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Prepared for:
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Sampling and Analysis Plan- Revision 1

The RETEC Group, Inc.
February 2008
Document No.: 02978-415-735

Merged with ENSR in 2007
RETEC

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Sampling and Analysis Plan- Revision 1

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Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction

This Sampling and Analysis Plan (SAP) presents the project organization, objectives and procedures associated with the collection of environmental samples at the former GE facility in Seattle, Washington. All quality assurance and quality control procedures related to this SAP are included in the Quality Assurance Project Plan (QAPP) found in Appendix A. This SAP meets the requirements of the Model Toxics Control Act (MTCA) (WAC 173-340-820) and is developed in accordance with applicable professional technical standards, Washington Department of Ecology guidelines (Ecology, 1991, 1995), and project-specific goals.

The SAP and QAPP describe the procedures that are implemented to ensure that the precision, accuracy, representativeness, and completeness of the project data are sufficient to satisfy the project objectives.

2.0 Project Organization

The organizational structure for the project consists of a Program Manager, Project Manager, Regional and Site Health and Safety Officer, Project Engineer/Scientist/Geologist, Sampling Technician, Quality Assurance (QA) Officer, and Data Validator.

2.1 Program and Project Manager Responsibilities

The Program Manager's primary responsibility is technical accuracy, completeness, and overall project management.

The Project Manager (PM) is the primary point of contact and is responsible for technical, financial, and scheduling matters. The PM's responsibilities include:

- Assignment of duties to the project staff and orientation of the staff to the needs and requirements of the project
- Supervision of the performance of project team members
- Monitoring all aspects of the project to verify that all work is completed in accordance with this SAP and attached QAPP
- Budget and schedule control
- Establishment of a project record-keeping system
- Coordination of all major project deliverables for technical accuracy and completeness
- Ecology contact.

2.2 Office and Site Health and Safety Officer Responsibilities

The Office Health and Safety Officer (HSO) has the following responsibilities:

- Interface with the Project Manager as required in matters of health and safety
- Approve the site-specific Health and Safety Plan (HASP) for the project and require amendment as site conditions warrant
- Appoint or approve a Site Safety Officer (SSO) to assist in implementing the HASP
- Monitor compliance with the HASP
- Assist the Project Manager in ensuring that proper health and safety equipment is available for the project
- Approve personnel to work on the site with regard to medical examinations and health and safety training.

The Site Safety Officer (SSO) is responsible for verifying that project personnel and visitors adhere to the site safety requirements outlined in the HASP. These responsibilities include:

- Conducting the health and safety training for project personnel as appropriate
- Modifying health and safety equipment or procedure requirements based on data gathered during the site work

- Determining the posting locations and routes to medical facilities, including poison-control centers, and arranging for emergency transportation to medical facilities
- Posting the telephone numbers of local public emergency services and facilities
- Performing site audits to verify adherence to the requirements of the HASP.

The SSO has authority to stop any operation that threatens the health or safety of the work team, visitors or surrounding populace. The daily health and safety activities may be conducted by the SSO or a designated replacement.

2.3 Project Engineer, Scientist and Geologist Responsibilities

The Project Engineer/Scientist/Geologist has the following responsibilities:

- Coordinating directly with property owners to confirm site access prior to sampling events
- Reviewing subcontractors' work and approve all subcontractor invoices
- Working with the subcontractors and analytical laboratories to ensure that all field activities are conducted appropriately and that field activities are properly documented
- Coordinating the sampling operations to verify that the sampling team members adhere to this SAP and all referenced reports/plans
- Providing daily schedules for field personnel including subcontractors
- Maintaining a field log for all work completed on site
- Preparing the field investigation data and information for reports.

Note that it is not necessary for the Project Engineer/Scientist/Geologist to be present on-site during all sampling activities or field operations. Coordination and communication with the Sampling Technician will ensure compliance with this SAP and QAPP.

The Project Geologist is also be responsible for over seeing any monitoring well installation, generating monitoring well boring logs, and generating site wide groundwater contour maps.

2.4 Sampling Technician

The primary responsibility of the Sampling Technician is the collection of site samples with proper documentation of all sampling activities, and following all sampling standard operating procedures (SOPs). The Sampling Technician reports to the Project Engineer/Geologist. The Sampling Technician has the following responsibilities:

- Following sampling procedures outlined in the SOPs and any site specific requirements
- Providing documentation of all activities during the sampling event
- Following the QAPP and the Site Health and Safety Plan
- Packing and shipping of all samples directly to the laboratory.

2.5 Quality Assurance Officer Responsibilities

The Quality Assurance (QA) Officer is responsible for audits and monitoring adherence to the project QA objectives and the QAPP. The QA Officer reports directly to the Project Manager. The QA Officer has the following responsibilities:

- Reviewing laboratory analytical data
- Coordinating QA/QC operation with the laboratory coordinator
- Providing the Data Validator with the laboratory analytical data and sampling field notes
- Collaborating with the Project Engineer/Geologist in establishing sampling and analysis programs
- Serving as liaison between the laboratory and Project Engineer or Sampling Technician
- Serving as the "focal point" for laboratory activities
- Coordinating laboratory and data activities by the analytical services staff
- Notifying the laboratory of specific laboratory nonconformances and changes
- Maintaining a complete set of laboratory data
- Releasing testing data and results to the Project Engineer.

2.6 Data Validator

Responsibilities of the Data Validator include:

- Identifying data to be classified as questionable or qualitative
- Comparing actual sampling and laboratory procedures to those outlined in this plan
- Reporting the validation results to the Project Engineer and QA Officer.

3.0 Sampling Procedures

The following sections describe the groundwater monitoring well sampling procedures that are followed at the site to ensure that quality data is collected. Figure 1 includes a site map showing the locations of all existing monitoring wells. The QAPP is included in Appendix A. Appendix B includes SOPs, and monitoring well boring logs are included in Appendix C.

3.1 Site Access

The former GE facility is currently owned by Keymac, LLC and is maintained by McKinstry Company. Select downgradient wells are on Merlano Construction property and in the City of Seattle right of way. The following table summarizes the locations of existing monitoring wells on site and the designated representative who should be notified when the wells are scheduled to be accessed.

Table 3-1: Site Monitoring Well Contact Information

Well ID	Point of Contact
MW-1 through MW-9, MW-13	Keymac/McKinstry (Alex Cordas) phone: 206-762-3311
MW-10 through MW-12, MW-14M/D, MW-19M, MW-20M, EPI-MW-1S/D through EPI-MW-4S/D	Merlano Construction (Heidi Kludt) phone: 206-762-9125.
MW-15M/D through MW-18M/D, MW-21S	City of Seattle Right of Way - Street Use Permit may be required contact: (206) 684-5283 http://www.seattle.gov/transportation/stuse_permits_online.htm

Note:

Wells located along the side walk may be subject to a street use permit depending on the scope of work

GW gauging/sampling does not require a street use permit

3.2 Water Level Measurement

Water-level data are used to indicate the directions of groundwater flow and areas of recharge and discharge, to evaluate the effects of manmade and natural stresses on the groundwater system, to define the hydraulic characteristics of aquifers, and to evaluate stream-aquifer relations. Measurements of the static-water level are also needed to estimate the amount of water to be purged from a well prior to sample collection, when purge volumes are based on well volumes, rather than stabilization of parameters (i.e., for samples collected by bailing, rather than using low flow techniques). Water level measurements are conducted in accordance with ENSR SOP 7101.

Upon arrival at a monitoring well, the surface seal and well protective casing is examined for any evidence of frost heaving, cracking, or vandalism. All observations are recorded in the fluid-level monitoring log or the project field book.

All the water-level measuring points are marked by the surveyor on the well casing itself, or are collected from the north side of the well casing. Water-level measurements are made using an electronic or mechanical device. Many types of electrical instruments are available for water-level measurement; most operate on the principle that a circuit is completed when two electrodes are immersed in water. Electrodes are generally contained in a weighted probe that keeps the tape taut while providing some shielding of the electrodes against false indications as the probe is being lowered into the well. Before lowering the probe in the well, the circuitry can be checked by dipping the probe in water and observing the indicator (a light, sound, and/or meter).

To reduce any potential effects of pressure build up inside the monitoring wells, all monitoring wells are vented prior to collecting water level measurements. This is accomplished by releasing the well caps and allowing the wells to vent for at least 15 minutes.

To obtain a water-level measurement, the decontaminated water level probe is slowly lower into the monitoring well until the indicator (light, sound, and/or meter) shows water contact. At this time the precise measurement is determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement.

The water-level measurement device is decontaminated immediately after use following the procedures described in Section 3.3.

3.3 Sample Collection Using Low Flow Methods

Groundwater samples will be collected via EPA-Approved Low Flow Groundwater Sampling Procedures and will following the procedures listed in SOP 7130 (Attachment B). Twenty-seven of the wells onsite have dedicated submersible bladder pumps and dedicated tubing. Five wells, located on the Merlano Construction property (also know as the Liberty Ridge Property) do not have dedicated pumps. All purging and samples are collected using the dedicated pumps or a single stainless steel bladder pump. Groundwater is collected from the five monitoring wells on the Liberty Ridge Property using a QED stainless steel bladder pump. The bladder pump is decontaminated prior to sampling and after each monitoring well is sampled (see Section 3.4 for decontamination details). The polyethylene bladder and all sampling and airline tubing is replaced after sampling at each monitoring well.

3.3.1 Purging

The pump inlet is placed at approximately the midway point between the lowest measured groundwater level and the bottom of the screen, for monitoring wells that screen the water table. Gauging data from the each event is compared to the historical low water level, and the pump is adjusted accordingly. For wells where the screen does not intercept the water table, the pump inlet is placed midway along the screen interval. Table 3-2 includes both depths and elevations of the pump inlets and the elevation of the top and bottom of each monitoring well screen based on the current historic low water level.

After adjustment of the pump inlet to the required elevation, monitoring well purging is initiated at a rate of less than 300 milliliters per minute. As required with the low-flow sampling technique, turbidity, dissolved oxygen, and oxidation-reduction potential in the groundwater is monitored during purging of each well. The pH, specific conductance, and temperature are also monitored. Purge volumes are based on obtaining stability, as determined by having consecutive measurements at least three minutes apart being within ten percent of the previous measurement, except for conductivity which is within three percent of the previous measurement. Field parameters are collected in accordance with ENSR SOPs 7320 and 7125 (see Appendix B).

3.3.2 Sample Collection

Upon stabilization of parameters, the purge rate is reduced to approximately 200 milliliters per minute to collect samples. Samples are collected from the discharge tube of the pump directly into appropriate sample containers. Analytical methods and requirements are summarized in Table 3-3. Analytical methods listed in Table 3-3 represent a routine GW monitoring event.

Table 3-4 provides analytical methods for additional constituents required by Ecology at this time. The sampling frequency for these additional constituents will be determined in a separate correspondence. Any other additional parameters may be called for in specific reports/correspondence; in such cases, the reports/correspondence will detail any additional handling and preservation requirements.

3.3.3 Health and Safety Plan

The potential human health risk associated with inhalation and/or contact with the constituents of concern (COCs) at the site is discussed in the site Health and Safety Plan. All sampling activities are conducted in accordance with the site Health and Safety Plan.

3.3.4 Documentation

Various documents are completed and maintained as a part of groundwater sample collection. These documents will provide a summary of the sample collection procedures and conditions, shipment method, analyses requested, and the custody history. These documents may include:

- Field book
- Groundwater sampling forms
- Sample labels
- Chain-of-custody
- Shipping receipts.

All documentation is stored in the project files.

3.4 Decontamination

Decontamination is performed as a quality assurance measure and as a safety precaution. It prevents cross-contamination between samples and also helps maintain a clean working environment. Equipment requiring decontamination may include hand tools, sample collection equipment, monitoring and testing equipment, personal protective equipment, or heavy equipment (e.g., loaders, backhoes, drill rigs, etc.).

All sampling equipment is decontaminated prior to use and between each sample collection point, in accordance with ENSR SOP 7600 (Appendix B). Waste products produced by the decontamination procedures such as rinse liquids, solids, rags, gloves, etc. are collected and disposed of properly based on the nature of site impact and site protocols. Any materials and equipment that are reused will be decontaminated or properly protected before being taken off-site.

The following summarizes the decontamination procedures:

- Remove gross visible solids from the equipment by brushing and then rinsing with tap water
- Wash with detergent or soap solution (e.g., Alconox and tap water)
- Rinse with tap or distilled water
- Repeat entire procedure or any parts of the procedure as necessary
- Rinse with distilled water
- After decontamination procedure is completed, avoid placing equipment directly on ground surface.

3.5 Groundwater Well Development

Well development is the process of cleaning the face of the borehole and the formation around the outside of the well screen to permit groundwater to flow easily into the monitoring well. Monitoring wells are developed for the following reasons:

- To restore the natural permeability of the formation adjacent to the borehole to permit the water to flow into the screen easily
- To remove the clay, silt, and other fines from the formation so that during subsequent sampling the water will not be turbid or contain suspended matter which can easily interfere with chemical analysis
- To remove any formation damage that may have occurred as a result of well drilling.

Well development is necessary for all newly completed wells and may be required for existing site wells (including recovery wells) that have been left dormant for some time or have accumulated significant quantities of sediment or biological fouling in the well, gravel pack, or surrounding formation. If groundwater well development is required, all monitoring well development will be performed in accordance with ENSR SOP 7221 (Appendix B).

Well development is accomplished by causing the natural formation water inside the well to move vigorously in and out through the screen. The suspended sediment is then removed from the well by bailing or pumping. Several techniques may be employed in developing a well. To be effective, all require reversals or surges in flow to avoid bridging by particles. These surges can be created by using surge blocks, air lifts, bailers, or pumps (described in detailed in ENSR SOP 7221). The use of water other than the natural formation water is not recommended during well development.

Copies of all well development or redevelopment field forms will be submitted to Ecology.

Well Development for Newly Completed Wells

Before developing the well, water depth, and well depth will be measured using an electronic or mechanical device. Approximately 10 well volumes (calculated from the length of the water column and the well casing diameter) are removed from the well during development. The discharge from the well is continuously monitored and development is continued until a particulate free discharge is apparent and the field parameters (pH, conductivity, and temperature) have stabilized within 10 percent of the previous reading. Field parameters are recorded on the well development record after each volume is removed. All materials and equipment used in conjunction with development will be decontaminated prior to use and all provisions made to prevent cross-contamination during development. Well depths are measured following development to determine whether sand or silt has accumulated in the well.

Regardless of the method employed, any discharges from the wells are properly disposed of depending on the nature of the liquid removed from the well. Additionally, all materials and equipment placed into the well in conjunction with development is decontaminated prior to use.

Well Development for Existing Wells

Indicators that trigger well development in existing wells include: a substantial increase in turbidity, decrease in well yield, or if, during pump maintenance, sediment accumulation (of within 1 inches of the groundwater sampling pump intake and 3 inches of the recovery pumps intake) is measured in the well. The total well depth can be measured and compared to the installed total well depth to identify if silt is accumulating at the bottom of the well. Measuring the total well depth is complicated at the site because of the dedicated pumping and tubing in all wells, with the exception of the Liberty Ridge EPI wells. Raising and lower groundwater pumps increases the potential for contamination from surface contacts. To minimize this risk an initial evaluation of turbidity, a decrease in well yield, and/or silt accumulation measured during pump maintenance will trigger measuring the total well depth.

A turbidity and well yield are measured during the routine groundwater sampling events. During these events, turbidity, drawdown rates, and purge rates will be compared to the pervious sampling event. If a change in any of these parameters is measured, the total well depth will be gauged to determine if silt has accumulated. If silt has not accumulated in the wells, a further evaluation of the pumps, tubing, and all associated equipment will be conducted to troubleshoot the reason for the observed change.

If well redevelopment is required, the procedures outlined above and detailed ENSR SOP 7221 (Appendix B) will be followed. Copies of all well redevelopment logs and documentation will be provided to Ecology in the groundwater monitoring report (Section 5).

4.0 Sample Custody and Packaging

Chain-of-custody procedures are intended to document sample possession from the time of collection to disposal. Packing and shipping is essential to provide a high degree of certainty that environmental samples arrive at their destination intact. Chain-of-custody procedures and packing and shipping are summarized below and described in detail in ENSR SOP 7510 and 7007 (Appendix B).

4.1 Chain-of-Custody

A sample is considered to be under custody if it is in one's possession, view, or in a designated secure area. Transfers of sample custody are documented by chain-of-custody forms. The chain-of-custody record will include, at a minimum, the following information:

- Client or project name, or unique identifier, if confidential
- Sample collector's name
- Company's (ENSR) mailing address and telephone number
- Designated recipient of data (name and telephone number)
- Analytical laboratory's name and city
- Description of each sample (i.e., unique identifier and matrix)
- Date and time of collection
- Quantity of each sample or number of containers
- Type of analysis required
- Date and method of shipment.

Additional information may include type of sample containers, shipping identification air bill numbers, etc.

When transferring custody, both the individual(s) relinquishing custody of samples and the individual(s) receiving custody of samples will sign, date, and note the time on the form. If samples are to leave the collector's possession for shipment to the laboratory, the subsequent packaging procedures are followed.

4.1.1 Packing for Shipment

To prepare a cooler for shipment, the sample bottles are inventoried and logged on the chain-of-custody form. All sample bottles are labeled. At least one layer of protective material is placed in the bottom of the container. As each sample bottle is logged on the chain-of-custody form, it is wrapped with protective material (e.g., bubble wrap, matting, plastic gridding, or similar material) to prevent breakage. Each sample bottle is placed upright in the shipping container. Each sample bottle cap is checked during wrapping and tightened if needed. Avoid over-tightening, which may cause bottle cap to crack and allow leakage. Additional packaging material such as bubble wrap or Styrofoam pellets is spread throughout the voids between the sample bottles.

Most samples require refrigeration as a minimum preservative. Ice placed in heavy duty zip-lock type bags is distributed over the top of the samples. A minimum of two bags of ice will be placed in each cooler. Additional packing material should then be placed to fill the balance of the cooler or container.

Place the original completed chain-of-custody record in a zip-lock type plastic bag and place the bag on the top of the contents within the cooler or shipping container. Alternatively, the bag may be taped to the underside of the container lid. Retain a copy of the chain-of-custody record with the field records.

Close the top or lid of the cooler or shipping container and rotate/shake the container to verify that the contents are packed so that they do not move. Add additional packaging if needed and re-close. Place signed and dated chain-of-custody seal at two different locations (front and back) on the cooler or container lid and overlap with transparent packaging tape. The chain-of-custody tape is placed on the container in such a way that opening the container will destroy the tape. Packaging tape should encircle each end of the cooler at the hinges.

Sample shipment is sent via courier or an overnight express service that can guarantee 24-hour delivery. Retain copies of all shipment records as provided by the shipper.

4.2 Sample Log-in

Upon receipt of samples (accompanied by a completed chain-of-custody record detailing requested analyses), the Quality Assurance Officer(s) or his/her delegate will:

- Verify all paperwork, chain-of-custody records, and similar documentation
- Log-in samples, assign unique laboratory sample numbers, and attach the numbers to the sample container(s)
- Store samples in a refrigerated sample bank.

5.0 Reporting

Quarterly groundwater monitoring reports are submitted to Ecology within 60 calendar days following the sampling event. Quarterly groundwater monitoring reports submitted comply with WAC 173-340-820, WAC 173-340-830, WAC 173-340-840. Reports include the following information:

- A narrative summary of sampling methods, sampling analytical results, and plans for the next sampling event.
- Tabulated COC concentrations and water table elevation data from the last sampled event as well as historical COC concentrations for all previous sampling events. Tables will include MTCA Method B groundwater, A (unrestricted) groundwater, and B surface water cleanup levels, and other State and Federal applicable ARARs, for reference.
- A narrative evaluation of the results of the data validation results and a description of all data qualified or rejected.
- Site wide groundwater level contour maps.
- Iso-concentration maps for the primary COCs of concern including: TCE, PCE, and 11-DCE.
- Groundwater pump inlet locations during sampling, with respect to well screen elevations and water levels.
- Copies of all laboratory analytical data sheets and chain of custody forms.
- Copies of field activity logs and groundwater stabilization data (including any well development or redevelopment logs).

6.0 References

Ecology, 1991. *Guidance and Specifications for Preparing Quality Assurance Project Plans.* Washington State Department of Ecology.

Ecology, 1995. *Guidance on Sampling and Data Analysis Methods.* Washington State Department of Ecology Toxics Cleanup Program.

Washington State Department of Ecology Toxics Cleanup Program, 2001b. *Model Toxics Control Act Cleanup Regulation Chapter 173-340 WAC.* Publication No. 94-06. February.

Tables

Table 3-2 MW Construction Details and Pump Setting Information

	TOC Elevation[1]	Depth of Low GW (feet - TOC PVC)	Elevation of Low GW (feet)	Total Well Depth (feet - TOC PVC)[2]	Elevation of Well Depth (feet)	Elevation to Top of Screen (feet)	Elevation to Bottom of Screen (feet)	Screen Length (feet)	Pump Tubing Length (feet)	Required Pump Inlet Depth (feet TOC PVC)[3]	Required Pump Inlet Elevation (feet)	Quarterly Pump Adjustment Required for Groundwater Sampling since previous Quarter (feet upward)
MW-1	18.38	9.98	8.40	15.5	2.9	12.9	2.9	10	13.6	12.7	5.6	0.00
MW-2	18.22	10.02	8.20	15.3	2.9	12.9	2.9	10	13.7	12.7	5.6	0.00
MW-3	16.87	9.06	7.81	15.5	1.4	11.4	1.4	10	13.7	12.3	4.6	0.00
MW-4	19.54	11.82	7.72	16.6	2.9	12.9	2.9	10	14.7	14.2	5.3	0.00
MW-5	17.92	9.98	7.94	18.6	-0.7	14.3	-0.7	15	16.4	14.3	3.6	0.00
MW-6	17.74	10.24	7.50	18.4	-0.7	14.3	-0.7	15	16.7	14.3	3.4	0.00
MW-7	20.38	12.75	7.63	18.7	1.7	16.7	1.7	15	16.7	15.7	4.7	0.00
MW-8S[4]	17.58	10.23	7.35	18.9	-1.3	13.7	-1.3	15	16.7	14.6	3.0	0.00
MW-8M	17.14	9.18	7.96	30.0	-12.9	-2.9	-12.9	10	25.5	25.5	-8.4	NA
MW-9	16.56	8.86	7.70	18.8	-2.2	12.8	-2.2	15	16.7	13.8	2.7	0.00
MW-10	17.44	10.09	7.35	14.6 [2]	2.8	12.8	2.8	10	12.7	12.3	5.1	0.00
MW-11	17.485	10.26	7.23	18.9	-1.4	13.6	-1.4	15	16.6	14.6	2.9	0.00
MW-12	17.75	10.58	7.17	19.0	-1.3	13.8	-1.3	15	17.1	14.8	3.0	0.00
MW-13	18.38	9.38	9.00	19.0	-0.6	14.4	-0.6	15	17.7	14.2	4.2	0.00
MW-14M[4]	17.38	9.22	8.16	29.6	-12.2	-2.2	-12.2	10	24.6	24.6	-7.2	NA
MW-14D	16.9	8.78	8.12	54.7	-37.8	-27.8	-37.8	10	49.7	49.7	-32.8	NA
MW-15M[4]	16.95	9.13	7.82	29.7	-12.8	-2.8	-12.8	10	24.7	24.7	-7.8	NA
MW-15D	16.62	8.81	7.81	54.7	-38.1	-28.1	-38.1	10	49.7	49.7	-33.1	NA
MW-16M[4]	16.68	9.17	7.51	29.7	-13.0	-3.0	-13.0	10	24.7	24.7	-8.0	NA
MW-16D	16.545	8.99	7.56	54.6	-38.1	-28.1	-38.1	10	49.6	49.6	-33.1	NA
MW-17M	17.735	9.41	8.33	29.9	-12.2	-2.2	-12.2	10	24.5	24.9	-7.2	NA
MW-17D	17.795	9.52	8.28	54.8	-37.0	-27.0	-37.0	10	50.0	49.8	-32.0	NA
MW-18M	15.755	7.54	8.22	29.8	-14.0	-4.0	-14.0	10	24.5	24.8	-9.0	NA
MW-18D	15.545	7.32	8.23	54.9	-39.4	-29.4	-39.4	10	50.0	49.9	-34.4	NA
MW-19M	17.645	8.98	8.67	29.1	-11.5	-1.5	-11.5	10	24.5	24.1	-6.5	NA
MW-20M	17.625	8.96	8.67	29.6	-11.9	-1.9	-11.9	10	24.5	24.6	-6.9	NA
MW-21S	17.09	9.19	7.90	16.0	1.1	-2.9	1.1	10	6.0	6.0	11.1	0.00

Notes:

1 Survey elevations based on Mean Lower Low Water NAVD 88 DATUM.
2 Total well depths as measured.
3 Required pump inlet depth based on placing pump inlet midway between the low water level and the bottom of the well (as measured).
4 MW -8, MW-14S, MW-15S, and MW-16S have been renamed MW-8S, MW-14M, MW-15M, and MW-16M to denote well screen placement.
NA – Not applicable, wells with submerged screens are not affected by changes in water level.

Table 3-3 Summary of Groundwater Analytical Methods

Chemical	Method	Reporting Limit (µg/L)	Bottles	Preservative	Holding Times
Volatile Organic Compounds					
Tetrachloroethene	SW8260-SIM	0.02	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Trichloroethene	SW8260-SIM	0.02	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Vinyl Chloride	SW8260-SIM	0.02	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,1,1,2-Tetrachloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,1,1-Trichloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,1,2,2-Tetrachloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,1,2-Trichloro-1,2,2-trifluoroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,1,2-Trichloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,1-Dichloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,1-Dichloroethene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,1-Dichloropropene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,2,3-Trichlorobenzene	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,2,3-Trichloropropane	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,2,4-Trichlorobenzene	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,2,4-Trimethylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,2-Dibromo-3-chloropropane	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,2-Dibromoethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,2-Dichlorobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,2-Dichloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,2-Dichloropropane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,3,5-Trimethylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,3-Dichlorobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,3-Dichloropropane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
1,4-Dichlorobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
2,2-Dichloropropane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
2-Butanone	SW8260B	1	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
2-Chloroethylvinylether	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
2-Chlorotoluene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
2-Hexanone	SW8260B	3	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
4-Chlorotoluene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days

Table 3-3 Summary of Groundwater Analytical Methods

Chemical	Method	Reporting Limit (µg/L)	Bottles	Preservative	Holding Times
Volatile Organic Compounds					
4-Isopropyltoluene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
4-Methyl-2-Pentanone (MIBK)	SW8260B	1	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Acetone	SW8260B	3	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Acrolein	SW8260B	5	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Acrylonitrile	SW8260B	1	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Benzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Bromobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Bromochloromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Bromodichloromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Bromoethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Bromoform	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Bromomethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Carbon Disulfide	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Carbon Tetrachloride	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Chlorobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Chloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Chloroform	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Chloromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
cis-1,2-Dichloroethene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
cis-1,3-Dichloropropene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Dibromochloromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Dibromomethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Ethylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Hexachlorobutadiene	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Isopropylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
m,p-Xylenes	SW8260B	0.4	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Methyl Iodide	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Methylene Chloride	SW8260B	0.3	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Naphthalene	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
n-Butylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
n-Propylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days

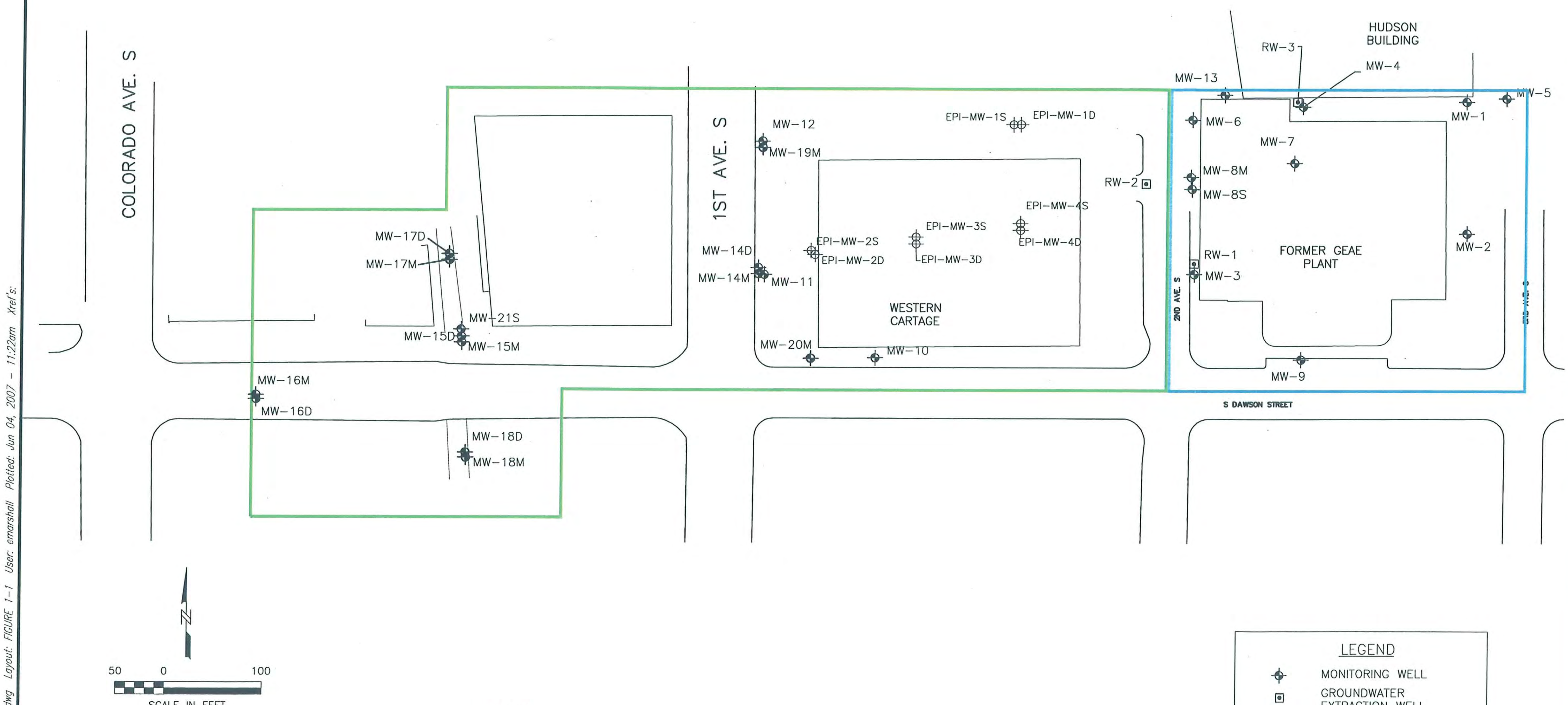
Table 3-3 Summary of Groundwater Analytical Methods

Chemical	Method	Reporting Limit (µg/L)	Bottles	Preservative	Holding Times
Volatile Organic Compounds					
o-Xylene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
sec-Butylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Styrene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
tert-Butylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Toluene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
trans-1,2-Dichloroethene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
trans-1,3-Dichloropropene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
trans-1,4-Dichloro-2-butene	SW8260B	1	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Trichlorofluoromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Vinyl Acetate	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days

Table 3-4 Summary of Groundwater Analytical Methods - Additional Parameters

Chemical	Method	Reporting Limit	Bottles	Preservative	Holding Times
1,4 Dioxane	SW8260-SIM	1.0 ug/L	40ml VOA containers	HCL, Cool to 4° C, Zero Headspace	14 Days
Total, Arsenic	SW846-6010B	0.001 mg/L	500-ml Poly	HCL, Cool, 4° C	30 days
Dissolved, Arsenic	SW846-6010B	0.001 mg/L	500-ml Poly	Field Filter, HCL, Cool, 4° C	30 days

Figures



NOTES:

1. MONITORING WELLS MW-8, MW-14S, MW-15S, AND MW-16S HAVE BEEN RENAMED MW-8S, MW-14M, MW-15M, AND MW-16M.

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GEAE - S. DAWSON STREET	SITE LOCATION MAP
GE001-19314-735	
DATE: 06/04/07	DRWN: E.M./SEA	FIGURE 1-1

File: H:\19314\19314S125.dwg Layout: FIGURE 1-1 User: emarshall Plotted: Jun 04, 2007 - 11:22am Xref's:

Appendix A

Quality Assurance Project Plan

ENSR | AECOM

Prepared for:
General Electric Aircraft Engines
1 Neumann Way, Mail Drop T165
Cincinnati, Ohio 45215

Quality Assurance Project Plan-Revision 1

The RETEC Group, Inc.
February 2008
Document No.: 02978-415-735

Merged with ENSR in 2007

RETEC

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Quality Assurance Project Plan – Revision 1

Jamie Stevens FOR

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Reviewed by Jamie Stevens, P.E.
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Reviewed by Linda Baker, R. G.
Program Manager

The RETEC Group, Inc.
February 2008
Document No.: 02978-415-735

Merged with ENSR in 2007

RETEC

Contents

1.0 Introduction

This Quality Assurance Project Plan (QAPP) details the quality assurance and quality control measures that will be taken during sample collection, shipment and analysis at the former General Electric facility located at 220 S. Dawson Street, Seattle WA (Site). The objective of this document is to ensure the procedures outlined in the Sampling and Analysis Plan (SAP) provide high quality data that can be used to accurately determine current site conditions. This document was prepared in accordance with Washington Department of Ecology Preparing Quality Assurance Project Plans for Environmental Studies, Publication No. 04-03-030 (Ecology, 2004).

Please refer to the SAP for project organization and detailed sampling procedures. A complete description of the project background can be found in the Interim Action Completion Report (RETEC, 2007).

2.0 Quality Assurance Procedures

2.1 Quality Control of Sample Collection

Samples collected for volatile analysis will be placed in two 40-ml volatile organic analyte (VOA) vials with zero headspace. Agitation will be minimized during sampling to reduce potential losses of volatile constituents. Table 3-3 of the SAP summaries sample handling, sample preservation requirements, and laboratory reporting limits for routine groundwater samples collected at the site. Additional parameters may be called for in specific reports/correspondence; in such cases, the reports/correspondence will detail any additional handling and preservation requirements.

At least one duplicate sample shall be collected for each 10 investigation samples. Trip blanks will be carried each day that more than one well is sampled for volatile constituents. Trip blanks will be prepared by the laboratory by filling representative glassware with known deionized water. These samples will be transported with the sample collection glassware and analyzed for evidence of systematic contamination from sample transport, glassware cleaning, and laboratory storage. Trip blanks will be sent with each day's samples shipped, one trip blank per cooler At least one matrix spike/matrix spike duplicate (MS/MSD) will be collected per 20 investigation samples.

2.2 Sample Custody

All Chain-of-custody procedures, packaging of samples, and sampling log-in will be done in accordance with the procedures out lined in Section 4 of the SAP and in ENSR SOP 7510 (Appendix B of the SAP).

2.3 Quality Control Parameters

Groundwater will be collected for laboratory analysis as described in Section 3 of the SAP. To achieve the project data quality requirements, the following quality-control parameters will be evaluated throughout the course of this project:

- Detection limits
- Data precision
- Data accuracy
- Representativeness
- Comparability and completeness.

These quality-assessment parameters are described in greater detail in the subsequent paragraphs.

2.3.1 Detection Limits

The method detection limit for a given parameter is determined by procedures specified in the method. Table 3-2 of the SAP summarizes the detection limits, and methods used for volatiles organic carbons. These detection limits will be observed for all laboratory analyses performed during this project, except where matrix interferences and high concentrations of target and non-target compounds increase the reporting detection limits.

2.3.2 Precision

Precision will be determined for field duplicate samples by examining sample results for degree of variance and determining if sampling error has occurred. Precision is a measure of agreement among individual measurements of the same parameter, usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation. The relative percent difference (RPD) parameter will be calculated to define the precision between duplicate analyses.

The RPD for each component is calculated using the following equation:

$$\%\,RPD = \frac{(X_2 - X_1)}{[(X_1 + X_2)/2]} \times 100$$

where:

X_1 = first duplicate sample value

X_2 = second duplicate sample value

The laboratory objective for precision is to generate RPD values that fall within the established control limits for the method employed. The field objective for precision is to generate RPD values that are between 0 and 50 percent for soil samples and 0 to 30 percent for groundwater samples. If the criteria are not met, the Data Validator will examine other quality-control criteria to determine the need for some qualification of the data.

2.3.3 Accuracy

Accuracy is defined as the degree of agreement between a measurement and an accepted reference of true concentration. Accuracy is determined by spiking samples with a known concentration of standard compounds and comparing the analytical results with the known value. Data accuracy will be assessed by determining the percent recovery of a spiked compound. Percent recovery (%R) is determined by the equation:

$$\%\,R = \frac{(C_1 - C_0)}{C_S} \times 100$$

where:

C_1 = measured concentration in the spiked sample

C_o = measured concentration in the unspiked sample

C_s = concentration at which the sample was spiked

The concentration at which the sample was spiked (Cs) is calculated, using the following equation:

$$C_S = \frac{(C_{spike} \times V_{spike})}{V_{sample} + V_{spike}}$$

where:

C_s = concentration at which the sample was spiked

C_{spike} = spike concentration

V_{spike} = volume of spike

V_{sample} = volume of sample

The laboratory objective for accuracy is to generate %Rs that fall within established control limits for the method employed.

Surrogate and matrix spiking compounds and sample selection for spiking are determined by current SW-846 methodologies. Percent recoveries indicate the actual performance of the analytical method on real world samples. Surrogate spikes, matrix spikes, matrix spike duplicates, and QC spikes will be conducted using standard laboratory methods.

2.3.4 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic population, a process control, or an environmental condition. Appropriate sampling procedures (i.e., those sampling procedures presented in the attached SOPs) will be implemented so that the samples are representative of the environmental matrices from which they were obtained.

2.3.5 Comparability and Completeness

Comparability is achieved through the use of the same analytical methods that were used previously, through use of trained personnel and through following procedures in the SOPs. Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. The completeness goal will be at least 90 percent.

2.4 Calibration Procedures and Frequency

This section establishes the procedures for maintaining the accuracy of instruments and measuring equipment to conduct field measurements and tests.

The Sampling Technician is responsible for the calibration of field equipment (see ENSR SOPs in Appendix B of the SAP). The responsibility for the calibration of laboratory equipment lies with the Analytical Laboratory internal project manager.

2.4.1 General Calibration Procedures

Field testing equipment used for analytical determinations falls into two categories: those calibrated prior to each use and those calibrated on a scheduled periodic basis. Frequency of calibration will be based on the type of equipment, inherent stability, manufacturer's recommendations, values given in national standards, the intended use and experience. The table below presents the calibration frequency of the field sampling equipment. Calibration procedures and quality assurance/quality control methods will conform to the SOP 7320, 7125, 7101, and 7315; summarized below.

Instrument	Calibration Procedure	Calibration Frequency
pH meter	Two-point calibration with pH buffers 7 and 4, or 10, as appropriate; see ENSR SOP 7320	Daily
Conductivity meter	See ENSR SOP 7320	Daily
DO meter	Two-point calibration; see ENSR SOP 7320	Daily
Redox meter	See ENSR SOP 7320	Daily
Thermometer	Check with ohm meter or standard thermometer; see ENSR SOP 7320	Annually
Photoionization detector	Isobutylene gas standard; see ENSR SOP 7315	Daily
Electric water-level probe	Test probe in tap water; check tape against known length see ENSR SOP 7101	Probe; as needed if malfunctions; tape

		length: annually
Turbidity Meter	3-point calibration; see ENSR SOP 7125	Daily

Equipment will be calibrated using reference standards (i.e., National Bureau of Standards (NBS), manufacturer's standards, or accepted values of natural physical constants). If national standards do not exist, the basis for calibration will be documented in the daily field activity log. Field equipment calibration will be performed as described by the equipment manufacturer.

2.4.2 Calibration Failures

Scheduled periodic calibration of testing equipment will not relieve field personnel of the responsibility to verify that equipment is functioning properly. If an individual suspects an equipment malfunction, she/he will remove the device from service, tag it so that it is not inadvertently used, and see that recalibration is performed or substitute equipment is obtained. Instruments past due for calibration will be immediately removed from service either physically or, if this is impractical, by tagging, sealing, labeling, or other means.

Results of activities performed using equipment that has failed recalibration will be evaluated by the Project Engineer/Geologist. If the activity results are adversely affected, the results of the evaluation will be documented, and the appropriate personnel notified. If water level measurements are found to be in error due to recalibration failure of the water level probe, the appropriate modifications will be made to the measurement according to the recalibration data and recorded in the data logbook. If pH, conductivity, or temperature meters fail recalibration, the data will be reviewed to determine whether alternate parameter data are sufficient to accept the groundwater sampling results. For instance, if the conductivity meter fails recalibration, pH and temperature readings will be used to verify that the purge water has stabilized. Since these parameters are calibrated prior to each use, it is unlikely that the data will be unacceptable.

2.4.3 Calibration Records and Maintenance

The Sampling Technician will document all calibration dates and methods on the calibration log or on the daily field log. Calibrated equipment will be uniquely identified by using the manufacturer's serial number or other means. Copies of all calibration records will be included in any summary reports generated for the field activities.

3.0 Analytical Procedures

The laboratories utilized for analysis of samples collected under the SAP shall perform all analysis according to EPA-accepted methods. Accepted EPA methods consist of those methods which are documented in the "*Contract Lab Program Statement of Work for Organic Analysis*" or any alternative method that has been approved by EPA for use during this project. The specific analytical methods to be used during the investigation will be specified in work plans. The analytical method procedures are detailed in the laboratory QA manual, available upon request from the laboratory.

3.1 Analytical Laboratories

Analytical Resources, Incorporated (ARI) of Seattle, Washington will perform analysis on all water samples collected as described in Section 3 of this SAP. The Laboratory Coordinator is Mark Harris.

3.2 General Requirements

In general, ARI will adhere to those recommendations as promulgated in 21 CFR Part 58, "Good Laboratory Practices," criteria described in Methods for Chemical Analysis of Water and Wastes, 1979 (EPA-600/4-79-020); procedures described in SW-846 Test Methods for Evaluating Solid Waste-Physical/Chemical Methods, Third Edition, 1994; and those criteria presented in 40 CFR 136, "Guidelines Establishing Test Procedures for Analysis of Pollutants Under the Clean Water Act."

3.3 Analytical Data Review and Reporting

Data quality and utility depends on many factors, including sampling methods, sample preparation, analytical methods, quality control, and documentation. Physical and chemical data have been divided into five categories (EPA Region V Model Quality Assurance Project Plan, 1991), as follows:

- **Level V B Nonstandard Methods.** Analyses by nonstandard protocols, such as ultra-low detection limits or analysis of an unusual chemical compound. These analyses often require method modification and/or development. CLP (Contract Laboratory Program) Special Analytical Services (SAS) projects are considered Level V.
- **Level IV B CLP Routine Analytical Services (RAS).** This level is characterized by rigorous QA/QC protocols and documentation, and it provides qualitative and quantitative analytical data. Some EPA regions have obtained similar support via their own regional laboratories, university laboratories, or other commercial laboratories.
- **Level III B Laboratory Analysis Using Methods Other than the CLP RAS.** This level is used primarily in support of engineering studies, using standard EPA-approved procedures. Some procedures may be equivalent to CLP RAS, without the CLP document requirements.
- **Level II B Field Analysis.** This level is characterized by the use of portable analytical instruments which can be used on-site or in mobile laboratories stationed near a site (close-support labs). Depending upon the types of impacts, sample matrix, and personnel skills, qualitative and quantitative data can be obtained.
- **Level I B Field Screening.** This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling point locations and for health and safety support. The types of data included are those generated on site through the use of PID, pH, conductivity, or other real-time monitoring equipment. Data can be generated regarding the presence or absence of certain materials (especially volatiles) at sampling locations.

The data generated in this project will be prepared and reviewed for Level III validation. ARI will use EPA methods to identify analytical values that do not meet the required ranges for surrogate recoveries and matrix spike recoveries. If such values are identified, then the analysis must be repeated. If the re-analyzed values are within required limits and holding times, they will be reported as true values. If, in the repeated analysis, the values are still outside required limits, the data are considered to be invalid, and matrix effects are considered to have caused the values to be outside of the acceptable recovery limits (Table 3-3 of the SAP).

3.4 Analytical Data

ARI will submit results which are supported by sufficient backup data and QA/QC results to enable the quality of the data to be determined conclusively. Prior to release of data, the ARI Laboratory Coordinator(s) will: review the data package for reasonableness; review QC data results; verify that calculation checks were properly performed; review chain-of-custody record(s), sample preservation, and holding-time requirements; and write a project narrative. Data that are not acceptable will be held until the problems are resolved. Section 2 of this QAPP describes the procedures that are employed to evaluate the precision, accuracy, representativeness, and completeness of the analytical test data generated during this project. It is the responsibility of the QA Officer to review these parameters. Validity of all data will be determined based on the criteria described in Section 2.

3.5 Final Reporting and Archiving of Documents

Upon successful completion of the data validation process, all data generated at the site will be tabulated and stored in an electronic data base file. Data summaries and results will be submitted in final report form. This report will consist of all pertinent sample and project information. It will also identify analytical procedures.

Copies of all analytical data and/or final reports will be retained in the laboratory files, and at the discretion of the Laboratory Coordinator(s), the data will be stored for a minimum of 1 year. After 1 year, or whenever the data become inactive, the files will be transferred to archives in accordance with standard laboratory procedure. Data may be retrieved from archives upon request.

4.0 Data Management and Assessment

The data collected and validated as part of the monitoring program will be combined with the extensive data already compiled for the Site. This section discusses the management of data generated as part the field effort.

4.1 Data Management

4.1.1 Reporting

After receipt of the analytical results, the QA Officer will review all raw data, including QA/QC data from the sample analyses.

Periodic reports will include a summary of data reduction results and a discussion of any inconsistencies that exist from a data-use standpoint. All field data sheets will be included as an appendix in the reports. All raw data will be appropriately identified in reports and included in a separate appendix of the report.

4.1.2 Representativeness

The determination of the representativeness of the data will be performed by:

- Comparing actual sampling procedures to those delineated in this plan;
- Examining the results of QC blanks for evidence of external or cross-contamination; such evidence may be cause for invalidations or qualification of the affected samples;
- Invalidating non-representative data or identifying data to be classified as questionable or qualitative. Only representative data will be used in subsequent data reduction, validation activities, and facility characterization.

The analytical results of the equipment blank samples (cross-contamination) and trip blank samples (external contamination) will be compared to the results of the field samples to determine if the level of impact is significant. The rule of 5x will be used when chemicals are measured in a blank sample. This rule states that if a sample concentration is less than five times (5x) the blank, the sample should be qualified as non-detectable (EPA, 1988).

4.1.3 Data Review

The objective of the data review is to identify any qualitative, unreliable, or invalid laboratory measurements. Data review entails a review of the laboratory-provided QC data to verify that the laboratory is properly performing the QC program and is operating within the required control limits. As a result, it will be possible to determine which samples, if any, are related to out-of-control laboratory QC samples. Laboratory data will be screened for inclusion of and frequency of the necessary QC supporting information, such as detection limit verification, duplicates, spikes, and method blanks. QC supporting information will be screened to determine whether any data are outside established control limits. Any out-of-control data without appropriate corrective action will be cause to qualify the affected measurement data. Missing or infrequent QC information will be cause to contact the laboratory concerning affected measurement data and to request additional QC supporting information for re-analysis.

4.2 Data Assessment

4.2.1 Field Procedures

Quality control procedures for field instruments will be limited to periodic instrument calibration as described in Section 5.

4.2.2 Laboratory Procedures

Following the assessment of laboratory data for the inclusion of required QC data, the QC data will be analyzed for accuracy and precision. If quality control audits result in the detection of unacceptable data, the QA Officer will be responsible for initiating corrective action, which may include:

- Re-analyzing samples if holding-time criteria permit;
- Re-sampling and analyzing;
- Evaluating and amending sampling and analytical procedures;
- Accepting data and acknowledging the level of uncertainty.

4.2.3 Accuracy

The accuracy of the data will be determined as follows:

- Computing percent recoveries for spiked samples;
- Calculating the standard deviation in the overall average recovery value;
- Determining the range of uncertainty at a given level of confidence.

The accuracy of the data will be used to determine any bias in the analytical methods. The field sample results will not be adjusted for bias, but the bias will be considered in the interpretation of the data.

4.2.4 Precision

The determination of the precision of the data will be performed by examining duplicate samples for degree of variance and by determining if sampling error has occurred by the variance of duplicates. The precision values calculated from the field duplicates will be used in the data interpretations to determine how sensitive the site characterizations are to the variances in the data.

Specific precision targets cannot be formulated without baseline precision data. However, the precision data will be summarized into the following categories. For each compound or element, the number of field duplicates with variance in the following ranges will be evaluated:

- Less than 10 percent
- 10 to 25 percent
- 25 to 50 percent
- Greater than 50 percent.

This will provide qualitative information to the individuals interpreting the data as to the range of variances and will also allow the proper planning for QC samples in future sampling episodes.

4.3 Data Validation

After reviewing the laboratory analytical data, the QA officer will provide the Data Validator with the data and field notes from the applicable sampling activities. The Data Validator will compare the actual sampling and laboratory procedures to those explained in this plan, identify any questionable or qualitative data, and report the validation results to the QA Officer.

5.0 References

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Appendix B

ENSR SOPs

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Chain-of-Custody Procedures

SOP Number 7007

Revision Number: 0.0

January 2008

Jamie C Stevens, P.E.
ENSR Project Manager
January 23, 2008

Renee Knecht, L.G.
ENSR Project QA Officer
January 23, 2008

ENSR Corporation
January 23, 2008

Chain-of-Custody Procedures

CONTENTS

LIST OF ACRONYMS

COC	Chain-of-Custody
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes chain-of-custody (COC) procedures applicable to ENSR sampling and analysis programs.

2.0 SUMMARY OF METHOD

The National Enforcement Investigations Center of the U.S. Environmental Protection Agency (USEPA) defines custody of evidence in the following manner:

- It is in your actual possession;
- It is in your view, after being in your physical possession;
- It was in your possession and then you locked or sealed it up to prevent tampering; or
- It is in a secure area.

Samples are physical evidence and should be handled according to certain procedural safeguards described in of this SOP.

3.0 HEALTH AND SAFETY WARNINGS

Not applicable.

4.0 INTERFERENCES

Not applicable.

5.0 PERSONNEL QUALIFICATIONS

Individuals responsible for completing COC documentation must be personnel working on the specific field program, have read this SOP, and have worked under the oversight of experienced personnel.

6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Sample Labels

- COC Form (Figure 1)
- COC Tape (Figure 2)
- Field project logbook/pen

7.0 METHODS

7.1 Field Custody

7.1.1 The field personnel is required to complete the following information on the COC form (Figure 1):

- Project Number (not project name)
- Project Location
- Field Sample Identification Number
- Date and Time of Sample Collection
- Sample Matrix
- Preservative
- Analysis Requested
- Sampler's Signature
- Signature of Person Relinquishing Sample Custody
- Date and Time Relinquished
- Sampler Remarks
- COC Tape Number

7.1.2 The COC must be filled out completely and legibly in ink. Corrections will be made, if necessary, by drawing a single line through and initialing and dating the error. The correct information is then recorded with indelible ink. All transfers from field personnel to laboratory personnel are recorded on the COC form in the "Relinquished By" and "Received By" sections.

7.1.3 If samples are to be shipped by overnight commercial courier (e.g., Federal Express), the field personnel must complete a COC form for each package (e.g., cooler) of samples and place a copy of each completed form inside the associated package before the package is sealed. Each completed COC form must accurately list the sample identification numbers of the samples with which it is packaged, and must contain the identification number of the COC tape on the package. It is not necessary for the shipping company to sign the COC.

Sample packaging will be conducted in accordance with ENSR SOP No. 7510 – Packaging and Shipment of Environmental Samples.

7.1.4 If samples are hand carried to a laboratory, the person hand carrying the samples is the sample custodian. If the carrier is a different person than the one who filled out the COC form and packaged the samples, then that person must transfer custody to the carrier by signing and dating each form in the "Relinquished By" section. The carrier must then sign and date each form in the adjacent "Received By" section. When the carrier transfers the samples to the laboratory, he or she must sign and date each form in the next "Relinquished By" section, and the laboratory sample custodian must sign and date each form in the adjacent "Received By" section.

7.2 Laboratory Sample Receipt and Inspection

7.2.1 Upon sample receipt, the coolers or packages are inspected for general condition and the condition of the COC tape. The coolers or boxes are then opened and each sample is inspected for damage.

7.2.2 Sample containers are removed from packing material and sample label field identification numbers are verified against the COC form.

7.2.3 The following information is recorded in the laboratory's records:

- Airbill Number
- Presence/absence of COC forms and COC tape
- Condition of samples
- Discrepancies noted
- Holding time and preservatives
- Sample storage location

7.2.4 The COC form is completed by signing and recording the date and time of receipt.

7.2.5 The ENSR Project Manager or designate must be notified of any breakage, temperature exceedances, or discrepencies between the COC paperwork and the samples.

8.0 DATA AND RECORDS MANAGEMENT

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion, and in the files of the laboratories that have performed the sample analyses.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

The records generated in this procedure are subject to review during data validation, in accordance with the Quality Assurance Project Plan (QAPP).

10.0 REFERENCES

ENSR SOP No. 7510 - Packaging and Shipment of Environmental Samples.

FIGURE 1 EXAMPLE CHAIN OF CUSTODY FORM

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CHAIN OF CUSTODY RECORD

Page ____ of ____

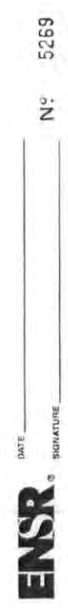
Client/Project Name:	Project Location:
Project Number:	Field Logbook No.:
Sampler: (Print Name) /Affiliation:	Chain of Custody Tape No.:
Signature:	Send Results/Report to:

Analysis Requested

Field Sample No./ Identification	Date	Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Sludge, Etc.)	Preservative	Field Filtered							Lab I.D.	Remarks

Relinquished by: (Print Name)	Date:	Received by: (Print Name)	Date:	Analytical Laboratory (Destination):
Signature:	Time:	Signature:	Time:	ENSR
Relinquished by: (Print Name)	Date:	Received by: (Print Name)	Date:	4303 W. LaPorte Ave.
Signature:	Time:	Signature:	Time:	Fort Collins, CO 80521
Relinquished by: (Print Name)	Date:	Received by: (Print Name)	Date:	(970) 416-0916
Signature:	Time:	Signature:	Time:	Serial No.

FIGURE 2 EXAMPLE CHAIN OF CUSTODY TAPE



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Water Level Measurements

SOP Number 7101

Revision Number: 0.0

January 2008

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January 23, 2008

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January 23, 2008

CONTENTS

LIST OF ACRONYMS

SAP	Sampling Analysis Plan
HASP	Health and Safety Plan
QAPP	Quality Assurance Project Plan
OSHA	Occupational Safety and Health Administration
SOP	Standard Operating Procedure

1.0 SCOPE AND APPLICABILITY

This Standard Operation Procedure (SOP) describes the methods to be used for measuring depth to groundwater levels and total depth of groundwater monitoring wells and piezometers. Similar procedures will also be used to measure the depth to water in surface water bodies from fixed structures such as bridges or culverts.

Water level and well depth measurements collected from monitoring wells or piezometers are used to assess:

- The horizontal hydraulic gradient and the direction of groundwater flow;
- The vertical hydraulic gradient, if well nests are used (i.e., the direction of groundwater flow in the vertical plane); and
- The calibration of a numerical groundwater flow model.

This information, when combined with other location-specific information, such as hydraulic conductivity or transmissivity, may be used to estimate the rate of constituent movement, etc. Total well depth measurements are also collected as an indicator of siltation within the well column, and to calculate well volumes if necessary.

2.0 SUMMARY OF METHOD

Measurements will involve measuring the depth to water or total well depth to the nearest 0.01 foot using an electronic probe (water level meter). The depths within wells will be measured from the top of the inner casing at the surveyed elevation point as marked on the top of the inner casing. Depths to surface water will be measured from a mark placed on the fixed structure (e.g., bridge, culvert) by the surveyor.

3.0 HEALTH AND SAFETY WARNINGS

Collecting water level measurements may involve chemical hazards associated with materials in the water being in contact with the water level measurement equipment. When collecting water level measurements, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Potential interferences could result in inaccurate readings if the sensor on the water level meter is wet or dirty, or if the cable cannot be kept vertically upright (for example, from a bridge in the wind). Care shall be taken to keep the probe clean. If wells are not installed plumb, the probe may rest against the side of the well, which may be wet. Care shall be taken in measuring water levels to reduce these interferences. If there is any concern that a particular reading may not be accurate, this shall be noted in the field log book.

5.0 PERSONNEL QUALIFICATIONS

Collecting water level measurements is a relatively simple procedure requiring minimal training and a relatively small amount of equipment. It is recommended that the collection of water level measurements be initially supervised by more experienced personnel.

Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials may be present.

It is the responsibility of the field personnel to be familiar with the procedures outlined within this SOP and health and safety requirements outlined within the Sampling Analysis Plan (SAP) and HASP. Field personnel are responsible for the proper use, maintenance, and decontamination of all equipment used for obtaining water level measurements, as well as proper documentation in the field logbook or field forms (if appropriate).

6.0 EQUIPMENT AND SUPPLIES

6.1 Electronic Water Level Meter

Electronic water level meters consist of a spool of small-diameter cable (or tape) with a weighted probe attached to the end. The cable (or tape) is marked with measurement increments in feet (accurate to 0.01 feet), with the zero point being the tip of the probe. When the probe comes in contact with the water, an electrical circuit is closed, and a light and/or buzzer within the spool will signal the contact. The probe shall be tested at the start of the field program to ensure proper operation.

6.2 Other Materials

Other materials that may be required:

- Health and safety supplies (as required by the HASP)
- Equipment decontamination materials (as required by ENSR SOP No. 7600Pines – Decontamination of Field Equipment)
- Plastic sheeting or bucket for resting instrument off the ground
- Water level field form (if applicable)
- Well construction records
- Approved plans (e.g., SAP, QAPP, HASP)
- Field project logbook/pen

7.0 METHODS

7.1 General Preparation

7.1.1 Well Records Review: Well completion diagrams should be reviewed to determine well construction characteristics. Historic static water level measurements and survey information should also be reviewed.

7.1.2 Water Level/Well Depth Measurement: The water level and well depth should be measured with a water level meter and written in the field logbook or field form. This information is used to calculate groundwater elevations. All data will be maintained in the project files.

7.1.3 Equipment Decontamination: All equipment should be decontaminated prior to use and between well locations in accordance with ENSR SOP No. 7600Pines - Decontamination of Field Equipment.

7.2 Measurement Procedures

7.2.1 At each location (well, piezometer, staff gauge, etc.), determine the location of the surveyed elevation mark. For wells, general markings include either a notch in the riser pipe or a permanent ink (generally black ink) mark on the riser pipe. For monitoring surface water levels, there may be a painted mark on an existing structure or the reference point must be known if not painted.

7.2.2 To obtain a water level measurement, lower the probe of a water level meter down into the water until the audible sound of the unit is detected or the light on an electronic sounder illuminates. In wells, the probe shall be lowered slowly into the well to avoid disruption of formation water and creation of turbulent surface water within the well. At this time, the precise measurement should be determined (to nearest 0.01 feet) by repeatedly raising and lowering the tape to converge on the exact measurement. Obtain the reading from the surveyed elevation mark.

7.2.3 Record the water level measurement as well as the location identification number, measuring point (surveyed elevation point), date, time, and weather conditions in the field logbook and/or field form.

7.2.4 To measure the total depth of a well, lower the probe (turn down signal as appropriate) slowly to the bottom of the well. The depth may be difficult to determine for wells with "soft" or silty bottoms. It may be helpful to lower the probe until there is slack in the tape, and gently pull up until it feels as if there is a weight at the end of the tape. Observe the measurement (to the nearest 0.01 foot) of the tape against the surveyed elevation mark.

7.2.5 Record the total well depth in the field logbook and/or field form.

7.2.6 The meter will be decontaminated in accordance with ENSR SOP No. 7600Pines – Decontamination of Field Equipment. Generally, only that portion of the tape that enters the water table needs to be decontaminated. It is important that the measuring tape is never placed directly on the ground surface or allowed to become kinked.

8.0 DATA AND RECORDS MANAGEMENT

All field information will be recorded in the field logbook or on a field collection form by field personnel. In addition, a field project logbook will be maintained detailing any problems or unusual conditions that may have occurred during the measurement process.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel will follow specific quality assurance guidelines as outlined in the Quality Assurance Project Plan (QAPP) and/or SAP. Where measured depths are not consistent with well records or previously measurements, the depths should be re-measured and verified.

10.0 REFERENCES

ENSR SOP No. 7600– Decontamination of Field Equipment. Revision 0.0.

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Field Measurement of Turbidity

SOP Number 7125

Revision Number: 0.0

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Field Measurement of Turbidity

CONTENTS

LIST OF ACRONYMS

SAP	Sampling Analysis Plan
HASP	Health and Safety Plan
NIST	National Institute of Standards
NTU	Nephelometric Turbidity Unit
QAPP	Quality Assurance Project Plan
OSHA	Occupational Safety and Health Administration
SOP	Standard Operating Procedure
USEPA	U. S. Environmental Protection Agency

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) provides basic instructions for routine calibration and operation of nephelometers or turbidity meters to measure turbidity (e.g., such as the HF Scientific Model DFT 15CE). This SOP is designed specifically for the measurement of turbidity in accordance with U.S. Environmental Protection Agency (USEPA) Method 180.1 and Standard Methods 2130 B which address turbidity measurements for drinking water, surface water and groundwaters, and saline waters.

2.0 SUMMARY OF METHOD

Turbidity is a measure of the clarity of the water being monitored. Turbidity data can be used to establish sufficiency of well purging prior to groundwater sampling, or provide general water quality information for any water being monitored.

For this project, turbidity will be measured in a separate container, not using a multi-parameter meter placed in a flow-through cell.

3.0 HEALTH AND SAFETY WARNINGS

Measuring turbidity may involve chemical hazards associated with materials in the water being monitored and instrument calibration solutions, and physical hazards associated with general field work. The health and safety considerations will be addressed in the site-specific Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Potential interferences will be controlled through appropriate calibration of the instruments, and decontamination between samples.

5.0 PERSONNEL QUALIFICATIONS

To properly perform turbidity measurements, the analyst must be familiar with the calibration and measurement techniques stated in this SOP. The analyst must also be experienced in the operation of the meter.

Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials may be present.

It is the responsibility of the field personnel to be familiar with the procedures outlined within this SOP and within the Sampling Analysis Plan (SAP), the Quality Assurance Project Plan (QAPP) and the health and safety requirements outlined HASP. Field personnel are responsible for the proper use, maintenance, and decontamination of all equipment used in the calibration and operation of the turbidity meter, as well as proper documentation in the field logbook or field forms (if appropriate).

6.0 EQUIPMENT SUPPLIES

6.1 Nephelometer/turbidity meter

The following materials are necessary for this procedure:

- Turbidity meter
- Turbidity meter manufacturer's instruction manual
- Turbidity-free water
- Clean, scratch-free sample tubes
- Formazin or polymer-based calibration standards
- Lint-free tissues
- National Institute of Standards and Technology (NIST)-traceable check standard
- Calibration/field data sheets and/or field logbooks/pen

6.2 Other Required Materials

Other materials that may be required to facilitate use of the instruments in the field include:

- Flow cup, bucket, or other container(s)
- Replacement batteries
- Health and safety supplies (as required by the HASP)
- Distilled/deionized water supply
- Deionized water dispenser bottler

- Equipment decontamination materials (as required by ENSR SOP No. 7600 – Decontamination of Field Equipment)
- Approved plans (e.g., HASP, SAP, QAPP)
- Field project logbook/pen

7.0 METHODS

7.1 Calibration Procedures

7.1.1 The turbidity meter must be calibrated daily before any analyses are performed. The check standard reading should be within the acceptance limits specified in the QAPP. It will also be checked daily with the calibration solutions at the end of use of the equipment (post-calibration).

Calibration records shall be recorded in the field logbook or a calibration form. Calibration documentation must be maintained in a thorough and consistent manner. At a minimum, the following information must be recorded:

- Date and time of calibration
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Expiration dates and batch numbers for all standards
- Reading for calibration standard before and after meter adjustment
- Comments

7.1.2 Follow the manufacturer's operating instructions for calibrating the turbidity meter.

7.1.3 Place check standards into clean, scratch-free sample tubes. Wipe the tube with a lint-free cloth and insert the tube into the analysis chamber.

7.1.4 Follow the manufacturer's operating instructions for reading samples.

7.1.5 Verify the calibration at the end of the day with a check standard (post-calibration). The check standard reading should be within the acceptance limits specified in the QAPP.

7.2 Collection of Measurements

7.2.1 Follow the manufacturer's operating instructions for operating the turbidity meter.

7.2.2 Place water samples into clean, scratch-free sample tubes. Wipe the tube with a lint-free cloth and insert the tube into the analysis chamber.

7.2.3 Follow the manufacturer's operating instructions for reading samples.

7.2.4 Sample turbidity results in Nephelometric Turbidity Units (NTUs) will be recorded on the appropriate field data sheets or logbooks. Turbidity readings should be recorded as follows:

Turbidity Range NTU	Report to the Nearest NTU
0-1.0	0.05
1-10	0.1
10-40	1
40-100	5
100-400	10
400-1000	50
>1000	100

7.2.5 Documentation for recorded data must include a minimum of the following

- Date and time of analysis
- Signature or initials of person performing the measurement
- Instrument identification number/model
- Sample identification/station location
- Comments

8.0 DATA AND RECORDS MANAGEMENT

Calibration records will be recorded in the field logbook or appropriate field form. All field information will be recorded in the field logbook or on a field collection form by field personnel.

In addition, a field project logbook will be maintained detailing any problems or unusual conditions that may have occurred during the calibration and measurement process.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel will follow specific quality assurance guidelines as outlined in the QAPP and/or SAP.

10.0 REFERENCES

ENSR SOP No. 7600 – Decontamination of Field Equipment. Revision 0.0.

Standard Methods for the Examination of Water and Wastewater, 17^{th} Edition, 1989.

Methods for the Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised 1983.

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Groundwater Sample Collection from Monitoring Wells – Low Flow

SOP Number 7130

Revision Number: 0.0

January 2008

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CONTENTS

LIST OF ACRONYMS

DO	Dissolved Oxygen
SAP	Sampling Analysis Plan
HASP	Health and Safety Plan
IDEM	Indiana Department of Environmental Management
L/min	Liter per minute
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NTU	Nephelometric Turbidity Units
OLQ	Office of Land Quality
ORP	Oxygen Reduction Potential
OSHA	Occupational Safety and Health Administration
QAPP	Quality Assurance Project Plan
QC	Quality Control
SOP	Standard Operating Procedure
TOC	Top of Casing
USEPA	United States Environmental Protection Agency

1.0 SCOPE AND APPLICABILITY

This Standard Operation Procedure (SOP) describes the method for collecting valid and representative samples of groundwater from monitoring wells. This SOP is written such that consideration of different sampling equipment may be used in different instances for collecting representative groundwater samples.

2.0 SUMMARY OF METHOD

Groundwater sample collection generally involves purging the stagnant water from a well while monitoring field parameters. After field parameters have stabilized, groundwater samples are then collected into the appropriate bottleware.

3.0 HEALTH AND SAFETY WARNINGS

Groundwater sampling may involve chemical hazards associated with exposure to materials in the groundwater being investigated and physical hazards associated with groundwater sampling equipment. When groundwater sampling is performed, adequate health and safety measures must be taken to protect field personnel. These measures will be addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Potential interferences could result from cross-contamination between samples and sample locations. Minimization of the cross-contamination will occur through the use of clean sampling tools at each location, which will require decontamination of sampling equipment as per ENSR SOP No. 7600 – Decontamination of Field Equipment.

5.0 PERSONNEL QUALIFICATIONS

Groundwater sample collection is a relatively involved procedure requiring formal training and a variety of equipment. It is recommended that initial sampling of groundwater wells be supervised by more experienced personnel.

Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

It is the responsibility of the field sampling personnel to be familiar with the sampling procedures outlined within this SOP, and with specific sampling, quality assurance, and health and safety requirements outlined in the Sampling Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), and HASP. Field personnel are responsible for collecting groundwater samples, decontamination of equipment, as well as proper documentation of sampling activities in the field logbook or field forms (as appropriate).

6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Purging and Sampling Pumps
  - Grundfos Redi-flo2™ submersible pumps
  - Bladder pumps
- Field Instruments
  - Individual or multi-parameter meter(s) to measure temperature, pH, specific conductance, dissolved oxygen (DO), oxidation reduction potential (ORP), and/or turbidity
  - Water level meter
- Sample Collection Records (Figure 1)
- Sample kit (i.e., bottles, labels, preservatives, custody records and tape, cooler, ice)
- Sample Chain-of-Custody forms (as required by ENSR SOP No. 7007 – Chain-of-Custody Procedures)
- Sample packaging and shipping supplies (as required by ENSR SOP No. 7510– Packaging and Shipment of Environmental Samples)
- Waterproof marker or paint
- Distilled/deionized water supply
- Deionized water dispenser bottler
- Flow measurement cup or bucket
- Buckets
- Instrument calibration solutions
- Power source

- Paper towels
- Plastic sheeting
- Trash bags
- Zipper-lock bags
- Equipment decontamination supplies (as required by ENSR SOP No. 7600 – Decontamination of Field Equipment)
- Health and safety supplies (as required by the HASP)
- Approved plans (e.g., HASP, SAP, QAPP)
- Field project logbook/pen

7.0 METHODS

7.1 Instrument Calibration

Field instruments will be calibrated daily according to the requirements of the QAPP and manufacturer's specifications for each piece of equipment (e.g., ENSR SOP No. 7320 - Operation and Calibration of a Multi-Parameter Water Quality Monitor). Equipment will also be checked daily with the calibration solutions at the end of use of the equipment. Calibration records shall be recorded in the field logbook or appropriate field form.

7.2 Well Security and Condition

At each monitoring well location, observe the conditions of the well and surrounding area. The following information may be noted on the Groundwater Sample Collection Record (Figure 1) or in the field logbook:

- Condition of the well's identification marker
- Condition of the well lock and associated locking cap
- Integrity of the well - protective outer casing, obstructions or kinks in the well casing presence of water in the annular space, and the top of the interior casing
- Condition of the general area surrounding the well

7.3 Measuring Point Determination

Before collecting a water level measurement, check for an existing measuring point (notch, or other visible mark) established either at the time of well installation or by the latest survey. Generally, the measuring point is referenced from the top of the well casing (TOC), not the protective casing. If no measuring point exists, a measuring point should be established, clearly marked, and identified on the Groundwater Sample Collection Record (Figure 1) or the field logbook. The same measuring point should be used for subsequent sampling events.

7.4 Water Level Measurement

Water level measurements should be collected in accordance with ENSR SOP No. 7101 – Water Level Measurements. The water level measurement should be entered on the Groundwater Sample Collection Record (Figure 1) or in the field logbook.

7.5 Purge Volume Calculation

Wells designated for sampling require purging to remove stagnant water in the well. A single casing volume of groundwater will be calculated after measuring the length of the water column and checking the well casing diameter. The Groundwater Sample Collection Record (Figure 1) provides information used to compute the casing volume, which includes a diagram, a numerical conversion table, and the standard calculation. The volume of standing water in the well (i.e., one purge volume) should be entered on the Groundwater Sample Collection Record (Figure 1).

7.6 Well Purging Methods and Procedures

7.6.1 Objectives

Prior to sample collection, purging must be performed for all groundwater monitoring wells to remove stagnant water from within the casing and gravel pack and to ensure that a representative groundwater sample is obtained.

All groundwater samples will be collected using low stress (low-flow) purging and sampling procedures according to the United States Environmental Protection Agency (USEPA) Region 1 SOP titled "Low Stress Purging and Sampling

Procedure for the Collection of Groundwater Samples from Monitoring Wells", Revision 2, July 1996 (USEPA, 1996) and Indiana Department of Environmental Management (IDEM) Office of Land Quality (OLQ) Geological Services Technical Memorandum titled "Micro-Purge Sampling for Monitoring Wells" dated January 8, 2003 (IDEM, 2003). The low-flow method emphasizes the need to minimize water level drawdown and low groundwater pumping rates to collect samples with minimal alterations to groundwater chemistry.

During well purging, the water level will be measured with a water level meter in accordance with ENSR SOP No. 7101 – Water Level Measurement. Water level drawdown and flow rate will be recorded on the Groundwater Collection Record (Figure 1). A final purging rate will be selected that does not exceed 0.5 liters per minute (L/min) (typically between 0.1 L/min and 0.3 L/min), and results in a stable drawdown, ideally less than 0.3 feet.

The general types of non-dedicated equipment used for well purging include surface pumps and down-well pumps. The purge method and equipment selected is specified in the SAP. For this project, peristaltic pumps will be used where depths to water are sufficiently shallow, and submersible pumps used where depths to water are too great for peristaltic pumps.

Purge water will be pumped through a flow-through cell and the following parameters will be measured: pH, specific conductivity, temperature, DO, and ORP. These parameters will be measured with a water quality meter, calibrated according to the manufacturer's specifications (see ENSR SOP No. 7105 - Operation and Calibration of a Multi-Parameter Water Quality Monitor). Turbidity will be measured separately with a nephelometer, also calibrated to the manufacturer's specifications (see ENSR SOP No. 7125 – Field Measurement of Turbidity). A round of parameter measurements will be recorded after the flow-through cell is full, approximately 10 minutes after the flow-through cell is full, and then approximately every 5 minutes thereafter, until parameter values have stabilized.

Purging is considered complete and sampling may begin when all parameter values have stabilized and turbidity is below 5 Nephelometric Turbidity Units (NTU). Stabilization is considered to be achieved when three consecutive readings, taken at 3- to 5-minute intervals, are within the following limits:

- Turbidity : less than 5 NTU or ± 10%
- DO : ± 10%
- Specific Conductance : ± 3%
- Temperature : ± 3%
- pH : ± 0.1 standard units
- ORP : ± 10 millivolts

Every effort will be made to lower the turbidity to less than 5 NTU before sampling. If the turbidity cannot be reduced to below 5 NTU, the pumping rate should be reduced. If turbidity still cannot be reduced below 5 NTU, samples may be collected if all other parameters are stable and the turbidity is stable, that is, not improving. The condition will be noted on the field form or in the logbook.

If low-flow purging cannot be achieved for a particular well (typically due to insufficient yield to establish a stable drawdown), the well may be purged dry, then sampled when sufficient water has recharged. The condition will be noted on the field form or in the logbook.

7.6.2 Surface Pumps

General

Well purging using pumps located at the ground surface can be performed with a peristaltic pump if the water level in the well is within approximately 20 feet of the top of the well.

Peristaltic pumps provide a low rate of flow typically in the range of 0.02-0.2 gallons/minute (gal/min) (0.075-0.750 L/min). Peristaltic pumps are suitable for purging situations where disturbance of the water column must be kept minimal for particularly sensitive analyses and where volatile organic compounds are not being analyzed.

7.6.3 Down-Well Pumps

General

Groundwater withdrawal using non-dedicated down-well pumps may be performed with a submersible pump or a bladder pump.

Electric submersible pumps provide an effective means for well purging and in some cases sample collection. Submersible pumps are particularly useful for situations where the depth to water table is greater than 20 feet and where the depth or diameter of the well requires that a large purge volume be removed before sample collection.

A commonly available submersible pump, the Grundfos Redi-Flo2™ pump, is suited for operation in 2-inch or larger internal diameter wells. Pumping rates are adjusted to low-flow levels by adjusting the current to the pump motor rather than using a flow valve.

As an alternative method to using the submersible pump, bladder pumps may also be used. Bladder Pumps usually consist of a stainless steel pump housing with an internal Teflon® or polyethylene bladder. Discharge and air line tubing is connected to the bladder pump to the air compressor and control unit. The pump is operated by lowering it into the water column within the well screen, then pulsing air into the bladder from the air compressor and pump controller unit. Pumps and controllers are often not interchangeable between manufacturers; therefore, it is usually necessary to have both items provided by the same manufacturer. Pump bladders are generally field-serviceable and replaceable.

A check of well condition may be required prior to inserting any down-well pump if the well has not been sampled for some time or if groundwater quality conditions are not known. The well condition check should include a check of casing plumbness as a bent well casing could cause a pump to get stuck. Casing plumbness can be checked by lowering a clean cylindrical tube with the approximate pump dimensions into the well. If the well casing is not plumb then an alternative purging method should be used.

Submersible pumps (i.e., Grundfos Redi-Flo2™) will generally be used in wells where water levels are too deep to allow use of a peristaltic pump.

Electric Submersible Pump Procedure

Slowly lower the submersible pump with attached discharge line into the monitoring well taking notice of any roughness or restriction within the well riser pipe. The pump should be placed in the uppermost section of the static water column of the monitoring well. The power cord should be attached to the discharge line with an inert material (i.e., zip-ties) to prevent the power cord from getting stuck between the pump, discharge line, and the well casing. Secure the discharge line and power cord to the well casing, using tape or a clamp, taking care not to crimp or cut either the discharge line or power cord.

Connect the power cord to the power source (i.e., rechargeable battery pack, auto battery, or generator) and turn the pump on. Voltage and amperage meter readings on the pump controller (if provided) should be monitored closely during purging. The operations manual for the specific pump used should be reviewed regarding changes in voltage/amperage and the potential impacts on pump integrity. The pumping rate will be adjusted so that drawdown is stabilized, ideally at a level less than 0.3 feet. Pumping should be discontinued if warning conditions occur and/or if the well is pumped to where drawdown falls below the pump's intake level.

Bladder Pump Procedure

As an alternative method to the submersible pump, bladder pumps may be used. To operate the bladder pump system, the pump and discharge line should be lowered into the well close to the bottom of the well screen, then secured to the well casing with a clamp. The air compressor should then be turned on to activate pumping. The pump controller is used to vary the discharge rate to the required flow. The pumping rate will be adjusted so that drawdown is stabilized, ideally at a level less than 0.3 feet.

7.7 Sample Collection Methods and Procedures

7.7.1 Objectives

Groundwater samples can be collected using similar methods employed for purging. In most cases during sampling, groundwater will be transferred to the appropriate containers directly from the discharge source. It is important that the tubing from the pump to the flow-through cell be disconnected prior to sample collection. During transfer, discharge tubing and other equipment shall not contact the inside of the sample containers.

7.7.2 Down-Well Pumps

Using the pump methods described in Section 7.6.3, groundwater samples can be collected from either the electric submersible or bladder pump directly from the discharge line (after tubing has been disconnected from the flow-through cell). Sample bottles will be filled directly from the discharge line of the pump.

7.8 Sample Handling and Preservation

- Once each sample container is filled, clean the rim and threads of the sample container by wiping with a paper towel.
- Cap and label the container with (at a minimum) the sample identifier and sampling date and time. Additional information such as preservation information and analytical tests may also be added to the sample label as appropriate.
- Place the sample containers into a cooler and maintain on ice.
- Complete sample chain-of-custody and other documentation per ENSR SOP No. 7007 – Chain-of-Custody Procedures.
- Package the samples for shipment to the laboratory per ENSR SOP No. 7510 – Packaging and Shipment of Environmental Samples.

7.9 Equipment Decontamination

All equipment that comes into contact with groundwater (e.g., submersible pumps) should be decontaminated in accordance with ENSR SOP No. 7600 – Decontamination of Equipment protocol before moving to the next location. Dedicated or disposable equipment does not need to be decontaminated.

8.0 DATA AND RECORDS MANAGEMENT

Specific information regarding sample collection should be documented in several areas: the sample chain-of-custody record, sample collection record, field logbook, and sample labels or tags. Additional information regarding each form of documentation is presented in the following paragraphs:

8.1 Sample Chain-of-Custody Record

This standard form requires input of specific information regarding each collected sample for laboratory analytical purposes, as specified in ENSR SOP No. 7007 – Chain-of-Custody Procedures and ENSR SOP No. 7510 – Packaging and Shipment of Environmental Samples.

8.2 Sample Collection Record

This form (Figure 1) requires input of specific information regarding the collection of each individual sample including sample identification, water quality parameters, collection method, and containers/preservation requirements.

8.3 Field Logbook

This logbook should be dedicated to the project and should be used by field personnel to maintain a general log of activities throughout the sampling program. This logbook should be used in support of, and in combination with, the sample collection record. Documentation within the logbook should be thorough and sufficiently detailed to present a concise, descriptive history of the sample collection process.

8.4 Sample Labels

Sample labels shall be completed at the time each sample is collected and attached to each sample container. Sample labeling will be conducted per the SAP and QAPP. Labels may include the information listed below.

- Project number (not project name)
- Sample number
- Sample designation

- Analysis type
- Preservative
- Sample collection date
- Sample collection time
- Sampler's name

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel should follow specific quality assurance guidelines as outlined in the QAPP and/or SAP.

Quality assurance requirements typically suggest the collection of a sufficient quantity of quality control (QC) samples such as field duplicate, equipment and/or field blanks and matrix spike/matrix spike duplicate (MS/MSD) samples. These requirements are outlined in the SAP and QAPP. Additional information regarding quality assurance sample collection relevant to groundwater sampling is described below.

9.1 Field Blank/Equipment Blank Sample Collection

Field blank samples serve as a quality assurance check of equipment and field conditions at the time of sampling. Field blank samples are usually prepared by transferring analyte-free water into a clean set of sample containers, then analyzing it as a sample. Sometimes, the analyte-free water is transferred over or through the sampling device before it is placed into the sample containers. This type of field blank sample is known as an equipment blank. The SAP and QAPP contains specific information regarding the type and number of field blanks or equipment blanks required for collection.

9.2 Field Duplicate Sample Collection

Field duplicate samples are collected for the purpose of providing two sets of results for comparison. To the extent possible based on available information, field duplicates will be selected at locations with the likelihood of detectable concentrations of constituents.

These samples are used to assess precision. Duplicate samples are usually prepared by splitting the sample into two sets of sample containers, then analyzing each set as a separate sample. The QAPP contains specific information regarding the type and number of duplicate samples for collection.

9.3 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample Collection

MS/MSDs provide information about the effect of the sample matrix on digestion and measurement methodology. For samples submitted for MS/MSD analysis, triple sample volume is generally required. The QAPP contains specific information regarding the frequency of MS/MSD samples.

10.0 REFERENCES

Code of Federal Regulations, Chapter 40 (Section 261.4(d)).

ENSR SOP No. 7320 - Operation and Calibration of a Multi-Parameter Water Quality Monitor.

ENSR SOP No. 7101– Water Level Measurements.

ENSR SOP No. 7125 – Field Measurement of Turbidity.

ENSR SOP No. 7007 – Chain-of-Custody Procedures.

ENSR SOP No. 7510 – Packaging and Shipment of Environmental Samples.

ENSR SOP No. 7600 – Decontamination of Field Equipment.

IDEM. 2003. OLQ Geologic Services Technical Memorandum – Micro-Purge Sampling for Monitoring Wells. Indiana Department of Environmental Management Office of Land Quality. January 8, 2003.

USEPA. 1996. Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples From Monitoring Wells, Revision 2. U.S. Environmental Protection Agency, Region 1. July 30, 1996.

FIGURE 1 – EXAMPLE GROUNDWATER SAMPLE COLLECTION RECORD

ENSR

Well ID:

Low Flow Ground Water Sample Collection Record

Client: ______ Date: ______ Time: Start ______ am/pm
Project No: ______ Finish ______ am/pm
Site Location: ______
Weather Conds: ______ Collector(s): ______

1. WATER LEVEL DATA: (measured from Top of Casing)

a. Total Well Length ______ c. Length of Water Column ______ (a-b) Casing Diameter/Material ______

b. Water Table Depth ______ d. Calculated System Volume (see back) ______

2. WELL PURGE DATA

a. Purge Method: ______

b. Acceptance Criteria defined (see workplan)

- Temperature	3%	-D.O.	10%
- pH	± 1.0 unit	- ORP	± 10mV
- Sp. Cond.	3%	- Drawdown	< 0.3'

c. Field Testing Equipment used: Make Model Serial Number

______
______

Time (24hr)	Volume Removed (Liters)	Temp. (°C)	pH	Spec. Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (feet)	Color/Odor

(continued on back)

d. Acceptance criteria pass/fail

	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Have parameters stabilized	☐	☐	☐

If no or N/A - Explain below.

______

3. SAMPLE COLLECTION: Method: ______

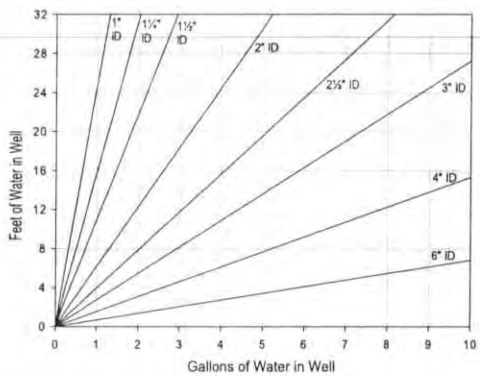
Sample ID Container Type No. of Containers Preservation Analysis Req. Time

______
______
______
______

Comments ______
______
______
______

Signature ______ Date ______

Purge Volume Calculation



Volume / Linear Ft. of Pipe		
ID (in)	Gallon	Liter
0.25	0.0025	0.0097
0.375	0.0057	0.0217
0.5	0.0102	0.0386
0.75	0.0229	0.0869
1	0.0408	0.1544
1.25	0.0637	0.2413
1.5	0.0918	0.3475
2	0.1632	0.6178
2.5	0.2550	0.9653
3	0.3672	1.3900
4	0.6528	2.4711
6	1.4688	5.5600

(continued from front)

Time (24 hr)	Volume Removed (Liters)	Temp (°C)	pH	Spec. Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Drawdown (ft)	Color/Odor

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Monitoring Well Development

SOP Number 7221

Revision Number: 0.0

January 2008

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January 23, 2008

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CONTENTS

APPENDICES

LIST OF ACRONYMS

SAP	Sampling Analysis Plan
HASP	Health and Safety Plan
IDW	Investigation Derived Waste
OSHA	Occupational Safety and Health Administration
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the methods used for developing newly installed monitoring wells and/or existing wells that may require redevelopment/rehabilitation. This SOP is applicable to any wells that require development in accordance with the Sampling Analysis Plan (SAP).

Monitoring well development and/or redevelopment is necessary for several reasons:

- To improve/restore hydraulic conductivity of the surrounding formations as they have likely been disturbed during the drilling process, or may have become partially plugged with silt;
- To remove drilling fluids (water, mud), when used, from the borehole and surrounding formations; and
- To remove residual fines from well filter materials and reduce turbidity of groundwater, therefore, reducing the chance of chemical alteration of groundwater samples caused by suspended sediments and provide representative groundwater samples.

2.0 SUMMARY OF METHOD

Well development generally involves withdrawal of an un-specified volume of water from a well using a pump, surge block or other suitable method such that, when completed effectively, the well is in good or restored hydraulic connection with the surrounding water bearing unit and is suitable for obtaining representative groundwater samples or for other testing purposes.

3.0 HEALTH AND SAFETY WARNINGS

Monitoring well development may involve chemical hazards associated with exposure to materials in the groundwater being investigated and physical hazards associated with use of well development equipment. When well development is performed, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Potential interferences could result from cross-contamination between sample locations. Minimization of the cross-contamination will occur through the use of clean tools at each location, which will require decontamination of sampling equipment as per ENSR SOP No. 7600 – Decontamination of Field Equipment.

The process of installing a well necessarily disturbs the geologic formation. Wells will be developed appropriately as described in this SOP. The wells will be allowed to stabilize a minimum of two weeks after development before a well is sampled. In no cases will methods using air (e.g., air jetting) be used for well development on this project as they have a high potential to change geochemical conditions in the vicinity of the well.

5.0 PERSONNEL QUALIFICATIONS

Well development procedures vary in complexity. It is recommended that initial development attempts be supervised by more experienced personnel.

Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials may be present.

It is the responsibility of the field personnel to be familiar with the procedures outlined within this SOP, quality assurance, and health and safety requirements outlined within the SAP, Quality Assurance Project Plan (QAPP), and HASP. Field personnel are responsible for proper well development, decontamination of equipment, as well as proper documentation in the field logbook or field forms (if appropriate).

6.0 EQUIPMENT AND SUPPLIES

Well development can be performed using a variety of methods and equipment. The specific method chosen for development of any given well is governed by the purpose of the well, well diameter and materials, depth, accessibility, geologic conditions, static water level in the well, and type of constituents present, if any.

The following list of equipment, each with their own particular application, may be used to develop and/or purge monitoring wells. In no cases will methods using air (e.g., air jetting) be used on this project as they have a high potential to change geochemical conditions in the vicinity of the well.

6.1 Bailer Purging

A bailer is used to purge silt-laden water from wells after using other devices such as a surge block. In some situations, the bailer can be used to develop a well by bailing and surging, often accompanied with pumping. A bailer can be used for purging in situations where the depth to static water is greater than 25 feet and/or where insufficient hydraulic head is available for use of other development methods.

6.2 Surge Block Development

Surge blocks are commercially available for use with Waterra™-type pumping systems or may be manufactured using a "plunger" attached to a rod or pipe of sufficient length to reach the bottom of the well. Well drillers usually can provide surge blocks if requested. A recommended design is shown in Figure 1.

6.3 Pump Development

A pump is often necessary to remove large quantities of silt-laden ground water from a well after using the surge block. In some situations, the pump alone can be used to develop the well and remove the fines by overpumping. Because the purpose of well development is to remove suspended solids from a well and the surrounding filter pack, the pump must be capable of moving some solids without damage. The preferred pump is a submersible pump, which can be used in both shallow and deep ground water situations. A centrifugal pump may be used in shallow wells, but will work only where the depth to static ground water is less than approximately 25 feet. Pumping may not be successful in low-yielding aquifer materials or in wells with insufficient hydraulic head.

6.4 Other Required Materials:

- Well Development Records (Figure 2)
- Boring and well construction logs (if available)
- Utility knife
- Plastic sheeting
- Buckets

- Paper towels
- Trash bags
- Power source (generator or 12-volt marine battery)
- Water level meter and/or well depth measurement device
- Water quality instrumentation to measure turbidity (i.e., nephelometer)
- Instrument calibration solutions
- Equipment decontamination supplies (as required by ENSR SOP No. 7600 – Decontamination of Field Equipment)
- Health and safety supplies (as required by the HASP)
- Appropriate containers and materials to manage investigation-derived waste (IDW) (as specified in the SAP)
- Approved plans (e.g., HASP, QAPP, SAP)
- Field project logbook/pen

7.0 METHODS

7.1 General Preparation

Well completion diagrams should be reviewed to determine well construction characteristics. Formation characteristics should also be determined from review of available boring logs.

Well development, similar to groundwater sampling, should be conducted in as clean an environment as possible. This usually requires, at a minimum, placing sheet plastic on the ground to provide a clean working area for development equipment.

Provisions should be in place for collection and management of IDW, specifically well development water and miscellaneous expendable materials generated during the development process. The collection of IDW in drums or tanks may be required depending on project-specific requirements.

The water level and well depth should be measured in accordance with ENSR SOP No. 7101 – Water Level Measurements and written on the Well Development Record (Figure 2). This information is used to calculate the volume of standing water (i.e., the well volume) within the well.

Drilling fluids such as mud or water, if used during the drilling and well installation process, should be removed during the well development procedure. It is recommended that a minimum of 3 times the volume of added fluid be removed from the well during development. If the quantity of added fluid is not known or cannot be reasonably estimated, removal of a minimum of 20 well volumes of water is recommended during the development procedure.

7.2 Development Procedure

7.2.1 Development Method Selection

The construction details of each well shall be used to define the most suitable method of well development. Some consideration should be given to the potential concentrations of constituents in each well as this will impact IDW containment requirements.

The criteria for selecting a well development method include well diameter, total well depth, static water depth, screen length, the likelihood and potential concentrations of constituents, and characteristics of the geologic formation adjacent to the screened interval.

The limitations, if any, of a specific procedure are discussed within each of the following procedures.

7.2.2 General Water Quality Measurements (optional)

Measurements for water quality parameters such as specific conductance may be monitored periodically during development using the available water quality instruments (e.g., ENSR SOP No. 7320 - Operation and Calibration of a Multi-Parameter Water Quality Monitor). These measurements may be used to determine whether or not well development is proceeding efficiently, determine whether or not the development process is effective with any given well and, potentially, may identify well construction irregularities (i.e., grout in well, poor well screen slot-size selection). Water quality parameters will be recorded on the Well Development Record (Figure 2).

7.2.3 Turbidity

Turbidity will be monitored during well development to monitor the progress of development. Visual observations on turbidity, such as silty or cloudy water, should be noted in the Well Development Record (Figure 2). Turbidity should also be measured quantitatively using a nephelometer. Turbidity should be measured a minimum of three times during development, including at the completion of development. All turbidity readings will be recorded in the Well Development Record (Figure 2).

7.2.4 Bailer Procedure

As stated previously, bailers shall preferably not be used for well development but may be used in combination with a surge block to remove silt-laden water from the well.

- When using a bailer to purge well water; select the appropriate bailer, then tie a length of bailer cord onto the end of it.

- Lower the bailer into the screened interval of the monitoring well. Silt, if present, will generally accumulate within the lower portions of the well screen.

- The bailer may be raised and lowered repeatedly in the screened interval to further simulate the action of a surge block and pull silt through the well screen.

- Remove the bailer from the well and empty it into the appropriate storage container.

- Continue surging/bailing the well until sediment-free water is obtained. If moderate to heavy siltation is still present, the surge block procedure should be repeated and followed again with bailing. If it is not possible to further reduce the visible turbidity, the well will be purged a maximum of four hours.

- Check turbidity and any other water quality parameters, periodically.

7.2.5 Surge Block Procedure

A surge block effectively develops most monitoring wells. This device first forces water within the well through the well screen and out into the formation, and then pulls water back through the screen into the well along with fine soil particles. Surge blocks may be manufactured to meet the design criteria shown in the example (Figure 1) or may be purchased as an adaptor to fit commercially available well purging systems such as the Waterra™ system.

- Insert the surge block into the well and lower it slowly to the level of static water. Start the surge action slowly and gently above the well screen using the water column to transmit the surge action to the screened interval. A slow initial surging, using plunger strokes of approximately 3 feet, will allow material that is blocking the screen to separate and become suspended.

- After 5 to 10 plunger strokes, silt-laden water will be removed from the well using a pump integrated with the surge block, or removing the surge block to purge the well using a pump or bailer. The returned water should be heavily laden with suspended silt and clay particles. Discharge the purged water into the appropriate storage container.

- Repeat the process. As development continues, slowly increase the depth of surging to the bottom of the well screen. For monitoring wells with long screens (greater than 10 feet) surging should be undertaken along the entire screen length in short intervals (2 to 3 feet) at a time. Continue this cycle of surging and purging until the water yielded by the well is free of visible suspended material. If it is not possible to further reduce the visible turbidity, the well will be purged a maximum of four hours.

- Check turbidity and any other water quality parameters periodically.

7.2.6 Pump Procedure

Well development using only a pump is most effective in monitoring wells that will yield water continuously. Theoretically, pumping will increase the hydraulic gradient and velocity of groundwater near the well by drawing the water level down. The increased velocity will move residual fine soil particles into the well and clear the well screen of this material. Effective development cannot be accomplished if the pump has to be shut off to allow the well to recharge.

- When using a submersible pump or surface pump, set the intake of the pump or intake line in the center of the screened interval of the monitoring well.

- Pump a minimum of three well volumes of water from the well and raise and lower the pump line through the screened interval to remove any silt/laden water.

- Continue pumping water from the well until sediment-free water is obtained. This method may be combined with the manual surge block method if well yield is not rapid enough to extract silt from the surrounding formations. If it is not possible to further reduce the visible turbidity, the well will be purged a maximum of four hours.

- Check turbidity and any other water quality parameters periodically.

7.3 Equipment Decontamination

All equipment that comes into contact with groundwater (e.g., surge block) will be decontaminated in accordance with ENSR SOP No. 7600 – Decontamination of Field Equipment before moving to the next location. The bailer should be properly discarded and disposed of in accordance with procedures for managing IDW.

8.0 DATA AND RECORDS MANAGEMENT

All field information will be recorded in the field logbook or on a field collection form by field personnel. In addition, a field project logbook will be maintained detailing any problems or unusual conditions that may have occurred during the development process.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel should follow specific quality assurance guidelines as outlined in the Quality Assurance Project Plan (QAPP) and/or SAP.

A well will have been successfully developed when one or more of the following criteria are met:

- The sediment load in the well has been eliminated or greatly reduced. Use of a nephelometer is required during the well development procedure to measure water turbidity if meeting a specific turbidity value is required by the SAP. Attaining low turbidity values in fine-grained formations may be difficult to achieve.

- If it is not possible to reduce turbidity to acceptable levels, the well will be developed for a maximum of four hours.

10.0 REFERENCES

ENSR SOP No. 7320 - Operation and Calibration of a Multi-Parameter Water Quality Monitor.

ENSR SOP No. 7101 – Water Level Measurements.

ENSR SOP No. 7600 – Decontamination of Field Equipment. Revision 0.0.

FIGURE 1 – RECOMMENDED SURGE BLOCK DESIGN

SURGE BLOCK DESIGN
(Not to Scale)

Steel washers should be 1/2" to 3/4" smaller in diameter than the well ID. Gasket can be rubber or leather and should be the same diameter or 1/8" smaller than the well ID to compensate for swelling of the leather/ Rod can be steel, fiberglass, or plastic but must be strong and lightweight.

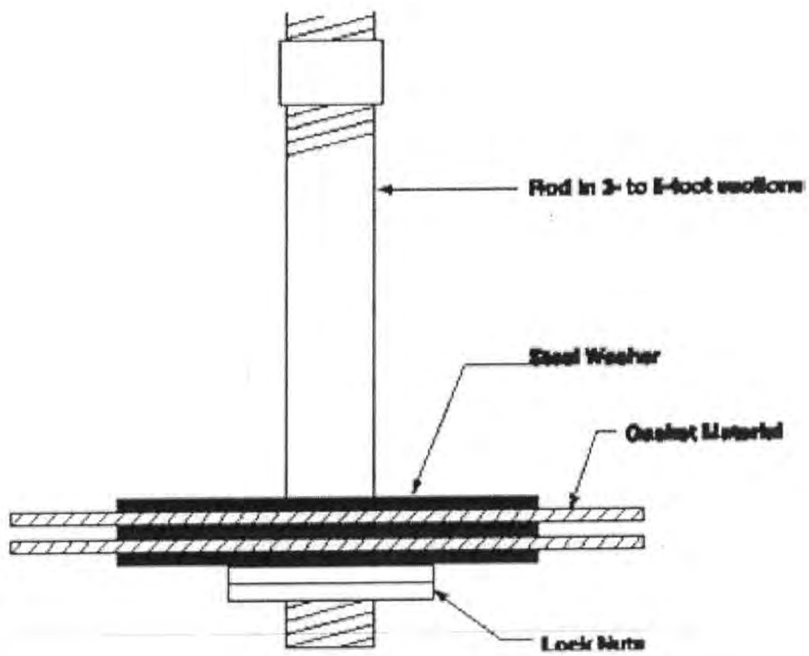

FIGURE 2 – EXAMPLE WELL DEVELOPMENT RECORD

ENSR

Well/Piez. ID:

Well/Piezometer Development Record

Client: ______________

Project No: ______________ Date: ________ Developer: ______________

Site Location: ______________

Well/Piezometer Data

Well ☐ Piezometer ☐ Diameter __________ Material __________

Measuring Point Description __________

Depth to Top of Screen (ft.) __________

Depth to Bottom of Screen (ft.) __________

Total Well Depth (ft.) __________

Depth to Static Water Level (ft.) __________

Geology at Screen Interval (if known) __________

Time of Water Level Measurement __________

Calculate Purge Volume (gal.) __________

Disposal Method __________

Headspace __________

Original Well Development ☐ Redevelopment ☐ Date of Original Development __________

DEVELOPMENT METHOD __________

PURGE METHOD __________

Time	Total Volume Purged (gal.)	Flow Rate (gpm)	Turbidity (NTU)	Color	pH	Temp	Other

ACCEPTANCE CRITERIA (from workplan)
Minimum Purge Volume Required _____ gallons
Maximum Turbidity Allowed _____ NTUs
Stabilization of parameters _____%

	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Has parameters stabilized	☐	☐	☐

If no or N/A explain below:

____

Signature ______________ Date: __________

APPENDIX A – GLOSSARY

Bridging: A condition within the filter pack outside the well screen whereby the smaller particles are wedged together in a manner that causes blockage of pore spaces.

Hydraulic Conductivity: a characteristic property of aquifer materials which describes the permeability of the material with respect to flow of water.

Hydraulic Connection: A properly installed and developed monitoring well should have good hydraulic connection with the aquifer. The well screen and filter material should not provide any restriction to the flow of water from the aquifer into the well.

Permeability Test: Used to determine the hydraulic conductivity of the aquifer formation near a well screen. Generally conducted by displacing the water level in a well and monitoring the rate of recovery of the water level as it returns to equilibrium. Various methods of analysis are available to calculate the hydraulic conductivity from these data.

Static Water Level: The water level in a well that represents an equilibrium or stabilized condition, usually with respect to atmospheric conditions in the case of monitoring wells.

Well Surging: That process of moving water in and out of a well screen to remove fine sand, silt and clay size particles from the adjacent formation.

Well Purging: The process of removing standing water from a well to allow surrounding formation water to enter the well.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. The perforated, or slotted, portion of a well is also known as the screened interval.

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Operation and Calibration of a Photoionization Detector

SOP Number 7315

Revision Number: 0.0

January 2008

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January 23, 2008

SOP NUMBER: 7315

Operation and Calibration of a Photoionization Detector (PID)

CONTENTS

LIST OF ACRONYMS

SAP	Sampling Analysis Plan
HASP	Health and Safety Plan
PID	Photoionization Detector
QAPP	Quality Assurance Project Plan
OSHA	Occupational Safety and Health Administration
SOP	Standard Operating Procedure

1.0 SCOPE AND APPLICABILITY

This document describes the procedures that will be followed by field staff for operation and calibration of a photoionization detector (PID). The PID will be used to determine the presence of volatiles in soil, either by screening the core or by headspace measurements.

2.0 SUMMARY OF METHOD

The PID is a non-specific vapor/gas detector. The unit generally consists of a hand-held probe that houses a PID, consisting of an ultraviolet (UV) lamp, two electrodes, and a small fan which pulls ambient air into the probe inlet tube. The probe is connected to a readout/control box that consists of electronic control circuits, a readout display, and the system battery. Units are available with UV lamps having an energy from 9.5 electron volts (eV) to 11.7 eV.

The PID analyzer measures the concentration of trace gas present in the atmosphere by photoionization. Photoionization occurs when an atom or molecule absorbs a photon of sufficient energy to release an electron and become a positive ion. This will occur when the ionization potential of the molecule (in electron volts (eV)) is less than the energy of the photon. The source of photons is an ultraviolet lamp in the probe unit. Lamps are available with energies ranging from 9.5 eV to 11.7 eV. All organic and inorganic vapor/gas compounds having ionization potentials lower than the energy output of the UV lamp are ionized and the resulting potentiometric change is seen as a positive reading on the unit. The reading is proportional to the concentration of organics and/or inorganics in the vapor.

Sample gases enter the probe through the inlet tube and enter the ion chamber where they are exposed to the photons emanating from the UV lamp. Ionization occurs for those molecules having ionization potentials near to or less than that of the lamp. A positive-biased polarizing electrode causes these positive ions to travel to a collector electrode in the chamber. Thus the ions create an electrical current which is amplified and displayed on the meter. This current is proportional to the concentration of trace gas present in the ion chamber and to the sensitivity of that gas to photoionization.

In service, the analyzer is first calibrated with a gas of known composition equal to, close to, or representative of that to be measured. Gases with ionization potentials near to or less than the energy of the lamp will be ionized. These gases will thus be detected and measured by the analyzer. Gases with ionization potentials greater than the energy of the lamp will not be detected. The ionization potentials of the major components of air, i.e., oxygen, nitrogen, and carbon dioxide, range from about 12.0 eV to 15.6 eV and are not ionized by any of the lamps available. Gases with ionization potentials near to or slightly higher than the lamp are partially ionized, with low sensitivity.

3.0 HEALTH AND SAFETY WARNINGS

Collecting PID measurements may involve chemical hazards associated with materials in the soil being in contact with the PID. When collecting measurements, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

Only PIDs stamped Division I Class I may be used in explosive atmospheres. Refer to the project HASP for instructions pertaining to instrument use in explosive atmospheres.

4.0 INTERFERENCES

Potential interferences could result in inaccurate readings under the following conditions.

4.1.1 Air currents or drafts in the vicinity of the probe tip may cause fluctuations in readings.

4.1.2 A fogged or dirty lamp, due to operation in a humid or dusty environment, may cause erratic or fluctuating readings. The PID should never be operated without the moisture trap in place.

4.1.3 Moving the instrument from a cool or air-conditioned area to a warmer area may cause moisture to condense on the UV lamp and produce unstable readings.

4.1.4 A zero reading on the meter should not necessarily be interpreted as an absence of air contaminants. The detection capabilities of the PID are limited to those compounds that will be ionized by the particular probe used.

4.1.5 Many volatile compounds have a low odor threshold. A lack of meter response in the presence of odors does not necessarily indicate instrument failure.

4.1.6 When high vapor concentrations enter the ionization chamber in the PID the unit can become saturated or "flooded". Remove the unit to a fresh air environment to allow the vapors to be completely ionized and purged from the unit.

Care shall be taken in using the PID to reduce these interferences. If there is any concern that a particular reading may not be accurate, this shall be noted in the field log book.

5.0 PERSONNEL QUALIFICATIONS

Collecting PID measurements is a relatively simple procedure requiring minimal training and a relatively small amount of equipment. Personnel responsible for using the PID should first read and thoroughly familiarize themselves with the instrument instruction manual. It is recommended that the collection of PID measurements be initially supervised by more experienced personnel.

Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials may be present.

It is the responsibility of the field personnel to be familiar with the procedures outlined within this SOP and health and safety requirements outlined within the Sampling Analysis Plan (SAP) and HASP. Field personnel are responsible for the proper use and maintenance of the PID, as well as proper documentation in the field logbook or field forms (if appropriate).

6.0 EQUIPMENT AND SUPPLIES

- Calibration Gas: Compressed gas cylinder of isobutylene in air or similar stable gas mixture of known concentration. The selected gas should have an ionization potential similar to that of the vapors to be monitored, if known. The concentration should be at 50-75% of the range in which the instrument is to be calibrated.

- Regulator for calibration gas cylinder

- Approximately 6 inches of Teflon® tubing
- Tedlar bag (optional)

- Commercially-supplied zero grade air (optional)

- "Magic Marker" or "Sharpie" or other waterproof marker
- Battery charger
- Moisture traps
- Spare lamps
- Manufacturer's instructions
- Field data sheets or logbook/pen

7.0 METHODS

7.1 Preliminary Steps

7.1.1 Preliminary steps (battery charging, check-out, calibration, maintenance) should be conducted in a controlled or non-hazardous environment.

7.2 Calibration

7.2.1 The PID must be calibrated in order to display concentrations in units equivalent to ppm. First a supply of zero air (ambient air or from a supplied source), containing no ionizable gases or vapors is used to set the zero point. A span gas, containing a known concentration of a photoionizable gas or vapor, is then used to set the sensitivity.

7.2.2 Calibrate the instrument according to the manufacturer's instructions. Record the instrument model and identification number, the initial and adjusted meter readings, the calibration gas composition and concentration, and the date and the time in the field records.

7.2.3 If the calibration cannot be achieved or if the span setting resulting from calibration is 0.0, then the lamp must be cleaned (Section 7.4).

7.3 Operation

7.3.1 Turn on the unit and allow it to warm up (minimum of 5 minutes). Check to see if the intake fan is functioning; if so, the probe will vibrate slightly and a distinct sound will be audible when holding the probe casing next to the ear. Also, verify on the readout display that the UV lamp is lit.

7.3.2 Calibrate the instrument as described in Section 7.2, following the manufacturer's instructions. Record the calibration information in the field records.

7.3.3 The instrument is now operational. Readings should be recorded in the field records.

7.3.4 When the PID is not being used or between monitoring intervals, the unit may be switched off to conserve battery power and UV lamp life; however, a "bump" test should be performed each time the unit is turned on and prior to taking additional measurements. To perform a bump test, connect the outlet tubing from a Tedlar bag containing a small amount of span gas to the inlet tubing on the unit and record the reading. If the reading is not within the tolerance specified in the project plan, the unit must be recalibrated.

7.3.5 At the end of each day, recheck the calibration. The check will follow the same procedures as the initial calibration (Section 7.2) except that no adjustment will be made to the instrument. Record the information in the field records.

7.3.6 Recharge the battery after each use (Section 7.4).

7.3.7 When transporting, ensure that the instrument is packed in its stored condition in order to prevent damage.

7.4 Routine Maintenance

7.4.1 Routine maintenance associated with the use of the PID includes charging the battery, cleaning the lamp window, replacing the detector UV lamp, replacing the inlet filter, and replacing the sample pump. Refer to the manufacturer's instructions for procedures and frequency.

7.4.2 All routine maintenance should be performed in a non-hazardous environment.

8.0 DATA AND RECORDS MANAGEMENT

All field information will be recorded in the field logbook or on a field collection form by field personnel. In addition, a field project logbook will be maintained detailing any problems or unusual conditions that may have occurred during the measurement process. Information to be recorded includes:

- Project name and number.
- Instrument manufacturer, model, and identification number.
- Operator's signature.
- Date and time of operation.
- Calibration gas used.
- Calibration check at beginning and end of day (meter readings before adjustment).
- Span setting after calibration adjustment.
- Meter readings (monitoring data obtained).
- Instances of erratic or questionable meter readings and corrective actions taken.
- Instrument checks and response verifications

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Calibration of the PID will be conducted at the frequency specified in the Quality Assurance Project Plan (QAPP) and/or SAP. In the absence of project-specific guidance, calibration will be performed at the beginning of each day of sampling and will be checked at the end of the sampling day or whenever instrument operation is suspect. The PID will sample a calibration gas of known concentration. The instrument must agree with the calibration gas within ±10%. If the instrument responds outside this tolerance, it must be recalibrated.

10.0 REFERENCES

United States Environmental Protection Agency. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM). USEPA, Region 4, SESD, Enforcement and Investigations Branch, Athens, GA. November 2001.

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Operation and Calibration of a Multi-Parameter Water Quality Monitor

SOP Number 7320

Revision Number: 0.0

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CONTENTS

LIST OF ACRONYMS

DO	Dissolved Oxygen
SAP	Sampling Ananlysis Plan
HASP	Health and Safety Plan
ORP	Oxydation-Reduction Potential
OSHA	Occupational Safety and Health Administration
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the procedure that will be followed by field staff for measuring water quality characteristics using a multi-parameter water quality meter.

The model used for the purposes of this SOP is model YSI 6920, and equivalent procedures may be used to operate similar instruments. Other multi-parameter meters are available and can be used as effectively as the YSI models. Specific calibration methods specified by the manufacturer should be used if a non YSI multi-parameter meter is used. The multi-parameter meters are equipped with sensors for the measurement of dissolved oxygen (DO), specific conductance, temperature, pH, and oxidation-reduction potential (ORP). Data can be viewed in real-time using a hand-held data logger.

2.0 SUMMARY OF METHOD

The multi-parameter meter is used to measured water quality parameters in the field, including DO, specific conductance, temperature, pH, and ORP. These may be used to establish the sufficiency of purging prior to collecting groundwater samples from monitoring wells, or to document water quality conditions in groundwater, surface water, and/or private well water.

The multi-parameter meter may be set directly into a water body, or within a flow-through cell or other container into which the water is placed or pumped. The instrument readings are displayed on a hand-held data logger. These readings may be recorded electronically by the datalogger or transcribed to the field log book or appropriate field data form.

3.0 HEALTH AND SAFETY WARNINGS

Measuring water quality parameters may involve chemical hazards associated with materials in the water being monitored and instrument calibration solutions, and physical hazards associated with general field work. When measuring water quality parameters, adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Potential interferences will be controlled through appropriate calibration of the instruments, and decontamination between sample locations.

5.0 PERSONNEL QUALIFICATIONS

To properly calibrate the instrument and perform water quality measurements, the field personnel must be familiar with the calibration and measurement techniques stated in this SOP. The field personnel must also be experienced in the operation of the meter.

Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials may be present.

It is the responsibility of the field personnel to be familiar with the procedures outlined within this SOP and health and safety requirements outlined within the Sampling Analysis Plan (SAP) and HASP. Field personnel are responsible for the proper use, maintenance, and decontamination of all equipment used in the calibration and operation of the multi-parameter meter, as well as proper documentation in the field logbook or field forms (if appropriate).

6.0 EQUIPMENT SUPPLIES

6.1 Multi-Parameter Meter

The following materials are necessary for calibration and operation of this instrument:

- YSI 6920 or equivalent multi-parameter meter with hand-held datalogger
- Calibration Standards
  - pH 4.0, 7.0, and 10.0 standard buffer solutions
  - Conductivity standard appropriate for field conditions expected
- YSI transport cup
- YSI probe guard
- Chemical-free paper towels
- YSI DO calibration kit (electrolyte solution and Teflon® membranes)
- Ring stand and clamps suitable for holding YSI unit during calibration

- Barometer
- Calibration Form (Figure 1)

6.2 Other Required Materials

Other materials that may be required to facilitate use of the instruments in the field include:

- YSI flow-through cell, bucket, or other container(s)
- Tubing to connect multi-parameter meter to pumps (as necessary)
- Replacement batteries for the datalogger display unit
- Health and safety supplies (as required by the HASP)
- Distilled/deionized water supply
- Deionized water dispenser bottler
- Equipment decontamination materials (as required by ENSR SOP No. 7600 – Decontamination of Field Equipment)
- Approved plans (e.g., HASP, SAP, QAPP)
- Field project logbook/pen

7.0 METHODS

7.1 General Preparation

Calibration of the YSI-6920 is required to assure performance of the meter. Specific calibration solutions are use for the calibration of specific conductance, pH, and ORP. Water is used for the calibration of DO. Temperature is not calibrated but may be checked against a secondary thermometer, if necessary.

7.2 Calibration

The YSI-6920 (or equivalent) will be calibrated daily prior to use according to the requirements of the QAPP and manufacturer's specifications. It will also be checked daily with the calibration solutions at the end of use of the equipment (post-calibration). Calibration records shall be recorded in the field logbook or Calibration Form (Figure 1). The required calibration procedures are summarized below.

All instruments except temperature may require calibration. During calibration, ensure that all sensors are immersed in the standard solutions. Use recommended volumes when performing calibrations.

Rinse the probes between calibration solutions using clean ambient temperature deionized water. For maximum accuracy, follow up by pre-rinsing the probes with a small amount of the calibration solution required for the next calibration.

Have clean, absorbent, lint-free, paper towels to dry the probes between rinses and calibration solutions. It is important to remove as much residual liquid as possible from the probes after each rinse. Drying the probes in this way reduces carry-over contamination of calibration solutions and increases the accuracy of the calibration.

After powering up the YSI-6920, the Main Menu will be displayed on the data logger. To access the calibration menu select option "2-Calibrate" from the Main Menu, the unit will display all the installed sensors which necessitate a pre-calibration prior to deployment and data acquisition (i.e., specific conductance, DO, pH, and ORP). The calibration procedure for each of the sensors is explained individually below.

7.2.1 Specific Conductance Sensor

Place enough specific conductance calibration solution in the YSI transport cup so that the probe will be entirely submerged in the solution.

Select the conductivity sensor off the Calibrate Menu to access the conductivity calibration procedure, then select SpCond to access the specific conductance calibration procedure.

Enter the calibration value of the standard you are using (mS/cm at 25 °C) and press ENTER. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

Observe the readings under SpCond and when no significant change occurs in the display for approximately 30 seconds, record the initial temperature and value in the field logbook or Calibration Form (Figure 1). Then press ENTER. The screen will indicate that the calibration has been performed successfully.

Now record the temperature, calibration value as well as date and time the calibration was performed in the field logbook or Calibration Form (Figure 1).

After the appropriate data has been recorded, the data logger will prompt you to press ENTER to return to the Calibrate Menu.

Rinse the probes in clean, deionized water and thoroughly dry.

7.2.2 DO Sensor

Place approximately 1/8" (3 mm) of water into the YSI transport cup and engage 1 or 2 threads on the probe. Make certain that the DO and temperature probes are not immersed in the water. Do not tighten; a loose connection which allows the transport cup to freely vent to the atmosphere is required to properly complete this calibration step. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperatures of the thermistor and the oxygen probe to equilibrate.

Select 2-Dissolved Oxy from the Calibrate Menu, then select 1-DO% to access the DO% calibration procedure. Enter the current local barometric pressure in mm Hg (inches Hg x 25.4 = mm Hg). Do not use barometer readings obtained from meteorological reports, these are corrected to sea level and will produce an inaccurate calibration.

A countdown timer will be displayed on the lower left of the screen that allows for the proper warm up time for the DO sensor. Wait for the countdown to be completed before proceeding. A message that indicates to press ENTER to continue will appear. Pressing ENTER will return the display to the DO calibration. When the DO% values reach a stabilized value, record the initial temperature and value in the field logbook or Calibration Form (Figure 1). Then press ENTER to accept the calibration.

The temperature, calibration value as well as date and time the calibration was performed should be recorded in the field logbook or Calibration Form (Figure 1).

NOTE: Calibration of the DO sensor following the DO% procedure will simultaneously achieve calibration in the DO mg/L mode and vice versa.

7.2.3 pH Probe (3-Point Calibration)

Place the appropriate volume of pH 7.0 standard buffer solution into a pre-rinsed transport cup and allow 1 minute for temperature equilibration before proceeding. From the Calibrate Menu, select 4-ISE1 pH to access the pH calibration procedure and select 3-3-point. Press ENTER and input the value of the buffer (7.0) at the prompt. Press ENTER and the current values received from the sensors will be displayed. When the unit has stabilized and there are no significant changes for approximately 30 seconds, record the initial temperature and value in the field logbook or Calibration Form (Figure 1). Then press ENTER to accept this calibration step. Now record the temperature, calibration value as well as date and time the calibration was performed in the field logbook or Calibration Form (Figure 1).

Press ENTER to continue with the second point in the calibration procedure. Rinse the probe in water and dry thoroughly before proceeding. Select the pH 4.0 standard buffer solution and place the appropriate volume into pre-rinsed transport cup. Press ENTER and input the value of the second buffer at the prompt. Following the same procedure as above, press ENTER and the current values received from the sensors will be displayed. When the unit has stabilized and there are no significant changes for approximately 30 seconds, record the initial temperature and value in the field logbook or Calibration Form (Figure 1). Then press ENTER to accept and complete this calibration step. Now record the temperature, calibration value as well as date and time the calibration was performed in the field logbook or Calibration Form (Figure 1).

Thoroughly rinse the probe and the calibration container in water and thoroughly dry. Repeat this procedure with the pH 10.0 standard solution.

Note that once field conditions are known, it may be possible to perform a 2-point calibration using the 4.0 to 7.0 or 7.0 to 10.0 range, ensuring that the expected range of field conditions is captured.

7.2.4 ORP

Calibration is not usually required for the ORP sensor. However, for some older probes, there may be deviation from the theoretical ORP value. To check for functionality, the ORP probe is placed in Zobell solution. If the probe is functioning properly, the reading should be within the range of 221 to 241 at normal ambient temperatures. If the reading is outside this range, the probe should be calibrated.

To calibrate, select ISE2-Orp from the calibrate menu. Immerse the probe into the Zobell solution and press ENTER. Enter in the Zobell solution value. Press ENTER and monitor the stabilization of the ORP and temperature readings. After no significant change occurs for approximately 30 seconds, record the initial temperature and value in the field logbook or Calibration Form (Figure 1). Then press ENTER to confirm the calibration. Now record the temperature, calibration value as well as date and time the calibration was performed in the field logbook or Calibration Form (Figure 1).

7.3 Collection of Measurements

Attach the field cable to the probe and hand tighten – DO NOT use tools! Make sure all port plugs are installed in all port connections where probes are not installed, it is extremely important to keep these electrical connections dry. Immerse the multi-parameter meter into the water being monitored. Ensure that the YSI data logger is properly connected and in RUN mode displaying data.

***NOTE*: Do not collect data until the sensor display has stabilized, particularly the parameters of DO and pH. Allow the DO sensor to warm up from 40 to 180 seconds after being immersed on station, depending on the water temperature.**

Record the displayed data on a field log sheet or in the field logbook.

7.4 Equipment Decontamination

The YSI-6920 multi-parameter meter should be decontaminated in accordance with ENSR SOP No. 7600 – Decontamination of Field Equipment between each sample location. Dedicated or disposable equipment does not need to be decontaminated.

Where the multi-parameter meter is used to monitor stabilization of parameter values during well purging, decontamination between locations is not needed as the purging process will effectively decontaminate the instruments as verified when parameters are stabilized.

8.0 DATA AND RECORDS MANAGEMENT

Calibration records will be recorded in the field logbook or appropriate field form. All field information will be recorded in the field logbook or on a field collection form by field personnel. In addition, a field project logbook will be maintained detailing any problems or unusual conditions that may have occurred during the calibration process.

The records generated in this procedure will become part of the permanent record supporting the associated field work. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field personnel will follow specific quality assurance guidelines as outlined in the Quality Assurance Project Plan (QAPP) and/or SAP.

10.0 REFERENCES

ENSR SOP No. 7600 – Decontamination of Field Equipment.

YSI 6920 Multi-Parameter Water Quality Monitor Operations and Instructions Manual.

FIGURE 1 – Example Calibration Form

Project Name: ____________________

Project Number: ____________________

Date: ____________________

Calibration Form

Parameter	Instrument Manf/Model	Instrument Serial No.	Standard Manf/Model	Standard SN/Exp. Date	Standard Value @ __C	Ambient Temp. C	Initial Value	Adjusted Value	Initials & Time	Comments
pH 4.00	YSI 6920				4.00 @ 25C					
								-------		Post Cal
pH 7.00					7.00 @ 25C					
								-------		Post Cal
pH 10.00					10.00 @ 25C					
								-------		Post Cal
Specific Cond.					____uS/cm @ 25C					
								-------		Post Cal
ORP					____mV @ ____C					
								-------		Post Cal
DO			H2O Saturated Air		____mg/L @ ____C					BP =
								-------		Post Cal: BP =

BP = Barometric Pressure (mmHg)

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Packaging and Shipment of Environmental Samples

SOP Number 7510

Revision Number: 0.0

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CONTENTS

LIST OF ACRONYMS

COC	Chain-of-Custody
DOT	Department of Transportation
HASP	Health and Safety Plan
OSHA	Occupational Safety and Health Adminstration
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
RCRA	Resource Conversation and Recovery Act
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the procedures associated with the packaging and shipment of environmental samples consisting of water, soil, and sediment submitted for routine environmental testing. Environmental samples are not considered a Resource Conservation and Recovery Act (RCRA) classified hazardous waste by definition; therefore, more stringent RCRA and Department of Transportation (DOT) regulations regarding sample transportation do not apply. Environmental samples do, however, require fairly stringent packaging and shipping measures to ensure sample integrity as well as safety for those individuals handling and transporting the samples.

This SOP is designed to provide a high degree of certainty that environmental samples will arrive at their destination intact. This SOP assumes that samples will often require shipping overnight by a commercial carrier service; therefore, the procedures are more stringent than may be necessary if a laboratory courier is used or if samples are transported directly to their destination by a field personnel. Should either of the latter occur, the procedures may be modified to reflect a lesser degree of packaging requirements.

2.0 SUMMARY OF METHOD

Sample packaging and shipment involves the placement of individual sample containers into a cooler or other similar shipping container and placement of packing materials and coolant in such a manner as to isolate the samples, maintain the required temperature, and to limit the potential for damage to sample containers when the cooler is transported.

3.0 HEALTH AND SAFETY WARNINGS

Sampling personnel should be aware that packaging and shipment of samples involves potential exposure and physical hazards primarily associated with handling of occasional broken sample containers and lifting of heavy objects. Adequate health and safety measures must be taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Sample containers with presumed high constituent concentrations should be isolated within their own cooler with each sample container placed into a zipper-lock bag.

5.0 PERSONNEL QUALIFICATIONS

Sample packaging and shipment is a relatively simple procedure requiring minimal training and a minimal amount of equipment. It is recommended that initial attempts be supervised by more experienced personnel.

Field personnel should be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials may be present.

It is the responsibility of the field personnel to be familiar with the procedures outlined within this SOP, quality assurance, and health and safety requirements outlined within the SAP, Quality Assurance Project Plan (QAPP), and HASP. Field personnel are also responsible for proper documentation in the field logbook.

6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Sample coolers
- Sample containers
- Shipping labels
- Chain-of-custody (COC) form (Figure 1)
- Custody tape (Figure 2)
- Bubble wrap or Styrofoam pellets
- Ice
- Temperature blank
- Transparent tape, or rubber bands
- Fiber tape
- Duct tape
- Utility knife

- Zipper-lock plastic bags
- Trash bags
- Health and safety supplies (as required by the HASP)
- Field project logbook/pen

7.0 METHODS

7.1 Preparation

The extent and nature of sample containerization will be governed by the type of sample, and the most reasonable projection of the sample's hazardous nature and constituents. U.S. Environmental Protection Agency (USEPA) regulations (40 CFR Section 261.4(d)) specify that samples of solid waste, water, soil or air, collected for the sole purpose of testing, are exempt from regulation under RCRA when any of the following conditions are applicable:

- Samples are being transported to a laboratory for analysis;
- Samples are being transported to the collector from the laboratory after analysis;
- Samples are being stored (1) by the collector prior to shipment for analyses, (2) by the analytical laboratory prior to analyses, or (3) by the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case.

7.1.1 Laboratory Notifications

Prior to sample collection, the ENSR Task Manager or designee must notify the laboratory project manager of the number, type, and approximate collection and shipment dates for the samples. If the number, type, or date of sample shipment changes due to program changes that may occur in the field, the ENSR Task Manager or alternate must notify the laboratory of the changes. Additional notification from the field is often necessary when shipments are scheduled for weekend delivery.

7.1.2 Cooler Inspection and Decontamination

Laboratories will often re-use coolers. Every cooler received at a project location should be inspected for condition and cleanliness. Any coolers that exhibit cracked interiors or exterior linings/panels or hinges should be discarded because the insulating properties of the coolers would be considered compromised. Any coolers missing one or both handles should also be discarded if replacement handles (i.e., knotted rope handles) can not be fashioned in the field.

The interior and exterior of each cooler should be inspected for cleanliness before using it. Excess strapping tape and old shipping labels should be removed. If the cooler interior exhibits visible contamination or odors it should not be used. Drain plugs should be sealed on the inside with duct tape.

7.2 Sample Packaging

7.2.1 Place plastic bubble wrap matting over the base of each cooler or shipping container as needed.

7.2.2 Insert a clean trash bag into the cooler to serve as a liner.

7.2.3 Check that each sample container is sealed, labeled legibly, and is externally clean. Re-label and/or wipe bottles clean if necessary. Clear tape should be placed over the labels to protect them and keep them from falling off the container. Wrap each sample bottle individually with bubble wrap secured with tape or rubber bands. For aqueous samples in glass containers, each sample should be sealed in a zipper-lock bag to prevent leakage and cross-contamination in the case of breakage. Place bottles into the cooler in an upright single layer with approximately one inch of space between each bottle. Do not stack bottles or place them in the cooler lying on their side. If plastic and glass sample containers are used, alternate the placement of each type of container within the cooler so that glass bottles are not placed side by side.

7.2.4 Insert the cooler temperature blank supplied by the laboratory into each cooler (if any).

7.2.5 Place additional vermiculite, bubble wrap, and/or styrofoam pellet packing material throughout the voids between sample containers within each cooler to a level that meets the approximate top of the sample containers. Packing material may require tamping by hand to reduce the potential for settling.

7.2.6 Double bag cubed ice in heavy duty zipper-lock plastic bags, close the bags, and distribute the bagged ice in a layer over the top of the samples. Loose ice should never be used. Cold packs should be used only if the samples are chilled before being placed in the cooler.

7.2.7 Add additional bubble wrap/styrofoam pellets or other packing materials to fill the balance of the cooler or container.

7.2.8 Obtain two pieces of COC tape as shown in Figure 2 and enter the custody tape numbers in the appropriate place on the COC form (Figure 1). Sign and date the COC tape.

7.2.9 Complete the COC form per ENSR SOP No. 7007 – Chain-of-Custody Procedures. If shipping the samples involves use of a third party commercial carrier service, sign the COC record thereby relinquishing custody of the samples. Shippers should not be asked to sign COC records. If a laboratory courier is used, or if samples are transported to the laboratory by field personnel, the receiving party should accept custody and sign the COC records. Remove the last copy from the multi-form COC and retain it with other field notes. Place the original (with remaining copies) in a zipper-lock plastic bag and tape the bag to the inside lid of the cooler or shipping container.

7.2.10 Close the lid of the cooler or the top of the shipping container.

7.2.11 Place the COC tape at two different locations (i.e., one tape on each side) on the cooler or container lid and overlap with transparent packaging tape.

7.2.12 Packaging tape should be placed entirely around the sample shipment containers. A minimum of two full wraps of packaging tape will be placed at least two places on the cooler/container.

7.2.13 Repeat the above steps for each cooler or shipping container.

7.3 Sample Shipping

Transport the cooler/container to the package delivery service office or arrange for package pick-up at the site. Fill out the appropriate shipping form or airbill and affix it to the cooler/container. Some courier services may use multi-package shipping forms where only one form needs to be filled out for all packages going to the same destination. If not, a separate shipping form should be used for each cooler/container. The receipt for package tracking purposes should be kept in the project files, in the event a package becomes lost.

Each cooler/container also requires a shipping label that indicates point of origin and destination. This will aid in recovery of a lost cooler/container if a shipping form gets misplaced.

Never leave coolers/containers unattended while waiting for package pick-up.

Airbills or waybills will be maintained as part of the custody documentation in the project files.

7.4 Sample Receipt

Upon receipt of the samples, the analytical laboratory will open the cooler or shipping container and will sign "received by laboratory" on each COC form. The laboratory will verify that the COC tape has not been broken previously and that the tape number corresponds with the number on the COC record. The laboratory will note the condition of the samples upon receipt and will identify any discrepancies between the contents of the cooler/container and COC. The analytical laboratory will then forward the back copy of the COC record to the project Quality Assurance (QA) Officer to indicate that sample transmittal is complete.

8.0 DATA AND RECORDS MANAGEMENT

Documentation supporting sample packaging and shipment consists of COC records and shipping records. All documentation will be retained in the project files following project completion.

9.0 QUALITY CONTROL AND QUALITY ASSURANCE

The potential for samples to break during transport increases greatly if individual containers are not snugly packed into the cooler. Packed coolers may be lightly shake-tested to check for any loose bottles. The cooler should be repacked if loose bottles are detected.

Environmental samples are generally shipped so that the samples are maintained at a temperature of approximately 4°C. Temperature blanks may be required for some projects as a quality assurance check on shipping temperature conditions. These blanks usually are supplied by the laboratory and consist of a 40-ml vial or plastic bottle filled with tap water. Temperature blanks should be placed near the center of the cooler.

10.0 REFERENCES

ENSR SOP No. 7007 – Chain-of-Custody Procedures.

FIGURE 1 - Example Chain of Custody Form

M901376

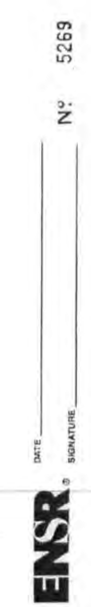
ENSR CHAIN OF CUSTODY RECORD Page ___ of ___

Client/Project Name:	Project Location:	Analysis Requested
Project Number:	Field Logbook No.:	
Sampler: (Print Name) /Affiliation	Chain of Custody Tape No.:	
Signature:	Send Results/Report to:	

Field Sample No./ Identification	Date	Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Sludge, Etc.)	Preservative	Field Filtered							Lab I.D.	Remarks

Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:	Analytical Laboratory (Destination): ENSR 4303 W. LaPorte Ave. Fort Collins, CO 80521 (970) 416-0916
Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:	
Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:	Serial No.

FIGURE 2 - Example Chain of Custody Tape



ENSR INTERNATIONAL

SOP NUMBER: 7515

Recording of Field Data

Date:	April 2005
Revision Number:	0
Author:	Debra McGrath
Discipline:	Quality Assurance

1.0 INTRODUCTION

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) provides instructions for recording data when documenting a sample collection event, field measurements, or a site visit. Field data may be recorded in field logbooks, on standardized forms, as annotated maps, as photo documentation, or electronically. Chain-of-custody records are also considered field data; however, these records are specifically addressed in SOPs 1007 (Chain-of-Custody Procedures) and 7510 (Packaging and Shipping of Environmental Samples).

1.2 Quality Assurance Planning Considerations

Field records provide evidence and support for technical decisions, interpretations, and judgments. It is therefore critical that procedures and systems be in place to ensure that they are legible, identifiable, and retrievable, and protected from loss or damage. In addition, client or regulatory requirements, or the end use of the data (e.g., to support litigation) may determine the format in which the data must be recorded. For example, some projects may require that all field information be recorded in the field logbook and may not allow the use of standardized forms. The requirements necessary to meet the data quality objectives for a particular project will be defined in the site-specific workplan and/or Quality Assurance Project Plan (QAPP) hereafter referred to as the project plan.

1.3 Health and Safety Considerations

Not applicable.

2.0 RESPONSIBILITIES

2.1 The Project Manager is responsible for ensuring that project-specific requirements are communicated to the project team and for providing the materials, resources, and guidance necessary to perform the measurements in accordance with this SOP and the project plan. In the absence of a Field Team Leader, the Project Manager is responsible for ensuring that field records are reviewed and approved as described below.

2.2 The Field Team Leader is responsible for reviewing and approving the field records for accuracy, completeness, and conformance to the procedures in this SOP.

2.3 Field personnel are responsible for recording data according to the procedures outlined in this SOP.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Bound field logbook (preferably waterproof, such as Rite-in-Rain™)
- Standardized field data sheets (refer to individual SOPs for test pit logs, boring logs, groundwater sample collection logs, etc.)
- Pen or Sharpie™
- Watch or other time-keeping device

The following materials may also be needed:

- Site maps
- Clipboard
- Three-ring binder or equivalent
- Camera
- Hand-held electronic recording device (e.g., PDA, laptop, or tablet PC)

4.0 METHOD

4.1 General

4.1.1 Field activities vary widely and no general rules can specify the exact information that must be recorded for each event. However, the field records must contain sufficient detail so that persons going to the site could reconstruct a particular situation without reliance on the collector's memory.

4.1.2 Field logbooks may be supplemented by standardized forms (e.g., well construction and development, sample collection forms, drum logs). In that case, the logbook provides a chronology of events, summary of personnel on site, and a narration of events not covered by the standardized forms. It is recommended that the details recorded on the standardized forms not be replicated in the logbook due to the potential for transcription errors and inconsistencies. References to standardized forms must be included in the logbook.

4.1.3 Entries will be recorded legibly in permanent ink (a black ballpoint pen is preferable) and will be signed and dated. No erasures or obliterations will be made. If an incorrect entry is made, the information will be crossed out with a single strike mark which is initialed and dated by the sampler, and the correct information added.

4.1.4 Pencil should not be used. If a ballpoint pen cannot be used because of adverse weather conditions (rain or freezing temperatures), a fine-point Sharpie™ is an acceptable substitute. If conditions are such that only pencil can be used, an explanation must be included in the logbook and the affected data should be photocopied, signed as verified copy, and maintained in the project files as documentation that the data has not been changed.

4.1.5 Information to be recorded should address the questions of who, where, what, when, how, and why. A specific list of information that should be recorded is included in Table 1.

4.1.6 Entries will be objective, factual, and free of personal feelings or inappropriate language. Cryptic notes and undefined abbreviations or acronyms should be avoided.

4.1.7 Information will be made in as close to real time as possible. Information recorded significantly after the fact must be dated as such.

4.2 Field Logbooks

4.2.1 Field logbooks will be bound water-proof field survey books or notebooks with consecutively numbered pages.

4.2.2 Logbooks will be assigned to field personnel, and will be identified by a unique document number. The logbook should be kept in the field person's possession or in a secure location during field activities and archived in the project files upon completion of the field program.

4.2.3 Logbooks should be specific to a project. Multiple projects should not be included in one logbook because of document retention and evidentiary reasons.

4.2.4 The title page of each logbook will contain the following:

- Person to whom the logbook is assigned, ENSR office location, and phone number,
- The logbook number,
- Project name and number, and
- Start and end dates of work covered by the logbook.

4.2.5 Logbook entries documenting sample collection or field measurements must clearly identify the task being completed (for example, water level measurements, headspace readings). Units must be included for all measurements.

4.2.6 For ease of reference, it is recommended that a new page be started for each sampling day and that the time be recorded in the far left column. Each day's entries will be signed and dated by the person making the entries. A diagonal line across the bottom of the page will indicate the end of an entry.

4.3 Standardized Forms

4.3.1 At a minimum, each form must include a title identifying the activity being documented and the project identification (name and number).

4.3.2 Each form must be signed and dated by the person completing the form.

4.3.3 There should be no blank spaces on the form. Each space must be filled in with the information requested or "NA" (not applicable).

4.3.4 Forms should not be loose, but should be maintained in an organized manner (e.g., clipboards, binders).

4.4 Maps and Drawings

4.4.1 Maps and drawings that document final sampling locations and which are separate from the field logbook must be referenced in the logbook. These maps or drawings must include the project name and number, site identification and location, and must be signed and dated by the person recording the locations.

4.4.2 Maps and drawings must include compass orientation and scale.

4.5 Photographs and Other Photo Documentation

4.5.1 Photo documentation, if permitted at the site, can provide invaluable information on site conditions, sample locations, and the sample itself.

4.5.2 Photographs, videos, or slides must be cross-referenced to entries in the field logbook or on a photo documentation log. Information to be recorded includes name of photographer, date, time, direction faced, description of subject, and sequential number of the photograph and roll number. An indication of scale is also helpful. Image-enhancing techniques (lenses, film) should also be noted.

4.6 Electronic Files

4.6.1 Electronically captured data may include data logging systems and hand-held electronic recording devices such as PDAs, laptops, or tablet PCs.

4.6.2 Field data that is captured electronically must be cross-referenced in the field logbook. Information to be recorded includes the identity of the person recording the data, instrument make and model number, measurement time and date, and file identification.

4.6.3 Sufficient backup systems must be in place to protect against the loss of data. Electronic files must be saved to a disk or backed up immediately upon completion. The backup disk or other media (CD, flash drive) should then be stored in a secure location separate from the laptop, tablet, or PDA.

4.6.4 Files must be uniquely identified and should be stored in the project files on the network. An unedited version of the file must be maintained and all subsequent manipulations tracked.

5.0 QUALITY CONTROL

5.1 The field records will be reviewed by the Field Team Leader, or by the Project Manager or his/her designate, for accuracy, completeness, and adherence to the requirements of this SOP. At a minimum, this must occur at the end of the field event. For field activities of extended duration, it is recommended that this review occur more frequently (e.g., daily or weekly).

5.2 If information recorded in the field is transcribed to another format, the original record must be retained for comparison purposes.

5.3 Periodic copying of the field records should be considered to insure against the loss or destruction of the original documents.

6.0 RECORDS MANAGEMENT

At the end of the field program, original field records must be placed in the project files and maintained for a certain retention time. The duration of record retention will be determined by project-specific requirements, or, in the absence of project requirements, by ENSR Corporate policy.

7.0 TRAINING/QUALIFICATIONS

The individual recording field data must have read, and be familiar with, the requirements of this SOP.

8.0 REFERENCES

USACE. 2001. Requirements for the Preparation of Sampling and Analysis Plans. EM 200-1-3. United States Army Corps of Engineers. 1 February 2001.

USEPA. 2004. Contract Laboratory Program Guidance for Field Samplers. OSWER 9240.0-35. EPA540-R-00-003. United States Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation. August 2004.

USEPA. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. United States Environmental Protection Agency, Region 4, Athens, GA. November 2001.

USEPA. 1998. Test Methods for Evaluating Solid Wastes. Physical/Chemical Methods (SW-846). Third edition, including all final updates.

USEPA. 1992. RCRA Ground-water Monitoring: Draft Technical Guidance. United States Environmental Protection Agency, Office of Solid Waste, Washington, DC. November 1992.

Table 1 Specific Information to be Recorded

- Site name and location
- Personnel on site (ENSR, clients, site contacts, regulators, oversight personnel, subcontractors, general public)
- Results of phone calls, conversations
- Chronology of activities, including mobilization, investigatory activities, and demobilization
- Weather conditions (initial and any changes; temperature, barometric pressure, wind conditions, precipitation)
- Tidal stage (if applicable)
- Inspections of equipment, materials, supplies (problems, corrective action)
- Subcontractor name, description of services to be provided, and any issues (problems, stand by time)
- Description of major equipment (drill rigs, backhoe, survey vessels, sampling platforms)
- Field measurements
    - –Description of procedure
    - –Instruments (make, model, serial number, lamp)
    - –Instrument calibration (date, time, personnel, standard, lot number, standard expiration date, true/measured results, units, corrective action, calibration checks and results)
    - –Results (including units of measure, any correction factors applied, documentation of calculations (if applicable)
    - –Date and time of measurement
    - –Identity of person performing the measurements
    - –Atmospheric conditions (if applicable)
- Equipment decontamination procedures and materials
- Well information (depth to water, static water depth, condition of well)
- Well purging information (procedure, equipment, volumes, pumping rate, criteria for acceptance, time and date)
- Presence and detection of immiscible layers, detection method, sampling method
- Sampling information
    - –Procedures and equipment (type and material)
    - –Sample (soil) selection criteria/rationale (PID, staining, water table)
    - –Sample location identification (e.g., boring, well identification)
    - –Sample location description (sketch, GPS coordinates, compass and distance measurements from fixed points).
    - –Sample depth
    - –Sample flow rate/drawdown
    - –Sample description (recovery, moisture, color, odor, texture, turbidity, artifacts)
    - –Sample manipulations (filtration, homogenization, compositing, preservation)
    - –Sample date and time
    - –Unique sample ID
    - –Identity of sampler
    - –Sample parameters, containers (size/type), preservation
    - –QC samples (field duplicates, trip blanks, field/equipment blanks, MS/MSDs, split samples) – include ID, associated field sample, method of collection
- Any pertinent field observations that could affect data quality (instrument problems, contamination sources)
- Deviations from approved plan (schedule modifications, relocation or elimination of sample locations, change orders), including rationale
- Investigation-derived waste (IDW) types, volumes, storage, and disposal
- Health and safety (H&S) meetings, personal protective equipment (PPE) worn, H&S monitoring

ENSR | AECOM

Decontamination of Field Equipment

SOP Number 7600

Revision Number: 0.0

January 2008

Jamie C Stevens, P.E.
ENSR Project Manager
January 23, 2008

Renee Knecht, L.G.
ENSR Project QA Officer
January 23, 2008

ENSR Corporation
January 23, 2008

LIST OF ACRONYMS

SAP	Sampling Analysis Plan
HASP	Health and Safety Plan
IDW	Investigation Derived Waste
OSHA	Occupational Safety and Health Administration
QC	Quality Control
SOP	Standard Operating Procedure
QAPP	Quality Assurance Project Plan

taken to protect field personnel. These measures are addressed in the project Health and Safety Plan (HASP). All work will be conducted in accordance with the HASP.

4.0 INTERFERENCES

Equipment decontamination should be performed a safe distance away from the sampling area so as not to interfere with sampling activities, but close enough to the sampling area to maintain an efficient working environment.

5.0 PERSONNEL QUALIFICATIONS

Decontamination of field equipment is a relatively simple procedure requiring minimal training. It is recommended that the initial decontamination of field equipment be supervised by more experienced personnel. Field personnel must be health and safety certified as specified by the Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

It is the responsibility of field personnel to be familiar with the decontamination procedures outlined within this SOP, quality assurance, and health and safety requirements outlined within Sampling Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), and Health and Safety Plan (HASP). Field personnel are responsible for decontamination of field equipment and for proper documentation in the field logbook.

6.0 EQUIPMENT AND SUPPLIES

General field supplies include the following items:

- Decontamination agents
  - Simple Green, or other non-phosphate and non-borate biodegradable detergent/degreaser
  - Distilled/deionized water
- Health and safety supplies (as required by the HASP)
- Chemical-free paper towels
- Waste storage containers: drums, 5-gallon buckets with covers, plastic bags
- Cleaning containers: plastic buckets or tubs
- Cleaning brushes
- Pressure sprayers (if applicable)

7.2 Decontamination for Inorganic (Metals) Analyses

7.2.1 This procedure applies to equipment used in the collection of environmental samples submitted for inorganic constituent analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, and other small items. Submersible pump decontamination procedures are outlined in Section 7.2.

7.2.2 Decontamination is to be performed before sampling events and between sampling points, unless otherwise noted in the SAP.

7.2.3 After a sample has been collected, remove all gross contamination from the equipment or material by brushing and then rinsing with available tap water. This initial step may be completed using a 5-gallon bucket filled with tap water. A water pressure sprayer may also be used to remove solids and/or other contamination.

7.2.4 Wash the equipment with a non-phosphate and non-borate detergent and tap water solution. This solution should be kept in a 5-gallon bucket with its own brush.

7.2.5 Rinse with tap water or distilled/deionized water until all detergent and other residue is washed away. This step can be performed over an empty bucket using a squeeze bottle or pressure sprayer.

7.2.6 Rinse with 10% nitric acid.

7.2.7 Rinse with distilled/deionized water to remove any residual acid.

7.2.8 Allow the equipment to air-dry in a clean area or blot with chemical-free paper towels before reuse. Wrap the equipment in aluminum foil with the shiny side out and/or seal it in a zipper-lock plastic bag if it will not be reused immediately.

7.2.9 Dispose of soiled materials and spent solutions in the designated IDW disposal containers.

7.3.7 Using a pressure sprayer with distilled/deionized water, rinse the exterior of the pump, discharge line, and power cord thoroughly, shake all excess water, then place the pump system into a clean trash bag for storage. If the pump system will not be used immediately, the pump itself should be wrapped with aluminum foil before placing it into the bag.

7.4 Decontamination of Large Equipment

7.4.1 A temporary decontamination pad may be established for decontamination of heavy equipment. This pad may include a membrane-lined and bermed area large enough to drive heavy equipment (e.g., drill rig, backhoe) onto with enough space to spread other equipment and to contain overspray. Usually a small sump is necessary to collect and contain rinsate (a pump is used to remove these wastes from the sump). A water supply and power source is also necessary to run steam cleaning and/or pressure washing equipment.

7.4.2 Upon arrival at the Area of Investigation, all heavy equipment (such as drill rigs) should be thoroughly cleaned. This can be accomplished by steam cleaning or high pressure water wash and manual scrubbing.

Between each sample location (i.e., between boreholes), heavy equipment that has been in the ground must be cleaned by steam cleaning or high pressure water wash and manual scrubbing. This may be performed at the decontamination pad or in the vicinity of the drilling location.

8.0 DATA AND RECORDS MANAGEMENT

Specific information regarding decontamination procedures should be documented in the project-specific field logbook. Documentation within the logbook should thoroughly describe the construction of any decontamination facility and the decontamination steps implemented in order to show compliance with the SAP. Decontamination events should be logged when they occur with the following information documented:

- Date, time, and location of each decontamination event
- Equipment decontaminated
- Method
- Solvents and/or acids used

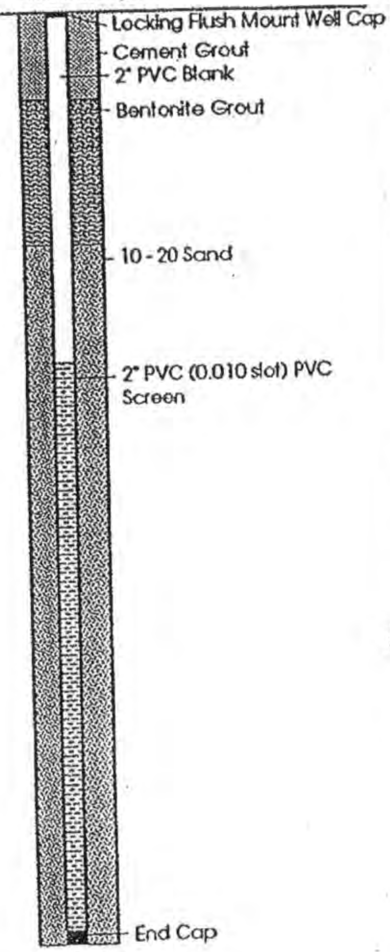
Appendix C

Boring Logs

Geological Boring Log and Well Completion Diagram

Depth in Feet	OVM	Blows/6"	Inches Driven / Inches Recovered	USCS	Lithologic Description
0				GP	ASPHALT with gravel base course. (fill)
	3.5	5, 7, 9	18 / 18	SM	Reddish brown silty fine grained SAND; slightly moist, medium dense.
				SP	Black medium grained SAND with trace gravel; slightly moist, medium dense.
	0	4, 6, 9	18 / 18	SM	Reddish brown silty fine grained SAND; slightly moist, medium dense.
5					- grading moist at 5' bgs.
	0	2, 2, 2	18 / 18	ML	Brown fine grained sandy SILT with trace clay; wet, loose.
				SP	Brown fine to medium grained SAND; wet, medium dense to loose.
▽	0	5, 5, 8	18 / 18		
10	0				
	0				
15	0	3, 5, 2	18 / 18		Boring completed at 16 1/2' bgs on 5/4/92. Groundwater measured at 8.4' bgs on 5/4/92.
20					

Well Description



Boring/Well No:	B-2 (MW-1)	Drilling Method:	Mobile B-61 Drill Rig w/ 4.25" ID Hollow Stem Auger
Client:	General Electric	Sample Method:	D&M U-Type Sampler driven by 300lb Hammer w/ 2.5" x 3" Stainless Steel Liners
Job No:	01674-881-005	Drill Contractor:	GeoBoring & Development, Inc.
Location:	Plant #1	Drill Date:	5/4/92
Geologist:	BF	Well installed:	5/4/92

Dames & Moore

FILENAME: GE_MW.DRW 10/13/92

Geological Boring Log and Well Completion Diagram

Depth in Feet	OVM	Blows/6"	Inches Driven / Inches Recovered
~1	3.5	11, 9, 5	18 / 18
~2.5	2	2, 1, 2	18 / 18
5	0	3, 3, 5	18 / 18
~7.5	0	4, 4, 4	18 / 18
10	0	2, 1, 4	18 / 18
15	0	4, 5, 7	18 / 18

USCS / Lithology	Lithologic Description
GP	ASPHALT with gravel base course. (fill)
SP	Black medium grained SAND with little fine gravel; slightly moist, medium dense.
SP	Grading brown fine grained SAND with trace silt; slightly moist, medium dense.
ML	Gray clayey SILT; slightly moist, soft.
SM	Gray silty fine grained SAND with root material; moist, loose.
SP	- grading brown fine to medium grained SAND; wet, loose to medium dense.

Boring completed at 16 1/2' bgs on 5/5/92.
Groundwater level measured at 8.08' bgs at 5/5/92.

Well Description

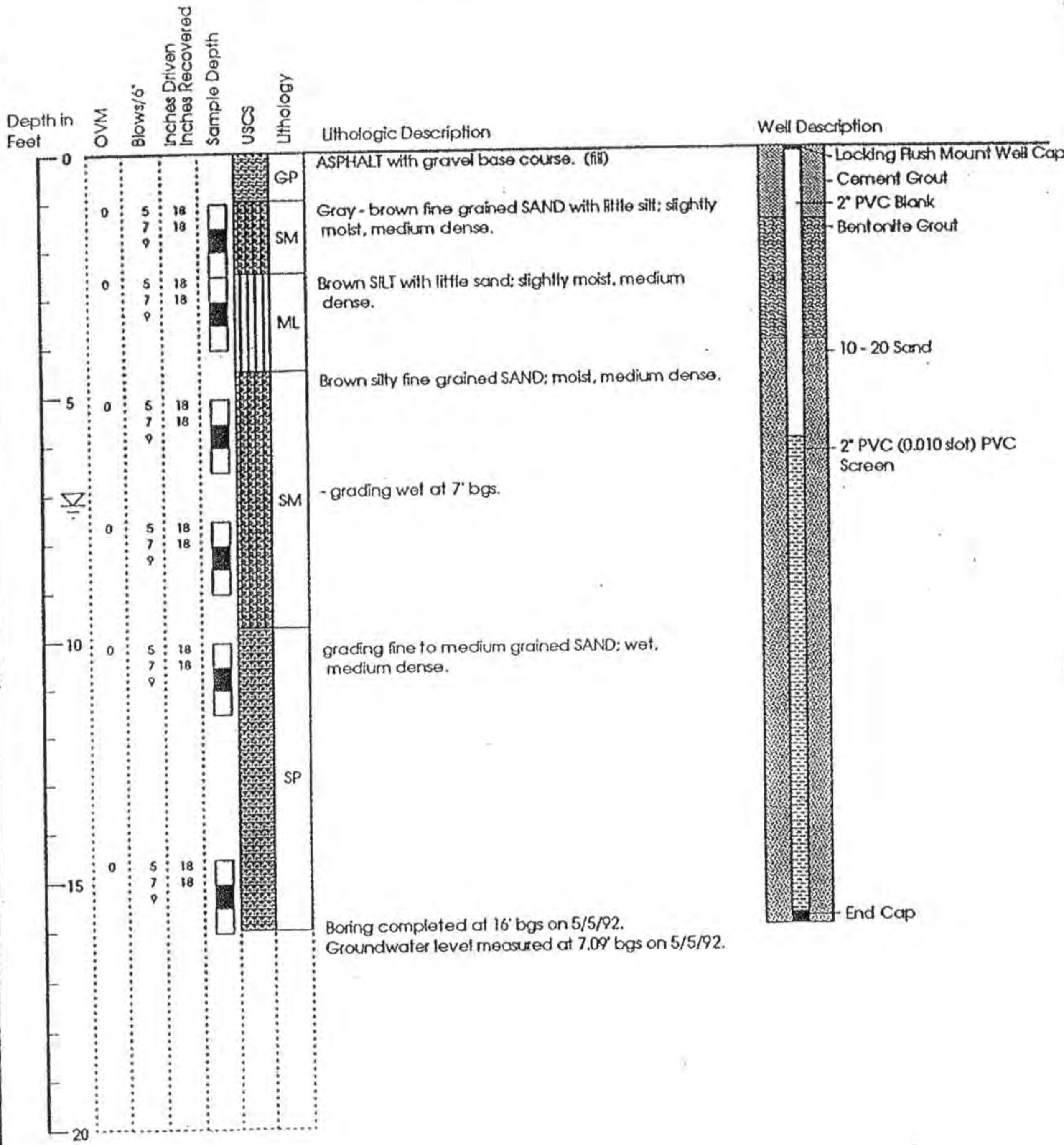
- Locking Flush Mount Well Cap
- Cement Grout
- 2" PVC Blank
- Bentonite Grout
- 10 - 20 Sand
- 2" PVC (0.010 slot) PVC Screen
- End Cap

Boring/Well No:	B-4 (MW-2)	Drilling Method:	Mobile B-61 Drill Rig w/ 4.25" ID Hollow Stem Auger
Client:	General Electric	Sample Method:	D&M U-Type Sampler driven by 300lb Hammer w/ 2.5" x 3" Stainless Steel Liners
Job No:	01674-881-005	Drill Contractor:	GeoBoring & Development, Inc.
Location:	Plant #1	Drill Date:	5/5/92
Geologist:	BF	Well installed:	5/5/92

Dames & Moore

FILENAME: GE_MW.DRW 10/13/92

Geological Boring Log and Well Completion Diagram



Boring/Well No:	B-3 (MW-3)	Drilling Method:	Mobile B-61 Drill Rig w/ 4.25" ID Hollow Stem Auger
Client:	General Electric	Sample Method:	D&M U-Type Sampler driven by 300lb Hammer w/ 2.5" x 3" Stainless Steel Liners
Job No:	01674-881-005	Drill Contractor:	GeoBoring & Development, Inc.
Location:	Plant #1	Drill Date:	5/5/92
Geologist:	BF	Well Installed:	5/5/92

Dames & Moore

FILENAME: GE_MW.DRW 10/13/92

Geological Boring Log and Well Completion Diagram

OVM	Blows/6"	Inches Driven	Inches Recovered
2	8, 12, 12	18	18
0	3, 6, 6	18	18
2	4, 2, 4	18	18
0	4, 5, 7	18	18
0	2, 2, 4	18	18
0	4, 5, 7	18	18
0	4, 6, 9	18	18
0	4, 5, 9	18	18

Depth in Feet	USCS / Lithology	Lithologic Description
0	GP	ASPHALT with gravel base course. (fill)
1–9	SM	Gray, fine grained SAND with little silt; slightly moist, loose to medium dense. - grading to black at 2' bgs. Brown silty fine grained SAND; moist, medium dense. - grading to gray at 7' bgs.
9–11	ML	Grayish brown sandy SILT; wet, loose. - 3" layer of bark and organics encountered at 10' bgs.
11–17	SP	Gray fine grained SAND with some silt; wet, medium dense.

Boring completed at 17' bgs on 5/4/92.
Groundwater level measured at 9.52' on 5/4/92 and 5/5/92.

Well Description
- Locking Flush Mount Well Cap
- Cement Grout
- 2" PVC Blank
- Bentonite Chips
- 10 - 20 Sand Pack
- 2" Sch. 40 PVC (0.010 slot) PVC Screen
- End Cap

Boring/Well No:	B-1 (MW-4)	Drilling Method:	Mobile B-61 Drill Rig w/ 4.25" ID Hollow Stem Auger
Client:	General Electric	Sample Method:	D&M U-Type Sampler driven by 300lb Hammer w/ 2.5" x 3" Stainless Steel Liners
Job No:	01674-881-005		
Location:	Plant #1	Drill Contractor:	GeoBoring & Development, Inc.
Geologist:	BF	Drill Date:	5/4/92
		Well installed:	5/4/92

RETEC

Boring/Well Log

Well #: MW-8M
Sheet 1 of 1

Project: Dawson St.	Monument: flush mount	Stick Up: --
Project #: GE001-18600-600	Northing: 5182.23 Easting: 5429.19	Ground Elevation: 17.86'
Location: Seattle, WA	Drill Rig Type: CME-75	MP Elevation: 17.41'
Client: GEAE	Method: Hollow Stem Auger	Total Depth: 30'
Start Date & Time: 9/16/05 0920	Casing ID: 2"	Filter Pack: 10/20 Col. Silica Sand / 18-30'
Finish Date & Time: 9/16/05 1105	Boring ID: 8.5"	Seal: 3/8" bentonite chips / 2-18'
Contractor: Cascade Drilling Inc.	Bit Type: 4.25" HSA	Grout: --
Operator: Frank Scott	Logged By: Chris Gero	Screen: 10-slot / 20-30'

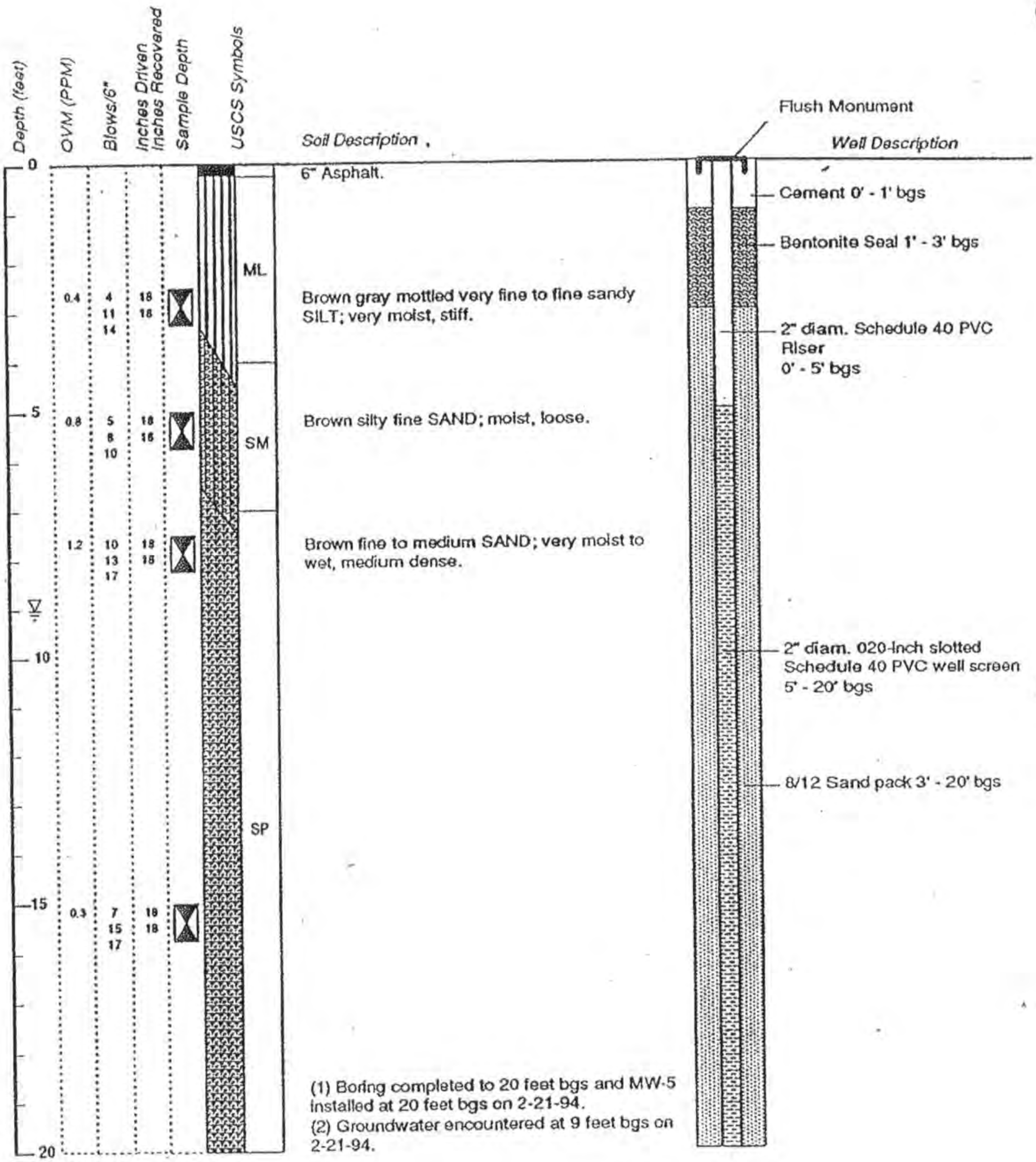
Sample Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Depth (ft.)	Soil and Rock Description (Classification Scheme: USCS)	Elevation (ft.)	Comments
					0		0	
ss	5-6.5'	60%	4/5/8		5	(5-6.5') SM: Dry to slightly moist, loose, medium brown, SILTY SAND. Fine to medium grained, no odor.	-5	
ss	10-11.5'	85%	6/11/8		10	(10-11.5') SM: Wet, medium dense, dark grayish brown SILTY SAND. Fine to medium grained, no odor. Some orange-brown iron oxide staining.	-10	
ss	15-16.5'	100%	6/9/11		15	(15-16.5') SM: Wet, medium dense, dark grayish brown SILTY SAND. Fine to medium grained, no odor. Heaving sands.	-15	
ss	20-21.5'	65%	11/11/15		20	(20-21.5') SM: Wet, medium dense, dark grayish brown SILTY SAND. Fine to medium grained, no odor. Heaving sands.	-20	
ss	25-26.5'	100%	22/23/26		25	(25-26.5') SM: Wet, dense, dark grayish brown SILTY SAND. Fine to medium grained, no odor. Heaving sands make sample appear loose. Fine silty stringer 1/4" thick at 26'.	-25	
ss	30-31.5'	100%	5/7/25		30	(30-31.5') SM: Wet, medium dense, dark grayish brown SILTY SAND. Fine to medium grained, no odor. Heaving sands.	-30	

Remarks and Datum Used: 300 lb. hammer, 30" stroke

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, WA 98134-1162
Phone: (206) 624-9349
Fax: (206) 624-2839

Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

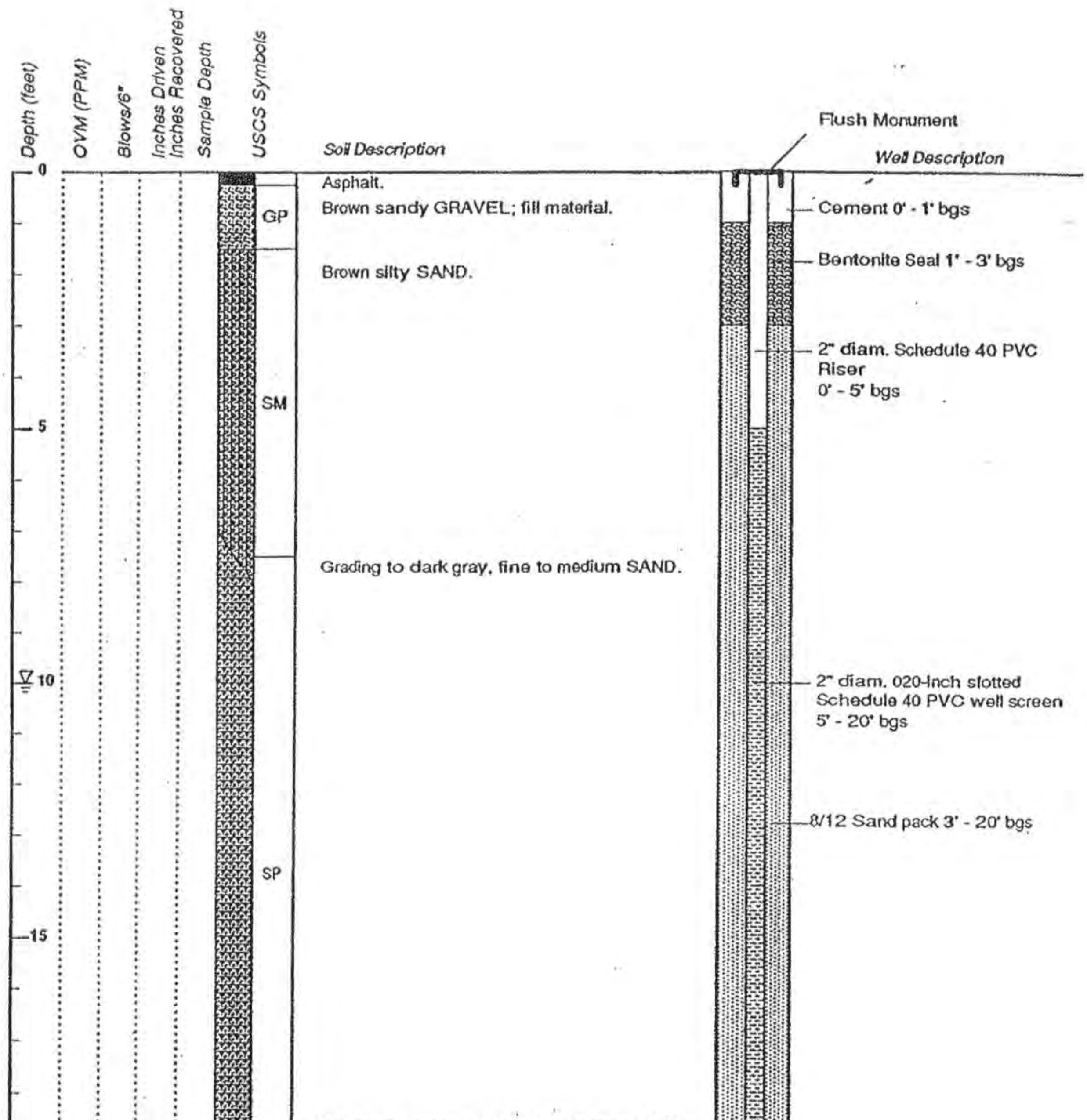
Groundwater		
Date	Time	Depth (ft.)



Client:	GEAE Plant1
Geologist:	JAK
Drilling Method:	8" Hollow Stem Auger, 140# Hammer
Sample Method:	D&M Split Spoon Sampler w/ 3" Stainless Steel Rings
Drill Contractor:	Cascade Drilling, Inc.
Drill Date:	February 21, 1994
TOC Elevation:	8.33
Ground Elevation:	8.62

MW-5

Boring Log and Monitoring Well As-Built Diagram
GE Plant1
Seattle, WA



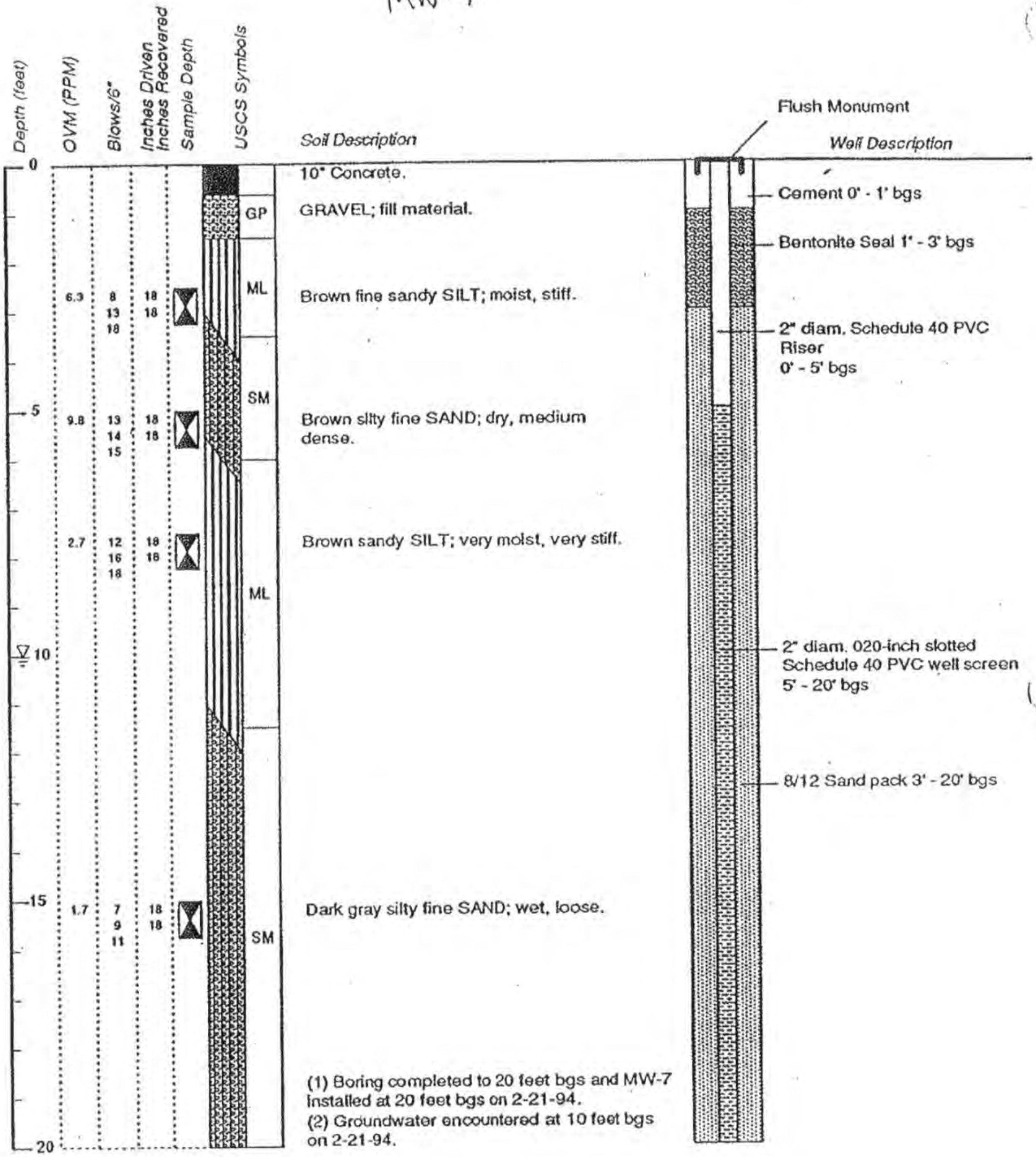
Client: GEAE Plant1
Geologist: JAK
Drilling Method: 8" Hollow Stem Auger , 140# Hammer
Sample Method: No soil samples collected, logged from cuttings
Drill Contractor: Cascade Drilling, Inc.
Drill Date: February 21, 1994
TOC Elevation: 8.17
Ground Elevation: 8.55

MW-6

Job No. 01674-970-005
DAMES & MOORE
File Name: GE-MW6.DRW

Boring Log and Monitoring Well As-Built Diagram
GE Plant1
Seattle, WA

MW-7



Client:	GEAE Plant1
Geologist:	JAK
Drilling Method:	8" Hollow Stem Auger , 140# Hammer
Sample Method:	D&M Split Spoon Sampler w/ 3" Stainless Steel Rings
Drill Contractor:	Cascade Drilling, Inc.
Drill Date:	February 21, 1994
TOC Elevation:	10.81
Ground Elevation:	11.08

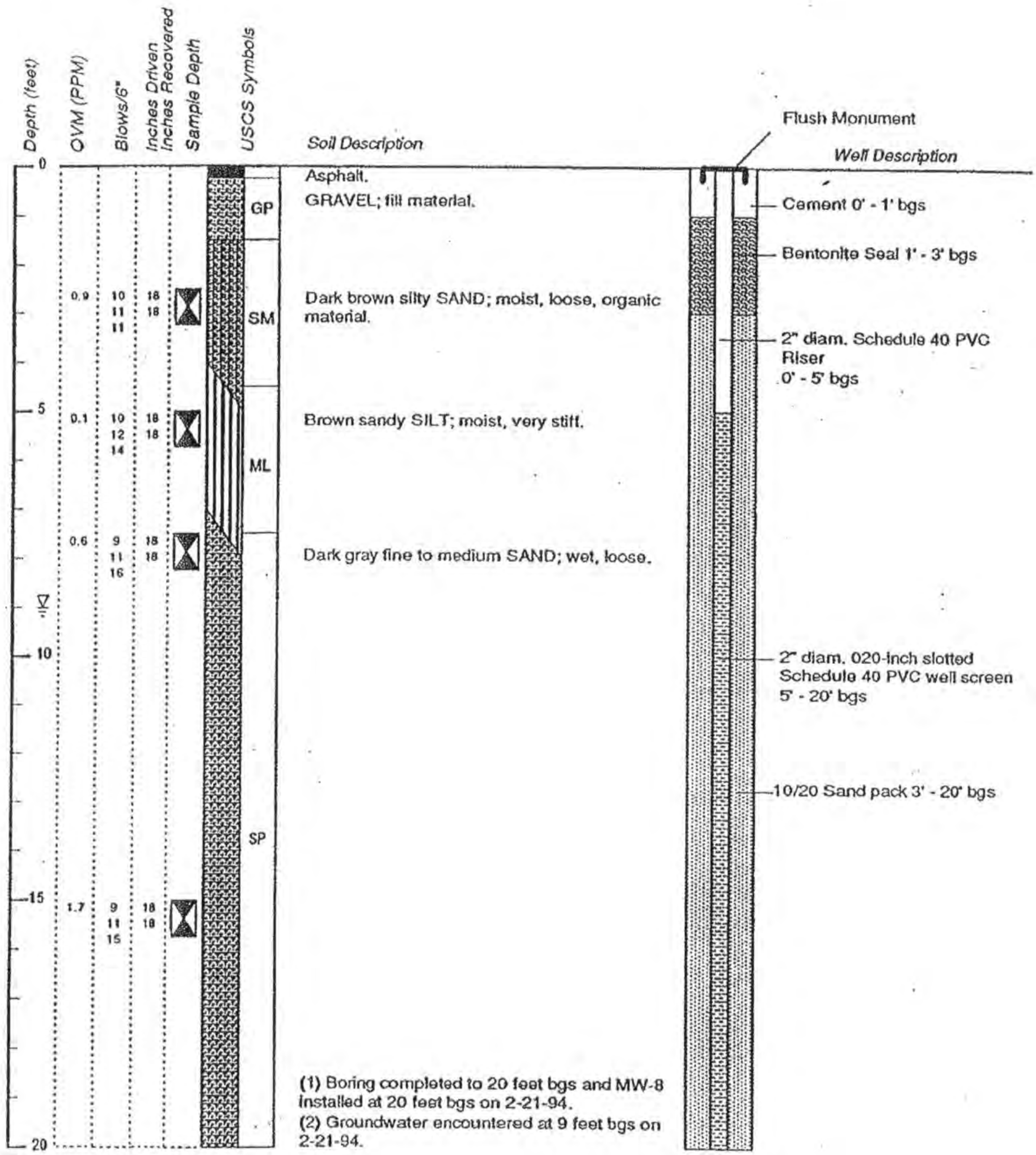
MW-7

Job No. 01674-970-005

DAMES & MOORE

File Name: GE-MW7.DRW

Boring Log and Monitoring Well As-Built Diagram
GE Plant
Seattle, V

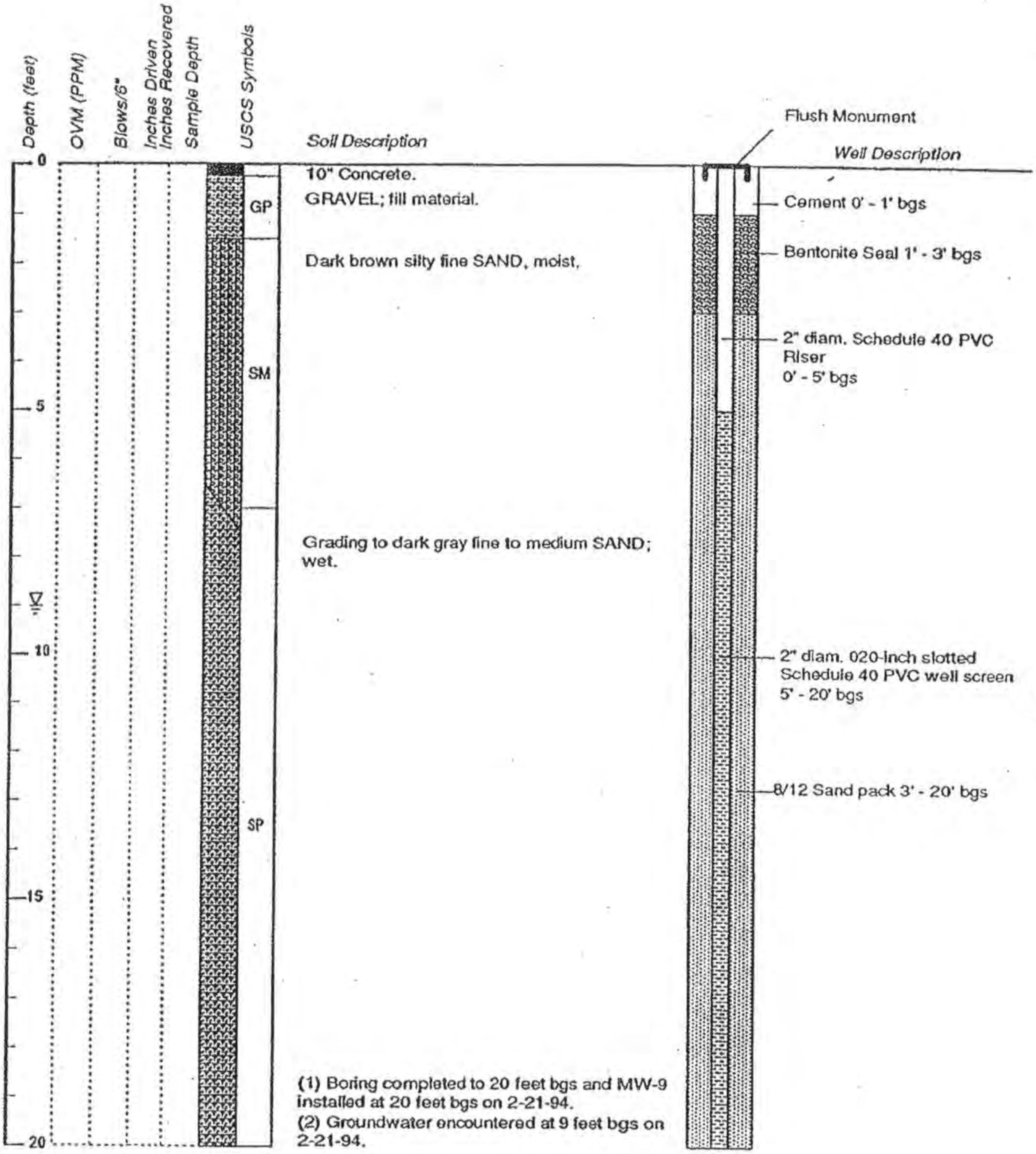


Client: GEAE Plant1
Geologist: JAK
Drilling Method: 8" Hollow Stem Auger , 140# Hammer
Sample Method: D&M Split Spoon Sampler w/ 3" Stainless Steel Rings
Drill Contractor: Cascade Drilling, Inc.
Drill Date: February 21, 1994
TOC Elevation: 8.06
Ground Elevation: 8.29

MW-8

Job No. 01674-970-005
DAMES & MOORE
File Name: GE-MW8.DRW

.Boring Log and Monitoring Well As-Built Diagram
GE Plant1
Seattle, WA

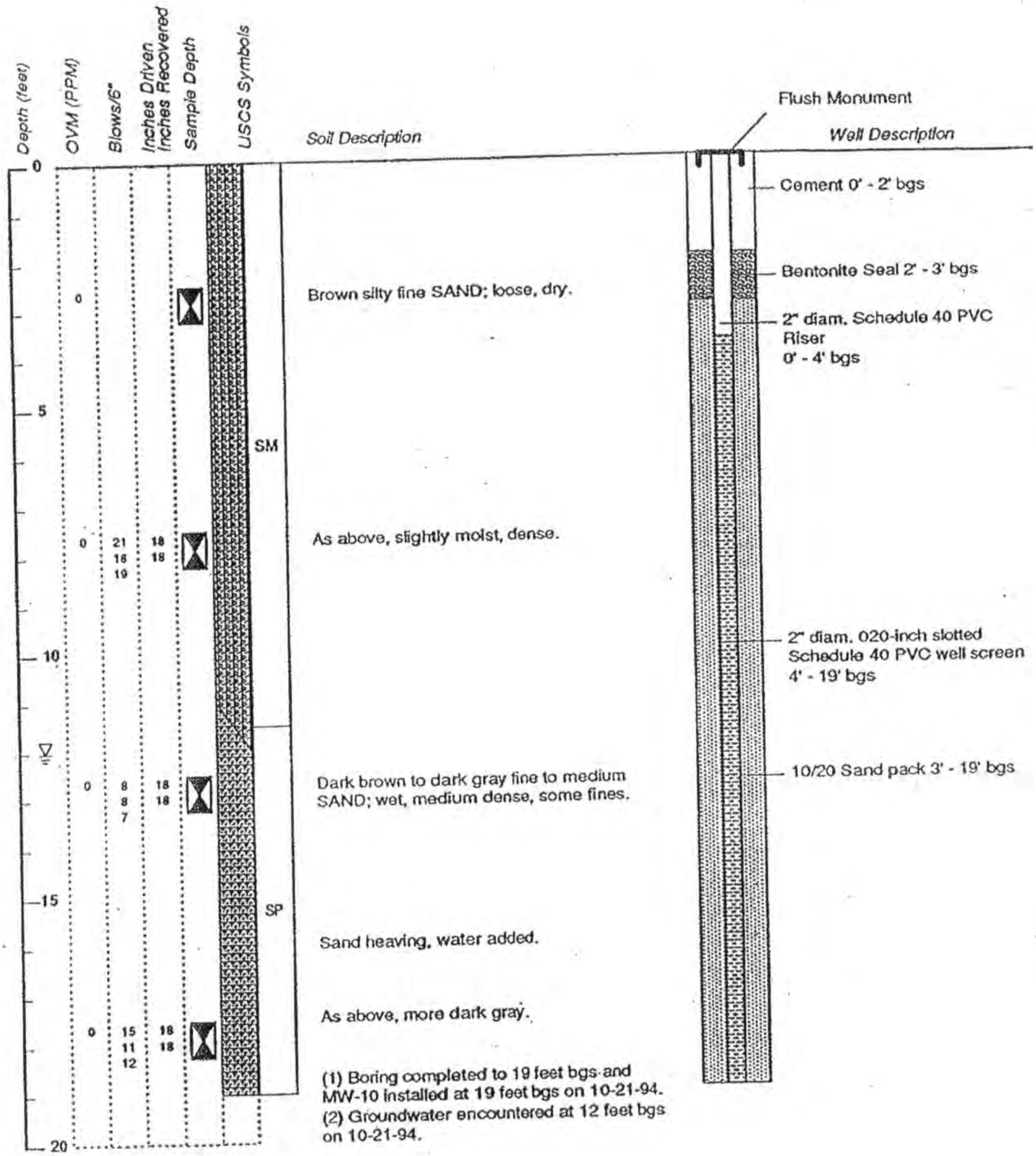


Client:	GEAE Plant1
Geologist:	JAK
Drilling Method:	8" Hollow Stem Auger , 140# Hammer
Sample Method:	No soil samples collected, logged from cuttings
Drill Contractor:	Cascade Drilling, Inc.
Drill Date:	February 21, 1994
TOC Elevation:	6.97
Ground Elevation:	7.33

MW-9

Job No. 01674-970-005
DAMES & MOORE
File Name: GE-MW9.DRW

Boring Log and Monitoring Well As-Built Diagram
GE Plant1
Seattle, WA



Client:	GEAE Plant1
Geologist:	JAK
Drilling Method:	Limited Access Hollow Stem Auger , 140# Hammer
Sample Method:	Split Spoon Sampler
Drill Contractor:	Cascade Drilling, Inc.
Drill Date:	October 21, 1994
TOC Elevation:	7.88
Ground Elevation:	8.17

MW-10

Job No. 01674-970-005

DAMES & MOORE

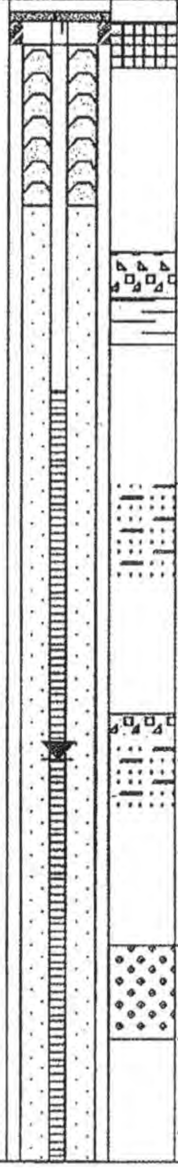
File Name: GE-MW10.DRW

Boring Log and Monitoring Well As-Built Diagram
GE Plant1
Seattle, WA

RETEC — Boring/Well Log

Well #: MW-13
Sheet 1 of 2

Project: **GEAE Interim Action**	Monument: **Flush Mount**	Ground Elevation: **NM**
Project #: **GE001-15547-730**	Northing: **NM** Easting: **NM**	MP Elevation: **NM**
Client: **GEAE**	Drill Rig Type: **Limited Access**	Total Depth: **19**
Well Area: **Seattle, Wa**	Method: **HSA**	Filter Pack: **#2/12 Monterey Sand**
Start Date & Time: **12/13/02 9:00 a.m.**	Casing ID: **NA**	Seal: **Bentonite Chips**
Finish Date & Time: **12/13/02 9:30 a.m.**	Boring ID: **9 inches**	Grout: **NA**
Contractor: **Cascade**	Bit Type: **Auger/5-tooth**	Riser: **2-inch, SCH 40 PVC**
Operator: **James Goble**	Logged By: **Rikka Bothun**	Screen: **4-19 ft, 20 slot, 2-in SCH 40 PVC**



Sample Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Depth (ft.)	Soil and Rock Description (Classification Scheme: USCS)	Elevation (ft.)	Comments
					0	0-0.5 ASPHALT	0	
	2.5-3.5	100	46-29-24	0		2.5-3 SANDY GRAVEL, gravel up to 1.5 inches in diameter, GP. Medium brown, slightly moist. Then about 1-2 inches of GRAVELLY SAND, very fine gravel and fine to coarse sand, SW. Grades to...		
						3-3.5 SILTY/CLAYEY SAND, ML. Medium to light brown, slightly moist, no odor or visible contamination (OVC).		
	5-6	75	50 for 6"	NM	5	5-6 (Top 2 inches SILTY/CLAYEY SAND (ML) as above.) SILTY SAND, very fine to very coarse sand with silt, SM. Medium brown, dry to slightly moist, no OVC.	5	
	7.5-8.5	100	19-21-26	NM		7.5-7.8 SANDY GRAVEL, gravel up to 1 inch diameter, GP. Medium brown, very moist, no OVC.		
						7.8-8.5 SILTY SAND, very fine to very coarse sand and silt, trace gravel, SM. Medium brown, hard, very moist, possibly saturated (water on outside of spoon barrel), no OVC.		
	10-11	100	15-22-17	NM	10	10-11 Well graded SAND. Very fine to very coarse sand (predominantly medium to very coarse size), SW. Dark grayish brown with approximately 15-20% light yellow grains. Saturated, no OVC.	10	

Remarks and Datum Used: Battery malfunction on OVA meter, unable to take PID measurements.

The RETEC Group, Inc.
23 Old Town Square Suite 250
Fort Collins, CO 80524
Phone: (970) 493-3700
Fax: (970) 493-2328

Sample Type
N = SPT
DP = Direct Push
GS = Grab Sample
C = Core

Groundwater

Date	Time	Depth (ft.)
12/13/02	9:15	8

Boring/Well Log

Well #: MW-13

Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USCS)	Elevation (ft.)	Comments
	12.5-13.5	100	50 for 6"	NM				12.5-13.5 Well graded SAND as above, SW. Slightly darker color than above. Saturated. No OVC.		
							15	Sand is beginning to heave in the augers at 13.5 feet. Stop sampling, plug auger, and drill to TD. Cuttings indicate more SAND (SW).	15	

Remarks and Datum Used: Battery malfunction on OVA meter, unable to take PID measurements.

The RETEC Group, Inc.
23 Old Town Square Suite 250
Fort Collins, CO 80524
Phone: (970) 493-3700
Fax: (970) 493-2328

Sample Type
N = SPT
DP = Direct Push
GS = Grab Sample
C = Core

Groundwater		
Date	Time	Depth (ft.)
12/13/02	9:15	8

RETEC

Boring/Well Log

Well #: MW-14D
Sheet 1 of 2

Project: GE Int. Action Add. MW Install	Monument: Flushmount	Stick Up:
Project #: GE001-15547-730	Northing: Easting:	Ground Elevation:
Location: N. of Dawson, E. side of 1st.	Drill Rig Type: HSA limited access	MP Elevation:
Client: GEAE	Method: HSA augering	Total Depth: 55 ft
Start Date & Time: 07/16/03 0715	Casing ID: 8"	Filter Pack: 43-55' 10/20 silica sand
Finish Date & Time: 07/16/2003 1015	Boring ID: 6"	Seal: 2-43' 3/8" bentonite chips
Contractor: Cascade Drilling	Bit Type:	Grout:
Operator: Brian Gose	Logged By: N. Bacher	Screen: 45-55' 0.020-slot Sch. 40 PVC

Sample Type & #	Sample Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme:)	Elevation (ft.)	Comments
	0-4	100					0	ASPHALT (0-0.5'): asphalt	0	
								ROAD BASE (0.5-1.5'): moist, loose, brown, sandy gravel.		
								SM (1.5-3'): moist, medium dense, brown gray FINE SAND w/ minor silt.		
	4-8	100					5	ML (3-3.5'): moist, firm, olive gray, slightly sandy SILT.	-5	
								SP (3.5-4'): moist, medium dense, orange brown FINE SAND.		
	8-12	90						SP (4-7'): Same as above.		
							10	SM (7-8.5'): wet, medium dense, orange brown, slightly silty FINE SAND.	-10	
	12-16	100						SP (8.5-12'): wet, medium dense, dark gray FINE to MEDIUM SAND.		
							15	SP (12-15.5'): saturated, medium dense, dark gray FINE to MEDIUM SAND.	-15	
	16-20	60						ML (15.5-16'): moist, firm, brown gray SILT w/ minor fine sand.		
								SP (16-20'): moist to wet, dense, dark gray FINE SAND. 3" firm, gray SILT lens at 18'.		
	20-24	80					20	SP (20-24'): Same as above with 1/2" firm, gray SILT lens at 20.5'.	-20	
	24-28	100					25	SP (24-28'): Same as above with 6" firm, gray SILT lens at 25'.	-25	

Remarks and Datum Used: Lithology for GeoProbe WP-243 across 1st Ave. No odor or visual contamination throughout core.

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, WA 98134-1162
Phone: (206) 624-9349
Fax: (206) 624-2839

Sample Type: N = SPT; DP = Direct Push; SS = Split Spoon; C = Core

Groundwater		
Date	Time	Depth (ft.)

RETEC

Boring/Well Log

Well #: MW-14D

Sample Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Depth (ft.)	Soil and Rock Description (Classification Scheme:)	Elevation (ft.)	Comments
	28-32	50			28-32	SP (28-32'): Same as above with 6" firm, gray SILT lens at 31'.	-28 to -32	
	32-36	80			32-36	SP (32-36'): moist to wet, medium dense, dark gray FINE SAND.	-32 to -36	
	40-42	75			40-42	SP (40-42'): wet, medium dense to dense, dark gray FINE SAND.	-40 to -42	
					45-45.5	ML (45-45.5'): wet, firm, gray SILT w/ minor to trace sand.		
	45-47	100			45.5-47	SP (45.5-47'): wet, medium dense, dark gray FINE SAND.		
					47-47.5	ML (47-47.5'): wet, firm, gray SILT w/ trace sand.		
					47.5-48	SP (47.5-48'): wet, medium dense, dark gray FINE SAND.		
	50-52	100			50-52	SP (50-52'): wet, dense, dark gray FINE SAND w/ trace silt.		

Remarks and Datum Used: Lithology for GeoProbe WP-243 across 1st Ave. No odor or visual contamination throughout core.

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Seattle, WA 98134-1162
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Fax: (206) 624-2839

Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)

RETEC Boring/Well Log

Well #: MW-15D
Sheet 1 of 2

Project: GE Int. Action Add. MW Install	Monument: Flushmount	Stick Up:
Project #: GE001-15547-730	Northing: Easting:	Ground Elevation:
Location: N. of Dawson on Utah St.	Drill Rig Type: HSA	MP Elevation:
Client: GEAE	Method: Hollow-stem auger	Total Depth: 56.5 ft
Start Date & Time: 07/14/2003 0920	Casing ID: 8"	Filter Pack: 43-55' 10/20 silica sand
Finish Date & Time: 07/17/2003 1230	Boring ID: 4"	Seal: 2-43' 3/8" bentonite chips
Contractor: Cascade Drilling	Bit Type:	Grout:
Operator: Brian Gose	Logged By: N. Bacher	Screen: 45-55' 0.020-slot Sch. 40 PVC

Sample					Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description Classification Scheme: USCS	Elevation (ft.)	Comments
Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)						
							0	ASPHALT (0-0.5'): asphalt	0 to -1	
								ROAD BASE (0.5-1.5'): moist, brown, sandy gravel. Slight odor.	-2	
								SM (1.5-3.0'): moist, loose, dark brown, SILTY SAND.	-3, -4	
	5-6.5	100	6/6/8				5	SM (5-6.5'): moist, slightly dense, dark brown, SILTY SAND	-5, -6	
	7.5-9	100	6/6/8					SP (7.5-9'): moist, slightly dense, dark brown (multicolored specs) FINE SAND w/ trace silt.	-7, -8, -9	
	10-11.5	80	7/7/7				10	SP (10-11.5'): Same as above but wet.	-10, -11	
	12.5-14	100	15/12/15					SP (12.5-14'): Same as above, still wet, more dense.	-12, -13, -14	
	15-16.5	100	10/10/11				15	SP (15-16.5'): Same as above but with minor silt.	-15, -16	
	17.5-19	100	3/6/15					SP/ML (17.5-18): moist, medium dense/soft, gray, interbedded fine sand and silt lenses.	-17, -18	
								SP (18-19'): moist, dense, dark gray, multicolored grains FINE SAND w/ trace silt.	-19	
	20-21.5	100	18/25/28				20	SP (20-21.5'): Same as above.	-20, -21	
	22.5-24	75	4/14/21					SP (22.5-24'): moist to wet, medium dense, dark gray, FINE SAND.	-22, -23, -24	
	25-26.5	100	12/24/30				25	SP (25-26.5'): wet, medium dense to dense, dark gray, FINE SAND.	-25, -26, -27	

Remarks and Datum Used: Hand cleared to 3 ft.
No odor or visual contamination throughout core except for in the road base layer.

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, WA 98134-1162
Phone: (206) 624-9349
Fax: (206) 624-2839

Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)

RETEC

Boring/Well Log

Sample Type & #	Sample Depth Range	% Rec	Blows per 6"	PID (ppm)	Depth (ft.)
	27.5-29	100	12/15/22		
	30-31.5	100	15/24/35		30
	32.5-34	80	15/25/35		
	35-36.5	100	21/30/41		35
	37.5-39	100	4/17/29		
	40-41.5	100	21/26/40		40
	42.5-44	100	8/15/50		
	45-46.5	100	15/21/27		45
	47.5-49	100	15/21/37		
	50-51.5	100	21/28/31		50
	52.5-54	100	8/10/17		
	55-56.5	100	8/10/20		55

Soil and Rock Description
Classification Scheme: USCS

- SP (27.5-29'): Same as above but with 2" silty clay lens at 28'.
- SP/ML (30-31'): moist to wet, medium dense, gray, interbedded fine sand and silt lenses.
- SP (31-31.5'): wet, medium dense, dark gray (multicolored grains) FINE SAND.
- SP (32.5-34'): soaking wet, medium dense, dark gray, FINE SAND.
- SP (35-36.5'): Same as above.
- SP (37.5-39'): Same as above.
- SP (40-41.5'): Same as above.
- SP (42.5-44'): wet, medium dense, dark gray, FINE SAND.
- SP (45-46.5'): moist, medium dense, dark gray, FINE SAND.
- SP (47.5-49'): wet, medium dense, dark gray, FINE SAND.
- SP (50-51.5'): wet, medium dense, dark gray (multicolored grained) FINE SAND.
- SP (52.5-54'): moist to wet, medium dense, gray (multicolored grains) FINE SAND.
- SP (55-56.5'): Same as above.

Elevation (ft.): -28, -29, -30, -31, -32, -33, -34, -35, -36, -37, -38, -39, -40, -41, -42, -43, -44, -45, -46, -47, -48, -49, -50, -51, -52, -53, -54, -55, -56

Comments:

Remarks and Datum Used: Hand cleared to 3 ft.
No odor or visual contamination throughout core except for in the road base layer.

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Seattle, WA 98134-1162
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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)

RETEC

Boring/Well Log

Well #: MW-16D
Sheet 1 of 2

Project: GE Int. Action Add. MW Install	Monument: Flushmount	Stick Up:
Project #: GE001-15547-730	Northing: Easting:	Ground Elevation:
Location: S. of Rabanco on Dawson St.	Drill Rig Type: HSA and GeoProbe	MP Elevation:
Client: GEAE	Method: HSA and GeoProbe	Total Depth: 57 ft
Start Date & Time: 07/15/2003 0800	Casing ID: 8"	Filter Pack: 43-55' 10/20 silica sand
Finish Date & Time: 07/15/2003 1145	Boring ID: 4"	Seal: 2-43' 3/8" bentonite chips
Contractor: Cascade Drilling	Bit Type:	Grout:
Operator: Dan XXX/Brian Gose	Logged By: N. Bacher	Screen: 45-55'.020-slot Sch. 40 PVC

Sample: Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USCS)	Elevation (ft.)	Comments
	0-4	100					0	ASPHALT (0-0.5'): asphalt.	0	
								ROAD BASE (0.5-2'): moist, brown, sandy gravel.	-1, -2	
								SP (2-4'): dry to moist, loost to slightly dense, brown (orange oxidation stains) FINE SAND.	-3, -4	
	4-8	80					5	SP (4-5.5'): Same as above.	-5	
								SP (5.5-8'): moist, slightly dense, dark gray (multicolored grains) FINE SAND.	-6, -7	
	8-12	90						SP (8-10.5'): Same as above with scattered 1/2" thick rust colored layers.	-8, -9	
							10	SP (10.5-12'): wet, medium dense, dark gray (multicolored grains) FINE SAND.	-10, -11	
	12-16	100					15	SP (12-16'): Same as above with rust colored interbeds of fine sand between 14.5-15.5.	-12, -13, -14, -15	
	16-20	70						SP (16-20'): saturated, medium dense, dark gray (multicolored grains) FINE SAND.	-16, -17, -18, -19	
	20-24	75					20	SP (20-24'): Same as above with a 2" gray silt lens at 21'.	-20, -21, -22, -23	
	24-28	100					25	SP (24-28'): Same as above with two 2" dense, gray silt lenses. One at 25' and the other at 25.5'.	-24, -25, -26, -27	

Remarks and Datum Used: Hole probed for lithology before well was set. No odor or contamination throughout the core.

The RETEC Group, Inc.
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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)

Boring/Well Log

Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Depth (ft.)	Soil and Rock Description (Classification Scheme: USCS)	Elevation (ft.)	Comments
	28-32	5			30	SP (28-32'): Very poor recovery. Recovered sample was same as above.	-28 to -32	
	32-36	100			35	SP/ML (32-36'): Interbeds of dense, gray silt adn dense, dark gray fine sands. Silt beds (8" thick) at 32.5' and 33.5'. Saturated.	-32 to -36	
	36-40	100			40	SP (36-40'): Core liner stuck in sampler, sample poured out. Wet, medium dense, dark gray FINE SAND.	-36 to -40	
	45-47	100			45	SP (45-47'): wet, medium dense, dark gray, FINE SAND.	-45 to -47	
	50-52	100			50	SP (50-52'): Same as above.	-50 to -52	
	55-57	100			55	SP (55-57'): Same as above.	-55 to -57	

Remarks and Datum Used: Hole probed for lithology before well was set. No odor or contamination throughout the core.

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Fax: (206) 624-2839

Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)

RETEC

Boring/Well Log

Well #: MW-17M
Sheet 1 of 1

Project: GE South Dawson St.	Monument: Flush mount road box	Stick Up: --
Project #: GE001-18600-730	Northing: 5097.54 Easting: 4675.32	Ground Elevation: 18.235'
Location: Seattle, WA	Drill Rig Type: CME 75	MP Elevation: 17.735'
Client: GEAE	Method: Hollow Stem Auger	Total Depth: 30.0'
Start Date & Time: 1/31/05 1332	Casing ID: 2"	Filter Pack: 18.0-30.0' 10/20 sand
Finish Date & Time: 1/31/05 1420	Boring ID: 4"	Seal: Bentonite chips, 2.0-18.0'
Contractor: Cascade	Bit Type: 4" HSA	Grout: -
Operator: Scott	Logged By: Renee Knecht	Screen: 0.020-inch slot, 20.0-30.0'

Sample: Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description Classification Scheme: USGS	Elevation (ft.)	Comments
							0	No lithology samples taken. See MW-17D boring log for lithology details.	0	
							5		-5	
							10		-10	
							15		-15	
							20		-20	
							25		-25	
							30		-30	

Remarks and Datum Used: 4" bottom cap on well.
Wood plug used during drilling to depth.

The RETEC Group, Inc.
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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)
1/31/05	1205	9.29'

RETEC

Boring/Well Log

Well #: MW-17D
Sheet 1 of 3

Project: GE South Dawson St.	Monument: Flush mount road box	Stick Up: --
Project #: GE001-18600-730	Northing: 5103.6 Easting: 4675.2	Ground Elevation: 18.23'
Location: Seattle, WA	Drill Rig Type: CME 75	MP Elevation: 17.795'
Client: GEAE	Method: Hollow Stem Auger	Total Depth: 55.0'
Start Date & Time: 1/31/05 0804	Casing ID: 2"	Filter Pack: 43.0-55.0' 10/20 sand
Finish Date & Time: 1/31/05 1035	Boring ID: 4"	Seal: Bentonite chips, 4.0-43.0'
Contractor: Cascade	Bit Type: 4" HSA	Grout: -
Operator: Scott	Logged By: Renee Knecht	Screen: 0.020-inch slot, 45.0-55.0'

Sample Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
					0	0.0-5.0' Not sampled.	0	
SS	5-6.5	13.5/18	7 9 10		5	5.0-6.5' SP: Sand, fine, brown to dark grayish brown, 10-15% silt, loose todense, damp to wet, no odor, no visual product.	-5	
						6.5-10.0' Not sampled.		
SS	10-11.5	11/18	7 9 10		10	10.0-11.5' SP: Sand, fine, dark grayish brown, 10% silt, 5% sand, medium, abundant quartz, loose, wet, no odor, no visual product.	-10	
						11.5-15.0' Not sampled.		
SS	15-16.5	18/18	16 18 22		15	15.0-16.5' SP: Sand, fine, dark rayish brown, 10% silt, 5% sand, medium, abundant quartz, dense, wet, no odor, no visual product.	-15	
						16.5-20.0' Not sampled.		

Remarks and Datum Used: Slight sand heaving at this location.
4" bottom cap on well.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)
1/31/05	1200	6.38'

RETEC

Boring/Well Log

Well #: MW-17D

Sample Type & #	Sample Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
SS	20-21.5	17/18	15 18 20				20	20.0-21.5' SP: Sand, fine, dark grayish brown, 30% sand, medium, 5% silt, abundant quartz, dense, wet, no odor, no visual product. Top of sampler few wood pieces and coal fragments seen on sluff.	-20	
								21.5-25.0' Not sampled.		
SS	25-26.5	15/18	12 15 16				25	25.0-26.5' SP: Sand, fine, dark grayish brown, 20% silt, 15% sand, medium, grayish brown, silt lense at 25.75', abundant quartz, dense, wet.	-25	
								26.5-30.0' Not sampled.		
SS	30-31.5	18/18	13 15 16				30	30.0-31.5' SP: Sand, fine, dark grayish brown, 20% sand, medium, 5% silt, silt increasing going down hole, abundant quartz, dense, wet, no odor, no visual product.	-30	
								31.5-35.0' Not sampled.		
SS	35-36.5	17/18	15 16 17				35	35.0-36.5' SP: Sand, fine, dark grayish brown to grayish brown, silt lense at 36.0', abundant quartz, dense, wet, no odor, no visual product.	-35	
								36.5-40.0' Not sampled.		

Remarks and Datum Used: Slight sand heaving at this location.

4" bottom cap on well.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)
1/31/05	1200	6.38'

RETEC

Boring/Well Log

Sample Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
SS	40-41.5	18/18	11 13 15		40	40.0-41.5' SP: Sand, fine, dark grayish brown, 15% sand, medium, 10% silt, abundant quartz, loose to dense, wet, no odor, no visual product.	-40	
						41.5-45.0' Not sampled.		
SS	45-46.5	14/18	12 15 18		45	45.0-46.5' SP: Sand, fine, dark grayish brown, 10% sand, medium, 5% silt, abundant quartz, wet, no odor, no visual product.	-45	
						46.5-50.0' Not sampled.		
SS	50-51.5	18/18	14 16 19		50	50.0-51.5' SP: Sand, fine, dark grayish brown to grayish brown, 10-15% sand, medium, 5% silt, abundant quartz, brownish gray silt 51.2-51.5', loose to dense, wet, no odor, no visual product.	-50	Bottom of hole collapsed in to 55.0'.
						51.5-55.0' Not sampled.		
SS	55-56.5	18/18	10 15 19		55	55.0-55.75' SP: Sand, fine, grayish brown, 15% sand, medium, dense, wet, no odor, no visual product.	-55	
						55.75-56.5' SM: Sand, fine, and silt, grayish brown, dense, wet, no odor, no visual product.		

Remarks and Datum Used: Slight sand heaving at this location.
4" bottom cap on well.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)
1/31/05	1200	6.38'

RETEC

Boring/Well Log

Well #: MW-18M
Sheet 1 of 1

Project: GE South Dawson St.	Monument: Flush mount road box	Stick Up: --
Project #: GE001-18600-730	Northing: 4899.05 Easting: 4693.18	Ground Elevation: 16.15'
Location: Seattle, WA	Drill Rig Type: CME 75	MP Elevation: 15.755'
Client: GEAE	Method: Hollow Stem Auger	Total Depth: 30.0'
Start Date & Time: 1/31/05 1332	Casing ID: 2"	Filter Pack: 18.0-30.0' 10/20 sand
Finish Date & Time: 1/31/05 1420	Boring ID: 4"	Seal: Bentonite chips, 2.0-18.0'
Contractor: Cascade	Bit Type: 4" HSA	Grout: -
Operator: Scott	Logged By: Renee Knecht	Screen: 0.020-inch slot, 20.0-30.0'

Sample: Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description Classification Scheme: USGS	Elevation (ft.)	Comments
							0	No lithology samples taken. See MW-18D boring log for lithology details.	0	
							5		-5	
							10		-10	
							15		-15	
							20		-20	
							25		-25	
							30		-30	

Remarks and Datum Used: 4" bottom cap on well.
Wood plug used during drilling to depth.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)
1/31/05	1446	7.35'

RETEC

Boring/Well Log

Well #: MW-18D
Sheet 1 of 3

Project: GE South Dawson St.	Monument: Flush mount road box	Stick Up: --
Project #: GE001-18600-730	Northing: 4904.02 Easting: 4692.82	Ground Elevation: 16.225'
Location: Seattle, WA	Drill Rig Type: CME 75	MP Elevation: 15.545'
Client: GEAE	Method: Hollow Stem Auger	Total Depth: 55.0'
Start Date & Time: 2/1/05 0910	Casing ID: 2"	Filter Pack: 43.0-55.0' 10/20 sand
Finish Date & Time: 2/1/05 1050	Boring ID: 4"	Seal: Bentonite chips, 4.0-43.0'
Contractor: Cascade	Bit Type: 4" HSA	Grout: -
Operator: Scott	Logged By: Renee Knecht	Screen: 0.020-inch slot, 45.0-55.0'

Sample Type & #	Sample Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
							0	0.0-5.0' Not sampled.	0	
SS	5-6.5	15/18	8 9 9				5	5.0-6.5' SP: Sand, fine, grayish brown, 10% silt, 5% sand, medium, 5% gravel, medium, subangular to subrounded, loose to dense, damp, no odor, no visual product.	-5	
								6.5-10.0' Not sampled.		
SS	10-11.5	10/18	11 13 15				10	10.0-11.5' SP: Sand, fine, grayish brown to brown, 10% sand, medium, 5% silt top 5", loose, wet, abundant quartz, no odor, no visual product.	-10	
								11.5-15.0' Not sampled.		
SS	15-16.5	18/18	9 10 15				15	15.0-16.5' SP: Sand, fine, dark grayish brown, 10% sand, medium, loose, wet, abundant quartz, no odor, no visual product.	-15	
								16.5-20.0' Not sampled.		

Remarks and Datum Used: Slight sand heaving at this location.
4" bottom cap on well.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)
2/1/05	1130	7.32'

Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
SS	20-21.5	18/18	4 15 15		20	20.0-21.5' SP: Sand, fine, dark grayish brown, 10% sand, medium, loose to dense, wet, abundant quartz, no odor, no visual product.	-20	
						21.5-25.0' Not sampled.		
SS	25-26.5	18/18	11 13 16		25	25.0-26.5' SP: Sand, fine, dark grayish brown, 10% sand, medium, loose to dense, wet, abundant quartz, no odor to slight chemical odor, no visual product.	-25	
						26.5-30.0' Not sampled.		
SS	30-31.5	18/18	10 15 17		30	30.0-31.0' SP: Sand, fine, dark grayish brown, 10% sand, medium, abundant quartz, loose to dense, wet, no odor, no visual product.	-30	
						31.0-31.5' SM: Silt and sand, fine, dark grayish brown, loose to dense, wet, no odor, no visual product.		
						31.5-35.0' Not sampled.		
SS	35-36.5	14/18	10 12 14		35	35.0-35.9' SP: sand, fine, dark grayish brown, 10% sand, medium, loose to dense, wet, no odor, no visual product.	-35	
						35.9-36.5' SM: Sand, fine, and silt, alternating lenses, dark grayish brown, loose to dense, wet, no odor, no visual product.		
						36.5-40.0' Not sampled.		

Remarks and Datum Used: Slight sand heaving at this location.
4" bottom cap on well.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)
2/1/05	1130	7.32'

Boring/Well Log

Sample Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
SS	40-41.5	14/18	10 14 16		40	40.0-41.5' SP: Sand, fine, dark grayish brown, 30% silt, silt lense at 40.75-41.0', 5 to 10% sand, medium, dense, wet, no odor, no visual product.	-40	
						41.5-45.0' Not sampled.		
SS	45-46.5	10/18	10 11 12		45	45.0-45.75' SP: Sand, fine, dark grayish brown to dark gray, 10% sand, medium, dense, wet, no odor, no visual product.	-45	
						45.75-46.5' ML: Silt, dark grayish brown to dark gray, 30% sand, fine, dense, wet, no odor, no visual product.		
						46.5-50.0' Not sampled.		
SS	50-51.5	8/18	10 10 11		50	50.0-51.5' ML: Silt, dark grayish brown to drak gray, 10% sand, fine, 5% clay, dense, wet, no odor, no visual product.	-50	Bottom of hole collapsed in to 55.0'.
						51.5-56.0' Not sampled.		
SS	55-56.5	18/18	11 11 13		55	55.0-56.5' SP: Sand, fine, dark grayish brown to dark gray, 10% sand, medium, 10% silt, abundant quartz, loose to dense, wet, no odor, no visual.	-55	

Remarks and Datum Used: Slight sand heaving at this location.
4" bottom cap on well.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)
2/1/05	1130	7.32'

RETEC

Boring/Well Log

Well #: MW-19M
Sheet 1 of 2

Project: GE South Dawson St.	Monument: Flush mount road box	Stick Up: --
Project #: GE001-18600-730	Northing: 5211.42 Easting: 4992.8	Ground Elevation: 17.965'
Location: Seattle, WA	Drill Rig Type: Limited Access	MP Elevation: 17.645'
Client: GEAE	Method: Hollow Stem Auger	Total Depth: 30.0'
Start Date & Time: 2/2/05 1050	Casing ID: 2"	Filter Pack: 18.0-30.0' 10/20 sand
Finish Date & Time: 2/2/05 1215	Boring ID: 4"	Seal: Bentonite chips, 2.0-18.0'
Contractor: Cascade	Bit Type: 4" HSA	Grout: -
Operator: Andy	Logged By: Renee Knecht	Screen: 0.020-inch slot, 20.0-30.0'

Sample Type & #	Sample Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
							0	0.0-5.0' Not sampled.	0	
SS	5-6.5	18/18	19 20 22				5	5.0-6.5' SM: Sand, fine, and silt with silt lenses 1" thick, medium gray brown, dense, damp to wet, no odor, no visual product.	-5	
								6.5-10.0' Not sampled.		
SS	10-11.5	12/12	12 50/6				10	10.0-11.5' SP: Sand, fine to medium, dark grayish brown, 5% silt, dense to loose, wet, no odor, no visual product.	-10	
								11.5-15.0' Not sampled.		

Remarks and Datum Used: Moderate sands heaving at this location.
4" bottom cap on well.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater Date	Time	Depth (ft.)
2/2/05	1214	8.92'

RETEC

Boring/Well Log

Sample: Type & #	Sample: Depth Range	Sample: % Rec	Sample: Blows per 6"	Sample: PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
SS	15-16.5	2/ 18	6 8 9				15	15.0-16.5' SP: Sand, fine to medium, dark gray, 5% silt, loose, wet, no odor, no visual product.	-15	
								16.5-20.0' Not sampled.		
SS	20-21.5	10/ 18	50/0				20	20.0-21.5' SP: Sand, fine to medium, dark gray, 5% silt, loose, wet, no odor, no visual product.	-20	
								21.5-25.0' Not sampled.		
SS	25-26.5	1/ heave	50/0				25	25.0-26.5' SP: Sand, fine with sand, medium, dark gray, 5% silt, loose, wet, no odor, no visual product.	-25	
								26.5-30.0' Not sampled.		
SS	30-31.5	12/ 12	22 50/6				30	30.0-31.5' SP: Sand, fine with sand, medium, dark gray, 5% silt, 1/2" silt lense at 31.0' with wood pieces, loose to dense, wet, no odor, no visual product.	-30	Soil unconsolidated and heaving, hole collapsed to 30' bgs.

Remarks and Datum Used: Moderate sands heaving at this location.
4" bottom cap on well.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater: Date	Time	Depth (ft.)
2/2/05	1214	8.92'

RETEC

Boring/Well Log

Well #: MW-20M

Project: GE South Dawson St.	Monument: Flush mount road box	Stick Up: --
Project #: GE001-18600-730	Northing: 4999.64 Easting: 5043.26	Ground Elevation: 17.885'
Location: Seattle, WA	Drill Rig Type: LA	MP Elevation: 17.625'
Client: GEAE	Method: Hollow Stem Auger	Total Depth: 30.0'
Start Date & Time: 2/2/05 0800	Casing ID: 2"	Filter Pack: 18.0-30.0' 10/20 sand
Finish Date & Time: 2/2/05 1018	Boring ID: 4"	Seal: Bentonite chips, 2.0-18.0'
Contractor: Cascade	Bit Type: 4" HSA	Grout: -
Operator: Andy	Logged By: Renee Knecht	Screen: 0.020-inch slot, 20.0-30.0'

Sample: Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
							0	0.0-5.0' Not sampled.	0	
SS	5-6.5	13/18	19 20 22				5	5.0-6.5' SP: Sand, fine, grayish brown to brown, 5% sand, medium, 5% silt, dense, wet, no odor, no visual product.	-5	
								6.5-10.0' Not sampled.		
SS	10-11.5	9/9	12 50/6				10	10.0-11.5' SP: Sand, fine, dark brown, 30% sand, medium, dense, wet, abundant black grains and quartz, no odor, no visual product.	-10	
								11.5-15.0' Not sampled.		

Remarks and Datum Used: Moderate heaving sands at this location.
4" bottom cap on well.

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater Date	Time	Depth (ft.)
2/2/05	1024	8.85'

RETEC

Boring/Well Log

Sample: Type & #	Sample: Depth Range	Sample: % Rec	Sample: Blows per 6"	Sample: PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USGS)	Elevation (ft.)	Comments
SS	15-16.5	13/ 18	6 8 9				15	15.0-16.5' SP: Sand, fine to medium, dark brown, 5% sand, coarse, abandant quartz, few wood pieces, wet, no odor, no visual product.	-15	
								16.5-20.0' Not sampled.		
SS	20-21.5	8/ 12	50/0				20	20.0-21.5' SP: Sand, fine, dark brown, 30% sand, medium, abundant quartz, loose to dense, wet, no odor, no visual product.	-20	
								21.5-25.0' Not sampled.		
SS	25-26.5	18/ 18	50/0				25	25.0-26.5' SP: Sand, fine, dark grayish brown, 20% silt, abundant quartz, loose to dense, wet, no odor, no visual product.	-25	
								26.5-30.0' Not sampled.		Soil unconsolidated and heaving, hole collapsed to 30' bgs.
SS	30-31.5	6/6	22 50/6				30	30.0-31.5' SP: Sand, fine, dark grayish brown, 5% sand, medium to coarse, dense, wet, no odor, no visual product.	-30	

Remarks and Datum Used: Moderate heaving sands at this location.
4" bottom cap on well.

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Sample Type
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DP = Direct Push
SS = Split Spoon
C = Core

Groundwater: Date	Time	Depth (ft.)
2/2/05	1024	8.85'

RETEC Boring/Well Log

Well #: MW-21S
Sheet 1 of 1

Project: Dawson St.	Monument: flush mount	Stick Up: --
Project #: GE001-18600-600	Northing: 5027.73 Easting: 4687.66	Ground Elevation: 17.48'
Location: Seattle, WA	Drill Rig Type: CME-55 Limited Access	MP Elevation: 17.09
Client: GEAE	Method: Hollow Stem Auger	Total Depth: 16'
Start Date & Time: 9/16/05 0755	Casing ID: 2"	Filter Pack: 10/20 Col. Silica Sand / 3-16'
Finish Date & Time: 9/16/05 0855	Boring ID: 8.5"	Seal: 3/8" bentonite chips / 2-3'
Contractor: Cascade Drilling Inc.	Bit Type: 4.25" HSA	Grout: --
Operator: David Gose	Logged By: Chris Gero	Screen: 10-slot / 6-16'

Sample: Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USCS)	Elevation (ft.)	Comments
							0	Soils logged from soil cuttings were uniformly SM: Moist, loose, medium to dark brown SILTY SAND. Few pebbles up to 0.5". Fine to medium grained, no odor. Boring located less than 10' from MW-15D. Refer to MW-15D boring log for detailed stratigraphy. Total boring depth = 16.8 ft.	0	
									-1	
									-2	
									-3	
									-4	
							5		-5	
									-6	
									-7	
									-8	
									-9	
							10		-10	
									-11	
									-12	
									-13	
									-14	
							15		-15	
									-16	

Remarks and Datum Used:

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Sample Type
N = SPT
DP = Direct Push
SS = Split Spoon
C = Core

Groundwater		
Date	Time	Depth (ft.)

RETEC

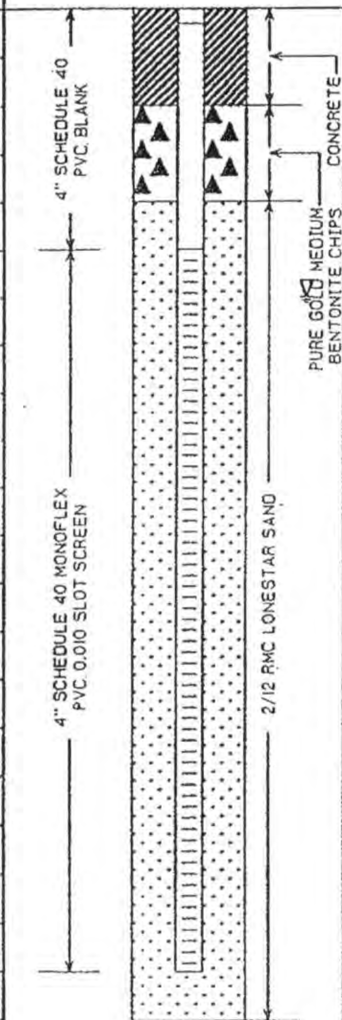
BORING/WELL INSTALLATION LOG

Recovery Well RW-1

1011 SW Klickitat Way
Suite 207
Seattle, WA 98134
(206) 624-9349

PROJECT NO: 1-2402-200 GE - S. Dawson St.		CLIENT: General Electric
LOCATION: Seattle, WA		DRILLING CO.: Cascade Drilling
START DATE: 5/13/96 TIME: 0730	BORING ID: 9"	DRILLER: Brent Maloy/James/Mike
COMPLETION DATE: 5/13/96 TIME: 0930	TOTAL DEPTH: 21'	RIG TYPE: CME 55
WATER LEVEL DURING DRILLING: 6' bgs	PVC STICK-UP: '	METHOD: HSA
SURFACE ELEV.: ' MSL	MP ELEV.: ' TOC PVC	LOGGED BY: S. Laxson

WELL CONSTRUCTION



DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION	TYPE	DEPTH	BLOWS /ft	%RECOVERY	PID (ppm)
0		ASPHALT:					
		FILL: broken concrete					
	SP	SAND: Brown; fine to medium; with trace silt; moist; loose; no odor; no sheen					
5			SS		9	100	0
	SM	SILTY SAND: Brown; fine to medium sand; moist; loose; no odor; no sheen					
			SS		11	100	0
	SP	SAND: Brown; fine to medium; wet; loose; no odor; no sheen					
10		Same as above; fine to coarse	SS		16	100	0
		Same as above; dark gray					
		Heaving sands; water added					
			SS		17	0	0
15		Same as above	SS		12	30	0
		Same as above; fine to medium sand	SS		25	10	0
20							
		Total depth = 21 feet bgs					
25							

REMARKS: SS = Split Spoon

RETEC

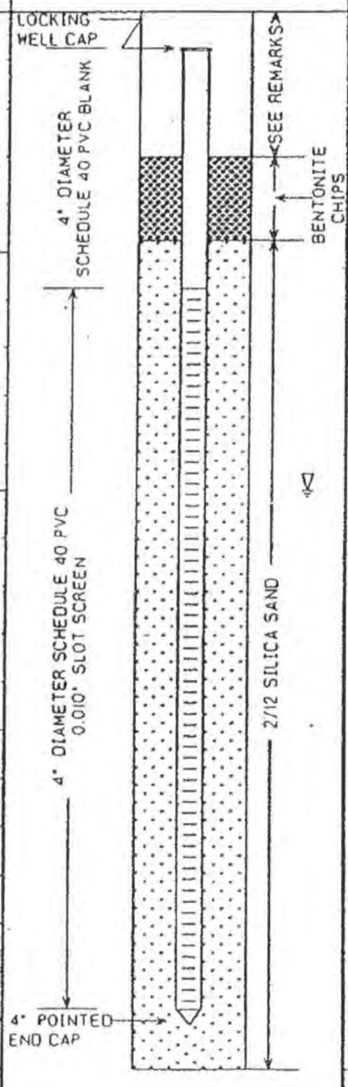
BORING/WELL INSTALLATION LOG

Recovery Well RW-2

1011 S.W. Klickitat Way
Suite #207
Seattle, Washington 98134
(206) 624-9349

PROJECT NO: *1-2402-300 S. Dawson Street*		CLIENT: *General Electric Company*
LOCATION: *Seattle, Washington; 80' North, 50' West of RW-1*		DRILLING CO.: *Cascade Drilling Company*
START DATE: *07/26/96* TIME: *04:30*	BORING ID: *12 inches*	DRILLER: *B. Maloy*
COMPLETION DATE: *07/26/96* TIME: *06:30*	TOTAL DEPTH: *22 feet*	RIG TYPE: *CME 55*
WATER LEVEL DURING DRILLING: *10' bgs*	TOP OF CASING: *-0.75 feet*	METHOD: *HSA*
SURFACE ELEV.:	MP ELEV.: *Ground Surface*	LOGGED BY: *G. Sega*

WELL CONSTRUCTION



SOIL DESCRIPTION

DEPTH (in feet)	U.S.C.S.	SOIL DESCRIPTION
0	GP	GRAVEL; Gravel roadbed (FILL).
	SW	SAND; Brown; fine- to medium-grained, well sorted; dry; no odor (FILL).
5		*5.0'-8.0'* - Brown; fine- to medium-grained, well sorted; trace silt; dry to moist; no odor.
	SW	SAND; Dark grey with reddish grains; medium-grained, moderately sorted; trace silt in 3-10 mm lenses; moist to wet; no odor.
10		*10.0'* - Becomes wet.
15		
		17.0'-22.0' - No sample recovery. Heaving sands; cuttings indicate sand as above.
20		
22		Total depth = 22.0' bgs.
25		

SAMPLE DATA

TYPE	DEPTH	BLOWS/ft	%RECOVERY	PID (ppm)
SS	5.0'	5 5 5	100	
SS		6 5 6	75	
SS	10.0'	4 5 5	100	
SS		4 3 3	75	
SS	15.0'	4 5 3	50	

REMARKS: ⊠ - Split-spoon Sample
Concrete vault to be installed at a later date.

Boring/Well Log

RETEC

Well #: RW-3

Project: **GEAE Interim Action**	Monument: **Recovery Well**	Ground Elevation: **NM**
Project #: **GE001-15547-730**	Northing: **NM** Easting: **NM**	MP Elevation: **NM**
Client: **GEAE**	Drill Rig Type: **Limited Access**	Total Depth: **20**
Well Area: **Seattle, Wa**	Method: **HSA**	Filter Pack: **#2/12 Monterey Sand**
Start Date & Time: **12/13/02 11:10 a.m.**	Casing ID: **NA**	Seal: **Bentonite Chips**
Finish Date & Time: **12/13/02 11:40 a.m.**	Boring ID: **9 inches**	Grout: **NA**
Contractor: **Cascade**	Bit Type: **Auger/5-tooth**	Riser: **4-inch, SCH 40 PVC**
Operator: **James Goble**	Logged By: **Rikka Bothun**	Screen: **5-20 ft, 20 slot, 4-in SCH 40 PVC**

Sample: Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: **USCS**)	Elevation (ft.)	Comments
							0	0-0.5 ASPHALT	0	
								0.5-2 GRAVELLY SAND, mix of sand (fine to very coarse) and gravel (up to 1.5 inch diameter), SW. Medium brown, slightly moist, no odor or visible contamination (OVC).		
								2-9 SILTY/CLAYEY SAND, fine sand and silt, SM. Medium brown to grayish brown, slightly moist, saturated at about 9 or 10 feet, no OVC.		
							5		5	
								9-20 Well graded SAND, fine to very coarse grained, SW. Saturated. No OVC.		
							10		10	

Remarks and Datum Used: Logged from cuttings. Used knock-out plug to prevent sands from heaving into augers.

The RETEC Group, Inc.
23 Old Town Square Suite 250
Fort Collins, CO 80524
Phone: (970) 493-3700
Fax: (970) 493-2328

Sample Type

N = SPT
DP = Direct Push
GS = Grab Sample
C = Core

Groundwater

Date	Time	Depth (ft.)
12/13/02	11:28	9

RETEC

Boring/Well Log

Sample: Type & #	Depth Range	% Rec	Blows per 6"	PID (ppm)	Well Completion Log	Graphic	Depth (ft.)	Soil and Rock Description (Classification Scheme: USCS)	Elevation (ft.)	Comments
							15		15	
							20		20	

Remarks and Datum Used: Logged from cuttings. Used knock-out plug to prevent sands from heaving into augers.

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