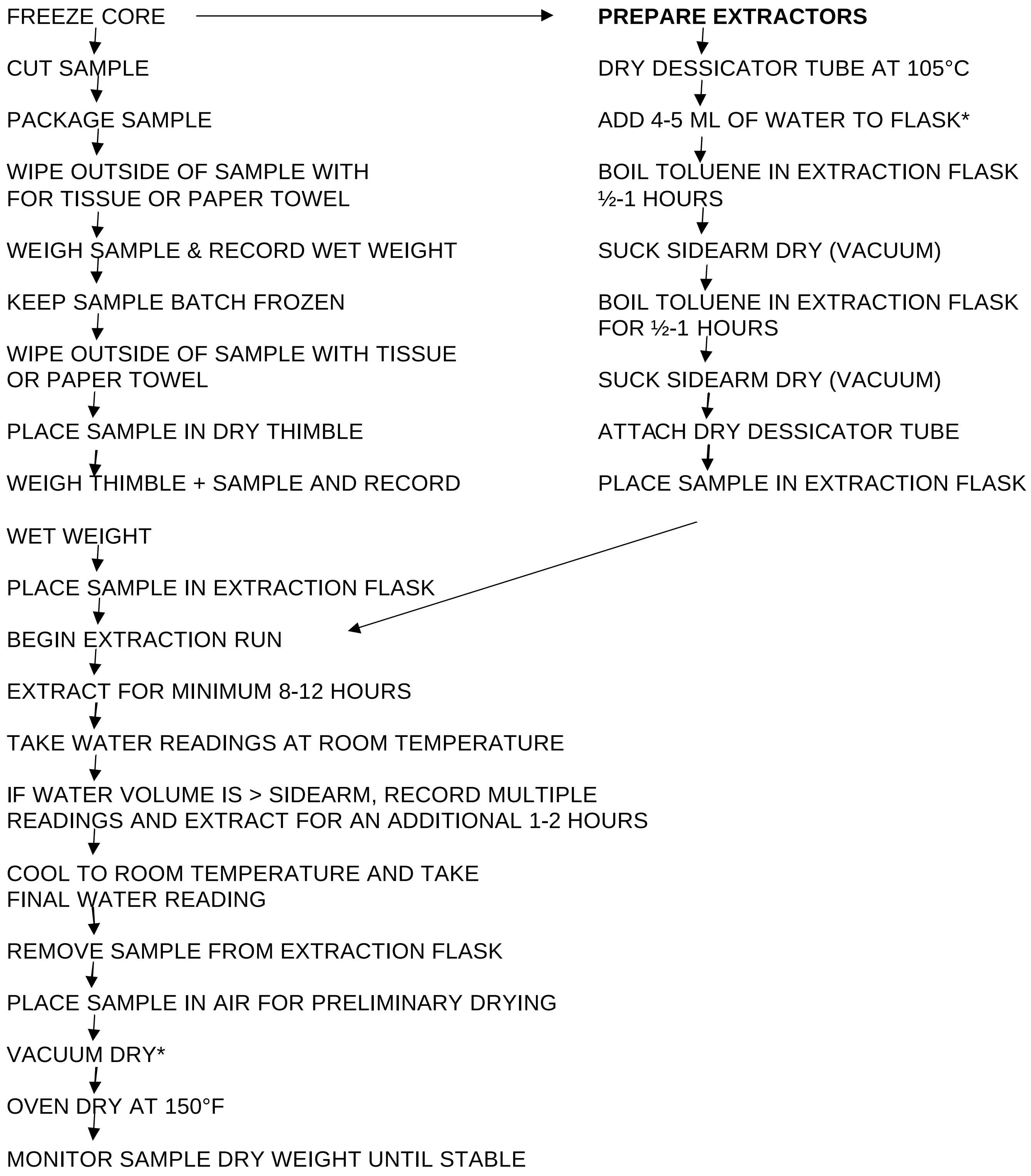
(Method: Dean Stark, API RP 40)

This document covers the standard procedure for extraction and drying of samples for pore fluid saturation determination. ANY deviation must be pre-approved by your Supervisor or Manager BEFORE proceeding. Job or Site specific instructions will take precedent.

1. Obtain samples from specified locations in requested orientation (horizontal or vertical).
2. Package for appropriate test program.
3. Record “WET SAMPLE PACKAGE WEIGHT” on data sheet with date and technician initials.
4. Place sample in dry extraction thimble with tissue on top and bottom of plug.
5. Record “WET SAMPLE + THIMBLE WEIGHT” on data sheet with date and technician initials.
6. Place thimble containing sample in prepared extraction unit with dry tube on condenser.
7. Record “SIDEARM NUMBER” on data sheet with date and technician initials.
8. Extract sample until water production stops.
    a. If water production exceeds sidearm volume, cool extractor, remove and record excess water on data sheet.
    b. Continue extraction until water production stops.
    c. Repeat 8a – 8b until final water reading can be taken without exceeding sidearm volume.
9. Cool extraction unit to room temperature.
10. Remove trapped toluene from sidearm water by adding 2-3 grains of dry soap and “twiddling” using appropriate brass rod.
11. Record final water volume and room temperature on data sheet.
12. Have 2nd technician verify water volume reading and initial data sheet BEFORE sample is removed from extractor.
13. Remove water from sidearm.
14. Remove thimble with sample from extraction unit being careful not to damage thimble.
15. Place thimble with sample in ventilating unit to remove excess toluene for 2-hours.
16. Place thimble with sample in vacuum oven and dry to stable weight.
17. Record weights on “Core Analyses Dry Weight Monitor” sheet with date and technician initials.
    a. Stable weight is +/- 0.01 gm over 4-hour period.
18. Place thimble and sample in “Plug Sample Only” drying oven at 150°F and dry to stable weight.
    a. Stable weight is +/- 0.01 gm over 4-hour period.
19. Record weights on “Core Analyses Dry Weight Monitor” sheet with date and technician initials.
20. Record final “THIMBLE + SAMPLE DRY WEIGHT” on data sheet(s) with date and technician initials.
21. Remove sample from thimble and record final “SAMPLE DRY WEIGHT” on data sheet(s) with date and technician initials.
    a. Note any grain loss in thimble and notify your supervisor BEFORE proceeding to next analysis step.

PORE FLUID SATURATIONS - DISTILLATION EXTRACTION FLOW CHART

(Method: Dean Stark, API RP 40)



FREEZE CORE

CUT SAMPLE

PACKAGE SAMPLE

WIPE OUTSIDE OF SAMPLE WITH
FOR TISSUE OR PAPER TOWEL

WEIGH SAMPLE & RECORD WET WEIGHT

KEEP SAMPLE BATCH FROZEN

WIPE OUTSIDE OF SAMPLE WITH TISSUE
OR PAPER TOWEL

PLACE SAMPLE IN DRY THIMBLE

WEIGH THIMBLE + SAMPLE AND RECORD

WET WEIGHT

PLACE SAMPLE IN EXTRACTION FLASK

BEGIN EXTRACTION RUN

EXTRACT FOR MINIMUM 8-12 HOURS

TAKE WATER READINGS AT ROOM TEMPERATURE

IF WATER VOLUME IS > SIDEARM, RECORD MULTIPLE
READINGS AND EXTRACT FOR AN ADDITIONAL 1-2 HOURS

COOL TO ROOM TEMPERATURE AND TAKE
FINAL WATER READING

REMOVE SAMPLE FROM EXTRACTION FLASK

PLACE SAMPLE IN AIR FOR PRELIMINARY DRYING

VACUUM DRY*

OVEN DRY AT 150°F

MONITOR SAMPLE DRY WEIGHT UNTIL STABLE

PREPARE EXTRACTORS

DRY DESSICATOR TUBE AT 105°C

ADD 4-5 ML OF WATER TO FLASK*

BOIL TOLUENE IN EXTRACTION FLASK
½-1 HOURS

SUCK SIDEARM DRY (VACUUM)

BOIL TOLUENE IN EXTRACTION FLASK
FOR ½-1 HOURS

SUCK SIDEARM DRY (VACUUM)

ATTACH DRY DESSICATOR TUBE

PLACE SAMPLE IN EXTRACTION FLASK

PTS Laboratories
ENVIRONMENTAL SERVICES

PORE FLUID SATURATIONS SOP ATTACHMENTS

(Method: Dean Stark, API RP 40)

Distillation Extraction Method (Dean-Stark); API RP40

Grain density may be calculated from the data obtained during the testing by slight modifications to the method proposed by Hensel, 1982.[1]

The bulk density, sometimes used in various laboratories, may be calculated by dividing the initial (whole) sample weight by the bulk volume.

4.2.2.5 Advantages

Advantages of the sidewall retort procedure include:

a. Gas, oil, and water measurements are made using one sample.
b. The method is relatively rapid.
c. This is a "direct" measurement method where gas, oil, and water measurements are made independently.

4.2.2.6 Limitations

Limitations of the sidewall retort procedure include:

a. The distilled liquids may form emulsions.
b. Oil and water calibration is required.
c. Volumes of oil <0.1 ml are difficult to determine accurately.
d. For very friable or unconsolidated sands the measured gas-filled pore volume may be high due to sample expansion when overburden pressure is released.
e. Samples must be handled carefully to minimize loss of liquids, especially water. In a low humidity atmosphere, water loss may be substantial.
f. Porosity and fluid saturation values can be in error if gypsum or hydratable clays (e.g., montmorillonite) are present and precautions are not taken in recording only "pore" water.
g. Calibration of all equipment is critical because samples are typically small and may contain equally small amounts of oil and water. Minute differences in recorded fluid volumes may result in significant ranges of saturation and porosity values.

4.2.2.7 Accuracy/Precision

Accuracy/precision for the sidewall retort procedure is:

a. The method's accuracy is strongly dependent on sample size, especially when determining oil volumes.
b. Analytical discretion should be used on testing samples with an initial weight of less than 3 grams.
c. By using oil volume correction curves, the precision of the oil value obtained is within ±5 percent of the measured volumes.
d. The precision of the water volumes is within ±3 percent of the measured volumes.

4.2.2.8 Calibration

Refer to 4.2.1.8 of the basic retort procedure.

4.3 DISTILLATION EXTRACTION METHOD (DEAN STARK)

4.3.1 Plug Samples

4.3.1.1 Principles of Analysis

This procedure is appropriate for plug samples and for rotary sidewall cores. The distillation extraction (Dean-Stark) method of determining fluid saturation depends upon the distillation of the water fraction, and the solvent extraction of the oil fraction from the sample. The sample is weighed and the water fraction is vaporized by boiling solvent. The water is condensed and collected in a calibrated receiver. Vaporized solvent also condenses, soaks the sample, and extracts the oil. The sample is oven dried and weighed. The oil content is determined by gravimetric difference.

4.3.1.2 Apparatus and Reagents

The following apparatus is suitable for this method and is illustrated in Figure 4-4. The apparatus should be set up in a fume hood or room suitable for exhausting solvent vapors.

a. General—The apparatus consists of an electric mantle or heating device with thermostatic controls. The distillation/extraction unit for one sample consists of a boiling flask, thimble, trap or calibrated sidearm, and condenser.
b. Flask—The flask is wide-mouthed, long-necked, and may contain indentations at the base of the neck to support the extraction thimble.
c. Trap—The trap or sidearm has a graduated section marked in 0.1 ml divisions. The graduated trap can be made smaller or larger to accommodate samples with very small or very large water volumes. Attached to the graduated section is a glass tube or arm that is bent at a right angle with a glass joint on the end. The glass joint has a drip tip molded on it and the opening in the tip should be designed so that the dripping solvent is directed in the center of the flask to ensure soaking of the core plug below. A modification to the trap (Figure 4-5) enables the water to be determined gravimetrically.
d. Condenser—The condenser is a water-cooled, reflux, glass-tube type, with a condenser jacket approximately 11.8 inches (300 millimeters) long and an inner tube (see Figure 4-4). The bottom is fitted with a drip tip and the inside tube should be vertical to reduce the difficulty of removing water from the surfaces of the condenser and trap.
e. Desiccant holder—A glass tube desiccant holder is fitted to the top of the condenser when samples are being extracted and a rubber stopper is used when the apparatus is idle.
f. Extraction thimbles—A glass thimble with a fritted glass bottom is recommended for holding a plug sample. Alternatively, a cellulose thimble may be used. However, types of thimble materials other than glass may cause errors in weighing because of absorption of atmospheric water. Also, thimbles made of glass allow viewing of the plug to ensure

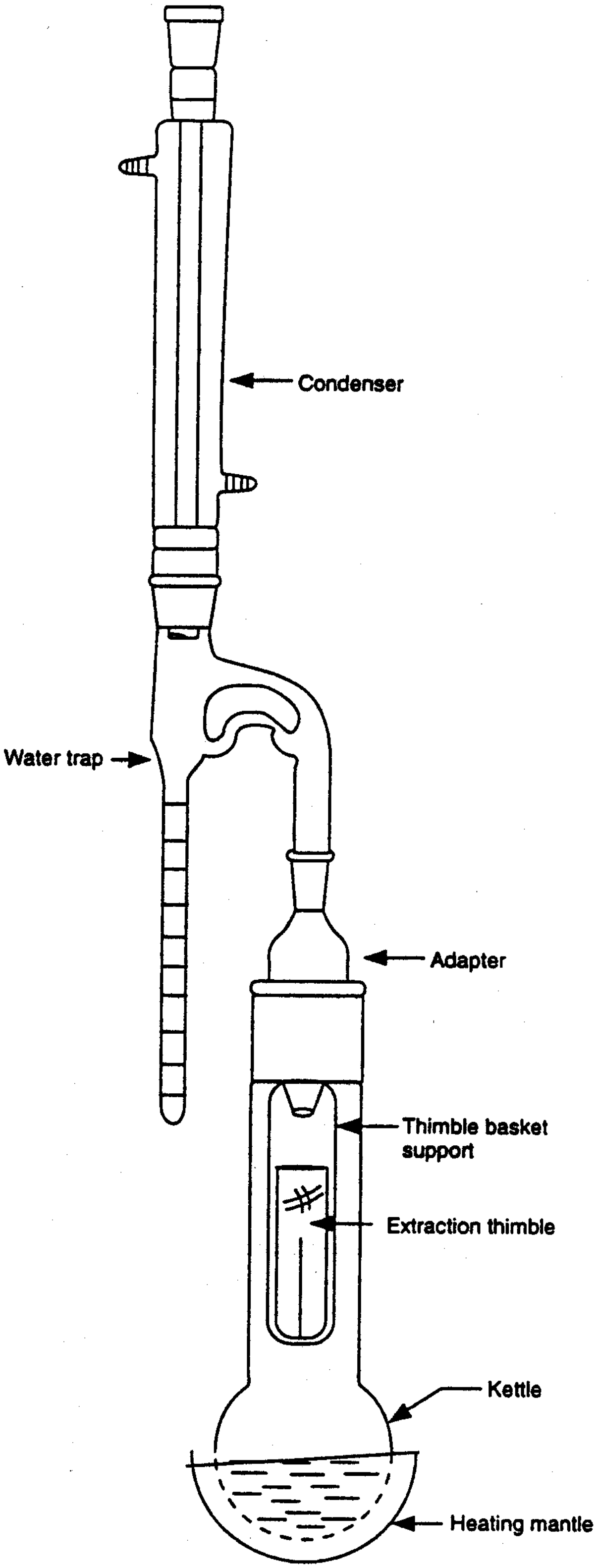


Figure 4-4—Dean-Stark Apparatus for Volumetric Determination of Water

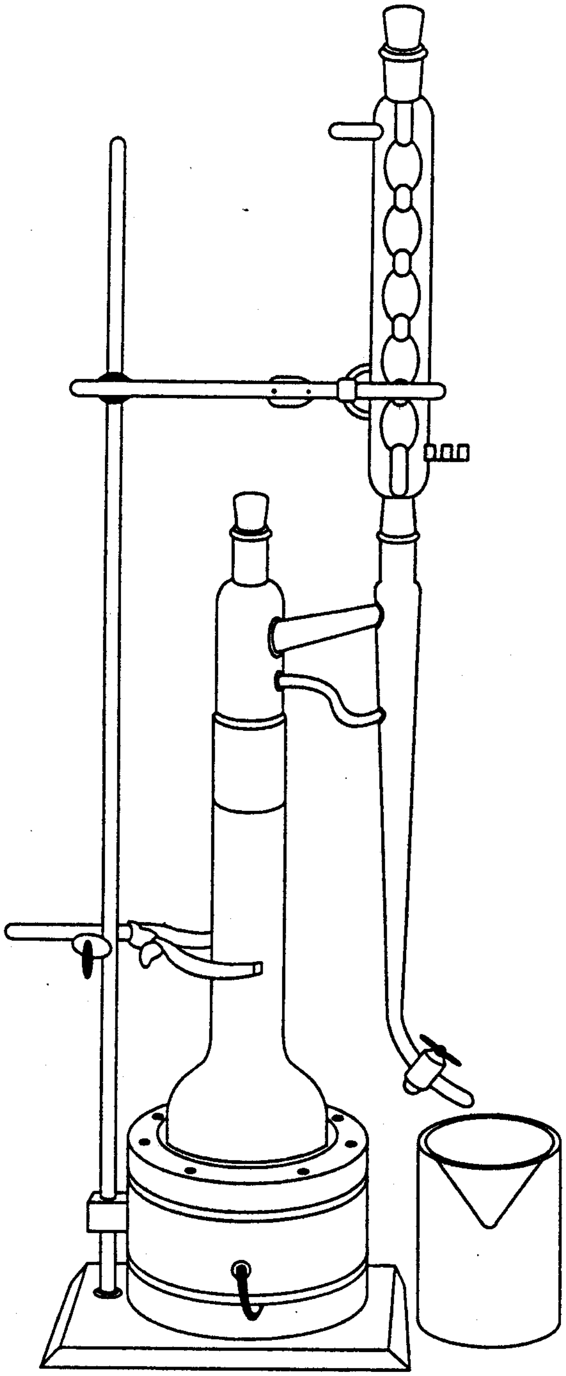


Figure 4-5—Dean-Stark Extraction Apparatus for Gravimetric Determination of Water

that the solvent is dripping and soaking the sample for thorough extraction. A small piece of glass wool may be used to cover the core plug to prevent erosion by the solvent reflux from the condenser.

g. Extraction cup—Cups fitted with siphons can be used to hold the thimbles and allow alternating immersion/drainage cycles. This can increase the efficiency of the extraction process.

h. Drying oven—A convection or vacuum oven may be used having a temperature control of ±2°C. An explosion-proof model is preferred, but non-explosion proof models can be used. For samples containing large amounts of montmorillonite and other clays, a humidity oven can be used to help preserve a single or double water layer to better approximate the expected hydration state of the clays in the reservoir. (Humidity levels during drying procedures are important in maintaining proper waters of hydration.)

i. Boiling chips—Glass beads or small chips of alundum material may be placed in the bottom of the boiling flask. These aid in reducing the tendency of the solvent to "bump" as it becomes more saturated with oil. If bumping or super heating occurs it creates an undesirable boiling process, contaminating the sample and extending the time required for the initial phase of the distillation extraction process.

j. Solvent—Toluene (reagent grade) or other suitable solvent.

4.3.1.3 Procedures/Precautions

4.3.1.3.1 Procedures

The samples are prepared using a fluid that is compatible with the fluid used to cut the whole core or drilled sidewall cores in the well. This ensures the preservation of residual oil or water saturation depending on the use of oil or water-based fluid. In the case of frozen oil sands samples, liquid nitrogen should be used. The excess fluid remaining on the sample after the trimming of the ends should be wiped off using a material that will remove the surface fluid but will not pull fluid from the interior in a sponge-like manner. This process is best described as a squeegee action. The sample's surface should appear dry (with a dull luster) and not shiny with excess fluid. The thimble/plug sample should be weighed to the nearest milligram (0.001 gram) on an analytical balance. The process should be accomplished quickly to minimize evaporation of the fluids in the sample. After final weighing, the samples and/or thimbles should be placed in the apparatus immediately, or should be stored in a container to prevent evaporation until they are placed in the apparatus. This storage period should be kept to a minimum. The necessity for weighing each component is to ensure complete accountability for weight loss. When extraction thimbles are used they should be at room temperature and thoroughly dry.

The samples are extracted with a solvent that does not donate to or absorb any of the collected water. Solvent conditioning can be provided by adding at least 1 percent water by volume to the solvent and pre-boiling the solvent until the water concentration is stable. Some laboratories add 15 percent water by volume to the solvent. Water should be in excess of the amount required to bring common solvents into equilibrium when the water is boiled away.

The desiccant trap ensures that atmospheric moisture (humidity) does not affect the water collected.

Water can adhere to the condenser and to the side of the trap. This fluid may cause appreciable error, particularly for a plug sample of low porosity. The adhered water is dislodged with a stiff solvent stream from a laboratory squirt bottle or a small gauge wire with a very small loop at the end. The wire is used to physically dislodge water particles that are not removed by the stream of solvent. Detergent is sometimes used to flatten the solvent/water interface for improved accuracy; but the use of detergent is not generally recommended because the effects of three phase fluid interaction are unpredictable and the wettability of the sample will be altered.

The distillation/extraction process continues for a minimum of 48 hours. Water levels should be monitored daily and the process stopped only when there is no change in volume of water recovered in 24 hours. Longer times may be required depending on the size of the plug sample and its permeability. This is to ensure that the solvent used has extracted all the oil possible from the plug material. Where heavy oil (low-gravity, high-asphaltene) is involved, another solvent type (see 3.1) is required to thoroughly clean the plug. A complete record of the volumes of water collected should be noted. The rate of extraction and efficiency may be increased by using extraction cups equipped with siphons. Alternative methods that speed extraction involve using the described apparatus until the amount of water collected is at a stable end point, and then doing one of the following with the samples and the thimbles:

a. Place the samples in a vapor phase unit to complete the oil extraction.

b. Place the samples in a CO_2-toluene pressure core cleaner to complete the oil extraction. This should be restricted to competent, low-permeability samples that will not be physically altered by this process.

c. Place the sample in a Soxhlet extractor for alternating immersion and drainage type oil extraction.

d. Place the sample in a flow-through oil extraction apparatus.

e. Alternate between solvent types (e.g., toluene and methanol).

The extraction efficiency is evaluated by treating the sample with chlorothene under an ultraviolet light source to determine if there is any remaining oil, that fluoresces, or by measuring the grain density of the sample. If the grain density is lower than anticipated for the rock type, the sample may need further extraction.

The sample/thimble should then be dried to a stable weight. Samples with high saturations of flammable solvents should be dried in an explosion-proof convection or vacuum oven, unless the excess solvent is allowed to evaporate before being put into the oven. This avoids a potential explosion or fire situation. When the sample/thimble is dried, it should be allowed to cool to room temperature in a sealed container such as a desiccator and the weighed. An oven that adds moisture to the sample should not be used for this step. However, when porosity and permeability will be measured, samples containing large amounts of montmorillonite and other clays may need to be dried in a humidity oven to preserve the hydrated state found in the reservoir. (The humidity level in the oven is important in maintaining proper waters of hydration for measuring permeability and porosity.)

Errors occur by not accounting for a chipped thimble, the core losing small particles, and/or the loss on the sample surface of precipitated salt from concentrated brines. In the case where heavy salt precipitation occurs, the salt is removed from the sample by extraction with methanol or similar solvent. The sample is then dried and weighed. The weight of water collected in the trap is subtracted from the total liquid weight loss to determine the oil weight extracted from the plug sample.

Proper water flow in the condenser will maintain a condenser temperature sufficiently cool so that the vapors condense in the bottom third of the condenser column.

4.3.1.3.2 Precautions

Local regulations regarding the safe use of reagents should be followed. In general, however, the following safety considerations should be noted:

a. Oil may contain compounds exhibiting carcinogenic properties. It may be flammable.

b. Toluene is moderately toxic by skin absorption and inhalation. It possesses irritant and anesthetic properties and is highly flammable.

c. Many other solvents, while effective for the oil removal process, may be dangerous and toxic. Consult relevant environmental regulations and local laws governing the use of these solvents.

d. Solvent vapors should condense in the lower third of the water-cooled heat exchanger on top of the water trap.

e. The analyst should be aware of the change in solvent boiling point with altitude or the change in the water boiling point due to salt in solution. The solvent's boiling point should be checked to ensure an adequate temperature for water distillation. When KCl drilling fluids are used, the filtrate water will have salt concentration on the order of 300,000 ppm, and, consequently, boil at a much higher temperature than fresher water. The use of orthoxylene is suggested as a substitute for toluene in these cases.

4.3.1.4 Calculations

The following calculations are appropriate for this method:

$$\text{Weight \% Water (Gravimetric)} = \frac{(\text{Weight of Water}) \times 100}{(\text{Initial Sample Weight})} \qquad (1)$$

or

$$\text{Weight \% Water (Volumetric)} = \frac{(\text{Volume of Water}) \times (\text{Density of Water}) \times 100)}{\text{Initial Sample Weight}}$$

$$\text{Weight \% Solids (Gravimetric)} = \frac{\text{Dry Weight of Sample} \times 100}{\text{Initial Sample Weight}} \qquad (2)$$

$$\text{Weight \% Oil (Gravimetric)} = \qquad (3)$$

$$\frac{(\text{Initial Weight} - \text{Dry Weight} - \text{Weight of Water}) \times 100}{\text{Initial Weight of Sample}}$$

The saturations are normally expressed as percentages of the sample pore space. Therefore, the sample porosity, water density, and oil density are required. If the connate water is a highly concentrated salt solution, the water density must be corrected for the salt in solution.

The following calculations apply:

$$\text{\% Water} = \frac{\text{Volume of Water} \times 100}{\text{Pore Volume}} \qquad (4)$$

$$\text{\% Oil} = \frac{(\text{Weight of Oil})/(\text{Density of Oil}) \times 100}{\text{Pore Volume}} \qquad (5)$$

The liquid content of the sample is reported to the nearest 0.1 percent of the pore space; e.g., 22.1 percent oil and 43.7 percent water.

Knowing the brine salinity and density, one can calculate volume of brine that was in the core from the volume of distilled water recovered as follows:

$$Vbr = [(Vw)(\rho_w)/\rho_b]\,[1{,}000{,}000/(1{,}000{,}000 - Cs)] \qquad (6)$$

Where:

Vbr = volume of brine corresponding to the volume of distilled water collected from the plug, cm^3.

Vw = volume of distilled water collected from the plug (e.g., Dean-Stark), cm^3.

ρ_w = density of distilled water, g/cm^3.

ρ_b = density of lease brine having a concentration C_s of salt, g/cm^3.

C_s = concentration of dissolved salts in lease brine, =

$$\frac{(1{,}000{,}000)(\text{Weight of Salt})}{(\text{Weight of Brine})}\,\text{ppm}$$

4.3.1.5 Advantages

Advantages of this method include:

a. Water volume determinations are generally very accurate.

b. Typically, the sample is not damaged and can be used for further testing. However, the wettability may be altered and certain clays (e.g., montmorillonite) or gypsum may also be subject to change.

c. Relatively low temperatures [212°F (100°C)] are used; hence, little if any of the clay hydroxyl waters are removed.

d. The procedure is simple and requires little attention during distillation.

4.3.1.6 Limitations

Limitations of this method include:

a. Inaccuracies arise in the water determination due to the following:

1. Atmospheric water condenses in the condenser when atmospheric humidity is high. Desiccant tubes can be used to avoid the problem.
2. Water evaporates from the sample at room temperature when it is not immediately set up in the extractor with the condenser water circulating.
3. Water droplets stick to unclean glass in the sidearm or condenser.
4. Salt may precipitate inside the sample from connate brines (saline interstitial water). This can result in significant changes in porosity and/or permeability. Salt can be removed from the sample with methanol extraction.
5. Correction for the higher density of salt water is required when the total solids concentration exceeds 20,000 ppm (see 4.3.1.4, Equation 5).
6. Incomplete drying of solvents.
7. Loss of water due to the joints of the extraction flask not being vapor tight, or from too high an extraction temperature, or from insufficient water flow in the condenser.
8. The density of air must be considered for buoyancy only when the sample is weighed to the nearest 0.1 mg.
9. Extraction time may be insufficient.
10. Water saturation may be too high if samples contain large amounts of gypsum (see 4.8) or montmorillonite clays (water of hydration). Permeability and porosity values can also be altered if waters of hydration that are present in the reservoir are removed during extraction and drying procedures (humidity oven drying may be preferred).
11. If the true oil density is not known, error is introduced into the calculation of oil saturation because an oil density value must be assumed.

b. Oil volumes are not found directly and may be inaccurate due to the following:

1. Additional water collected or lost from the sample as mentioned above.
2. Loss of solids.
3. Incomplete cleaning of oil.
4. Drying at a higher temperature than the extraction temperature may remove additional water of hydration and overstate the oil volume.

c. Rock wettability may be altered.

d. The clay fabric may be altered, that may result in inaccurate permeability measurements.

e. There is no check on the analysis accuracy.

4.3.1.7 Accuracy/Precision

There are no documented standards and the accuracy of the methods cannot be assessed. However, with the calibration procedures noted in 4.3.1.8, water volume reproducibility can be evaluated. Similar procedures assess oil volume accuracy. On relatively small samples or samples containing high gas saturation with residual volumes of oil and water, the percent error for liquid saturations may be ±50 percent of values measured. Percent error will be significantly less as liquid volumes increase.

4.3.1.8 Calibration

The water measurement accuracy should be checked regularly to be sure no bias affects the results.

a. For gravimetric determination—Known weights of water added to the extractors are plotted against the weights of water recovered by extraction under conditions identical to those used in extracting an oil sand sample. The water correction factors may change due to the efficiency of the condensers used in the apparatus. Typical values are listed below:

$$\text{Corrected Weight Water} = (\text{Weight Water} \times a) + b$$

Where: a and b, respectively, are the slope and intercept of the calibration equation, that is, $a = 1.003, \pm 0.001$; $b = 0.090, \pm 0.009$.

b. For volumetric determination—A calibrated buret is used to deliver known volumes of water into the water trap. The traps should have a maximum scale error of 0.02 ml. Volume correction factors can be calculated and applied, if necessary.

4.3.2 Full Diameter Cores

4.3.2.1 Principles of Analysis

The distillation extraction method of determining fluid saturations for full diameter samples is governed by the same principles and procedures as those for plug samples (see 4.3.1.1). Differences in the procedure and apparatus are discussed below.

FREE PRODUCT (NAPL) MOBILITY - CENTRIFUGAL METHOD PROCEDURE

(Method: ASTM D425M-88)

Purpose

The purpose of this test is to demonstrate whether NAPL present in a soil is mobile and if so, what is the residual saturation after mobile NAPL is removed from the soil. ASTM Method D425 is used to provide a starting point for the methodology and is chosen because it is relatively simple, has widespread usage, and 1000 X Gravity when applied for one hour is a conservative value for driving a sample to a residual saturation.

Method Summary

Free product (NAPL) mobility of soils is determined by inserting undisturbed (native-state) samples into Beckman type PIR 16.5 rotor and standard rock (soil) core buckets (centrifuge cups) and centrifuging for 1 hour at a force equal to 1000 times that of gravity at a controlled temperature of 20 ± 1°C. Fluids produced during centrifuging and collected and volumes measured. Residual fluid saturations are determined by Dean-Stark extraction and sample properties determined at completion of the centrifuge run.

Sample Preparation

The core is maintained in frozen condition to preserve water and NAPL saturations.

A one and one-half inch (1-1/2") diameter sample is cut from core selected by CLIENT COMPANY personnel for free product mobility; residual, and initial saturation analyses. The sample is cut parallel to core axis (vertical) and tested in native-state condition.

A flexible Teflon jacket and stainless steel end screens are applied to the sample.

Free Product (NAPL) Mobility

Following cutting and packaging, the sample is allowed to thaw and is then loaded into a centrifuge cup for free product mobility evaluation. A centrifugal force of 1000 times gravity is applied to the sample for one hour (ASTM D425M). The sample is monitored for mobile NAPL (produced NAPL) and water production.

a. Record volume of any NAPL produced.
b. Record volume of any water produced.
c. Record all visual observations of sample behavior and produced fluids.
d. OPTIONAL: Samples may be centrifuged under water instead of air.

Sample Properties

Following spinning at 1000 X G for one hour, the sample is removed from the centrifuge cup and extracted with toluene (Dean-Stark method) for residual saturations (fluid saturation confirmation). Initial saturations are determined by material balance (fluid summation). Following Dean-Stark extraction, the sample is dried to stable weight and sample properties (porosity, dry bulk density, and grain density) determined.

Reporting

Data is reported in tabular format and can be presented in an EDD format.

FREE PRODUCT (NAPL) MOBILITY - CENTRIFUGAL METHOD PROCEDURE

(Method: ASTM D425M-88)

Modifications to ASTM D425

1.1 Covers determination of residual saturation and NAPL mobility by centrifuge method.
1.2 This test uses *undisturbed* specimens of rock or soil.
4.1 Residual saturation determination is conducted on a native-state (undisturbed) sample by centrifuging for 1 h at a force equal to 1000 times that of gravity at a controlled temperature of 20 ± 1°C. Fluids produced are monitored for mobility evaluation and material balance calculations.
5.2 When water and NAPL are present in a sample, the centrifuge moisture equivalent approximates conservative residual saturations for water and NAPL.
6.1-6.3 Beckman type PIR 16.5 rotor and standard rock (soil) core buckets (centrifuge cups) are used for centrifuging samples.
6.6-6.10 The samples are tested in undisturbed condition and Dean-Stark extraction method (API RP40) is used to determine residual saturations.
7.1-7.2 The samples are tested in undisturbed condition. A 1-1/2”dia. x 2” long sample is used.
8.1 A native-state (undisturbed) sample is placed in the centrifuge cup for centrifuging.
8.4 Immediately after centrifuging, the volume or mass of fluids produced is recorded and the sample is weighed and placed in the Dean-Stark extraction vessel. Following Dean-Stark extraction, bulk density and porosity are determined.
9.1 The test may be performed on only one sample due to core or material availability constraints.
10.1.2 Post-centrifuging residual saturations and pre-centrifuging initial saturations are reported as pore fluid saturations, percent pore volume.

Ultracentrifuge with rotor and standard rock (soil) core buckets.

Gas Works Park
Northeast Corner Investigation

Data Report

Appendix E
Waste Profiling Chemical Analysis Results

CCI
ANALYTICAL
LABORATORIES
A Division of DataChem Laboratories, Inc.

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER 601 UNION STREET SUITE 600 SEATTLE, WA 98101	DATE:	9/19/2007
		CCIL JOB #:	0709087
		DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:00 FS DRUM 1
CCIL SAMPLE #: -01

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
Benzene	EPA-8021	0.82	MG/KG	9/18/2007	DLC
Toluene	EPA-8021	ND(<0.5)	MG/KG	9/18/2007	DLC
Ethylbenzene	EPA-8021	5.5	MG/KG	9/18/2007	DLC
Xylenes	EPA-8021	2.0	MG/KG	9/18/2007	DLC
TPH-Diesel Range	NWTPH-DX	790	MG/KG	9/18/2007	EBS
TPH-Oil Range	NWTPH-DX	690	MG/KG	9/18/2007	EBS
Pyridine	EPA-8270	ND(<10000)	UG/KG	9/19/2007	RAL
N-Nitrosodimethylamine	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Phenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Aniline	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Bis(2-Chloroethyl)Ether	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2-Chlorophenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
1,3-Dichlorobenzene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
1,4-Dichlorobenzene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Benzyl Alcohol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
1,2-Dichlorobenzene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2-Methylphenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Bis(2-Chloroisopropyl)Ether	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
4-Methylphenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
N-Nitroso-Di-N-Propylamine	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Hexachloroethane	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Nitrobenzene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Isophorone	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2-Nitrophenol	EPA-8270	ND(<13000)	UG/KG	9/19/2007	RAL
2,4-Dimethylphenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Benzoic Acid	EPA-8270	ND(<50000)	UG/KG	9/19/2007	RAL
Bis(2-Chloroethoxy)Methane	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2,4-Dichlorophenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
1,2,4-Trichlorobenzene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Naphthalene	EPA-8270	29000	UG/KG	9/19/2007	RAL
4-Chloroaniline	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2,6-Dichlorophenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Hexachlorobutadiene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
4-Chloro-3-Methylphenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL

CERTIFICATE OF ANALYSIS

CLIENT: FLOYD SNIDER
601 UNION STREET SUITE 600
SEATTLE, WA 98101

DATE: 9/19/2007
CCIL JOB #: 0709087
DATE RECEIVED: 9/18/2007
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:00 FS DRUM 1
CCIL SAMPLE #: -01

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
2-Methylnaphthalene	EPA-8270	14000	UG/KG	9/19/2007	RAL
1-Methylnaphthalene	EPA-8270	6400	UG/KG	9/19/2007	RAL
Hexachlorocyclopentadiene	EPA-8270	ND(<25000)	UG/KG	9/19/2007	RAL
2,4,6-Trichlorophenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2,4,5-Trichlorophenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2-Chloronaphthalene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2-Nitroaniline	EPA-8270	ND(<13000)	UG/KG	9/19/2007	RAL
Acenaphthylene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Dimethylphthalate	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2,6-Dinitrotoluene	EPA-8270	ND(<13000)	UG/KG	9/19/2007	RAL
Acenaphthene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
3-Nitroaniline	EPA-8270	ND(<13000)	UG/KG	9/19/2007	RAL
2,4-Dinitrophenol	EPA-8270	ND(<25000)	UG/KG	9/19/2007	RAL
4-Nitrophenol	EPA-8270	ND(<25000)	UG/KG	9/19/2007	RAL
Dibenzofuran	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
2,4-Dinitrotoluene	EPA-8270	ND(<13000)	UG/KG	9/19/2007	RAL
2,3,4,6-Tetrachlorophenol	EPA-8270	ND(<13000)	UG/KG	9/19/2007	RAL
Diethylphthalate	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Fluorene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
4-Chlorophenyl-Phenylether	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
4-Nitroaniline	EPA-8270	ND(<13000)	UG/KG	9/19/2007	RAL
4,6-Dinitro-2-Methylphenol	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
N-Nitrosodiphenylamine	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Azobenzene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
4-Bromophenyl-Phenylether	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Hexachlorobenzene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Pentachlorophenol	EPA-8270	ND(<2500)	UG/KG	9/19/2007	RAL
Phenanthrene	EPA-8270	13000	UG/KG	9/19/2007	RAL
Anthracene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Carbazole	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Di-N-Butylphthalate	EPA-8270	ND(<6500)	UG/KG	9/19/2007	RAL
Fluoranthene	EPA-8270	54000	UG/KG	9/19/2007	RAL
Pyrene	EPA-8270	69000	UG/KG	9/19/2007	RAL
Butylbenzylphthalate	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
3,3'-Dichlorobenzidine	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL

CERTIFICATE OF ANALYSIS

CLIENT: FLOYD SNIDER
601 UNION STREET SUITE 600
SEATTLE, WA 98101

DATE: 9/19/2007
CCIL JOB #: 0709087
DATE RECEIVED: 9/18/2007
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:00 FS DRUM 1
CCIL SAMPLE #: -01

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
Benzo[A]Anthracene	EPA-8270	19000	UG/KG	9/19/2007	RAL
Chrysene	EPA-8270	23000	UG/KG	9/19/2007	RAL
Bis(2-Ethylhexyl)Phthalate	EPA-8270	ND(<6500)	UG/KG	9/19/2007	RAL
Di-N-Octylphthalate	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Benzo[B]Fluoranthene	EPA-8270	24000	UG/KG	9/19/2007	RAL
Benzo[K]Fluoranthene	EPA-8270	16000	UG/KG	9/19/2007	RAL
Benzo[A]Pyrene	EPA-8270	25000	UG/KG	9/19/2007	RAL
Indeno[1,2,3-Cd]Pyrene	EPA-8270	18000	UG/KG	9/19/2007	RAL
Dibenz[A,H]Anthracene	EPA-8270	ND(<5000)	UG/KG	9/19/2007	RAL
Benzo[G,H,I]Perylene	EPA-8270	22000	UG/KG	9/19/2007	RAL
Arsenic	EPA-6010	ND(<5.0)	MG/KG	9/18/2007	CEO
Cadmium	EPA-6010	ND(<1.0)	MG/KG	9/18/2007	CEO
Chromium	EPA-6010	30	MG/KG	9/18/2007	CEO
Lead	EPA-6010	14	MG/KG	9/18/2007	CEO
Mercury	EPA-7471	0.07	MG/KG	9/18/2007	CEO

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCT WHICH IS LIKELY BUNKER C OR SIMILAR PRODUCT.

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES.

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

APPROVED BY:

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER 601 UNION STREET SUITE 600 SEATTLE, WA 98101	DATE:	9/19/2007
		CCIL JOB #:	0709087
		DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:05 FS DRUM 2
CCIL SAMPLE #: -02

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
Benzene	EPA-8021	ND(<0.15)	MG/KG	9/18/2007	DLC
Toluene	EPA-8021	ND(<0.25)	MG/KG	9/18/2007	DLC
Ethylbenzene	EPA-8021	0.33	MG/KG	9/18/2007	DLC
Xylenes	EPA-8021	0.72	MG/KG	9/18/2007	DLC
TPH-Diesel Range	NWTPH-DX	6600	MG/KG	9/18/2007	EBS
TPH-Oil Range	NWTPH-DX	1600	MG/KG	9/18/2007	EBS
Pyridine	EPA-8270	ND(<8000)	UG/KG	9/19/2007	RAL
N-Nitrosodimethylamine	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Phenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Aniline	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Bis(2-Chloroethyl)Ether	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2-Chlorophenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
1,3-Dichlorobenzene	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
1,4-Dichlorobenzene	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Benzyl Alcohol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
1,2-Dichlorobenzene	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2-Methylphenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Bis(2-Chloroisopropyl)Ether	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
4-Methylphenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
N-Nitroso-Di-N-Propylamine	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Hexachloroethane	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Nitrobenzene	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Isophorone	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2-Nitrophenol	EPA-8270	ND(<10000)	UG/KG	9/19/2007	RAL
2,4-Dimethylphenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Benzoic Acid	EPA-8270	ND(<40000)	UG/KG	9/19/2007	RAL
Bis(2-Chloroethoxy)Methane	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2,4-Dichlorophenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
1,2,4-Trichlorobenzene	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Naphthalene	EPA-8270	18000	UG/KG	9/19/2007	RAL
4-Chloroaniline	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2,6-Dichlorophenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Hexachlorobutadiene	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
4-Chloro-3-Methylphenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER 601 UNION STREET SUITE 600 SEATTLE, WA 98101	DATE:	9/19/2007
		CCIL JOB #:	0709087
		DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:05 FS DRUM 2
CCIL SAMPLE #: -02

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
2-Methylnaphthalene	EPA-8270	12000	UG/KG	9/19/2007	RAL
1-Methylnaphthalene	EPA-8270	18000	UG/KG	9/19/2007	RAL
Hexachlorocyclopentadiene	EPA-8270	ND(<20000)	UG/KG	9/19/2007	RAL
2,4,6-Trichlorophenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2,4,5-Trichlorophenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2-Chloronaphthalene	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2-Nitroaniline	EPA-8270	ND(<10000)	UG/KG	9/19/2007	RAL
Acenaphthylene	EPA-8270	11000	UG/KG	9/19/2007	RAL
Dimethylphthalate	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2,6-Dinitrotoluene	EPA-8270	ND(<10000)	UG/KG	9/19/2007	RAL
Acenaphthene	EPA-8270	8200	UG/KG	9/19/2007	RAL
3-Nitroaniline	EPA-8270	ND(<10000)	UG/KG	9/19/2007	RAL
2,4-Dinitrophenol	EPA-8270	ND(<20000)	UG/KG	9/19/2007	RAL
4-Nitrophenol	EPA-8270	ND(<20000)	UG/KG	9/19/2007	RAL
Dibenzofuran	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
2,4-Dinitrotoluene	EPA-8270	ND(<10000)	UG/KG	9/19/2007	RAL
2,3,4,6-Tetrachlorophenol	EPA-8270	ND(<10000)	UG/KG	9/19/2007	RAL
Diethylphthalate	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Fluorene	EPA-8270	17000	UG/KG	9/19/2007	RAL
4-Chlorophenyl-Phenylether	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
4-Nitroaniline	EPA-8270	ND(<10000)	UG/KG	9/19/2007	RAL
4,6-Dinitro-2-Methylphenol	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
N-Nitrosodiphenylamine	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Azobenzene	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
4-Bromophenyl-Phenylether	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Hexachlorobenzene	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Pentachlorophenol	EPA-8270	ND(<20000)	UG/KG	9/19/2007	RAL
Phenanthrene	EPA-8270	87000	UG/KG	9/19/2007	RAL
Anthracene	EPA-8270	24000	UG/KG	9/19/2007	RAL
Carbazole	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Di-N-Butylphthalate	EPA-8270	ND(<5200)	UG/KG	9/19/2007	RAL
Fluoranthene	EPA-8270	160000	UG/KG	9/19/2007	RAL
Pyrene	EPA-8270	200000	UG/KG	9/19/2007	RAL
Butylbenzylphthalate	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
3,3'-Dichlorobenzidine	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER	DATE:	9/19/2007
	601 UNION STREET SUITE 600	CCIL JOB #:	0709087
	SEATTLE, WA 98101	DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:05 FS DRUM 2
CCIL SAMPLE #: -02

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
Benzo[A]Anthracene	EPA-8270	54000	UG/KG	9/19/2007	RAL
Chrysene	EPA-8270	67000	UG/KG	9/19/2007	RAL
Bis(2-Ethylhexyl)Phthalate	EPA-8270	ND(<5200)	UG/KG	9/19/2007	RAL
Di-N-Octylphthalate	EPA-8270	ND(<4000)	UG/KG	9/19/2007	RAL
Benzo[B]Fluoranthene	EPA-8270	54000	UG/KG	9/19/2007	RAL
Benzo[K]Fluoranthene	EPA-8270	42000	UG/KG	9/19/2007	RAL
Benzo[A]Pyrene	EPA-8270	69000	UG/KG	9/19/2007	RAL
Indeno[1,2,3-Cd]Pyrene	EPA-8270	48000	UG/KG	9/19/2007	RAL
Dibenz[A,H]Anthracene	EPA-8270	12000	UG/KG	9/19/2007	RAL
Benzo[G,H,I]Perylene	EPA-8270	60000	UG/KG	9/19/2007	RAL
Arsenic	EPA-6010	16	MG/KG	9/18/2007	CEO
Cadmium	EPA-6010	ND(<1.0)	MG/KG	9/18/2007	CEO
Chromium	EPA-6010	22	MG/KG	9/18/2007	CEO
Lead	EPA-6010	55	MG/KG	9/18/2007	CEO
Mercury	EPA-7471	0.08	MG/KG	9/18/2007	CEO

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCTS WHICH ARE LIKELY DIESEL FUEL AND LUBE OIL.

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES.

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

APPROVED BY:

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER	DATE:	9/19/2007
	601 UNION STREET SUITE 600	CCIL JOB #:	0709087
	SEATTLE, WA 98101	DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT:	KATE SNIDER
CLIENT PROJECT ID:	GAS WORKS NE CORNER
CLIENT SAMPLE ID:	9/18/2007 9:10 ENSR DRUM 1
CCIL SAMPLE #:	-03

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
Benzene	EPA-8021	0.08	MG/KG	9/18/2007	DLC
Toluene	EPA-8021	0.06	MG/KG	9/18/2007	DLC
Ethylbenzene	EPA-8021	0.08	MG/KG	9/18/2007	DLC
Xylenes	EPA-8021	0.34	MG/KG	9/18/2007	DLC
TPH-Diesel Range	NWTPH-DX	110	MG/KG	9/18/2007	EBS
TPH-Oil Range	NWTPH-DX	130	MG/KG	9/18/2007	EBS
Pyridine	EPA-8270	ND(<200)	UG/KG	9/19/2007	RAL
N-Nitrosodimethylamine	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Phenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Aniline	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Bis(2-Chloroethyl)Ether	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
2-Chlorophenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
1,3-Dichlorobenzene	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
1,4-Dichlorobenzene	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Benzyl Alcohol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
1,2-Dichlorobenzene	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
2-Methylphenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Bis(2-Chloroisopropyl)Ether	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
4-Methylphenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
N-Nitroso-Di-N-Propylamine	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Hexachloroethane	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Nitrobenzene	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Isophorone	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
2-Nitrophenol	EPA-8270	ND(<250)	UG/KG	9/19/2007	RAL
2,4-Dimethylphenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Benzoic Acid	EPA-8270	ND(<1000)	UG/KG	9/19/2007	RAL
Bis(2-Chloroethoxy)Methane	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
2,4-Dichlorophenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
1,2,4-Trichlorobenzene	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Naphthalene	EPA-8270	2400	UG/KG	9/19/2007	RAL
4-Chloroaniline	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
2,6-Dichlorophenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Hexachlorobutadiene	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
4-Chloro-3-Methylphenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL

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CERTIFICATE OF ANALYSIS

CLIENT: FLOYD SNIDER
601 UNION STREET SUITE 600
SEATTLE, WA 98101

DATE: 9/19/2007
CCIL JOB #: 0709087
DATE RECEIVED: 9/18/2007
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:10 ENSR DRUM 1
CCIL SAMPLE #: -03

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
2-Methylnaphthalene	EPA-8270	1400	UG/KG	9/19/2007	RAL
1-Methylnaphthalene	EPA-8270	960	UG/KG	9/19/2007	RAL
Hexachlorocyclopentadiene	EPA-8270	ND(<500)	UG/KG	9/19/2007	RAL
2,4,6-Trichlorophenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
2,4,5-Trichlorophenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
2-Chloronaphthalene	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
2-Nitroaniline	EPA-8270	120	UG/KG	9/19/2007	RAL
Acenaphthylene	EPA-8270	1100	UG/KG	9/19/2007	RAL
Dimethylphthalate	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
2,6-Dinitrotoluene	EPA-8270	ND(<250)	UG/KG	9/19/2007	RAL
Acenaphthene	EPA-8270	240	UG/KG	9/19/2007	RAL
3-Nitroaniline	EPA-8270	ND(<250)	UG/KG	9/19/2007	RAL
2,4-Dinitrophenol	EPA-8270	ND(<500)	UG/KG	9/19/2007	RAL
4-Nitrophenol	EPA-8270	ND(<500)	UG/KG	9/19/2007	RAL
Dibenzofuran	EPA-8270	110	UG/KG	9/19/2007	RAL
2,4-Dinitrotoluene	EPA-8270	ND(<250)	UG/KG	9/19/2007	RAL
2,3,4,6-Tetrachlorophenol	EPA-8270	ND(<250)	UG/KG	9/19/2007	RAL
Diethylphthalate	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Fluorene	EPA-8270	860	UG/KG	9/19/2007	RAL
4-Chlorophenyl-Phenylether	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
4-Nitroaniline	EPA-8270	ND(<250)	UG/KG	9/19/2007	RAL
4,6-Dinitro-2-Methylphenol	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
N-Nitrosodiphenylamine	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Azobenzene	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
4-Bromophenyl-Phenylether	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Hexachlorobenzene	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Pentachlorophenol	EPA-8270	ND(<500)	UG/KG	9/19/2007	RAL
Phenanthrene	EPA-8270	5600	UG/KG	9/19/2007	RAL
Anthracene	EPA-8270	1100	UG/KG	9/19/2007	RAL
Carbazole	EPA-8270	110	UG/KG	9/19/2007	RAL
Di-N-Butylphthalate	EPA-8270	ND(<130)	UG/KG	9/19/2007	RAL
Fluoranthene	EPA-8270	4200	UG/KG	9/19/2007	RAL
Pyrene	EPA-8270	5900	UG/KG	9/19/2007	RAL
Butylbenzylphthalate	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
3,3'-Dichlorobenzidine	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL

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CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER 601 UNION STREET SUITE 600 SEATTLE, WA 98101	DATE:	9/19/2007
		CCIL JOB #:	0709087
		DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:10 ENSR DRUM 1
CCIL SAMPLE #: -03

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
Benzo[A]Anthracene	EPA-8270	1800	UG/KG	9/19/2007	RAL
Chrysene	EPA-8270	2100	UG/KG	9/19/2007	RAL
Bis(2-Ethylhexyl)Phthalate	EPA-8270	300	UG/KG	9/19/2007	RAL
Di-N-Octylphthalate	EPA-8270	ND(<100)	UG/KG	9/19/2007	RAL
Benzo[B]Fluoranthene	EPA-8270	1300	UG/KG	9/19/2007	RAL
Benzo[K]Fluoranthene	EPA-8270	1300	UG/KG	9/19/2007	RAL
Benzo[A]Pyrene	EPA-8270	2100	UG/KG	9/19/2007	RAL
Indeno[1,2,3-Cd]Pyrene	EPA-8270	1500	UG/KG	9/19/2007	RAL
Dibenz[A,H]Anthracene	EPA-8270	460	UG/KG	9/19/2007	RAL
Benzo[G,H,I]Perylene	EPA-8270	1700	UG/KG	9/19/2007	RAL
Arsenic	EPA-6010	ND(<5.0)	MG/KG	9/18/2007	CEO
Cadmium	EPA-6010	ND(<1.0)	MG/KG	9/18/2007	CEO
Chromium	EPA-6010	19	MG/KG	9/18/2007	CEO
Lead	EPA-6010	10	MG/KG	9/18/2007	CEO
Mercury	EPA-7471	0.03	MG/KG	9/18/2007	CEO

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCT WHICH IS LIKELY BUNKER C OR SIMILAR PRODUCT.

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES.

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

APPROVED BY:

CERTIFICATE OF ANALYSIS

CLIENT: FLOYD SNIDER
601 UNION STREET SUITE 600
SEATTLE, WA 98101

DATE: 9/19/2007
CCIL JOB #: 0709087
DATE RECEIVED: 9/18/2007
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:15 DECON WATER 1
CCIL SAMPLE #: -04

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
Benzene	EPA-8021	ND(<1)	UG/L	9/18/2007	DLC
Toluene	EPA-8021	ND(<1)	UG/L	9/18/2007	DLC
Ethylbenzene	EPA-8021	20	UG/L	9/18/2007	DLC
Xylenes	EPA-8021	4	UG/L	9/18/2007	DLC
TPH-Diesel Range	NWTPH-DX W/CLEANUP	1300	UG/L	9/18/2007	EBS
TPH-Oil Range	NWTPH-DX W/CLEANUP	ND(<250)	UG/L	9/18/2007	EBS
Pyridine	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
N-Nitrosodimethylamine	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Phenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Aniline	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Bis(2-Chloroethyl)Ether	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2-Chlorophenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
1,3-Dichlorobenzene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
1,4-Dichlorobenzene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Benzyl Alcohol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
1,2-Dichlorobenzene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2-Methylphenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Bis(2-Chloroisopropyl)Ether	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
4-Methylphenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
N-Nitroso-Di-N-Propylamine	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Hexachloroethane	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Nitrobenzene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Isophorone	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2-Nitrophenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2,4-Dimethylphenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Benzoic Acid	EPA-8270	27	UG/L	9/18/2007	RAL
Bis(2-Chloroethoxy)Methane	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2,4-Dichlorophenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
1,2,4-Trichlorobenzene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Naphthalene	EPA-8270	580	UG/L	9/18/2007	RAL
4-Chloroaniline	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2,6-Dichlorophenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Hexachlorobutadiene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
4-Chloro-3-Methylphenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL

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CLIENT:	FLOYD SNIDER 601 UNION STREET SUITE 600 SEATTLE, WA 98101	DATE:	9/19/2007
		CCIL JOB #:	0709087
		DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:15 DECON WATER 1
CCIL SAMPLE #: -04

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
2-Methylnaphthalene	EPA-8270	280	UG/L	9/18/2007	RAL
1-Methylnaphthalene	EPA-8270	160	UG/L	9/18/2007	RAL
Hexachlorocyclopentadiene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2,4,6-Trichlorophenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2,4,5-Trichlorophenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2-Chloronaphthalene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2-Nitroaniline	EPA-8270	16	UG/L	9/18/2007	RAL
Acenaphthylene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Dimethylphthalate	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2,6-Dinitrotoluene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Acenaphthene	EPA-8270	25	UG/L	9/18/2007	RAL
3-Nitroaniline	EPA-8270	ND(<25)	UG/L	9/18/2007	RAL
2,4-Dinitrophenol	EPA-8270	ND(<50)	UG/L	9/18/2007	RAL
4-Nitrophenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Dibenzofuran	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
2,4-Dinitrotoluene	EPA-8270	12	UG/L	9/18/2007	RAL
2,3,4,6-Tetrachlorophenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Diethylphthalate	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Fluorene	EPA-8270	10	UG/L	9/18/2007	RAL
4-Chlorophenyl-Phenylether	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
4-Nitroaniline	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
4,6-Dinitro-2-Methylphenol	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
N-Nitrosodiphenylamine	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Azobenzene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
4-Bromophenyl-Phenylether	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Hexachlorobenzene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Pentachlorophenol	EPA-8270	ND(<25)	UG/L	9/18/2007	RAL
Phenanthrene	EPA-8270	19	UG/L	9/18/2007	RAL
Anthracene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Carbazole	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Di-N-Butylphthalate	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Fluoranthene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Pyrene	EPA-8270	11	UG/L	9/18/2007	RAL
Butylbenzylphthalate	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
3,3'-Dichlorobenzidine	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL

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CLIENT: FLOYD SNIDER
601 UNION STREET SUITE 600
SEATTLE, WA 98101

DATE: 9/19/2007
CCIL JOB #: 0709087
DATE RECEIVED: 9/18/2007
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:15 DECON WATER 1
CCIL SAMPLE #: -04

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
Benzo[A]Anthracene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Chrysene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Bis(2-Ethylhexyl)Phthalate	EPA-8270	540	UG/L	9/18/2007	RAL
Di-N-Octylphthalate	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Benzo[B]Fluoranthene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Benzo[K]Fluoranthene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Benzo[A]Pyrene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Indeno[1,2,3-Cd]Pyrene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Dibenz[A,H]Anthracene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Benzo[G,H,I]Perylene	EPA-8270	ND(<10)	UG/L	9/18/2007	RAL
Arsenic	EPA-6010	ND(<40)	UG/L	9/19/2007	CEO
Cadmium	EPA-6010	ND(<5)	UG/L	9/19/2007	CEO
Chromium	EPA-6010	56	UG/L	9/19/2007	CEO
Lead	EPA-6010	ND(<40)	UG/L	9/19/2007	CEO
Mercury	EPA-7470	ND(<0.2)	UG/L	9/19/2007	CEO

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCT WHICH IS LIKELY WEATHERED DIESEL FUEL.

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES.

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

APPROVED BY:

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER	DATE:	9/19/2007
	601 UNION STREET SUITE 600	CCIL JOB #:	0709087
	SEATTLE, WA 98101	DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT:	KATE SNIDER
CLIENT PROJECT ID:	GAS WORKS NE CORNER
CLIENT SAMPLE ID:	9/18/2007 9:20 DECON WATER 2
CCIL SAMPLE #:	-05

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
Benzene	EPA-8021	1	UG/L	9/18/2007	DLC
Toluene	EPA-8021	ND(<1)	UG/L	9/18/2007	DLC
Ethylbenzene	EPA-8021	9	UG/L	9/18/2007	DLC
Xylenes	EPA-8021	3	UG/L	9/18/2007	DLC
TPH-Diesel Range	NWTPH-DX W/CLEANUP	30000	UG/L	9/18/2007	EBS
TPH-Oil Range	NWTPH-DX W/CLEANUP	580	UG/L	9/18/2007	EBS
Pyridine	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
N-Nitrosodimethylamine	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Phenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Aniline	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Bis(2-Chloroethyl)Ether	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2-Chlorophenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
1,3-Dichlorobenzene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
1,4-Dichlorobenzene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Benzyl Alcohol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
1,2-Dichlorobenzene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2-Methylphenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Bis(2-Chloroisopropyl)Ether	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
4-Methylphenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
N-Nitroso-Di-N-Propylamine	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Hexachloroethane	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Nitrobenzene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Isophorone	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2-Nitrophenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2,4-Dimethylphenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Benzoic Acid	EPA-8270	27	UG/L	9/19/2007	RAL
Bis(2-Chloroethoxy)Methane	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2,4-Dichlorophenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
1,2,4-Trichlorobenzene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Naphthalene	EPA-8270	400	UG/L	9/19/2007	RAL
4-Chloroaniline	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2,6-Dichlorophenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Hexachlorobutadiene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
4-Chloro-3-Methylphenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL

CERTIFICATE OF ANALYSIS

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		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:20 DECON WATER 2
CCIL SAMPLE #: -05

DATA RESULTS

ANALYTE	METHOD	RESULTS*	UNITS**	ANALYSIS DATE	ANALYSIS BY
2-Methylnaphthalene	EPA-8270	230	UG/L	9/19/2007	RAL
1-Methylnaphthalene	EPA-8270	140	UG/L	9/19/2007	RAL
Hexachlorocyclopentadiene	EPA-8270	ND(<2)	UG/L	9/19/2007	RAL
2,4,6-Trichlorophenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2,4,5-Trichlorophenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2-Chloronaphthalene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2-Nitroaniline	EPA-8270	16	UG/L	9/19/2007	RAL
Acenaphthylene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Dimethylphthalate	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2,6-Dinitrotoluene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Acenaphthene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
3-Nitroaniline	EPA-8270	ND(<25)	UG/L	9/19/2007	RAL
2,4-Dinitrophenol	EPA-8270	66	UG/L	9/19/2007	RAL
4-Nitrophenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Dibenzofuran	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
2,4-Dinitrotoluene	EPA-8270	12	UG/L	9/19/2007	RAL
2,3,4,6-Tetrachlorophenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Diethylphthalate	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Fluorene	EPA-8270	43	UG/L	9/19/2007	RAL
4-Chlorophenyl-Phenylether	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
4-Nitroaniline	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
4,6-Dinitro-2-Methylphenol	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
N-Nitrosodiphenylamine	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Azobenzene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
4-Bromophenyl-Phenylether	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Hexachlorobenzene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Pentachlorophenol	EPA-8270	ND(<25)	UG/L	9/19/2007	RAL
Phenanthrene	EPA-8270	110	UG/L	9/19/2007	RAL
Anthracene	EPA-8270	23	UG/L	9/19/2007	RAL
Carbazole	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Di-N-Butylphthalate	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Fluoranthene	EPA-8270	51	UG/L	9/19/2007	RAL
Pyrene	EPA-8270	86	UG/L	9/19/2007	RAL
Butylbenzylphthalate	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
3,3'-Dichlorobenzidine	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL

CCI
ANALYTICAL
LABORATORIES
A Division of DataChem Laboratories, Inc.

CERTIFICATE OF ANALYSIS

CLIENT: FLOYD SNIDER
601 UNION STREET SUITE 600
SEATTLE, WA 98101

DATE: 9/19/2007
CCIL JOB #: 0709087
DATE RECEIVED: 9/18/2007
WDOE ACCREDITATION #: C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER
CLIENT SAMPLE ID: 9/18/2007 9:20 DECON WATER 2
CCIL SAMPLE #: -05

DATA RESULTS

ANALYTE	**METHOD**	**RESULTS***	**UNITS****	**ANALYSIS DATE**	**ANALYSIS BY**
Benzo[A]Anthracene	EPA-8270	18	UG/L	9/19/2007	RAL
Chrysene	EPA-8270	20	UG/L	9/19/2007	RAL
Bis(2-Ethylhexyl)Phthalate	EPA-8270	120	UG/L	9/19/2007	RAL
Di-N-Octylphthalate	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Benzo[B]Fluoranthene	EPA-8270	12	UG/L	9/19/2007	RAL
Benzo[K]Fluoranthene	EPA-8270	11	UG/L	9/19/2007	RAL
Benzo[A]Pyrene	EPA-8270	19	UG/L	9/19/2007	RAL
Indeno[1,2,3-Cd]Pyrene	EPA-8270	12	UG/L	9/19/2007	RAL
Dibenz[A,H]Anthracene	EPA-8270	ND(<10)	UG/L	9/19/2007	RAL
Benzo[G,H,I]Perylene	EPA-8270	15	UG/L	9/19/2007	RAL
Arsenic	EPA-6010	ND(<40)	UG/L	9/19/2007	CEO
Cadmium	EPA-6010	ND(<5)	UG/L	9/19/2007	CEO
Chromium	EPA-6010	400	UG/L	9/19/2007	CEO
Lead	EPA-6010	85	UG/L	9/19/2007	CEO
Mercury	EPA-7470	0.29	UG/L	9/19/2007	CEO

NOTE: CHROMATOGRAM INDICATES SAMPLE CONTAINS PRODUCTS WHICH ARE LIKELY WEATHERED DIESEL FUEL AND LUBE OIL.

* "ND" INDICATES ANALYTE ANALYZED FOR BUT NOT DETECTED AT LEVEL ABOVE REPORTING LIMIT. REPORTING LIMIT IS GIVEN IN PARENTHESES.

** UNITS FOR ALL NON LIQUID SAMPLES ARE REPORTED ON A DRY WEIGHT BASIS

APPROVED BY:

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER 601 UNION STREET SUITE 600 SEATTLE, WA 98101	DATE:	9/19/2007
		CCIL JOB #:	0709087
		DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER

QUALITY CONTROL RESULTS

SURROGATE RECOVERY

CCIL SAMPLE ID	METHOD	SUR ID	% RECV
0709087-01	EPA-8021	TFT	*
0709087-01	NWTPH-DX	C25	**
0709087-01	EPA-8270	2-Fluorophenol	44
0709087-01	EPA-8270	Phenol-d6	45
0709087-01	EPA-8270	Nitrobenzene-d5	64
0709087-01	EPA-8270	2-Fluorobiphenyl	51
0709087-01	EPA-8270	2,4,6-Tribromophenol	*
0709087-01	EPA-8270	Terphenyl-d14	54
0709087-02	EPA-8021	TFT	85
0709087-02	NWTPH-DX	C25	**
0709087-02	EPA-8270	2-Fluorophenol	91
0709087-02	EPA-8270	Phenol-d6	107
0709087-02	EPA-8270	Nitrobenzene-d5	118
0709087-02	EPA-8270	2-Fluorobiphenyl	90
0709087-02	EPA-8270	2,4,6-Tribromophenol	123
0709087-02	EPA-8270	Terphenyl-d14	89
0709087-03	EPA-8021	TFT	80
0709087-03	NWTPH-DX	C25	120
0709087-03	EPA-8270	2-Fluorophenol	78
0709087-03	EPA-8270	Phenol-d6	92
0709087-03	EPA-8270	Nitrobenzene-d5	90
0709087-03	EPA-8270	2-Fluorobiphenyl	88
0709087-03	EPA-8270	2,4,6-Tribromophenol	121
0709087-03	EPA-8270	Terphenyl-d14	97
0709087-04	EPA-8021	TFT	95
0709087-04	NWTPH-DX W/CLEANUP	C25	90
0709087-04	EPA-8270	2-Fluorophenol	51
0709087-04	EPA-8270	Phenol-d6	35
0709087-04	EPA-8270	Nitrobenzene-d5	89
0709087-04	EPA-8270	2-Fluorobiphenyl	76
0709087-04	EPA-8270	2,4,6-Tribromophenol	*
0709087-04	EPA-8270	Terphenyl-d14	103
0709087-05	EPA-8021	TFT	95
0709087-05	NWTPH-DX W/CLEANUP	C25	108
0709087-05	EPA-8270	2-Fluorophenol	43
0709087-05	EPA-8270	Phenol-d6	*
0709087-05	EPA-8270	Nitrobenzene-d5	84
0709087-05	EPA-8270	2-Fluorobiphenyl	72
0709087-05	EPA-8270	2,4,6-Tribromophenol	135
0709087-05	EPA-8270	Terphenyl-d14	108
0709087-05 DILUTION	NWTPH-DX	C25	88

* SURROGATE DILUTED OUT OF CONTROL LIMITS

** SURROGATE HIGH DUE TO COELUTING COMPOUNDS.

CERTIFICATE OF ANALYSIS

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601 UNION STREET SUITE 600
SEATTLE, WA 98101

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CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER

QUALITY CONTROL RESULTS

BLANK RESULTS

METHOD	MATRIX	QC BATCH ID	ASSOCIATED SAMPLES	ANALYTE	RESULT	UNITS
EPA-8021	Soil	GS091307	0709087 -01 to 03	Benzene	ND(<0.03)	MG/KG
EPA-8021	Soil	GS091307	0709087 -01 to 03	Toluene	ND(<0.05)	MG/KG
EPA-8021	Soil	GS091307	0709087 -01 to 03	Ethylbenzene	ND(<0.05)	MG/KG
EPA-8021	Soil	GS091307	0709087 -01 to 03	Xylenes	ND(<0.2)	MG/KG
NWTPH-DX	Soil	DS091507	0709087 -01 to 03	TPH-Diesel Range	ND(<25)	MG/KG
NWTPH-DX	Soil	DS091507	0709087 -01 to 03	TPH-Oil Range	ND(<50)	MG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Pyridine	ND(<200)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	N-Nitrosodimethylamine	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Phenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Aniline	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Bis(2-Chloroethyl)Ether	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2-Chlorophenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	1,3-Dichlorobenzene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	1,4-Dichlorobenzene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Benzyl Alcohol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	1,2-Dichlorobenzene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2-Methylphenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Bis(2-Chloroisopropyl)Ether	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4-Methylphenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	N-Nitroso-Di-N-Propylamine	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Hexachloroethane	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Nitrobenzene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Isophorone	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2-Nitrophenol	ND(<250)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,4-Dimethylphenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Benzoic Acid	ND(<1000)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Bis(2-Chloroethoxy)Methane	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,4-Dichlorophenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	1,2,4-Trichlorobenzene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Naphthalene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4-Chloroaniline	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,6-Dichlorophenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Hexachlorobutadiene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4-Chloro-3-Methylphenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2-Methylnaphthalene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	1-Methylnaphthalene	ND(<100)	UG/KG

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER 601 UNION STREET SUITE 600 SEATTLE, WA 98101	DATE:	9/19/2007
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		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER

QUALITY CONTROL RESULTS

BLANK RESULTS

METHOD	MATRIX	QC BATCH ID	ASSOCIATED SAMPLES	ANALYTE	RESULT	UNITS
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Hexachlorocyclopentadiene	ND(<500)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,4,6-Trichlorophenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,4,5-Trichlorophenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2-Chloronaphthalene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2-Nitroaniline	ND(<250)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Acenaphthylene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Dimethylphthalate	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,6-Dinitrotoluene	ND(<250)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Acenaphthene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	3-Nitroaniline	ND(<250)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,4-Dinitrophenol	ND(<500)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4-Nitrophenol	ND(<500)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Dibenzofuran	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,4-Dinitrotoluene	ND(<250)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,3,4,6-Tetrachlorophenol	ND(<250)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Diethylphthalate	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Fluorene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4-Chlorophenyl-Phenylether	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4-Nitroaniline	ND(<250)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4,6-Dinitro-2-Methylphenol	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	N-Nitrosodiphenylamine	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Azobenzene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4-Bromophenyl-Phenylether	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Hexachlorobenzene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Pentachlorophenol	ND(<500)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Phenanthrene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Anthracene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Carbazole	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Di-N-Butylphthalate	ND(<130)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Fluoranthene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Pyrene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Butylbenzylphthalate	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	3,3'-Dichlorobenzidine	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Benzo[A]Anthracene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Chrysene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Bis(2-Ethylhexyl)Phthalate	ND(<130)	UG/KG

CERTIFICATE OF ANALYSIS

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QUALITY CONTROL RESULTS

BLANK RESULTS

METHOD	MATRIX	QC BATCH ID	ASSOCIATED SAMPLES	ANALYTE	RESULT	UNITS
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Di-N-Octylphthalate	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Benzo[B]Fluoranthene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Benzo[K]Fluoranthene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Benzo[A]Pyrene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Indeno[1,2,3-Cd]Pyrene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Dibenz[A,H]Anthracene	ND(<100)	UG/KG
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Benzo[G,H,I]Perylene	ND(<100)	UG/KG
EPA-7471	Soil	HGS091807-1	0709087 -01 to 03	Mercury	ND(<0.02)	MG/KG
EPA-6010	Soil	ICP091807-5	0709087 -01 to 03	Arsenic	ND(<5.0)	MG/KG
EPA-6010	Soil	ICP091807-5	0709087 -01 to 03	Cadmium	ND(<1.0)	MG/KG
EPA-6010	Soil	ICP091807-5	0709087 -01 to 03	Chromium	ND(<1.0)	MG/KG
EPA-6010	Soil	ICP091807-5	0709087 -01 to 03	Lead	ND(<5.0)	MG/KG
EPA-8021	Water	GW091707	0709087 -04 to 05	Benzene	ND(<1)	UG/L
EPA-8021	Water	GW091707	0709087 -04 to 05	Toluene	ND(<1)	UG/L
EPA-8021	Water	GW091707	0709087 -04 to 05	Ethylbenzene	ND(<1)	UG/L
EPA-8021	Water	GW091707	0709087 -04 to 05	Xylenes	ND(<3)	UG/L
NWTPH-DX	Water	DW091207	0709087 -04 to 05	TPH-Diesel Range	ND(<130)	UG/L
NWTPH-DX	Water	DW091207	0709087 -04 to 05	TPH-Oil Range	ND(<250)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Pyridine	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	N-Nitrosodimethylamine	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Phenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Aniline	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Bis(2-Chloroethyl)Ether	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2-Chlorophenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	1,3-Dichlorobenzene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	1,4-Dichlorobenzene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Benzyl Alcohol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	1,2-Dichlorobenzene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2-Methylphenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Bis(2-Chloroisopropyl)Ether	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	4-Methylphenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	N-Nitroso-Di-N-Propylamine	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Hexachloroethane	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Nitrobenzene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Isophorone	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2-Nitrophenol	ND(<2)	UG/L

CERTIFICATE OF ANALYSIS

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	601 UNION STREET SUITE 600	CCIL JOB #:	0709087
	SEATTLE, WA 98101	DATE RECEIVED:	9/18/2007
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CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER

QUALITY CONTROL RESULTS

BLANK RESULTS

METHOD	MATRIX	QC BATCH ID	ASSOCIATED SAMPLES	ANALYTE	RESULT	UNITS
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,4-Dimethylphenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Benzoic Acid	ND(<10)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Bis(2-Chloroethoxy)Methane	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,4-Dichlorophenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	1,2,4-Trichlorobenzene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Naphthalene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	4-Chloroaniline	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,6-Dichlorophenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Hexachlorobutadiene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	4-Chloro-3-Methylphenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2-Methylnaphthalene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	1-Methylnaphthalene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Hexachlorocyclopentadiene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,4,6-Trichlorophenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,4,5-Trichlorophenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2-Chloronaphthalene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2-Nitroaniline	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Acenaphthylene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Dimethylphthalate	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,6-Dinitrotoluene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Acenaphthene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	3-Nitroaniline	ND(<5)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,4-Dinitrophenol	ND(<10)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	4-Nitrophenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Dibenzofuran	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,4-Dinitrotoluene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,3,4,6-Tetrachlorophenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Diethylphthalate	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Fluorene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	4-Chlorophenyl-Phenylether	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	4-Nitroaniline	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	4,6-Dinitro-2-Methylphenol	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	N-Nitrosodiphenylamine	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Azobenzene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	4-Bromophenyl-Phenylether	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Hexachlorobenzene	ND(<2)	UG/L

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER 601 UNION STREET SUITE 600 SEATTLE, WA 98101	DATE:	9/19/2007
		CCIL JOB #:	0709087
		DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER

QUALITY CONTROL RESULTS

BLANK RESULTS

METHOD	MATRIX	QC BATCH ID	ASSOCIATED SAMPLES	ANALYTE	RESULT	UNITS
EPA-8270	Water	SVW091107	0709087 -04 to 05	Pentachlorophenol	ND(<5)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Phenanthrene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Anthracene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Carbazole	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Di-N-Butylphthalate	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Fluoranthene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Pyrene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Butylbenzylphthalate	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	3,3'-Dichlorobenzidine	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Benzo[A]Anthracene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Chrysene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Bis(2-Ethylhexyl)Phthalate	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Di-N-Octylphthalate	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Benzo[B]Fluoranthene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Benzo[K]Fluoranthene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Benzo[A]Pyrene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Indeno[1,2,3-Cd]Pyrene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Dibenz[A,H]Anthracene	ND(<2)	UG/L
EPA-8270	Water	SVW091107	0709087 -04 to 05	Benzo[G,H,I]Perylene	ND(<2)	UG/L
EPA-7470	Water	HGW091907-1	0709087 -04 to 05	Mercury	ND(<0.2)	UG/L
EPA-6010	Water	ICPW091907-2	0709087 -04 to 05	Arsenic	ND(<40)	UG/L
EPA-6010	Water	ICPW091907-2	0709087 -04 to 05	Cadmium	ND(<5)	UG/L
EPA-6010	Water	ICPW091907-2	0709087 -04 to 05	Chromium	ND(<7)	UG/L
EPA-6010	Water	ICPW091907-2	0709087 -04 to 05	Lead	ND(<40)	UG/L

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER	DATE:	9/19/2007
	601 UNION STREET SUITE 600	CCIL JOB #:	0709087
	SEATTLE, WA 98101	DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER

QUALITY CONTROL RESULTS

SPIKE/SPIKE DUPLICATE RESULTS

METHOD	MATRIX	QC BATCH ID	ASSOCIATED SAMPLES	ANALYTE	SPIKE RECOVERY	SPIKE DUP RECOVERY	RPD
EPA-8021	Soil	GS091307	0709087 -01 to 03	Benzene	92 %	92 %	0
EPA-8021	Soil	GS091307	0709087 -01 to 03	Toluene	93 %	93 %	0
EPA-8021	Soil	GS091307	0709087 -01 to 03	Ethylbenzene	91 %	91 %	0
EPA-8021	Soil	GS091307	0709087 -01 to 03	Xylenes	91 %	92 %	1
NWTPH-DX	Soil	DS091507	0709087 -01 to 03	TPH-Diesel Range	87 %	89 %	2
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Phenol	74 %	74 %	1
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2-Chlorophenol	73 %	73 %	0
EPA-8270	Soil	SVS091807	0709087 -01 to 03	1,4-Dichlorobenzene	75 %	73 %	3
EPA-8270	Soil	SVS091807	0709087 -01 to 03	N-Nitroso-Di-N-Propylamine	48 %	47 %	2
EPA-8270	Soil	SVS091807	0709087 -01 to 03	1,2,4-Trichlorobenzene	83 %	83 %	0
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4-Chloro-3-Methylphenol	73 %	76 %	4
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Acenaphthene	78 %	81 %	4
EPA-8270	Soil	SVS091807	0709087 -01 to 03	4-Nitrophenol	49 %	54 %	9
EPA-8270	Soil	SVS091807	0709087 -01 to 03	2,4-Dinitrotoluene	70 %	77 %	10
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Pentachlorophenol	76 %	83 %	9
EPA-8270	Soil	SVS091807	0709087 -01 to 03	Pyrene	129 %	136 %	6
EPA-7471	Soil	HGS091807-1	0709087 -01 to 03	Mercury	100 %	96 %	4
EPA-6010	Soil	ICP091807-5	0709087 -01 to 03	Arsenic	101 %	103 %	2
EPA-6010	Soil	ICP091807-5	0709087 -01 to 03	Cadmium	102 %	103 %	1
EPA-6010	Soil	ICP091807-5	0709087 -01 to 03	Chromium	101 %	103 %	2
EPA-6010	Soil	ICP091807-5	0709087 -01 to 03	Lead	102 %	103 %	1
EPA-8021	Water	GW091707	0709087 -04 to 05	Benzene	90 %	92 %	2
EPA-8021	Water	GW091707	0709087 -04 to 05	Toluene	98 %	100 %	2
EPA-8021	Water	GW091707	0709087 -04 to 05	Ethylbenzene	99 %	101 %	2
EPA-8021	Water	GW091707	0709087 -04 to 05	Xylenes	101 %	103 %	2
NWTPH-DX	Water	DW091207	0709087 -04 to 05	TPH-Diesel Range	80 %	81 %	1
EPA-8270	Water	SVW091107	0709087 -04 to 05	Phenol	52 %	56 %	6
EPA-8270	Water	SVW091107	0709087 -04 to 05	2-Chlorophenol	68 %	68 %	1
EPA-8270	Water	SVW091107	0709087 -04 to 05	1,4-Dichlorobenzene	36 %	39 %	9
EPA-8270	Water	SVW091107	0709087 -04 to 05	N-Nitroso-Di-N-Propylamine	36 %	37 %	5
EPA-8270	Water	SVW091107	0709087 -04 to 05	1,2,4-Trichlorobenzene	40 %	41 %	3
EPA-8270	Water	SVW091107	0709087 -04 to 05	4-Chloro-3-Methylphenol	72 %	75 %	5
EPA-8270	Water	SVW091107	0709087 -04 to 05	Acenaphthene	61 %	59 %	3
EPA-8270	Water	SVW091107	0709087 -04 to 05	4-Nitrophenol	37 %	13 %	96
EPA-8270	Water	SVW091107	0709087 -04 to 05	2,4-Dinitrotoluene	73 %	71 %	3
EPA-8270	Water	SVW091107	0709087 -04 to 05	Pentachlorophenol	68 %	21 %	104

CERTIFICATE OF ANALYSIS

CLIENT:	FLOYD SNIDER 601 UNION STREET SUITE 600 SEATTLE, WA 98101	DATE:	9/19/2007
		CCIL JOB #:	0709087
		DATE RECEIVED:	9/18/2007
		WDOE ACCREDITATION #:	C142

CLIENT CONTACT: KATE SNIDER
CLIENT PROJECT ID: GAS WORKS NE CORNER

QUALITY CONTROL RESULTS

SPIKE/SPIKE DUPLICATE RESULTS

METHOD	MATRIX	QC BATCH ID	ASSOCIATED SAMPLES	ANALYTE	SPIKE RECOVERY	SPIKE DUP RECOVERY	RPD
EPA-8270	Water	SVW091107	0709087 -04 to 05	Pyrene	89 %	91 %	3
EPA-7470	Water	HGW091907-1	0709087 -04 to 05	Mercury	115 %	104 %	10
EPA-6010	Water	ICPW091907-2	0709087 -04 to 05	Arsenic	103 %	103 %	0
EPA-6010	Water	ICPW091907-2	0709087 -04 to 05	Cadmium	102 %	102 %	0
EPA-6010	Water	ICPW091907-2	0709087 -04 to 05	Chromium	102 %	102 %	0
EPA-6010	Water	ICPW091907-2	0709087 -04 to 05	Lead	103 %	102 %	1

APPROVED BY:

CCI Analytical Laboratories
8620 Holly Drive
Everett, WA 98208
Phone (425) 356-2600
(206) 292-9059 Seattle
(425) 356-2626 Fax
http://www.ccilabs.com

Chain Of Custody/ Laboratory Analysis Request

CCI Job# (Laboratory Use Only)

Date 9/15/07 Page 1 Of 1

CLIENT COPY

PROJECT ID: GAS Works NE Corner
REPORT TO COMPANY: Floyd Snider
PROJECT MANAGER: Kate Snider
ADDRESS: 601 Union St. Ste 600
Seattle WA 98101
PHONE: 206 292 2078 FAX:
P.O. NUMBER: E-MAIL: kate.snider@floydsnider.com
INVOICE TO COMPANY: SAA
ATTENTION: Tiffany Velosin
ADDRESS:

SAMPLE I.D.	DATE	TIME	TYPE	LAB#	NWTPH-HCID	NWTPH-DX	NWTPH-GX	BTEX by EPA-8021	MTBE by EPA-8021 ☐ EPA-8260 ☐	Halogenated Volatiles by EPA 8260	Volatile Organic Compounds by EPA 8260	EDB / EDC by EPA 8260 SIM (water)	EDB / EDC by EPA 8260 (soil)	Semivolatile Organic Compounds by EPA 8270	Polycyclic Aromatic Hydrocarbons (PAH) by EPA-8270 SIM ☐	PCB ☐ Pesticides ☐ by EPA 8081/8082	Metals-MTCA-5 ☒ RCRA-8 ☐ Pri Pol ☐ TAL ☐	Metals Other (Specify)	TCLP-Metals ☐ VOA ☐ Semi-Vol ☐ Pest ☐ Herbs ☐	OTHER (Specify)							NUMBER OF CONTAINERS	RECEIVED IN GOOD CONDITION?
1. FS DRUM 1	9/15/07	09:00	S			X		X						X			X										3	
2. FS DRUM 2	↓	0905	S			X		X						X			X										3	
3. ENSR DRUM 1	↓	0910	S			X		X						X			X										3	
4. DECON WATER 1	↓	0915	W			X		X						X			X										5	
5. DECON WATER 2	↓	0920	W			X		X						X			X										5	
6.																												
7.																												
8.																												
9.																												
10.																												

SPECIAL INSTRUCTIONS

CCI Analytical Laboratories, Inc accepts and processes this request on the terms and conditions set forth on the reverse side. By its signature hereon, Customer accepts these terms and conditions.

SIGNATURES (Name, Company, Date, Time):

1. Relinquished By: F/S 10:25 9/15
   Received By: CCI 9/15/07 1025
2. Relinquished By:
   Received By:

TURNAROUND REQUESTED in Business Days*

Organic, Metals & Inorganic Analysis

10 (Standard) 5 3 2 [✓ 1] SAME DAY

Fuels & Hydrocarbon Analysis

5 (Standard) 3 [✓ 1] SAME DAY

OTHER:

Specify: call when results done – [illegible] 206-291-7713

* Turnaround request less than standard may incur Rush Charges

Gas Works Park
Northeast Corner Investigation

Data Report

Appendix F
Waste Profiles and Disposal Certifications

DR
KAW.

V07104486

Please print or type. (Form designed for use on elite (12-pitch) typewriter.) DI1614835

PPW 05/27/2007

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST	1. Generator ID Number WAD980976252	2. Page 1 of 1	3. Emergency Response Phone (800) 483-3718	4. Manifest Tracking Number 001076548 FLE

5. Generator's Name and Mailing Address
Seattle Parks Department
4200 W. Marginal Way SW
Seattle, WA 98106
Generator's Phone: 206 624-7292 ATTN: Nina Jodi Sinclair

Generator's Site Address (if different than mailing address)
2100 North Northlake Way
Seattle, WA 98103

6. Transporter 1 Company Name
Clean Harbors Env Services Inc
U.S. EPA ID Number
MAD039322250

7. Transporter 2 Company Name
TW Company
U.S. EPA ID Number
UTD988074712

8. Designated Facility Name and Site Address
Clean Harbors Env Services Inc
2247 South Highway 71
Kimball, NE, 69145
Facility's Phone: (308) 235-4012
U.S. EPA ID Number
NED981723513

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
X	1. HAZARDOUS WASTE, SOLID, N.O.S., (BENZENE,NAPTHALENE), 9, NA3077, PG III	001	DM	0300 ~~0400~~	P	D018
	2. NON HAZARDOUS, NON D.O.T. REGULATED, N/A, NONE, (GROUNDWATER)	003	DM	1200	P	NONE
	3.					
	4.					

14. Special Handling Instructions and Additional Information
1. CH274523
2. CH274525
ERG#171
1x55DM
3x55DM

15. **GENERATOR'S/OFFEROR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name: Peter D. Rude City of Seattle
Signature:
Month Day Year: 9 28 07

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit:
Transporter signature (for exports only): Date leaving U.S.:

17. Transporter Acknowledgment of Receipt of Materials
Transporter 1 Printed/Typed Name: Daniel J Rohde
Signature: Daniel J Rohde
Month Day Year: 9 28 07

Transporter 2 Printed/Typed Name: MARK NORWOOD
Signature: M Norwood
Month Day Year: 10 1 07

18. Discrepancy
18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection

Manifest Reference Number:

18b. Alternate Facility (or Generator)
U.S. EPA ID Number
Facility's Phone:
18c. Signature of Alternate Facility (or Generator)
Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1.	2.	3.	4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a
Printed/Typed Name
Signature
Month Day Year: 10 17 07

Form 8700-22 (Rev. 3-05) Previous editions are obsolete.

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST (Continuation Sheet)

21. Generator ID Number WAD980971682

22. Page 2 of 2

23. Manifest Tracking Number 001076548FLE

GENERATOR

24. Generator's Name Seattle Parks

25. Transporter 3 Company Name Clean Harbors U.S. EPA ID Number MAD039322250

26. Transporter 4 Company Name TW Company U.S. EPA ID Number UTD988074712

27a. HM	27b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	28. Containers No.	28. Containers Type	29. Total Quantity	30. Unit Wt./Vol.	31. Waste Codes
	TPO					

32. Special Handling Instructions and Additional Information

TRANSPORTER

33. Transporter 3 Acknowledgment of Receipt of Materials

Printed/Typed Name Mandy Hendley Signature Mandy Hendley Month Day Year 10 30 07

34. Transporter 4 Acknowledgment of Receipt of Materials

Printed/Typed Name GLENN PLOTNER Signature G P Month Day Year 10 18 07

DESIGNATED FACILITY

35. Discrepancy

36. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

EPA Form 8700-22A (Rev. 3-05) Previous editions are obsolete.

DESIGNATED FACILITY TO DESTINATION STATE (IF REQUIRED)

AUTH. V0710131

BI1813820
BI1813820

PPW 06/27/2007
PPW 06/27/2007

Please print or type. (Form designed for use on elite (12-pitch) typewriter.) Form Approved. OMB No. 2050-0039

GENERATOR

UNIFORM HAZARDOUS WASTE MANIFEST	1. Generator ID Number WAD980976252	2. Page 1 of 1	3. Emergency Response Phone (800) 483-3718	**4. Manifest Tracking Number** 001076504 FLE

5. Generator's Name and Mailing Address
Seattle Parks Department
4209 W. Marginal Way SW
Seattle, WA 98106
Generator's Phone: 206 733-9179 ATTN: Nina Jodi Sinclair

Generator's Site Address (if different than mailing address)
2100 North Northlake Way
Seattle, WA 98103

6. Transporter 1 Company Name: Clean Harbors Env Services Inc
U.S. EPA ID Number: MAD039322250

7. Transporter 2 Company Name: TCJ Company
U.S. EPA ID Number: UTD988074712

8. Designated Facility Name and Site Address
Clean Harbors Env Services Inc
2247 South Highway 71
Kimball, NE, 69145
Facility's Phone: (308) 235-4012
U.S. EPA ID Number: NED981723513

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
X	1. HAZARDOUS WASTE, SOLID, N.O.S., (BENZENE,NAPTHALENE), 9, NA3077, PG III	009	DM	7200	P	D018
	2. NON HAZARDOUS, NON D.O.T. REGULATED, N/A, NONE, (GROUNDWATER)	002	DM	1000	P	NONE
	3.					
	4.					

14. Special Handling Instructions and Additional Information
1. CH274523 9x55 ERG#171
2. CH274525 2x55

CR	✓S
FS	
OFFC	

15. **GENERATOR'S/OFFEROR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. ~~If export shipment and I am the~~ Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name: Pete Rude City of Seattle
Signature:
Month 9 Day 21 Year 07

INT'L

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit:
Transporter signature (for exports only): Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials
Transporter 1 Printed/Typed Name: ARBEN FERKO
Signature: A. FERKO
Month 09 Day 21 Year 07

Transporter 2 Printed/Typed Name: KEITH SNEATHEN
Signature:
Month 9 Day ~~24~~ 25 Year 07

DESIGNATED FACILITY

18. Discrepancy

18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection

Manifest Reference Number:

18b. Alternate Facility (or Generator)
U.S. EPA ID Number:
Facility's Phone:

18c. Signature of Alternate Facility (or Generator)
Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1.	2.	3.	4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a
Printed/Typed Name:
Signature:
Month 10 Day 01 Year 07

EPA Form 8700-22 (Rev. 3-05) Previous editions are obsolete.

DESIGNATED FACILITY TO DESTINATION STATE (IF REQUIRED)

Clean Harbors has the appropriate permits for and will accept the waste the generator is shipping.

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST
(Continuation Sheet)

21. Generator ID Number WAD980974252

22. Page 2

23. Manifest Tracking Number 001076504FLE

24. Generator's Name Seattle Parks

25. Transporter _______ Company Name Clean Harbors U.S. EPA ID Number MAD039322250

26. Transporter _______ Company Name Tri-state MOTOR TRANSIT U.S. EPA ID Number MOD095038998

GENERATOR

27a. HM	27b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	28. Containers No.	28. Containers Type	29. Total Quantity	30. Unit Wt./Vol.	31. Waste Codes

32. Special Handling Instructions and Additional Information

TRANSPORTER

33. Transporter _______ Acknowledgment of Receipt of Materials

Printed/Typed Name Ashley Clarke Signature Ashley Clarke Month 9 Day 27 Year 07

34. Transporter _______ Acknowledgment of Receipt of Materials

Printed/Typed Name John Hamlin Signature John Hamlin Month 10 Day 2 Year 07

DESIGNATED FACILITY

35. Discrepancy

36. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

EPA Form 8700-22A (Rev. 3-05) Previous editions are obsolete.

DESIGNATED FACILITY TO DESTINATION STATE (IF REQUIRED)