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Letter of Transmittal

Attention: Brad Barquest

Date: February 6, 2009

Project reference: UTC – Laguna Campus
Redmond, WA

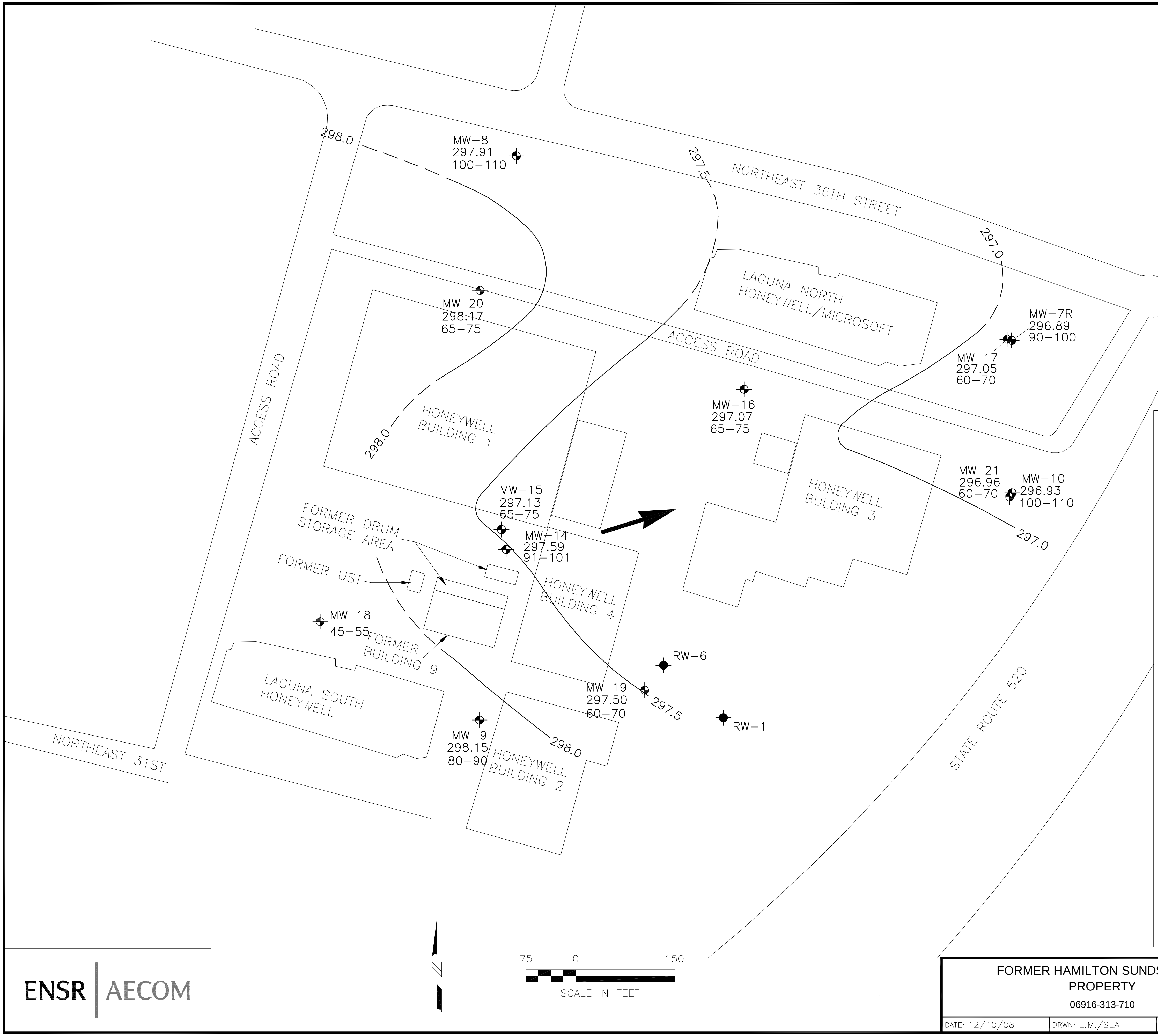
Project number: 06916-313

We are sending you the following:

Number of originals:	Number of copies:	Description:
1	0	Figure 1

The attached figure shows the final monitoring well locations installed during the October 2008 Field Work. All field work was done in accordance with the procedures listed in the attached Supplemental Investigation Work Plan, prepared by ENSR in September 2008.

Jamie C. Stevens



LEGEND

⊕ MW–19 297.50 60–70	EXISTING MONITORING WELL LOCATION AND ID GROUNDWATER ELEVATION (FEET) SCREENED–INTERVAL (FEET BELOW GROUND SURFACE)
●	INACTIVE INDUSTRIAL WELL LOCATION
297.0	GROUNDWATER ELEVATION CONTOUR LINE (FEET) (DASHED WHERE INFERRED)
➞	APPROXIMATE OVERALL GROUNDWATER FLOW DIRECTION

NOTES

1. GROUNDWATER ELEVATIONS FOR MW–18 IS NOT INCLUDED BECAUSE MW–18 IS BELIEVED TO BE IN A PERCHED WATER ZONE AND SO IS NOT CONSISTENT WITH OTHER GROUNDWATER DATA.
2. ALL GROUNDWATER MONITORING WELLS WERE GAUGED ON 10/21/2008 WITH THE EXCEPTION OF MW–15.
3. MW–15 WAS GAUGED ON 10/23/2008 BECAUSE IT WAS INACCESSIBLE DUE TO A CAR PARKED OVER THIS LOCATION.
4. THE NOTABLE DIFFERENCE IN ELEVATION AT MW–14 AND MW–15 MAY HAVE BEEN INFLUENCED BY THE DIFFERENT DAYS THEY WERE GAUGED, OR FROM THE DIFFERENCE IN SCREEN INTERVALS BETWEEN THESE TWO WELLS.
5. ELEVATIONS IN FEET NAVD 88.

File: L:\Laguna\GW_ELEV_10-08.dwg Layout: FIGURE 1 User: MarshallE Plotted: Dec 11, 2008 – 1:35pm Xref's:

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FORMER HAMILTON SUNDSTRAND
PROPERTY
06916-313-710

OCTOBER 2008
GROUNDWATER ELEVATION MAP

DATE: 12/10/08
DRWN: E.M./SEA

FIGURE 1

Prepared for:
Hamilton Sundstrand Corporation
Redmond, Washington

Supplemental Investigation Work Plan

ENSR Corporation
September 2008
Document No.: 06916-313-700

Prepared for:
Hamilton Sundstrand Corporation
Redmond, Washington

Supplemental Investigation Work Plan

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September 2008
Document No.: 06916-313-700

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1.0 Introduction

ENSR has prepared this scope of work for additional groundwater and subsurface investigation activities at the former Hamilton Sundstrand Corp. (HS) Laguna Property located at 15001 NE 36th Street in Redmond, Washington. The purpose of this work is to further define the nature and extent of chemically affected soil and shallow groundwater to support the development of site-wide remedial recommendations. The Work Plan is divided into two phases and summarized below:

- **Phase 1 – Confirm extent of chemicals of interest (COIs) in groundwater.** The primary goal of Phase 1 is to evaluate whether the COIs in groundwater extend to the property boundary (a likely conditional point of compliance) at concentrations exceeding the Model Toxic Control Act (MTCA) Method A criteria. The secondary goal is to evaluate the feasibility of monitored natural attenuation (MNA) as a potential remedy for the property.
- **Phase 2 – Expanded COI investigation.** Phase 2 is an optional phase and its implementation will be contingent on whether COIs are detected in groundwater at the downgradient property boundary at concentrations exceeding MTCA Method A criteria. The objective of the Phase 2 scope of work would be to further characterize onsite soils and evaluate whether soil is a potential ongoing source of COIs to groundwater in the general vicinity of monitoring wells MW-15 and MW-16. The information collected during the Phase 2 investigation will be used to target the source area where more aggressive source control measures may be warranted.

Consultants representing HS have characterized chemistry of deeper groundwater at this property and received a No Further Action (NFA) determination from the Washington State Department of Ecology (Ecology 2003). Ecology recently re-opened the NFA determination based on COI concentrations detected in shallow groundwater. HS intends to implement the scope of work outlined in this plan, reenter the Ecology Voluntary Cleanup Program (VCP), and complete necessary remedial actions in coordination with Ecology.

1.1 Background

1.1.1 Property location and use history

The Laguna Property is located at approximately 47.64° N latitude by 122.14° W longitude in the city of Redmond, King County, Washington (see Figure 1-1). The area is zoned as the Overlake Business and Advanced Technology (OBAT) area.

Currently, the total property area is 15 acres, with approximately 5 acres covered by buildings and approximately 10 acres paved parking lots or roadways (see Figure 1-2). The ground surface is approximately 350 to 360 feet above mean sea level (MSL). The property is generally flat with gentle slope to both the northeast and south.

The property is bounded to the east by State Route (SR) 520, to the north by NE 36th Street, to the west by Cedar Court and 148th Avenue NE, and to the south by a commercial development and the on-ramp/off-ramp complex for 148th Avenue NE and SR 520. There is a gentle drainage divide across the property with surface water on the north portion draining into the Sammamish River basin and the south portion draining into the Kelsey Creek basin. The nearest surface water is the Sammamish River approximately 1.5 miles to the northeast.

Numerous parties have conducted aerospace manufacturing operations on the property since the early 1960s to present (United Controls, Inc.; Sundstrand Data Control, Inc.; Allied Aerospace [Allied Signal]; and Honeywell-Aerospace Electronics [Honeywell]). Hines Interests Limited Partnership (Hines) is the current owner of the property, and Honeywell leases the property and continues aerospace manufacturing operations. A brief description of the land use history and development is provided below (Farallon 2007):

- **1950:** Subject area was primarily residential with very few commercial-scale structures
- **1960-1961:** United Controls, Inc. constructs Building 1 and begins industrial operations.
- **1967:** Sundstrand Data Control, Inc. (Sundstrand) continues industrial operations.
- **1968-1978:** Sundstrand constructs Buildings 2, 3 and 4
- **1981:** Sundstrand constructs Building 9
- **1993:** July 1993, Allied Signal purchases the property and continues industrial operations
- **1999:** Honeywell-Aerospace Electronics acquired Allied Signal and continues industrial operations; Building 9 is demolished and a parking lot is built in its place.

- Hines purchases the property and continues leasing it to Honeywell

Historically, petroleum products and chlorinated solvents associated with operations were used and stored at the property. The chlorinated solvents trichloroethylene (TCE), 1, 1, 1-trichloroethane (TCA), and perchloroethylene (PCE) were used for manufacturing of electronic components for the aerospace industry. Table 1-1 provides the storage locations of various chemicals kept on the property (Kleinfelder 2002).

Industrial extraction and injection wells were operated from 1960 to 1994 (Farallon 2007). Groundwater was extracted for non-contact cooling water in an air conditioning and heating system; some of this water was re-injected via injection wells. Water was extracted from wells PW-2, PW-4, and PW-5, and injected into wells RW-3 and RW-6 (Farallon 2007) (Figure 1-2). The non-contact cooling water use and injection continued through 1998.

Various soil, groundwater, subslab vapor, and indoor air investigations and cleanups have been conducted at the property. Section 2 summarizes these investigations and the cleanup history.

1.1.2 Surrounding land use

Zoning maps classify the property and surrounding area as Overlake Business and Advance Technology (OBAT). The property and surrounding area are currently occupied by commercial buildings. The land drops off abruptly on the northeast boundary towards SR 520. The nearest surface water is the Sammamish River approximately 1.5 miles to the northeast. The nearest residential area is approximately 250 feet west of Building 1.

The City of Redmond is planning to reconfigure Northeast 36th Street, which runs along the north of the site. The construction work is expected to affect the north-east corner of the property and one parking lot located in the north-west portion of the property. The construction work associated with the north-east corner includes the building of additional road sections, constructed as an overpass of SR 520. The work associated with the north-west parking lot includes the construction of an additional section of roadway connecting Northeast 36th Street and the access road running between Honeywell Building 3 and Laguna North buildings. Figure 1-3 includes the proposed modification received from the City or Redmond on September 12, 2008.

1.1.3 Geology and hydrogeology

The geologic unit exposed at the surface of the property is the Vashon Till. Vashon Advance Outwash (otherwise known as the Esperanza Sand) and Transitional Beds underlie the Vashon Till. The Vashon Till consists of dense to very dense, poorly-sorted silty, gravelly sand. The Vashon Till ranges in thickness from approximately 22 to 72 feet, and thickens to the east-northeast. The underlying Advance Outwash ranges in grain size from silt to coarse cobble gravel. The Advance Outwash ranges in thickness from approximately 40 to 100 feet, with the thickest section located in the north-central portion of the property. The Transitional Beds, which underlie the Advance Outwash, consist of silty, gravelly clay that grade laterally into brown and blue clays. Transitional Beds have a relatively uniform thickness of 40 to 50 feet where encountered, and thicken to the east-northeast (Kleinfelder 2002).

Groundwater is encountered at an average depth of 55 to 60 feet below ground surface (bgs). Groundwater flow across the property is from the southwest to northeast. The gradient ranges from 2 to 3 feet per 1,000 feet, (0.002 to 0.003 feet/foot). The uppermost aquifer is unconfined Vashon Advance Outwash deposits. Most monitoring wells are completed in the deeper portion of the aquifer, approximately 90 to110 feet bgs. Only monitoring wells MW-15 and MW-16 are completed within the shallow portion of aquifer, 65 to75 feet (Kleinfelder 2002, Farallon, 2007).

Groundwater flow, as measured in deeper wells (screened generally 90-110 feet bgs), is generally to the northeast (figure 1-4). All site wells were resurveyed on September 15, 2008, with the exception of MW-15[1]. The measured ground surface elevation at MW-15 was used to estimate the water level based on the distance between groundwater surface and top of casing. Water levels in water table monitoring wells MW-15 and MW-16 are approximately 0.45 to 0.21 feet higher than water levels in the deeper monitoring wells. This suggests a slight downward gradient. Northeastward groundwater flow in the shallow aquifer is currently inferred based on water levels in both the shallower and deeper monitoring wells. Shallow wells installed as part of this work plan (see Section 3) will help refine shallow groundwater flow direction and vertical gradients.

1.2 Work plan organization

The four principle tasks described in this Work Plan are:

- Installation of and sampling from additional groundwater monitoring wells
- Delineation of the area of chlorinated volatile organic compounds (VOCs) exceeding MTCA criteria
- Assessment of the potential applicability of natural attenuation as a remedial alternative
- Should VOC exceed applicable MTCA criteria offsite, investigation of soils and evaluation whether there are potential ongoing source areas in the subsurface (e.g., vadose zone) in the vicinity of former Building 9.

These proposed tasks are detailed in Sections 3 and 4. Investigative history and extent of chemically affected media are discussed in Section 2. Quality Assurance procedures are discussed in Section 5. A schedule for the work is included in Section 6. Section 7 provides a list of references.

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[1] An elevation was not measured for MW-15 because it was not accessible, but the top of casing, and thus the groundwater elevation can be approximated based on the adjacent monitoring well MW-14.

2.0 Investigation and remediation history

2.1 Site investigations

2.1.1 Groundwater investigation

Investigative and remediation activities at the property have been ongoing since 1987. A detailed groundwater, soil, and soil gas investigation and cleanup history is provided in Table 2-1. All of the referenced documents have previously been submitted to Ecology.

Between 1960 and 2006, 17 monitoring wells have been installed at the facility. These include groundwater extraction and injection wells for industrial purposes, and groundwater monitoring wells. Monitoring well designations are presented in Table 2-2 and are summarized below (Farallon 2007):

- **Process water supply wells: PW-2, PW-4, PW-5.** These wells were used to supply groundwater as part of the cooling of the site buildings from 1930 through 1998. PW-2 was decommissioned in 1999; wells PW-4 and PW-5 remain on the property. PW-4 and PW-5 have a total well depth of 105 and 135 feet, respectively.
- **Re-injection wells: RW-1, RW-3, and RW-6.** These wells were used to inject the non-contact cooling water back into the groundwater aquifer, after being used in the facility cooling process. RW-1 was not used for the re-injection (Kleinfelder 2002). Available information indicates that RW-1 and RW-6 remain inactive and have a total well depth of 100 and 118 feet, respectively. RW-3 was decommissioned 1998.
- **Monitoring wells: MW-7R through MW-16.** These wells were installed to monitor and characterize the environmental condition of the groundwater. The primary purpose was to evaluate the intermediate portion of the aquifer. Two monitoring wells (MW-15 and MW-16) were installed in 2006 and screened across the water table to evaluate conditions at the water table interface. Table 2-2 summarizes well construction details. The water table monitoring wells have a total well depth of 75 feet, and the intermediate monitoring wells have a total well depth greater than 90 feet. MW-7 was decommissioned in 1998 and replaced with MW-7R; the replacement well was relocated approximately 175 feet east of the original location.

A brief summary of groundwater investigation performed at the site is provided below.

- **Aquifer pump testing and process water supply and discharge system:** From 1978 to 1979 aquifer pump tests were performed on the water supply wells. These pump tests confirmed that the aquifer was unconfined.

  In 1987 a study of the existing cooling water supply and discharge system was performed. The study indicated flow rates of the supply wells, buildings they supplied, and the discharge locations of excess tempered water. This information is summarized below (Kleinfelder 2002).

Table 2-3 Process Water Supply System Details

Supply Well	Flow Rate (gallon per min)	Supplied Building	Discharge Location
PW-2	400	Building 1	RW-3 and Storm Sewer
PW-4	280	Buildings 2 and 3	Storm Sewer
PW-5	400	Building 4	RW-6

- **Previous Groundwater sampling (1986-2003):** Groundwater samples were collected from water supply and injection wells between 1986 and 1996. The September 1993 monitoring event included storm sewer sampling in addition to groundwater sampling for characterization of waste water (Kleinfelder 2002).

  Monitoring wells were first installed and sampled in 1993 (MW-7 through MW-10) Periodic groundwater samples were collected between 1996 and 2003. The monitoring schedule varied from year to year, but generally at least semiannual sampling occurred through 2002, with some years having additional sampling events (Kleinfelder 2002).

  Monitoring wells MW-11 through MW-13, located in the vicinity of injection well RW-3, were installed and initially sampled in 1995; the last round of sampling was performed in 1996, and these monitoring wells were decommissioned in 1998 (Kleinfelder 2002).
- Monitoring wells MW-7R and MW-14 were installed in 2002 and were sampled in May and September 2002.**Reconnaissance groundwater sampling (2002):** Groundwater samples were collected with temporary well screens during the drilling of MW-14 and MW-7R in 2001. Samples were collected at 64, 80, and 101 feet bgs from MW-14, and at 63, 80, 100 feet bgs from MW-7R (Kleinfelder 2002).

- **Recent Groundwater sampling (2006-2008):** Groundwater samples were collected from MW-7R, MW-8, MW-10, MW-14 and the two new water table monitoring wells, MW-15 and MW-16 in November 2006 (Farallon, 2007) and from a similar suite of monitoring wells in March 2008 (ENSR, 2008).

2.1.2 Soil investigation

Surface and subsurface soil samples were collected across the property. The focus of soil sampling activities has been in the vicinity of former Building 9, Building 2, and the former underground storage tank (UST). In addition, some soil removal actions have been performed. The following is a summary of both soil sampling activities and removal actions.

- **Shallow Soil Sampling – Building 9 Vicinity.** In 1999 a screening level investigation was performed using a soil gas survey to identify whether VOCs may be present in soil. Based on the results of the soil gas survey, eight soil sample locations were selected. Using a Strataprobe rig, 10 soil samples were obtained from 2 to 5 feet (CH2MHILL, 1999a).

  Based on the results of the shallow soil sample analyses, 8 additional samples were collected in the footprint of Building 9 at depths of approximately 0 to 2 feet (CH2MHILL 1999b).

  Soil samples from both phases of the Building 9 investigation were analyzed for VOCs using EPA Method 8260B.
- **Subsurface Soil Sampling.** In 1993, monitoring wells MW-7 through MW-10 were installed. At location MW-9, soil samples were collected at depths of 20 feet and 40 feet to evaluate the potential vertical extent of VOCs.

  In 1995, one soil sample was collected at a depth of 85 feet during the drilling of MW-11 and was analyzed for VOCs and semi-volatile organic compounds (SVOCs).

  In 2001, MW-14 was installed in the vicinity of Building 9 to assess the presence of VOCs, and MW-7R was installed to replace MW-7, which was decommissioned during the construction of a building on the Laguna property. Soil samples were collected approximately 101 feet bgs at MW-14 and approximately 70 feet bgs at MW-7R and submitted for VOC analysis.

In December 2006, MW-15 and MW-16 were installed to a total depth of 75 feet bgs to evaluate soil and groundwater quality in the former Building 9 source area. Soil samples were collected from boring MW-15 at depths of 40 and 65 feet bgs. MW-16 was sampled at 5-foot intervals from 49 to 75 feet bgs. Samples were submitted for VOC analysis.

Three soil removal actions have taken place at the property. These actions included excavation in the vicinity of former Building 9, excavation of the TCA spill area west of Building 2, and the excavation associated with the removal of the former 3,000-gallon UST. A brief summary of the excavation activities are listed below:

- **Building 9.** During the 1999 demolition of Building 9 and subsequent construction activities, chemically-affected soils in the vicinity of Building 9 were reportedly excavated and disposed offsite. The excavation ranged from 1 to 2 feet in some areas to 20 feet bgs in other areas. Reports that documented the final limits of the excavations and results from confirmation soil samples were not available for review at the time this work plan was prepared.

  Prior to demolition of Building 9, multiple shallow soil investigations were performed to investigate the subsurface conditions below and surrounding Building 9.
- **Building 2.** Under the supervision of Ecology, the 1987 a TCA spill area was reportedly excavated to a depth of approximately 16 feet bgs. The excavation was approximately 8 feet by 16 feet wide. Soil samples were collected from the excavation walls and the soil disposal drums.
- **Former UST.** A 3,000-gallon gasoline UST (used for vehicle refueling), located west of former Building 9, was removed in 1986. No samples were reportedly taken following this removal and reportedly no soil was removed.

2.1.3 Soil vapor and indoor air investigation

In December of 2006, Farallon collected subslab soil vapor samples from three locations in Buildings 1, 2, and 4 (Farallon 2007).

Additional subslab vapor and indoor air samples were conducted in February and August 2007 by MWH. Sample activities focused on Building 2. Eight subslab samples from a depth of 12 inches were collected and analyzed for VOCs. Based on these results, Honeywell completed an indoor air quality assessment in March and August 2007. During each study, eleven indoor and two outdoor ambient air samples were collected (MWH 2007a and 2007b).

2.2 Nature and extent of chemically-affected media

2.2.1 Groundwater

Groundwater data collected in 2006 and 2008 include detected concentrations of TCE, 1, 1,-dichloroethene and chloroform at concentrations exceeding potable screening criteria[2] (MTCA Method A groundwater for TCE and MTCA Method B groundwater for 1, 1,-dchloroethene and chloroform because there is no MTCA Method A value) at monitoring wells MW-15 and MW-16. Monitoring well MW-15 is located near the confirmed historic source areas (Buildings 9 and 2). Monitoring well MW-16 is located hydraulically downgradient of monitoring well MW-15. Measured TCE concentrations at monitoring well MW-16 were two orders of magnitude lower than monitoring well MW-15.

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[2] MTCA Method a Groundwater value: TCE (5 µg/L); MTCA Method B Groundwater value: 1, 1,-Dichloroethene (72 µg/L) and chloroform (7.17 µg/L).

TCE concentrations measured at monitoring wells that are hydraulically downgradient of monitoring wells MW-15 and MW-16 (adjacent to the property line) are below MTCA Method A criteria and have remained relatively consistent during the 2006 and 2008 sampling events. Downgradient monitoring wells near the property boundary (MW-7R, MW-8, and MW-10) are screened at deeper intervals than monitoring wells MW-15 and MW-16 (90 to110 feet bgs compared to about 65 to 75 feet bgs).

Table 2-4 summarizes the November 2006 and March 2008 sampling results (Figure 2-1). Groundwater elevations are based on the March 2008 sampling and gauging events. A site wide survey was conducted on September 15, 2008 by True North Surveyors. Table 2-5 includes a summary of the revised surveyed data.

2.2.2 Soil

In various locations where samples were collected, subsequent removal actions have reportedly occurred. In those areas (such as the Building 9 demolition and soil removal area), previous soil analytical results no longer represent current conditions. Therefore, the following paragraphs refer to historical soil analytical results from areas outside the removal action areas.

Soil borings advanced during the Dames and Moore 1993 investigation and the Farallon 2007 investigation found TCE above MTCA Method A criteria (both industrial and unrestricted use) in the vicinity of Building 9 to depths of 15 and 65 feet, respectively).

Soil borings advanced during an investigation in 1993 (Dames and Moore 1993) indicated that petroleum hydrocarbon-affected soil below the former UST area above MTCA Method A criteria extended to a depth of approximately 20 feet bgs. Soil exceeding MTCA Method A criteria have been identified, primarily in the general vicinity of Building 9.

2.2.3 Subslab vapor and indoor air

In previous investigations conducted in 2006 (Farallon 2006), three subslab soil vapor samples were collected from Buildings 1, 2, and 4 from sample locations VP-1, VP-2, and VP-3, respectively. TCE was detected in a soil vapor sample collected from beneath Building 2 at concentrations above MTCA Method B criteria for indoor air. It should be noted that comparison of subslab vapor concentrations to inhalation screening levels is highly conservative (as soil gas concentrations would be substantially diluted once they migrate to ambient air). Analytical reports from soil gas collected at VP-1 and VP-3 did not indicate any detected concentrations.

Additional subslab vapor samples were collected in February 2007 (MWH 2007a). Sample activities focused in Building 2, with eight subslab samples from 12 inches below grade being collected and analyzed for VOCs. Based on the results of the subslab vapor investigation, an indoor air quality assessment was conducted in March and August 2007. Eleven indoor and two outdoor ambient air samples were collected during the two rounds of sampling.

TCE, PCE, benzene, and chloroform were detected in indoor locations at concentrations below MTCA Method C criteria, but exceeding MTCA Method B criteria[3]. PCE concentrations exceeded MTCA Method B air cleanup levels at one outdoor location. Chloroform and xylenes were detected at some indoor and outdoor locations at concentrations that exceed MTCA Method B criteria. It is possible that the detected outdoor concentrations represent ambient background and that, therefore, the concentrations that were detected indoor are representative of ambient conditions.

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[3] MTCA Method C Air levels: TCE (0.22 µg/m^3); PCE (4.20 µg/m^3); benzene (3.20 µg/m^3); and chloroform (1.10 µg/m^3). MTCA Method B Air levels: TCE (0.02 µg/m^3); PCE (0.42 µg/m^3); benzene (0.32 µg/m^3); and chloroform (0.11 µg/m^3).

3.0 Phase 1 scope of work – groundwater characterization

Multiple investigations have taken place on the property since 1987 (see Section 2). The confirmation of VOCs in the shallow portion of the aquifer during the 2007 and 2008 investigations prompted the development of this Work Plan, and the proposed additional soil and groundwater investigation activities.

The scope of work has been subdivided into two phases: Phase I, which is described in this Work Plan, and Phase II, which is contingent on the results of Phase I activities. The scope of work of the Phase I investigation is described in the following subsections. It will include shallow water table well installation and sampling hydraulically downgradient of the historical source area, near the property boundary. The work scope for the second phase of work, if needed, will be defined based on the results of the first phase. This Section discusses the scope of the first phase of work. The contingent scope for the second phase of work is discussed in Section 4.

The objectives of the Phase I investigations are to:

- Evaluate whether the chemically-affected groundwater extends to the property boundary (conditional point of compliance) at concentrations exceeding screening criteria
- Assess the lateral and vertical extent of VOCs exceeding potable water standards
- Evaluate the feasibility of monitored natural attenuation (MNA) as a final remedy.

In addition, the investigation will provide additional information on the source of the downgradient VOCs.

The investigation will include installation of additional groundwater monitoring wells, characterization of soil samples collected during well installation, and two rounds of groundwater monitoring. Monitoring well locations will be selected to fill data gaps and to better characterize nature and extent chemical effects in the shallow portion of the aquifer. All standard operating procedures and quality assurance and quality control procedures related to field work are found in Appendix A.

The following sections detail the groundwater monitoring well installation, soil investigation, and groundwater monitoring.

3.1 Well installation and development

Six additional monitoring wells (MW-17 through MW-22) are proposed. Monitoring well locations are provided on Figure 3-2 and construction details are included in Table 3-1. Water level measurement in water table monitoring wells varies somewhat from nearby deeper monitoring wells. Currently, there are only two water table monitoring wells on site and flow direction can not be clearly delineated in the shallower portion of the aquifer. For the goal of locating additional water table monitoring wells, shallow groundwater flow direction was assumed to be similar to deeper flow within the same aquifer. The proposed monitoring well network will provide the necessary delimitation of flow direction and characterization of any vertical gradients. Proposed monitoring wells will be screened in the shallow portion of the aquifer, consistent with the screen depths of MW-15 and MW-16 (approximately 65-75 feet) where TCE concentrations were detected above MTCA Method A criteria.

The proposed water table monitoring wells include:

- MW-17 will be installed at the northeast property boundary near MW-07R, to characterize the nature and extent of VOC in shallow groundwater associated with the northeast property boundary;
- MW-18 will be installed near the Former Building 9 historic release areas;
- MW-19 will be installed to characterize groundwater in the shallow portion of the aquifer hydraulically down gradient from the historic 1,1,1-TCA spill area;
- MW-20 will be installed north of Building 1 to further delineate the extent of chemical affected media north of the suspected source area;

- MW-21 will be installed adjacent to MW-10, which is screened at an interval 100-110 feet bgs, to characterize the nature and extent of VOC in shallow groundwater; and
- MW-22 will be installed in the southeast property boundary to characterize the nature and extent of VOC in shallow groundwater associated with the southwest property boundary.

3.1.1 Well installation

Monitoring wells will be installed in accordance with the requirements for resource protection wells in Minimum Standards for the Construction and Maintenance of Wells (Chapter 173-160 WAC) and ENSR Standard Operating Procedures (SOP) # 7220 and 7221. Boreholes will be excavated using hollow-stem auger drilling techniques and decontaminated drilling equipment. During excavation of the borehole for well installation, soil samples will be collected using a split-spoon sampler at 2.5 foot intervals. Samples will be observed for soil characteristics (lithology) and evidence of contamination with the use of a photoionization detector (PID). Soil samples will be retained for chemical analysis as described in Section 3.2. The PID will provide a field screening tool to evaluate areas of potential contamination.

Monitoring wells will be constructed of 2-inch Schedule 40 polyvinyl chloride (PVC) casing and a 0.020-inch slot size PVC screen. A ten-foot screened interval is planned with the screen being located near or across the water table. Well screens are expected to extend from approximately 65 to 75 feet bgs, but may be adjusted based on groundwater levels observed during installation. The annulus surrounding the screen and to approximately 2 feet above the screen will be filled with sand. A bentonite seal will be placed on top of the sand pack to approximately 1 foot bgs. The monitoring wells will be sealed with a locking well cap, and a surface flush mount well head will be constructed. All equipment will be cleaned between locations and again before leaving the property.

Prior to all drilling activities a utility locate at each new monitoring location will be performed using a private utility location service and by contacting the One-Call Center for utility location. The new water table monitoring wells, and any existing non-surveyed wells on site, will be surveyed by a WA licensed surveyed.

3.1.2 Well development for newly completed monitoring wells

Well development will be conducted in accordance with ENSR SOP# 7221 (Appendix A). Before developing the well, water depth, and well depth will be measured using an electronic or mechanical device.

Approximately ten well volumes (calculated from the length of the water column and the well casing diameter) will be removed from the well during development. The discharge from the well will be continuously monitored and development will be 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 will be 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 will be measured following development to determine whether sand or silt has accumulated in the well.

3.2 Soil sample collection and data analysis

A hollow-stem auger drilling rig will be used to drill and construct the monitoring wells, and subsurface soil samples will be collected at 2.5-foot intervals from 2.5 feet bgs to the bottom of the boring for lithological logging purposes. Soil samples will be collected in accordance with ENSR SOP# 7115. Soils will be logged in accordance with the Unified Soil Classification System and American Society of Testing and Materials (ASTM) D2488-93 (Appendix A).

A minimum of two subsurface soil samples will be submitted to the laboratory for chemical analysis from each borehole. Samples will be selected for analysis at representative depths (shallow – top five feet- and deeper within the unsaturated zones) where there is no field evidence of contamination. Should contamination be identified (either during the PID field screening or visual screening), a minimum of one representative sample will be submitted for analysis from this interval. Where soil impacts appear different in two or more soil horizons, additional samples will be analyzed.

Samples will be handled in accordance with ENSR SOP# 1007 and 7510 (Appendix A). Analytical soil samples will be placed in pre-preserved laboratory supplied jars, labeled accordingly to include all requested information on the sample label, placed in a laboratory supplied cooler and packed with ice for preservation, and sent to Analytical Resources Inc., a Washington State Certified Laboratory located in Tukwila, Washington.

Soil samples will be submitted for analysis of VOCs by EPA Method 8260. PCE, TCE, and vinyl chloride will be analyzed by EPA Method 8260 using Selective Ion Monitoring (SIM) methods to achieve lower reporting limits. Analytical parameters, holding times, and requested reporting limits are included on Table 3-2.

3.3 Groundwater sample collection and data analysis

After the monitoring wells are installed, two rounds of site-wide groundwater sampling will be conducted; one each in the dry and wet season. If Work Plan approval can be secured in time, the dry season sampling will be completed by October 2008. The wet season sampling will be completed in February or March 2009. Should approval not be received in time to install and sample monitoring wells during the dry season of 2008, this sampling will be deferred to August 2009. The groundwater sampling will include VOCs and monitored natural attenuation parameters (see Section 3.3.2).

Groundwater samples will be collected from the following monitoring wells (see Figure 3-2): MW-7R, MW-8, MW-09, MW10, MW-11, MW-14 through MW-22.

This groundwater sampling network is presented in Table 3-1.

3.3.1 Sample collection using low flow methods

Groundwater samples will be collected via EPA-approved low flow groundwater sampling procedures and will follow the procedures listed in ENSR SOP 7130 (Appendix A).

All samples will be collected using QED stainless steel bladder pumps. The bladder pump will be 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 will be replaced after sampling at each monitoring well.

3.3.1.1 Water level measurement

Water-level data will be collected to evaluate groundwater conditions and monitor drawdown during purging and monitoring of stabilization of parameters. Water level measurements will be conducted in accordance with ENSR SOP 7101 (Appendix A).

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

3.3.1.2 Groundwater sample purging

For monitoring wells where the screen does not intercept the water table, the pump inlet will be placed midway along the screen interval. If the water level falls below the top of screen level, the pump inlet will be placed between the water level and the bottom of screen.

After placement of the pump inlet at the required elevation, monitoring well purging will be 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 will be monitored during purging of each well. The pH, specific conductance, and temperature will also be monitored. Purge volumes will be 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 will be collected in accordance with ENSR SOPs 7320 and 7125 (see Appendix A).

3.3.1.3 Groundwater sample collection

Groundwater samples will be collected via EPA-approved low flow groundwater sampling procedures and will following the procedures listed in ENSR SOP 7130 (Appendix A). Samples collected from each monitoring well will be placed in pre-preserved laboratory supplied jars, labeled accordingly to include all requested information on the sample label, placed in a laboratory supplied cooler and packed with ice for preservation, and sent to Analytical Resources Inc., a Washington State Certified Laboratory located in Tukwila, Washington. Groundwater samples will be submitted for analysis of VOCs by EPA Method 8260 and TCE, PCE and vinyl chloride by EPA Method 8260 using SIM methods to achieve lower reporting limits (Table 3-2).

Field parameters (dissolved oxygen, pH, Oxidation Reduction Potential, conductivity, temperature, and turbidity) will also be measured during the low-flow purging of each groundwater monitoring well to ensure that representative samples are collected for laboratory analysis.

3.3.1.4 Field quality assurance/quality control

At least one duplicate sample will be collected for each 10 investigation samples. 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 and one trip blank will be placed in each cooler.

3.3.1.5 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.

3.3.2 Natural attenuation assessment and data analysis

Groundwater samples to assess the applicability of natural attenuation will be collected during both sampling events (the dry and wet season). Samples will be collected from all groundwater monitoring wells. Table 3-3 lists the natural attenuation parameters that will be included for analysis.

The data will be used to evaluate whether conditions at the site are conducive to natural attenuation processes as shown in Figure 3-1. In general, the following describes the use of each of the parameters to be evaluated (Air Force, 1996):

- **Ethane/ethene –** daughter products in degradation processes.
- **Chloride –** final product of chlorinated solvent reduction.
- **Dissolved Oxygen –** concentrations less than 1 mg/L (Air Force, 1996) or 0.5 mg/L (USEPA, 1998) generally indicate anaerobic conditions.
- **Oxidation/Reduction Potential (ORP) –** the ORP in groundwater influences and is influenced by the biologically mediated degradation of contaminants. Literature values indicating ORP values conducive to various degradation pathways will be compared to site ORP values.
- **Nitrate/Nitrite, Ferrous/Ferric iron, Sulfate/Sulfides –** evaluate the presence of alternate electron acceptors.
- **Methane –** used to indicate degradation via methanogenesis.
- **CO_2 –** final product of chlorinated solvent reduction.
- **Ferrous Iron –** used to determine presence of electron competitors decreasing efficiency of reductive dechlorination.
- **Ammonia –** used to evaluate degradation by ammonia oxidizers.
- **pH –** biodegradation processes can be pH dependant.
- **Conductivity –** general water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system.
- **Total Organic Carbon –** used to determine if co-metabolism is possible in the absence of anthropogenic carbon.

VOC data from downgradient monitoring wells will be used to assess the areal attenuation rate between the source area and the northeast site boundary, by evaluating the change in VOC concentration with distance downgradient. Natural attenuation parameters will be used to evaluate the potential for aerobic and/or anaerobic biodegradation. Together, the VOC and natural attenuation data will further characterize the area.

3.4 Health and safety plan

The potential human health risk associated with inhalation and/or contact with the COIs at the property is discussed in the site Health and Safety Plan. All sampling activities are conducted in accordance with the site Health and Safety Plan (ENSR, 2007).

3.5 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 A). 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 impact and 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.

3.6 Management of investigation-derived waste

Investigation-derived waste management will follow guidance described in the Office of Solid Waste and Emergency Response (OSWER) document, Guide to Management of Investigation-Derived Wastes (EPA, 1992). This guidance discusses factors to consider as part of an investigation-derived waste (IDW) management program. These factors include protectiveness of human health and the environment, compliance with applicable and relevant or appropriate requirements (ARARs), land disposal restrictions, storage requirements, record keeping and manifesting, and handling of non- Resource Conservation and Recovery Act (RCRA) hazardous wastes. The IDW management program described in this section incorporates these factors.

With the exception of waste PPE, all IDW generated during this investigation will be containerized, sealed, labeled, and retained on-site in Department of Transportation (DOT) approved 55-gallon drums. The drums will be labeled as non-hazardous waste.

All waste derived during investigation will be disposed in accordance with appropriate regulations. Soils will be transported in 55-gallon drums to an EPA approved disposal facility for treatment or direct land disposal depending on laboratory analytical results, and waste characterization.

The drums will be stored temporarily within the locked fenced area at the property until the waste is profiled using existing site-specific analytical data or existing profiles, or until new laboratory analytical results are obtained, and the waste is properly characterized for disposal. If existing chemical analytical data from the site is not acceptable for use in characterizing the IDW, analytical samples will be collected at a frequency of one for every five drums of similar media.

If the results of decontamination water samples indicate contaminant levels are below the King County sanitary sewer discharge limits, and approval from the King County wastewater treatment division, decontamination water will be disposed of through the park sanitary sewer connection, otherwise, drums containing decontamination water will be transferred from the site by a licensed disposal facility for treatment and/or disposal.

IDW drum labels will include the following information:

- Drum contents and source (i.e., drill cuttings SB-1, decontamination water)
- Date generated
- Generator contact information and phone number

- Non-hazardous waste.

4.0 Phase 2 scope of work – further source area delineation (optional based on Phase I results)

The Phase 2 investigation will be implemented if chemically-affected groundwater at the property boundary is encountered at concentrations exceeding MTCA Method A criteria.

In the event that Phase 2 would be necessary, the objective is to investigate the site soils in likely source areas and identify areas where site soils may be a source of VOC to groundwater. The investigation would likely focus on the vicinity of MW-15 and MW-16. Should Phase 1 groundwater sampling data suggest other likely source areas, additional soil investigation may be conducted in these areas as well. The information collected during the Phase 2 investigation would be used to target the source area where more aggressive source control measures may be needed.

The objectives and scope of the Phase 2 investigation would be determined based on the findings of Phase 1, and an amendment to the Work Plan would be generated based on the results of Phase 1.

Phase 2 may include, but would not necessarily be limited to, one or more of the following investigative measures:

- Additional collection of soil samples in suspected source areas. Borings would likely be completed in areas with previous detections of TCE in shallow soil, soil vapor or high concentrations in groundwater. Samples would likely be collected from the surface to the water table to vertically and horizontally delineate potential on going sources in soil.
- A ground penetrating radar survey to identify whether there are any underground structures present.

While specific sampling locations are not known at this time, general procedures used to collect additional data are anticipated and summarized below. HS will identify planned sample locations in a Work Plan Addendum for Ecology consideration prior to implementing Phase 2 work (as applicable).

4.1 Soil sample collection

Borings would be excavated in areas with previous detections of TCE in shallow soil, soil vapor or high concentrations in groundwater. Samples would likely be collected from near the surface to the water table to vertically and horizontally delineate potential on going sources in soil.

Soil samples would be collected using a hollow stem auger drill rig equipped with a split-spoon sampler at 2.5-foot intervals. Sample collection, handling, and laboratory analysis would be conducted according to the methods and procedures previously discussed in Section 3.2.1.

4.2 Ground penetrating radar

A Ground Penetrating Radar (GPR) survey may be used to identify whether there are any underground structures present that may represent a historic or ongoing source to soil or groundwater.

GPR establishes a relative depth, size and ground projection of subsurface objects (i.e. to determine if the object is indicative or is not indicative of a historic structure and/or fill). The expected horizontal and vertical resolution with GPR should be within a half-foot. Shallow ground penetrating radar surveys are conducted by one person, hand-towing the antenna along GPR exploration traverses on a grid pattern within the defined project area. The radar antenna transmits an electromagnetic step-pulse. When the signal encounters a change in electrical properties/permittivity, a portion of the signal energy is reflected back to the surface. The reflected signal is received by the antenna processed by a radar processor with signal gain control and the raw data is recorded by an outboard computer. The radar displays the data in real-time, and is available for review in the field. The recorded raw data is recorded by the computer, and then later processed to remove unwanted peripheral effect by proprietary GPR software.

This survey would be conducted according to generally accepted methods and field procedures

4.3 Other considerations

Procedures identified for Phase 1 work for health and safety, decontamination and management of industrial derived wastes (Section 3) would be followed for Phase 2 work.

5.0 Quality assurance procedures

5.1 Quality control parameters

Groundwater and soil samples will be collected for laboratory analysis as described in Section 3 and Section 4. 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.

5.1.1 Detection limits

The method detection limit for a given parameter is determined by procedures specified in the method. Table 3-2 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.

5.1.2 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:

$$\%\,\mathrm{RPD} = \frac{\left(\mathrm{X}_2 - \mathrm{X}_1\right)}{\left[\left(\mathrm{X}_1 + \mathrm{X}_2\right)/2\right]} \times 100$$

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.

5.1.3 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:

$$\% \mathrm{R} = \frac{(\mathrm{C}_1 - \mathrm{C}_0)}{\mathrm{C}_\mathrm{S}} \times 100$$

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 (C_s) is calculated, using the following equation:

$$\mathrm{C}_\mathrm{S} = \frac{(\mathrm{C}_\mathrm{spike} \times \mathrm{V}_\mathrm{spike})}{\mathrm{V}_\mathrm{sample} + \mathrm{V}_\mathrm{spike}}$$

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.

5.1.4 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.

5.1.5 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.

5.2 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 A). The responsibility for the calibration of laboratory equipment lies with the Analytical Laboratory internal project manager.

5.2.1 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, and values given in national standards, the intended use and experience. Table 5-1 presents the calibration frequency of the field sampling equipment. Calibration procedures and quality assurance/quality control methods will conform to the ENSR SOP# 7121, 7123, 7124, 7510, 7515, and 7600: these are summarized below.

Table 5-1 Field Sampling Equipment Calibration Frequency

Instrument	Calibration Procedure	Calibration Frequency
pH meter	Two-point calibration with pH buffers 7 and 4, or 10, as appropriate	Daily
Conductivity meter	See ENSR SOP# 7124	Daily
DO meter	Two-point calibration	Daily
Redox meter	Specific to water quality meter – check manual for water quality meter	Daily
Thermometer	Check with ohm meter or standard thermometer	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	Probe; as needed if malfunctions; tape length: annually
Turbidity Meter	3-point calibration	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.

5.2.2 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.

5.2.3 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.

5.3 Analytical laboratories

Analytical Resources, Incorporated (ARI) of Seattle, Washington will perform analysis on all water samples collected as described in Section 3 and Section 4. The Laboratory Coordinator is Mark Harris.

5.3.1 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."

5.3.2 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.

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.

5.4 Data management

5.4.1 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.

5.4.2 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).

5.4.3 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.

5.5 Data assessment

5.5.1 Field procedures

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

5.5.2 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.

5.5.3 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.

5.5.4 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.

5.6 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.

5.7 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.

6.0 Reporting and schedule

The table below provides a preliminary schedule to implement the scope of work described above. This schedule includes a 1-week review for Hines LLC and Honeywell Aerospace.

Table 6-1 Work plan proposed schedule Modify based on a 1-week review

Item	Brief Description	Estimated Duration	Time Frame for Completion
Field Work – Phase 1	MW installation, first round of GW Samples (dry season); assumes standard turn around and includes data validation	4 weeks	4th Quarter 2008
Field Work – Phase 1	Second round of GW Samples (wet season); assumes standard turn around and includes data validation	5 weeks	1st Quarter 2009
Review results and Draft Addendum	Review groundwater quality and MNA results and evaluate need for and scope of Phase 2	6 weeks	2nd Quarter 2009
Addendum to Work Plan (summary of Phase 1 results and Phase 2 scope, if needed)	Summarize the Phase 1 results and planned next steps	5 days	2nd Quarter 2009
Field Work – Phase 2	Assumes standard turn around and includes data validation	8 weeks	2nd Quarter 2009
Draft RI/FS	Review of site data and evaluation of alternatives for remedial action	10 weeks	3rd Quarter 2009
Submittal of RI/FS to Ecology	Includes a complete review of Phase 1 and Phase 2 data and includes evaluation of alternatives for remedial action	2 weeks	3rd Quarter 2009

7.0 References

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MWH 2007a. *Sub-Slab Soil Vapor and Indoor Air Quality Investigation Report for Building 2*. MWH Americas, Inc., May 23, 2007.

MWH 2007b. Follow-up Indoor Air Quality Investigation Report For Building 2. MWH Americas, Inc., September 24, 2007.

Tables

Table 1-1 Chemical Storage Locations

Location	Chemicals
Building 1	Hazardous/flammable materials storage. No chlorinated solvents reportedly used in Building 1.
Building 2	1,1,1-TCA, methyl ethyl ketone, ethylene glycol, oil based coolants and lubricants, kerosene, paints, phosphoric, nitric and sulfuric acids, alkaline cleaners and cyanide.
Building 3	Various chlorinated and non chlorinated solvents including TCE
Building 4	1,1,1 TCA
Former Building 9	Chemical supplies, hazardous materials and hazardous waste, 3,000 gallon gasoline UST

Notes:
VOC - Volitale Organic Compounds
TCE - Trichloroethene
1,1,1 - TCA - 1,1,1 - Trichloroethane

Table 2-1 Investigation and Cleanup History

Date	Activity	Contractor	Reference
1986	A 3,000-gallon gasoline UST, was removed from the west side of former Building 9. No contamination was reported and soil samples were not collected at the time of tank removal.	Dames & Moore 1993a	Dames and Moore Group. 1993a. *Final Report, Phase I Environmental Site Assessment, Phase II Soil and Groundwater Monitoring and Asbestos Survey, Sundstrand Data Control, Redmond, WA.* Prepared for Rockwell international Corporation
1987	A transfer pump and tank system released 50 gallons of 1,1,1 - TCA located to the west of Building 2. Soil was contaminated. Ecology excavated to a depth of 16 feet bgs.		
1993a	Four soil borings were drilled near former Building 9 and four monitoring wells (MW-7 to MW-10) were installed. In soils samples, concentrations of petroleum hydrocarbons were detected in the area adjacent to the former UST. In soil samples near the location of the reported 1,1,1-TCA leak, methylene Chloride,TCE and TCA concentrations were detected above MTCA Method A cleanup levels. MW-7 through MW-10, concentrations of TCE and chloroform were detected above MTCA Method A and B cleanup levels		
1993b	Near former Building 9, seven soil boring were drilled and 33 soil gas samples were collected. Concentrations of VOCs were detected below MTCA A cleanup levels. Concentrations of petroleum hydrocarbons were detected above MTCA A cleanup levels in one soil sample collected from the former UST area.	Harding Lawson Associates	Harding Lawson Associates (HLA). 1993. *Building 9 Soil Investigation, Sundstrand Data Control, 15001 Northeast 36th Street, Redmond, Washington.* December 9.
1994	Re-injection of non contact cooling water at injection RW-3 was discontinued		
1995	Monitoring wells MW-11 through MW-13 were installed in the vicinity of RW-3. A groundwater sample collected from RW-3 detected TCE and chloroform above MTCA Method A and B cleanup levels. TCE and chloroform were non-detect in groundwater samples from MW-11 through MW-13.	Environmental Management Resources	Environmental Management Resources (EMR). 1995a. *Preliminary Report for Concrete Structure Investigation, AlliedSignal, Inc.* , 15001 Northeast 36th Street, Redmond, Washington. March 3.
1996	Groundwater samples were collected from MW-11 through MW-13 and injection well RW-3		
1998	Monitoring wells MW-11 through MW-13 and injection well RW-3 were decommissioned.		
1998	Monitoring well MW-7 was decommissioned	—	—
1999a	Concentrations of TCE exceeding MTCA Method A cleanup level was detected in shallow soil samples collected beneath the former Building 9 slab and adjacent areas. Soil vapor samples collected at depths ranging from 5 to 10 feet bgs also detected elevated TCE concentrations.	CH2MHILL	CH2M HILL. 1997, 1999, 2000, and 2001. *Selected Groundwater Contours and Plots of Groundwater Quality Results for TCE, 1,1,1,- TCA. Freon -113, and chloroform.*
1999b	Building 9 was demolished and TCE-contaminated soil was removed.	—	—
2001	A replacement well for MW-7 (MW-7R), and MW-14 were installed. MW-14 was installed adjacent to the northeast side of former Building 9. Concentrations of TCE, 1,1,1-TCA, chloroform, and 1,1-DCE exceeding MTCA Method A or B cleanup levels were detected in reconnaissance groundwater samples collected from MW-14. Reconnaissance soil samples collected from MW-7R were reported non-detect.	Kleinfelder	Kleinfelder, Inc. 2002. *Voluntary Cleanup Program, Site Investigation & Closure Report, Honeywell Aerospace Electronics Facility* , 15001 NE 36th Street, Redmond, Washington. December 13.
2002a	Laboratory analytical results for MW-7R and MW-14 for VOCs were reported non-detect.	—	—
2002b	Another well is installed downgradient of Cedar Court per Ecology's request. VOCs were reported as non-detect in the new well.	Farallon	Farallon Consulting. 2007.Subsurface Investigation, Hart Properties - Laguna Campus,15001 NE 36th Street, Redmond, Washington, January 2
2002c	Kleinfelder prepares and submits a report requesting a NFA for the Laguna Campus concluding that soil impacted by past releases from the UST and surface spills had been remediate.	Kleinfelder	Kleinfelder, Inc. 2002. *Voluntary Cleanup Program, Site Investigation & Closure Report, Honeywell Aerospace Electronics Facility* , 15001 NE 36th Street, Redmond, Washington. December 13.
2003	Ecology issued a NFA for the Cedar Court property, and a subsequent NFA for determination of TCA in groundwater on the laguna campus. However, the NFA states residual concentrations of TCE and PCE7 exceeding MTCA Method A soil cleanup levels were present in the former Building 9.	—	—
2006a	Installation of monitoring wells MW-15 and MW-16 was completed. Soil samples collected from MW-15's boring at depths of 40 to 65 feet bgs detected concentrations of TCE exceeding the MTCA Method A cleanup level. A soil sample collected at a depth of 54 feet bgs for MW-16 was reported non-detect.	Farallon	Farallon Consulting. 2007.*Subsurface Investigation, Hart Properties - Laguna Campus,* 15001 NE 36th Street, Redmond, Washington. January 2.
2006b	Low concentrations of TCE, chloroform, chloromethane and/or carbon disulfide were detected in groundwater samples collected at MW-8 and MW-10. Groundwater samples collected from MW-7R and MW-14 were reported as non-detect for VOCs and SVOCs. Groundwater samples from MW-15 and MW-16, reported TCE, chloroform and 1,1 DCE concentrations exceeded MTCA Method A or B cleanup levels.		
2006c	Soil vapor samples were collected from VP-1 through VP-3. TCE concentrations exceeding MTCA Method B were detected in soil vapor samples taken at VP-2. Soil vapor samples collected at VP-1 and VP-3 were reported non-detect		
2007	Subslab and indoor air sampling conducted at Building 2. Detections of TCE, PCE, Benzene, xylenes, and chloroform; all detections below MTCA Method C levels - select compounds exceed MTCA Method B levels.	MWH	MWH 2007. Sub Slab Vapor and Indoor Air Quality Investigation Report for Building 2. May 2007. And Follow-up Indoor Air Quality Investigation Report for Building 2. September 2007.
2008	CVOCs in groundwater samples collected from MW-15 and MW-16 exceeded MTCA Method A cleanup levels.	ENSR	ENSR 2008. March 2008 Groundwater Sampling Report. ENSR, August 15, 2008.

Notes:

VOC - Volatile Organic Compounds
TCE - Trichloroethylene
1,1,1, - TCA -1,1,1 - Trichloroethane
1,1,2 - Trichlorotrifluorethane
UST - Underground Storage Tank
MTCA - Model Toxic Control Act
NFA - No Further Action
PCE - Tetrachloroethylene
1,1 - DCE - Dichloroethene

Table 2-2 Well Network Designation

Monitoring Wells

Well ID	Depth to Bottom (ft-toc)	Screened Interval (ft-bgs)[1]	Completion Date	Decomission Date
MW-7	—	—	1993	1998
MW-7R	100	90-100	2001	NA
MW-8	110	100-110	1993	NA
MW-9	100	80-90	1993	NA
MW-10	110	100-110	1993	NA
MW-11*	95	85-95	1995	1998
MW-12*	115	93-113	1995	1998
MW-13*	112	104-114	1995	1998
MW-14	101	91-101	2001	NA
MW-15	75	65-75	2006	NA
MW-16	75	65-75	2006	NA

Supply Wells

Well ID	Depth to Bottom (ft-toc)	Screened Interval (ft-bgs)[1]	Completion Date	Decomission Date
PW-2	145	Unknown	1960	1999
PW-4	105	95-105	1968	NA
PW-5	133	118-133	1979	NA

Injection Wells

Well ID	Depth to Bottom (ft-toc)	Screened Interval (ft-bgs)[1]	Completion Date	Decomission Date
RW-1	100	Unknown	1960	NA
RW-3	185	164-184	1968	1998
RW-6	118	52-86	1979	NA

Notes:

[1] From November 2006: Farallon Consulting LLC *Report Subsurface Investigation* dated January 2,2007

[2] Proposed construction details will be determined in the field

* Well depth obtained from boring logs/Kleinfelder report

ft-bgs: feet below ground surface

ft-toc: feet below top of well casing

Table 2-3   Water Supply System Details

Supply Well	Flow Rate (gpm)	Supplied Building	Discharge Location
PW-2	400	Building 1	RW-3 and Storm sewer
PW-4	280	Buildings 2 and 3	Storm Sewer
PW-5	400	Building 4	RW-6

Table 2-4 December 2006 & March 2008 Groundwater Monitoring Results

Well ID	Depth to Bottom (ft-bgs)	Screened Interval (ft-bgs)*	Sample Date	TCE (Trichloroethene)	1,1,1-TCA (1,1,1-Trichloroethane)	1,1-DCE (1,1,-Dichloroethene)	Vinyl Chloride	PCE (Tetrachloroethene)	Chloroform
MW-7R	100	90-100	Dec-06	<0.2	<0.2	<0.2	NR	NR	<0.2
			Mar-08	<0.2	**0.3**	<0.2	<0.2	<0.2	**0.7**
MW-8	110	100-110	Dec-06	<0.2	<0.2	<0.2	NR	NR	<0.2
			Mar-08	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
MW-10	110	100-110	Dec-06	**1.5**	<0.2	<0.2	NR	NR	**3.1**
			Mar-08	**2.8**	**0.2**	<0.2	<0.2	<0.2	**5**
MW-14	101	91-101	Dec-06	<0.2	<0.2	<0.2	NR	NR	<0.2
			Mar-08	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
MW-15	75	65-75	Dec-06	**700**	**130**	**77**	NR	NR	**810**
			Mar-08	**1,400**	**160**	**95**	<0.2	<0.2	**820**
MW-16	75	65-75	Dec-06	**33**	**1.7**	**5.8**	NR	NR	**0.24**
MW-16			Mar-08	**26**	**1.5**	<0.6	<0.6	<0.6	**5**
Duplicate			Mar-08	**26**	**1.6**	**0.3**	<0.2	<0.2	**5.4**
MTCA Method A Drinking Water Standard				5	200	NV	0.2	5	NV
MTCA Method B Drinking Water Standard*				---	---	72	---	---	7.17

Notes:

🟩 Shading denotes value detected above MTCA Method A Screening Level

*MTCA Method A used for all compounds except 1,1-DCE and Chloroform. MTCA Method B values were used for the latter two analytes because MTCA A values are not available.

All units are µg/L

ft-bgs: feet below ground surface

ft-toc: feet below top of well casing

NV - No screening value available

NR - Not reported in data tables

* From November 2006: Farallon Consulting LLC Report 'Subsurface Investigation' dated January 2, 2007

Other VOCs generally ND, except for Freon (1,1,2-Trichloro-1,2,2-trifluoroethane), detected aprox. 400 ug/L: Method BGW = 24,000

Table 2-5 Revised Site Survey Data (September 2008)

Monitroing Well ID	Northing	Easting	Top of PVC Casing Elevation	Top of Metal Casing Elevation	Ground Elevation	Notes
MW 7R	236239.12	1319170.99	357.05	357.40	---	
MW 8	236517.48	1318423.39	362.97	363.50	---	
MW 9	235666.5	1318368.48	356.33	356.70	---	
MW 10	236009.14	1319171.53	353.79	354.12	---	
MW 14	235923.92	1318407.87	360.26	360.83	---	
MW-15	235953.70	1318400.99	NM	NM	360.7	Monitoring well blocked by a vehicle
MW 16	236165.34	1318767.18	359.12	359.45	---	
RW 6	235749.11	1318645.66	355.78	355.90	---	

Notes:

Site Elevations Established by Bench Mark Name "Overlake" Elevation 369.552 NAVD 88

Site Coordinates are NAD 83/91

Top of Metal Casing is the Same as Ground Unless Otherwise Noted.

Survey conducted by True North Surveyors, September 15, 2008

Table 3-1 Phase I Ground Water Investigation

Existing Monitoring Wells

Well ID	Depth to Bottom (ft-toc)	Screened Interval (ft-bgs)[1]	Completion Date	Purpose
MW-7R	100	90-100	2001	Monitor down-gradient groundwater
MW-8	110	100-110	1993	Phase I & II soil and groundwater monitoring
MW-9	90	80-90	1993	Phase I & II soil and groundwater monitoring
MW-10	110	100-110	1993	Phase I & II soil and groundwater monitoring
MW-14	101	91-101	2001	Assess Building 9 area for the presence of VOCs in groundwater
MW-15	75	65-75	2006	Assess potential release and/or migration of hazardous substances from confirmed and suspected release locations
MW-16	75	65-75	2006	

Proposed Monitoring Wells

Well ID	Depth to Bottom	Screened Interval (ft-bgs)[2]	Completion Date	Purpose
MW-17	75	65-75	—	Monitor shallow groundwater migrating off site. Located NE property boundary, near MW-7R.
MW-18	75	65-75	—	Monitor shallow groundwater in the vicinity of former Building 9 area.
MW-19	75	65-75	—	Monitor shallow groundwater migration down gradient of 1,1,1-TCA spill area. Located Adjacent to RW-6
MW-20	75	65-75	—	Bound north delineation of chemical extent. Located North of Building 1.
MW-21	75	65-75	—	Monitor shallow groundwater migrating off site. Located adjacent to MW-10.
MW-22	75	65-75	—	Bound south-east delineation of chemical extent, located downgradient of MW-19.

Notes:

[1] From November 2006: Farallon Consulting LLC Report 'Subsurface Investigation' dated January 2,2007

[2] Proposed construction details will be determined in the field

ft-bgs: feet below ground surface
ft-toc: feet below top of well casing

Table 3-2 Lower Reporting Limits of EPA Method 8260 and VOCs by EPA Method 8260 (SIM)

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^o C, Zero Headspace	14 Days
Trichloroethene	SW8260-SIM	0.02	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Vinyl Chloride	SW8260-SIM	0.02	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,1,1,2-Tetrachloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,1,1-Trichloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,1,2,2-Tetrachloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,1,2-Trichloro-1,2,2-trifluoroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,1,2-Trichloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,1-Dichloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,1-Dichloroethene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,1-Dichloropropene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,2,3-Trichlorobenzene	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,2,3-Trichloropropane	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,2,4-Trichlorobenzene	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,2,4-Trimethylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,2-Dibromo-3-chloropropane	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,2-Dibromoethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,2-Dichlorobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,2-Dichloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,2-Dichloropropane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,3,5-Trimethylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,3-Dichlorobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,3-Dichloropropane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
1,4-Dichlorobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
2,2-Dichloropropane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
2-Butanone	SW8260B	1	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
2-Chloroethylvinylether	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
2-Chlorotoluene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
2-Hexanone	SW8260B	3	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
4-Chlorotoluene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
4-Isopropyltoluene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
4-Methyl-2-Pentanone (MIBK)	SW8260B	1	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Acetone	SW8260B	3	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Acrolein	SW8260B	5	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Acrylonitrile	SW8260B	1	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Benzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Bromobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Bromochloromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Bromodichloromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Bromoethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Bromoform	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Bromomethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Carbon Disulfide	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Carbon Tetrachloride	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Chlorobenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Chloroethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Chloroform	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Chloromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
cis-1,2-Dichloroethene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
cis-1,3-Dichloropropene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Dibromochloromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Dibromomethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Ethylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Hexachlorobutadiene	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Isopropylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
m,p-Xylenes	SW8260B	0.4	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Methyl Iodide	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Methylene Chloride	SW8260B	0.3	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Naphthalene	SW8260B	0.5	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
n-Butylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
n-Propylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
o-Xylene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
sec-Butylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Styrene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
tert-Butylbenzene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Toluene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
trans-1,2-Dichloroethene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
trans-1,3-Dichloropropene	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
trans-1,4-Dichloro-2-butene	SW8260B	1	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Trichlorofluoromethane	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days
Vinyl Acetate	SW8260B	0.2	40ml VOA containers	HCL, Cool to 4^o C, Zero Headspace	14 Days

Table 3-3 Natural Attenuation Parameters

Parameter	Method	Required Reporting Limit*	Bottles	Preservative	Holding Times
CO_2	GC/TCD				
Methane	GC/FID	1 µg/L	40 mL vial	none	14 days
Ethane/Ethene	GC/FID	1 µg/L	40 mL vial	none	14 days
Alkalinity	SM 2320	1.0 mg/L	500 mL HDPE	none	14 days
Chloride	EPA 300.0	0.1 mg/L	500 mL HDPE	none	28 days
Dissolved Arsenic	EPA 6010	50 ug/L	500 mL HDPE	HNO_3	6 months
Iron – Total Dissolved (Filtered)	EPA 6010	50 ug/L	500 mL HDPE	HNO_3	6 months
Iron – Ferrous (Filtered)	SM 3500 FeD/HACH Kit 8146	0.04 mg/L	250 mL AG	HCl	24 hours
Manganese (Filtered)	EPA 6010	1.0 ug/L	500 mL HDPE	HNO_3	6 months
Nitrate	EPA 300.0	0.1 mg/L	500 mL HDPE	none	48 hours
Nitrite	EPA 300.0	0.1 mg/L	500 mL HDPE	none	48 hours
Ammonia	EPA 350.1	0.01 mg/L	500 mL HDPE	H_2SO_4	28 days
Sulfate	EPA 300.0	0.1 mg/L	500 mL HDPE	none	28 days
Sulfides	EPA 376.2	0.05 mg/L	500 mL HDPE	Zinc Acetate	7 days
Total Organic Carbon	*Pending****	1.5 mg/L**	250 mL AG	H_2SO_4	28 days
Conductivity	Field Method	---	---	---	---
Dissolved Oxygen	Field Method	---	---	---	---
pH	Field Method	---	---	---	---
Oxidation Reduction Potential (ORP)	Field Method	---	---	---	---
Temperature	Field Method	---	---	---	---
Turbidity	Field Method	---	---	---	---

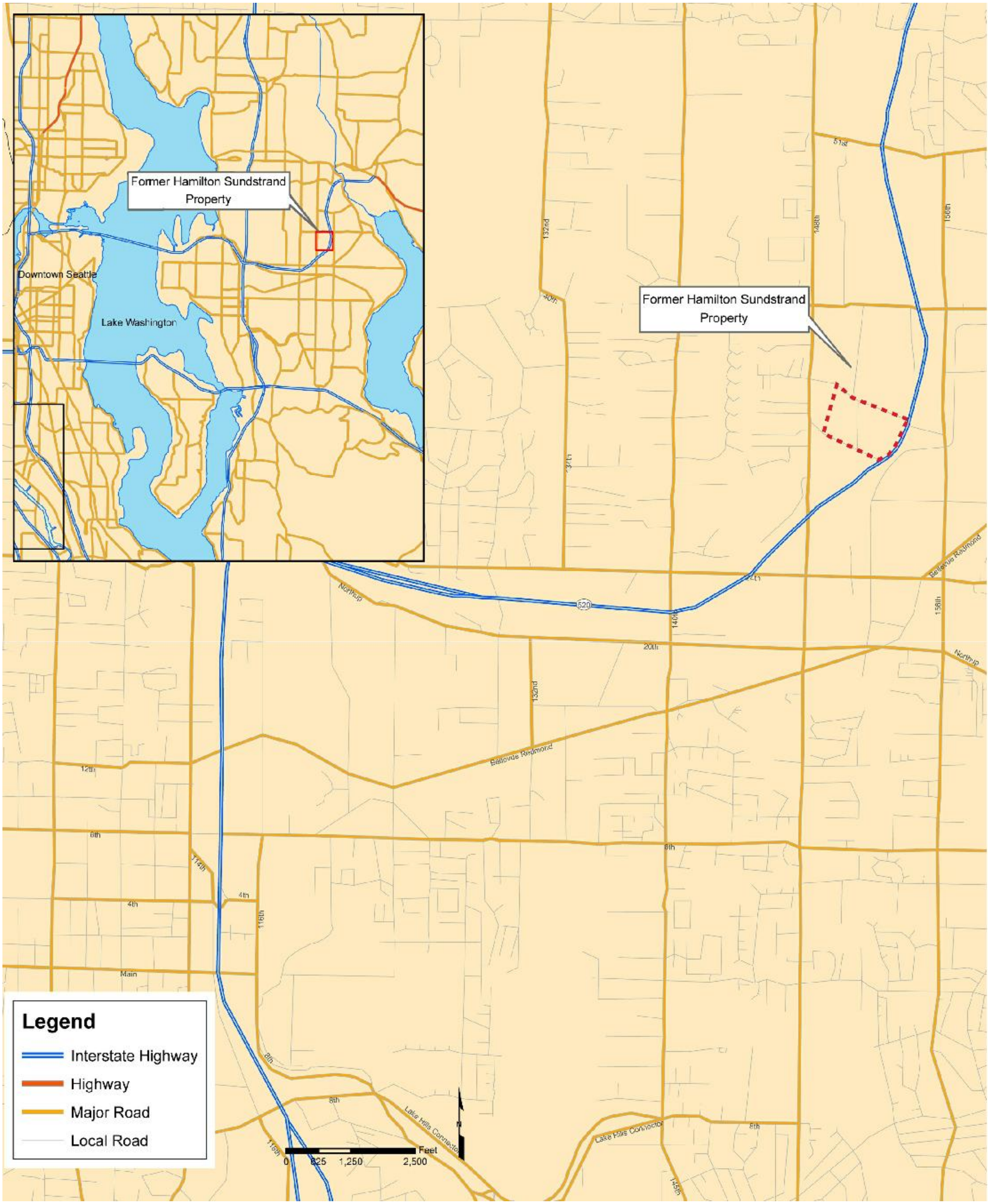
* Reporting limits are affected by matrix interference. The required reporting limits will be achieved by the laboratory under normal circumstances, but may not be achievable under all circumstances.

** TOC reporting limit in EPA guidance is listed as 0.1 mg/L; however, laboratories in the Seattle area, ARI and North Creek, report at concentrations of 1.5 and 2 mg/L, respectively.

*** TOC Analytical Method to be determined in consultation with Ecology and Manchester Laboratories. Agreement on TOC method will be documented in correspondence with Ecology, and will be incorporated into this work plan by reference.

Reporting limits, holding times, and sample preservation for CO2 will be determined prior to sampling.

Figures



ENSR | AECOM

FORMER HAMILTON
SUNDSTRAND PROPERTY

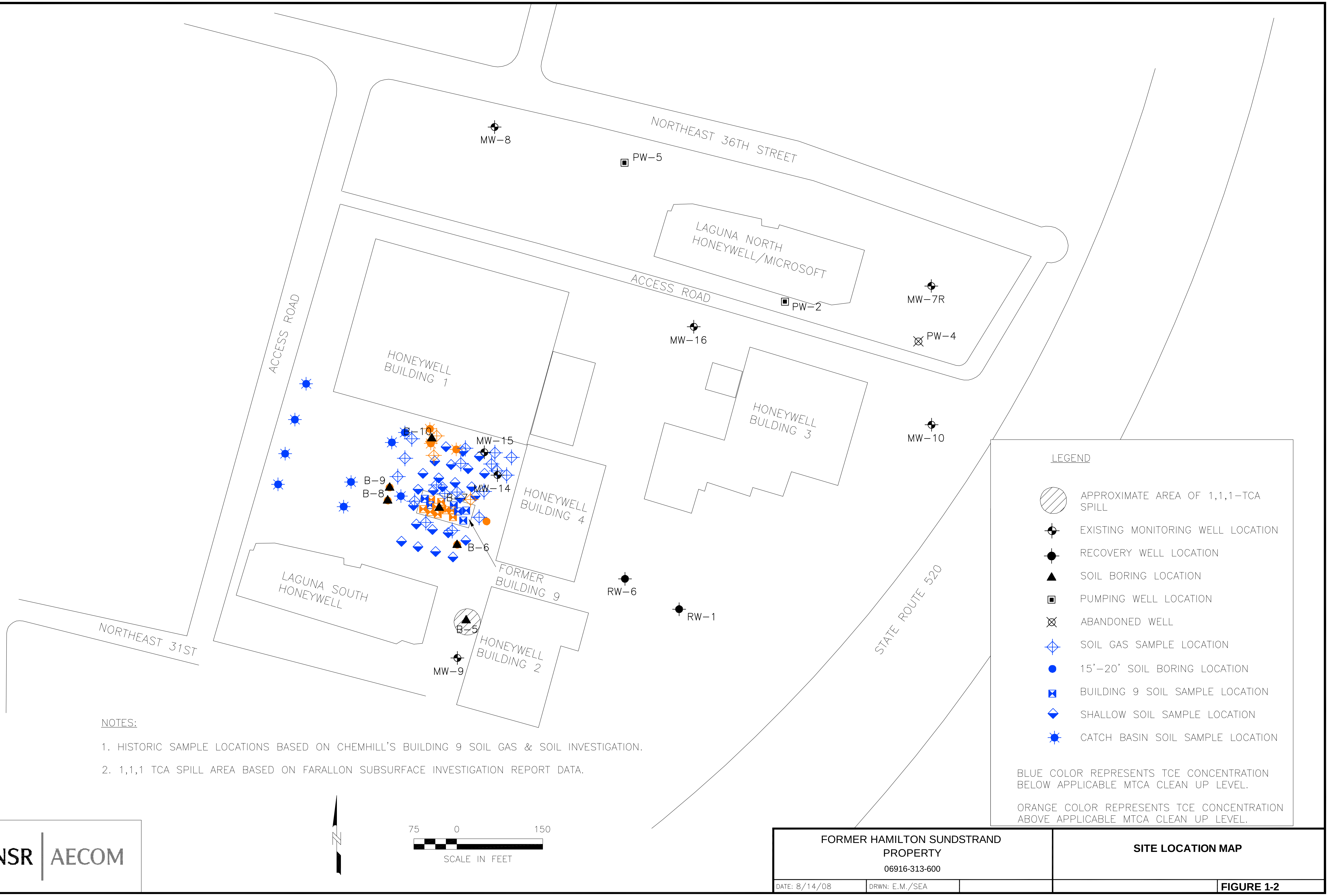
06916-313-600

VICINITY MAP

DATE: 08/08/08 DRWN: E.M./SEA

FIGURE 1-1

File: L:\Laguna\VICINITY MAP.dwg Layout: FIGURE 1-1 User: emarshall Plotted: Aug 18, 2008 - 9:04am Xref's:



NOTES:

1. HISTORIC SAMPLE LOCATIONS BASED ON CHEMHILL'S BUILDING 9 SOIL GAS & SOIL INVESTIGATION.

2. 1,1,1 TCA SPILL AREA BASED ON FARALLON SUBSURFACE INVESTIGATION REPORT DATA.

LEGEND

▨ APPROXIMATE AREA OF 1,1,1–TCA SPILL
⌖ EXISTING MONITORING WELL LOCATION
● RECOVERY WELL LOCATION
▲ SOIL BORING LOCATION
▣ PUMPING WELL LOCATION
☒ ABANDONED WELL
◇ SOIL GAS SAMPLE LOCATION
● 15'–20' SOIL BORING LOCATION
☒ BUILDING 9 SOIL SAMPLE LOCATION
◆ SHALLOW SOIL SAMPLE LOCATION
✹ CATCH BASIN SOIL SAMPLE LOCATION

BLUE COLOR REPRESENTS TCE CONCENTRATION BELOW APPLICABLE MTCA CLEAN UP LEVEL.

ORANGE COLOR REPRESENTS TCE CONCENTRATION ABOVE APPLICABLE MTCA CLEAN UP LEVEL.

ENSR | AECOM

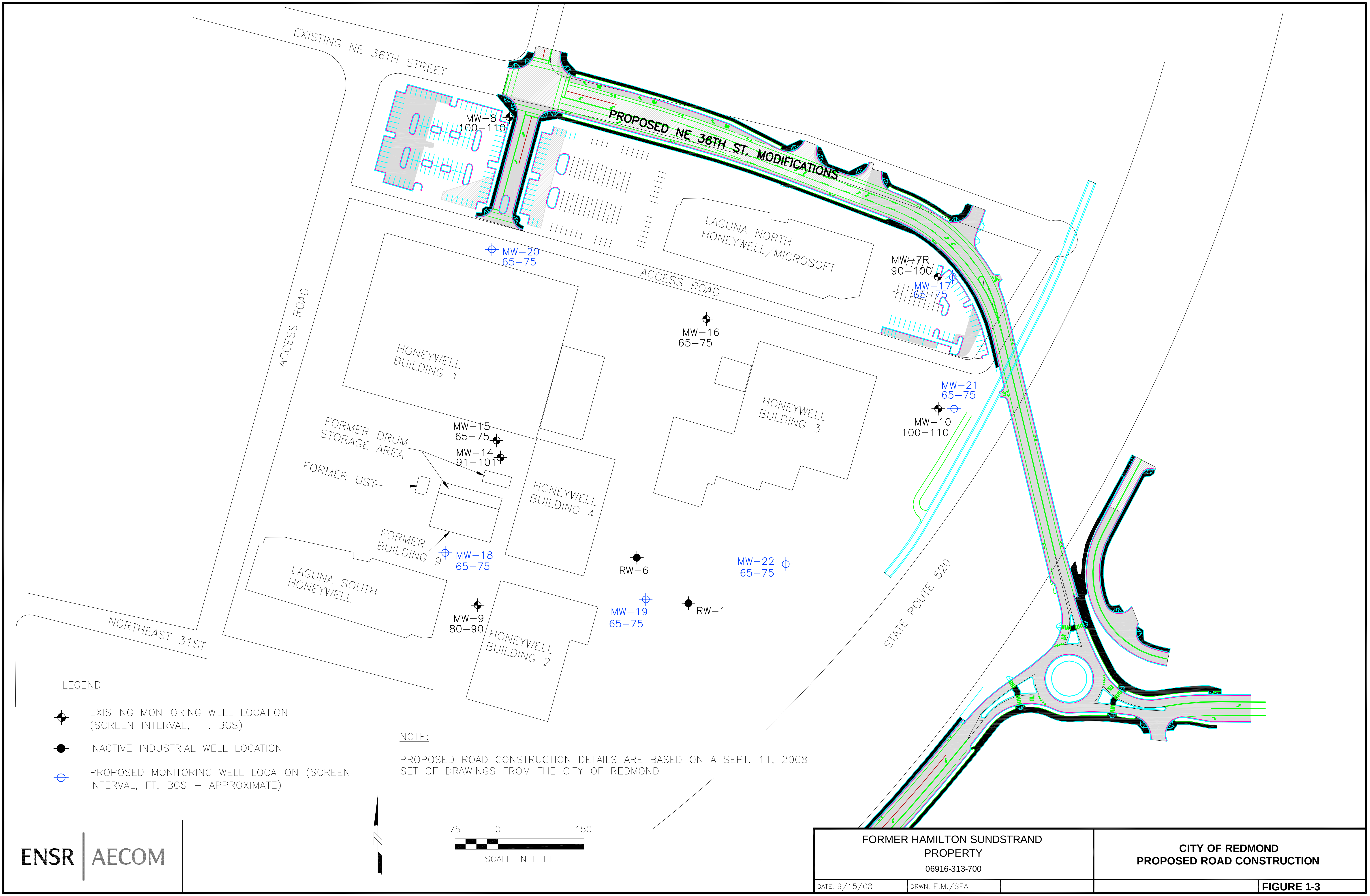
FORMER HAMILTON SUNDSTRAND PROPERTY
06916-313-600

SITE LOCATION MAP

DATE: 8/14/08
DRWN: E.M./SEA

FIGURE 1-2

File: L:\Laguna\SITE LOCATION.dwg Layout: ANSI_BI-CP User: emarshall Plotted: Aug 15, 2008 – 1:32pm Xref's:



LEGEND

⌖ EXISTING MONITORING WELL LOCATION (SCREEN INTERVAL, FT. BGS)

● INACTIVE INDUSTRIAL WELL LOCATION

⌖ PROPOSED MONITORING WELL LOCATION (SCREEN INTERVAL, FT. BGS – APPROXIMATE)

NOTE:

PROPOSED ROAD CONSTRUCTION DETAILS ARE BASED ON A SEPT. 11, 2008 SET OF DRAWINGS FROM THE CITY OF REDMOND.

ENSR | AECOM

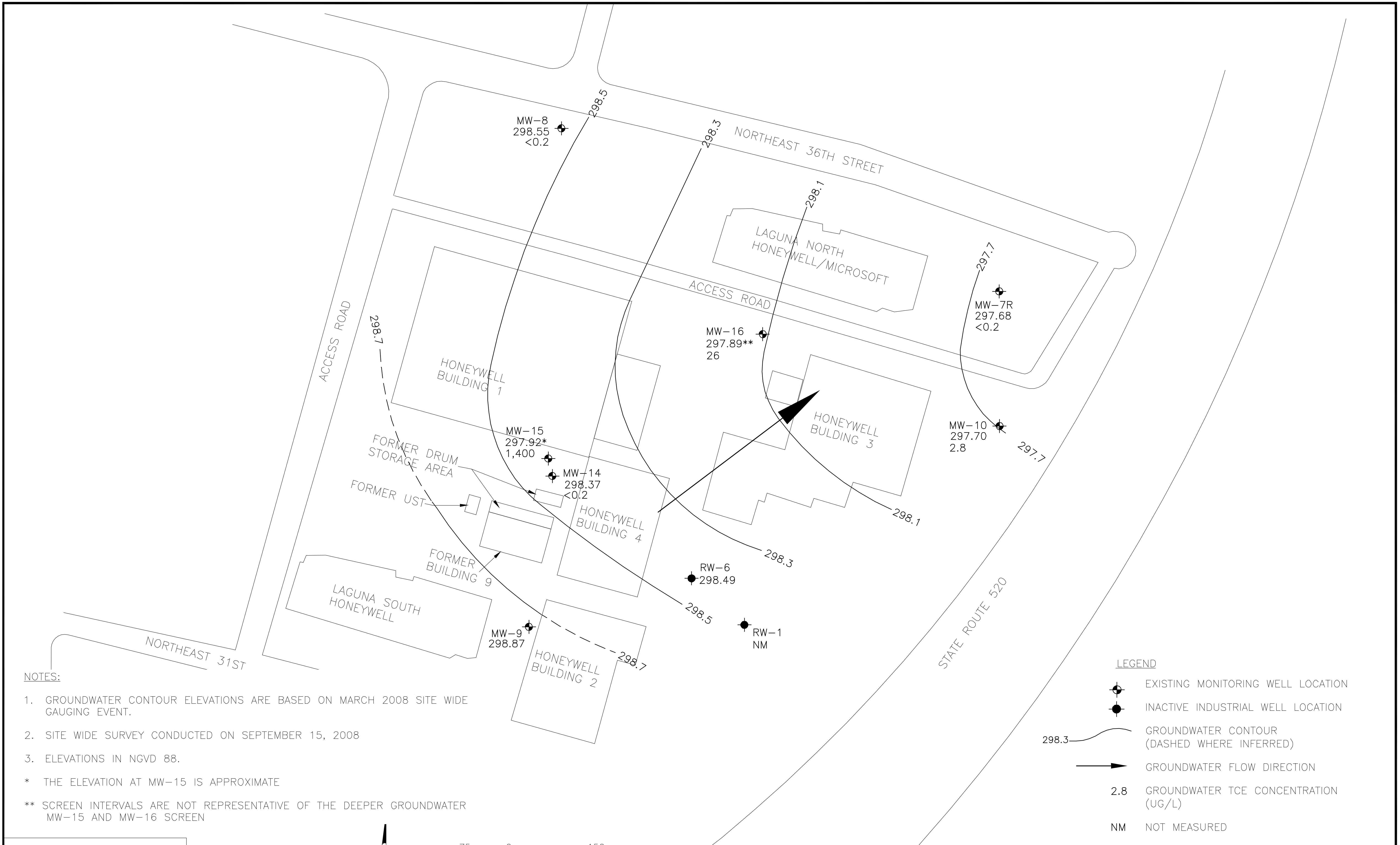
FORMER HAMILTON SUNDSTRAND
PROPERTY
06916-313-700

CITY OF REDMOND
PROPOSED ROAD CONSTRUCTION

DATE: 9/15/08
DRWN: E.M./SEA

FIGURE 1-3

File: L:\Laguna\road construction.dwg Layout: FIGURE 1-3 User: MarshallE Plotted: Sep 18, 2008 – 3:31pm Xref's:



NOTES:

1. GROUNDWATER CONTOUR ELEVATIONS ARE BASED ON MARCH 2008 SITE WIDE GAUGING EVENT.
2. SITE WIDE SURVEY CONDUCTED ON SEPTEMBER 15, 2008
3. ELEVATIONS IN NGVD 88.

* THE ELEVATION AT MW-15 IS APPROXIMATE

** SCREEN INTERVALS ARE NOT REPRESENTATIVE OF THE DEEPER GROUNDWATER MW-15 AND MW-16 SCREEN

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FORMER HAMILTON SUNDSTRAND
PROPERTY
06916-313-700

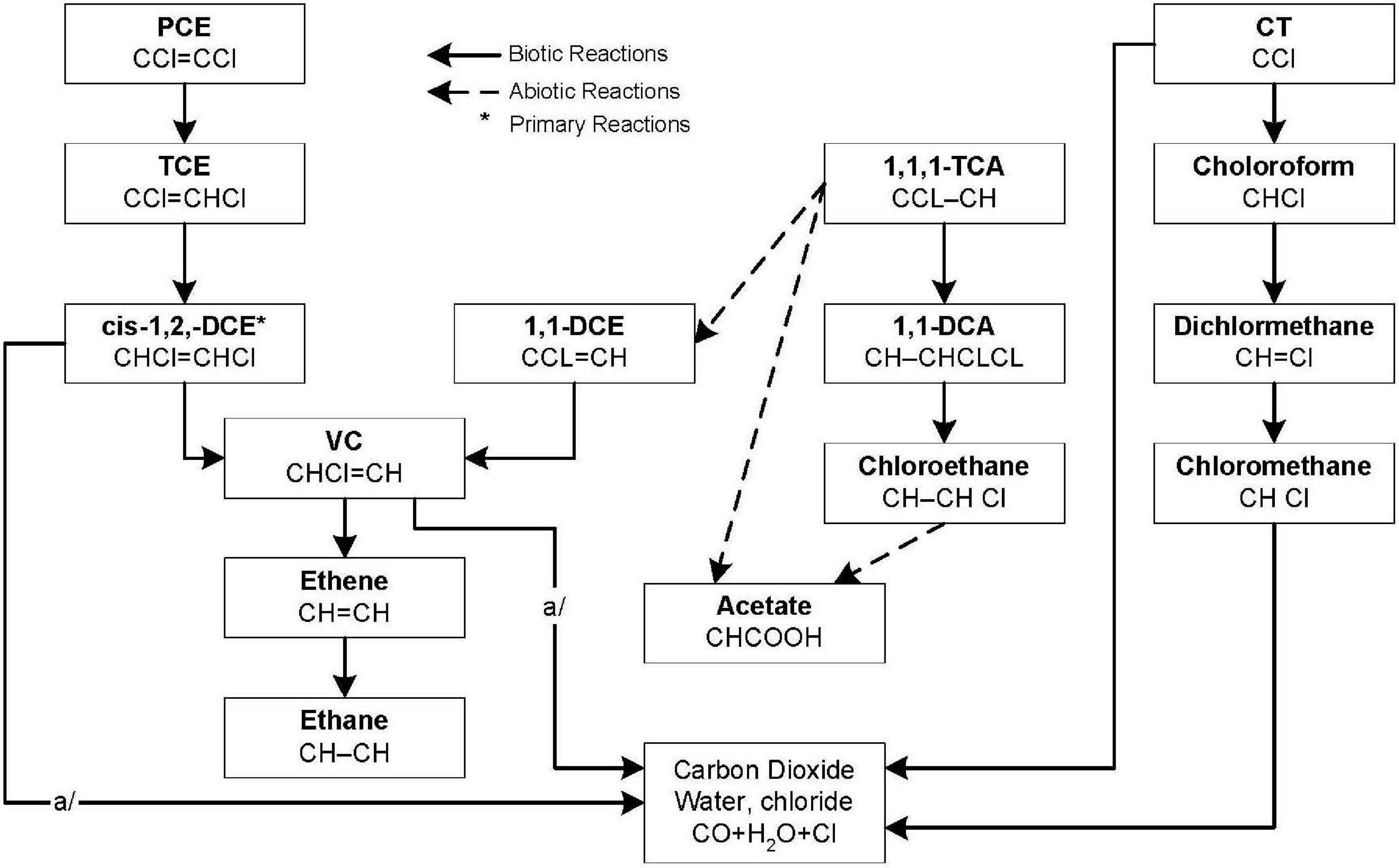
DATE: 9/18/08
DRWN: E.M./SEA

GROUNDWATER CONTOUR & TCE CONC. MAP
MARCH 2008

FIGURE 1-4

File: L:\Laguna\GW_TCE CONCENTRATIONS.dwg Layout: FIGURE 1-4 User: MarshallE Plotted: Sep 19, 2008 - 11:38am Xref's:

File: L:\Laguna\CVOC DEGRADATION.dwg Layout: FIGURE 3-1 User: emarshall Plotted: Aug 08, 2008 - 11:20am Xref's:



a/ - oxidative biological pathway; all other biological pathways are reductive

ENSR | AECOM

UTC-LAGUNA PROPERTIES
REDMOND, WASHINGTON

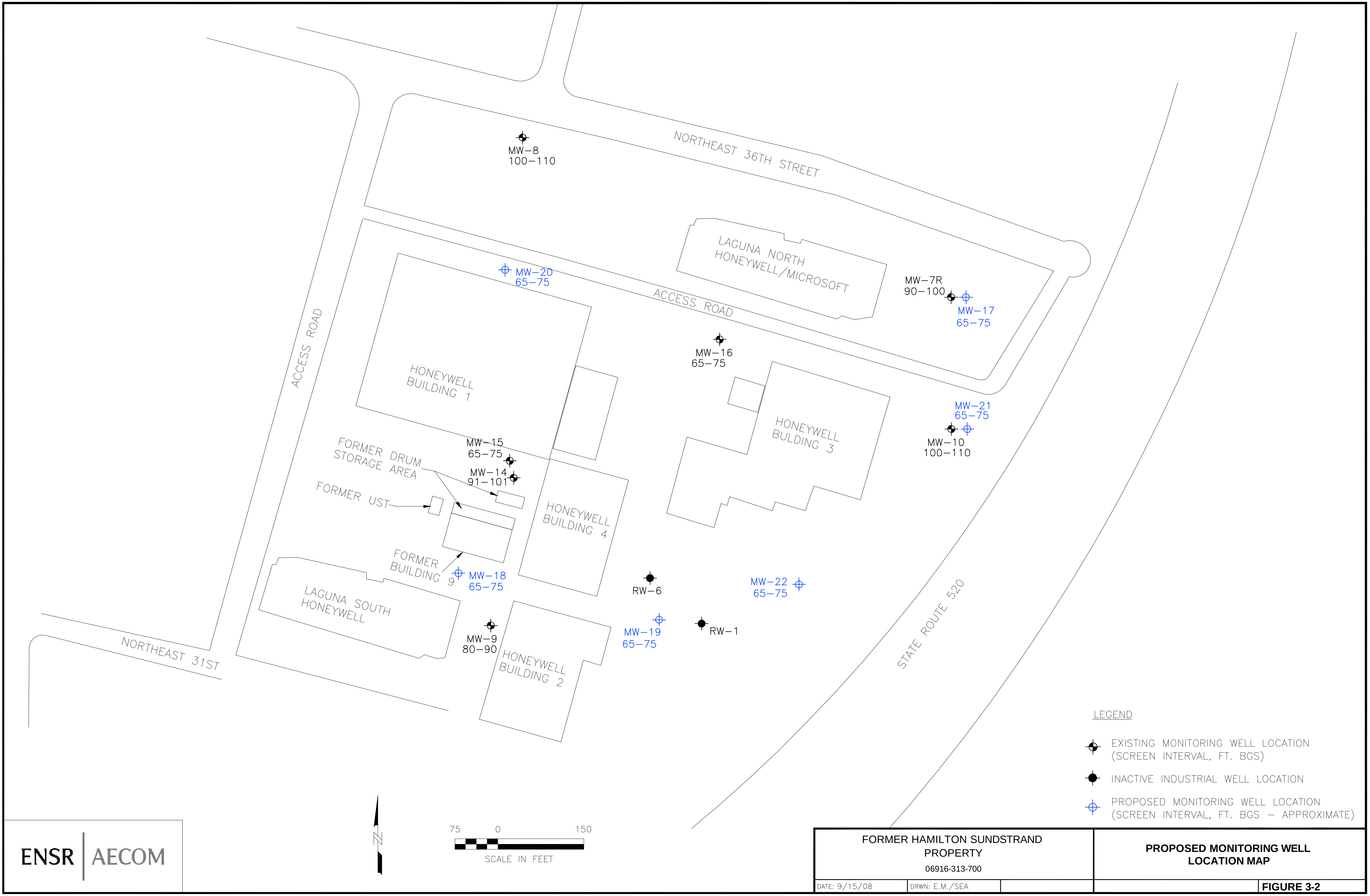
06916-313-600

DATE: 08/08/08 DRWN: E.M./SEA

CVOC DEGRADATION PROCESS

FIGURE 3-1

File: L:\Laguna\PROPOSED WELLS(b).dwg Layout: FIGURE 3-2 User: MarshallE Plotted: Sep 18, 2008 - 3:30pm Xref's:



ENSR | AECOM

FORMER HAMILTON SUNDSTRAND
PROPERTY
06916-313-700

**PROPOSED MONITORING WELL
LOCATION MAP**

DATE: 9/15/08
DRWN: E.M./SEA

FIGURE 3-2

Appendix A

ENSR Standard Operation Procedures

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Standard Operating Procedure

Chain-of-Custody Procedures

Procedure Number: 1007

Revision No.: 2

Revision Date: February 2008

SOP Contributors:

- Allen Bennett
- Linda Beran
- Don Boyé
- David Decourcy Bower
- Kristen Durocher
- Scott Ross
- Tony Sacco
- Caryn Spiak
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Debra L. Simmons
Debra L. Simmons, SOP Team Leader
Date: 2/8/08

Todd Schwendeman,
Stakeholder/Service Line Leader
Date: 2/18/08

Robert C. Weber
Robert C. Weber,
President and Chief Executive Officer
Date: 18 February 2008

Annual review of this SOP has been performed
and the SOP still reflects current practice.

Initials: ________ Date: ________
Initials: ________ Date: ________

Standard Operating Procedure

Chain-of-Custody Procedures

SOP No.: 1007
Revision: 2
Date: February 2008

Contents

Standard Operating Procedure

Chain-of-Custody Procedures

SOP No.: 1007
Revision: 2
Date: February 2008

1.0 Scope and applicability

1.1 Chain of custody (COC) is defined as the unbroken trail of accountability that ensures the physical security of samples, data, and records (EPA Glossary of Quality-Related Terms). This standard operating procedure (SOP) describes COC procedures applicable to environmental samples collected by ENSR during field sampling and analysis programs. Custody procedures within the laboratories analyzing the samples are not addressed.

1.2 Samples are physical evidence. The objective of COC procedures is to provide sufficient evidence of sample integrity to satisfy data defensibility requirements in legal or regulatory situations.

1.3 The National Enforcement Investigations Center (NEIC) of the U.S. Environmental Protection Agency (EPA) 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.

1.4 This SOP is to be utilized to conduct the work identified in the title of this SOP. In the event the Project Manager or Project Team determines that the protocols and procedures listed in this SOP are not applicable to the project, there is the option to either adapt this SOP or to develop a site-specific SOP to more closely match the requirements of the project. Refer to SOP 1011, Preparation and Control of Standard Operating Procedures, for SOP modification and Project Operating Procedure (POP) development procedures.

2.0 Health and safety considerations

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the site-specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the ENSR Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Interferences

The following may impact the legal or regulatory defensibility of the data:

- The samples are not accompanied by a COC form,
- The information recorded on the COC form is incomplete, inaccurate, or differs from the information recorded on the sample containers,

- The documentation of person-to-person transfer of sample custody is incomplete, or contains unexplained gaps in time,
- COC seals or tape were not applied, were not applied correctly, or were lost or removed, for sample coolers/packages being transported by a party other than the sample custodian.

4.0 Equipment and materials

4.1 The following materials are relevant to this procedure:

- COC Form (Figure 1)
- Sample labels
- COC tape or seal (Figure 2)
- Indelible pen or Sharpie™
- Clear plastic sealing tape

4.2 Materials identified in related SOPs may also be needed.

5.0 Procedures

5.1 Pre-sample collection activities

5.1.1 Some measurement methods require preparation of sample collection media or special treatment of sample containers prior to sample collection. In these cases, COC procedures should be initiated with the media preparation or container treatment. This requires that sample identification numbers or media/container identification numbers be assigned. These numbers should be entered on the COC form, leaving room for the subsequent recording of the associated sample numbers. In this variation, the custodian responsible for media preparation or container treatment has the responsibilities outlined in Section 5.2, and the sampler or field sample custodian has the responsibilities stated in Section 5.3 when he or she receives the prepared media or treated containers. There are a number of acceptable approaches to this variation, and the detailed procedures should be defined in the project-specific QAPP.

5.2 Sample collection phase

5.2.1 As few people as possible should handle the samples. For certain programs, it is helpful if a single person is designated as the sample custodian (the person responsible for the care and custody of the samples until they are transferred to the laboratory for analysis).

5.2.2 While in the field, sampling personnel should be able to testify that tampering of the samples could not occur without their knowledge. Examples of actions taken may include sealing the sample containers with COC tape or locking the samples in a secure area.

5.2.3 If samples are to be shipped by commercial overnight carrier, the field sampler or sample custodian completes a COC form (Figure 1) for each cooler/package of samples and places the original of completed form inside the associated cooler/package before the package is sealed (a copy is retained and kept in the field record files). Each completed COC form should accurately list the sample identification numbers of the samples with which it is packaged, and should contain the identification number of the COC tape on the cooler/package. Representatives of commercial carriers are not required to sign the COC form. Refer to ENSR SOP 7510 – Packaging and Shipment of Environmental Samples for specific packaging procedures.

5.2.4 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 transfers custody to the carrier by signing and dating each form in the "Relinquished By" section. The carrier then signs and dates each form in the adjacent "Received By" section. When the carrier transfers the samples to the laboratory, he or she signs and dates each form in the next "Relinquished By" section, and the laboratory sample custodian signs and dates each form in the adjacent "Received By" section.

5.2.5 If samples are transmitted to the laboratory by courier, the procedures described in either Section 5.2.3 or 5.2.4 are followed, depending on whether the courier is a commercial courier or laboratory representative, and whether the cooler has been secured by COC seals prior to pick up by a laboratory courier.

5.3 Sample labeling

5.3.1 Labeling of samples occurs at the time of sample collection.

5.3.2 Waterproof, adhesive labels are preferred. Labels should be applied to the container, not the lid whenever possible. Additional interior labels may be required for certain biological samples.

5.3.3 Sample tags may be required for certain projects requiring a strict level of legal or regulatory data defensibility. If tags are utilized, their use will be addressed in the project-specific work plan or QAPP.

5.3.4 Labels should be completed in waterproof, indelible ink. Covering the label with clear plastic tape is recommended to protect the legibility of the label and to prevent the label from detaching from the sample container.

5.3.5 The following information should be recorded on the sample label:

- Project identification (project name and number/client/site)
- Field sample identification code (exactly as it appears on the COC form)
- Sampler’s initials
- Date and time of sample collection
- Analyses requested
- Preservation

5.4 Documentation of sample history

5.4.1 Sample history includes, but is not limited to, preparation of sample containers or collection media (for example, wipes), collection, handling (such as subsampling or compositing), storage, shipment, analytical preparation and analysis, reporting, and disposal.

5.4.2 Refer to SOP 7515, Recording of Field Data, for specific guidance on documentation of field activities, field measurements, and sample collection.

5.5 Documentation of custody

5.5.1 It is recommended that a COC form (Figure 1 or equivalent) be initiated upon sample collection. If this is not feasible for a particular project, the COC form may be initiated at the time of sample packaging. If this is the case, the sample collection records will serve as the initial custody document and will document the collection of the sample (sample location and identification, date and time of collection, sampler, and parameters to be analyzed, including containers and preservatives).

5.5.2 The following information is recorded on the COC form:

- Project identification (ENSR project number, client, site name and location).
- Page number (for example, 1 of 2, 2 of 2).
- Field sample identification code. This code should be unique to the sampling event and to the program. This code should agree exactly with the field sample identification code recorded on the bottle label.
- Sampling point location (optional if recorded elsewhere in field records).
- Date and time of sample collection.
- Sample matrix (soil, water, air, etc.).
- Preservative.
- Analysis requested.
- Number of containers.
- Type of sample (grab or composite). Identifying if aqueous samples have been filtered in the field is recommended.
- Signature(s) of sampling personnel and signatures of all personnel handling, receiving, and relinquishing the samples.
- Date(s) and time(s) of each sample transfer.
- Sampler remarks. These comments may serve to alert the laboratory to highly contaminated samples or identify quality control (QC) sample requirements.
- Airbill number (if shipped by overnight commercial carrier).
- Laboratory name and address.
- COC tape numbers.

5.5.3 The COC is filled out completely and legibly in indelible ink. There should be no unexplained blank spaces. Blank lines should be lined out and initialed and dated.

5.5.4 Data will not obliterated. Corrections are made, if necessary, by drawing a single line through and initialing and dating the error. The correct information is then recorded with indelible ink.

5.5.5 Information on the COC should agree exactly with that recorded on the sample containers. Discrepancies may result in the samples being incorrectly logged into the laboratory or delays in initiating sample analysis.

5.6 Sample receipt and inspection

5.6.1 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.

5.6.2 Sample containers are removed from packing material and sample label information is verified against the COC form.

5.6.3 The condition upon receipt, including any discrepancies or problems, is documented and the COC form is completed by signing and recording the date and time of receipt.

5.6.4 Receipt and inspection of samples by subcontractor analytical laboratories will adhere to written procedures established by the laboratory.

6.0 Quality assurance / quality control

6.1 The records generated in this procedure are subject to review by the sampling team leader, project manager, or designee.

6.2 The records generated in this procedure will become a part of the evidence reviewed in the data validation process (see ENSR SOP 1009, Data Validation).

7.0 Data and records management

7.1 The records generated in this procedure are part of the permanent record supporting the associated measurements and may include, as applicable, the COC forms, sample tags, carrier waybills, and field and laboratory records of sample history (collection, handling, storage, analysis, etc.).

7.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) should be appropriately documented in the project records.

7.3 Records associated with the activities described in this SOP should be maintained according to the document management policy for the project.

8.0 Personnel qualifications and training

8.1 Qualifications and training

8.1.1 The individual executing these procedures should have read, and be familiar with, the requirements of this SOP.

8.1.2 No specialized skills are necessary in order to implement these procedures; however, an understanding of the concept of custody is useful.

8.2 Responsibilities

8.2.1 The project manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

8.2.2 The individual performing the work is responsible for implementing the procedures as described in this SOP and any project-specific work plans.

8.2.3 For certain sampling programs, the project manager, sampling team leader, or designee may assign an individual to serve as sample custodian. This individual is responsible for supervising the implementation of COC procedures in accordance with this SOP and any project-specific work plans or QAPP.

9.0 References

American Society for Testing and Materials (ASTM). 2004. Standard Guide for Sample Chain-of-Custody Procedures. D 4840-99 (Reapproved 2004).

ENSR SOP 1009 – Data Validation.

ENSR SOP 1011 – Preparation and Control of Standard Operating Procedures.

ENSR SOP 7510 – Packaging and Shipment of Environmental Samples.

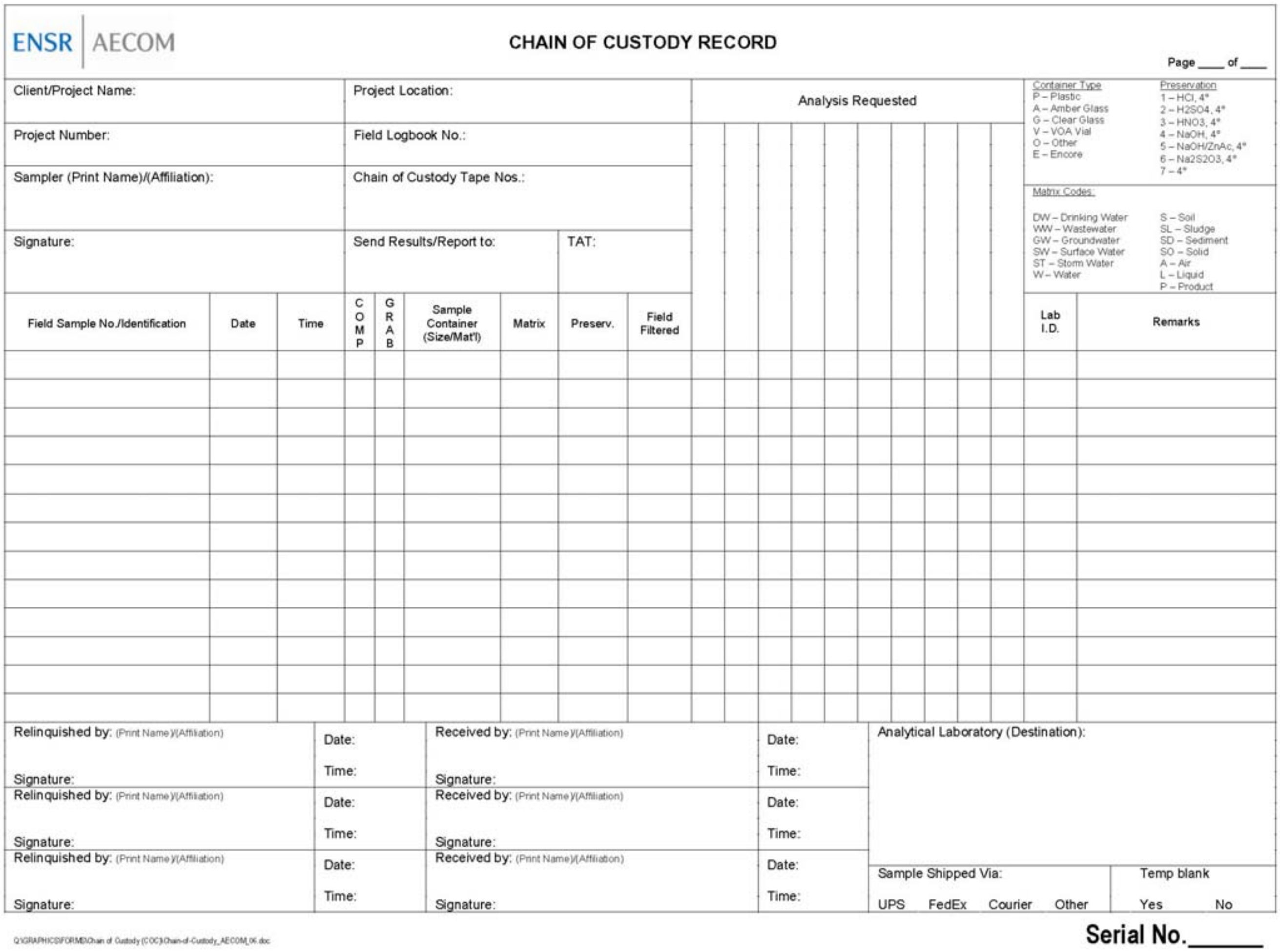
ENSR SOP 7515 – Recording of Field Data.

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

10.0 Revision history

Revision	Date	Changes
0	NA	NA
1	4th Quarter, 1994	Reformatted and expanded from SOP 010-010-601
2	February 2008	Complete rewrite and format update

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 Nos.:
Signature:
Send Results/Report to:
TAT:

Container Type
P – Plastic
A – Amber Glass
G – Clear Glass
V – VOA Vial
O – Other
E – Encore

Preservation
1 – HCl, 4°
2 – H2SO4, 4°
3 – HNO3, 4°
4 – NaOH, 4°
5 – NaOH/ZnAc, 4°
6 – Na2S2O3, 4°
7 – 4°

Matrix Codes:

DW – Drinking Water
WW – Wastewater
GW – Groundwater
SW – Surface Water
ST – Storm Water
W – Water

S – Soil
SL – Sludge
SD – Sediment
SO – Solid
A – Air
L – Liquid
P – Product

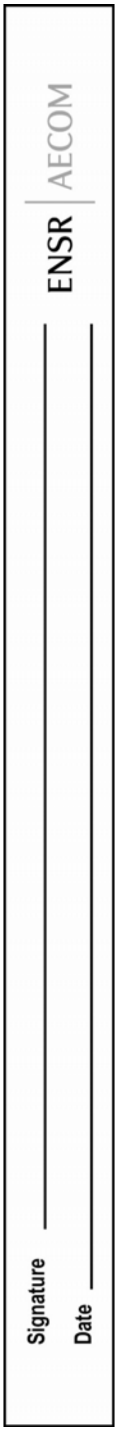
									Analysis Requested											
Field Sample No./Identification	Date	Time	C O M P	G R A B	Sample Container (Size/Mat'l)	Matrix	Preserv.	Field Filtered											Lab I.D.	Remarks

Relinquished by: (Print Name)/(Affiliation) Signature:	Date: Time:	Received by: (Print Name)/(Affiliation) Signature:	Date: Time:	Analytical Laboratory (Destination):
Relinquished by: (Print Name)/(Affiliation) Signature:	Date: Time:	Received by: (Print Name)/(Affiliation) Signature:	Date: Time:	
Relinquished by: (Print Name)/(Affiliation) Signature:	Date: Time:	Received by: (Print Name)/(Affiliation) Signature:	Date: Time:	Sample Shipped Via: UPS FedEx Courier Other Temp blank Yes No

Q:\GRAPHICS\FORMS\Chain of Custody (COC)\Chain-of-Custody_AECOM_06.doc

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

Original Signed

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

Original Signed

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

ENSR Corporation
January 23, 2008

SOP NUMBER: 7101

Water Level Measurements

Date: January 2008
Revision Number: 0.0
Page: 1 of 7

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. 7600 – 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. 7600 - 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. 7600 – 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.

ENSR

SOP NUMBER: 7115

Subsurface Soil Sampling by Split Spoon

Date:	3rd Qtr. 1994
Revision Number:	3
Author:	Charles Martin
Discipline:	Geosciencies

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) describes the methods used in obtaining subsurface soil samples for physical and/or chemical analysis. Subsurface soil samples are obtained in conjunction with soil boring programs and provide information as to the physical and/or chemical makeup of the subsurface environment.

The purpose of this SOP is to provide a description of a specific method or procedure to be used in the collection of subsurface soil samples. Subsurface soil is defined as unconsolidated material which may consist of one or a mixture of the following materials: sand, gravel, silt, clay, peat (or other organic soils), and fill material. Subsurface soil sampling, conducted in accordance with this SOP will promote consistency in sampling and provide a basis for sample representativeness.

This SOP covers subsurface soil sampling by split-spoon only, as this is the means most often used for obtained samples of unconsolidated deposits. Other types of equipment are available for use in subsurface soil sampling, including thin-wall tube samplers (Shelby tubes), piston samplers, and continuous core barrel samplers. Information on the use of these other sampling devices may be found in several available drilling handbooks and respective state and/or federal agency technical guidance documents. The American Society for Testing and Materials (ASTM) also provides procedures for use of split-spoon and other sampling devices.

Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.2 General Principles

Split-spoon subsurface soil sampling generally requires use of a drilling rig and typically the hollow-stem auger or other common drilling method to generate a borehole in which to use the split-spoon sampler. The split-spoon sampler is inserted through the augers (or other type of drill casing) then is driven into the subsurface soil with a weighted hammer. The sampler is then retrieved and opened to reveal the recovered soil sample. Soil samples may be collected at a continuous interval or at pre-selected vertically spaced intervals within the borehole.

1.3 Quality Assurance Planning Considerations

Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific Quality Assurance Project Plan (QAPP). Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements outlined in the QAPP typically suggest the collection of a sufficient quantity of field duplicate, field blank, and other samples.

1.4 Health and Safety Considerations

Subsurface soil sampling may involve chemical hazards associated with the types of contaminants potentially encountered and will always involve potential physical hazards associated with use of drilling equipment. When sampling is performed in materials which may contain hazardous constituents, or when the quality assurance objectives of the project require the use of hazardous solvents, adequate Health and Safety measures must be taken to protect sampling personnel. These measures must be addressed in the project Health and Safety Plan (HASP). This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing sampling, and must be adhered to as field activities are performed.

2.0 RESPONSIBILITIES

2.1 Drilling Subcontractor

It will be the responsibility of the drilling subcontractor to provide the necessary materials for obtaining subsurface soil samples. This generally includes one or more split-spoon samplers in good operating condition and sample containers used for stratigraphic characterization samples (sample containers for environmental samples should be provided by the designated analytical laboratory). It is the drilling subcontractor's responsibility to provide and maintain their own boring logs if desired. Equipment decontamination materials should also be supplied by the subcontractor and should meet project specifications.

2.2 Project Geologist/Sampling Engineer

It will be the responsibility of the project geologist/sampling engineer to conduct subsurface soil sampling in a manner which is consistent with this SOP. The project geologist/sampling engineer will observe all activities pertaining to subsurface soil sampling to ensure that the SOP is followed, and to record all pertinent data onto a boring log. It is also the project geologist/sampling engineer's responsibility to indicate the specific targeted sampling depth or sampling interval to the drilling subcontractor. The project geologist/sampling engineer is also responsible for the collection of representative environmental or stratigraphic characterization samples once the sampling device has been retrieved and opened. Additional sample collection responsibilities include labeling, handling, and storage of samples until further chain-of-custody procedures are implemented.

3.0 REQUIRED MATERIALS

In addition to those materials provided by the subcontractor, the project geologist/sampling engineer will require:

- Project Sampling Plan, QAPP, and HASP
- Boring logs
- Teaspoon or spatula (stainless steel is recommended)
- Sample kit (bottles, labels, custody records and tape, cooler)
- Sample collection pen
- Folding rule or tape measure
- Equipment decontamination materials
- Health and safety equipment (as required by HASP)
- Field project notebook/pen

4.0 METHOD

4.1 General Method Description

Split-spoon sampling devices are typically constructed of steel and are most commonly available in lengths of 18 and 24 inches and diameters of 1.5 to 3 inches. The split-spoon consists of a tubular body with two halves that split apart lengthwise, a drive head on the upper end with a ball-check valve for venting, and a hardened steel cutting shoe at the bottom. The soil sample enters the split-spoon through the cutting shoe as the device is driven into the ground. A replaceable plastic or metal basket is often inserted into the shoe to assist with retaining samples. Once the sampler is retrieved, the drive head and cutting shoes are removed and the split-spoon halves are then separated, revealing the sample.

Sample depth intervals are usually defined on a project-specific basis with these requirements specified in the project sampling plan. Sampling intervals typically range from one (1) sample per five (5) feet of drilling to continuous sampling where the entire drilled interval is sampled.

Subsurface soil sampling is usually accomplished as part of a drilling program where a soil boring is advanced with drilling equipment to the designated depth prior to collection of a representative sample. The general procedures outlined briefly in the following section provide requirements for advancing drill casing/augers in preparation for sampling.

4.2 General Procedures - Borehole Preparation

4.2.1 Advancing Casing/Augers

Soil borings that are completed for soil sampling purposes are typically advanced using hollow-stem augers and sometimes drive-and-wash or other casing methods. The casing/augers must be of sufficient diameter to allow for soil sampling at a minimum. The casing/augers will be advanced according to project requirements to the required depth for sampling. If hollow-stem augers are used, a temporary plug shall be used in the lead auger to prevent the auger from becoming filled with drill cuttings while drilling is in progress.

4.2.2 Obstructions

For those borings which encounter obstructions, the casing/augers will be advanced past or through the obstruction if possible. Caution should be exercised when obstructions are encountered and an effort made to identify the obstruction before drilling is continued. If the obstruction is not easily drilled through or removed, the boring should be relocated to an adjacent location.

4.2.3 Use of Added Water

The use of added or recirculated water during drilling is permitted when necessary. Use of extraneous water should be minimized or avoided if possible as it may impact sample quality. Water usage should be documented in the field notebook. Sampling and analysis of added or recirculated water may be required for quality assurance purposes (refer to QAPP). If a well is installed within the completed borehole, removal of the added water may be required.

4.3 Sampling Procedure

4.3.1 Equipment Decontamination

Each split-spoon must be decontaminated prior to its initial use and following collection of each soil sample. Site-specific requirements for equipment decontamination should be outlined within the Project Sampling Plan. Equipment decontamination procedures are also outlined within SOP 7600 - Decontamination of Equipment.

4.3.2 Standard Penetration Test

The drilling subcontractor will lower the split-spoon into the borehole. Samples are generally obtained using the Standard Penetration Test (SPT) in accordance with ASTM standards (ASTM D 1586-84). Following this method, the sampler will be driven using the 140-pound hammer with a vertical free drop of 30 inches using two turns of the rope on the cathead. The number of hammer blows required for every 6 inches of penetration will be recorded on the boring log. Blowcount information is used as an indicator of soil density for geotechnical as well as stratigraphic logging purposes. Once the split-spoon has been driven to its fullest extent, or to refusal, it will be removed from the borehole.

4.3.3 Sample Recovery

The split-spoon will be immediately opened upon removal from the casing/auger. The open sampler shall then be screened for volatile organics with a photoionization device (PID) if required by the Project Sampling Plan. If the Sampling Plan also requires individual soil sample headspace screening for volatile organic compounds, then a small portion of the split-spoon sample shall be removed and properly contained for that purpose.

Sample recovery will be determined by the project geologist/sampling engineer who will examine the soil core once the sampler is opened. The length of sample shall then be measured with a folding rule or tape measure. Any portion of the split-spoon contents which are not considered part of the true sample (i.e., heaved soils) will be discarded. If the sample recovery is considered inadequate for sample characterization or analytical testing purposes, another sample should be collected from the next vertical interval if possible before drilling is reinitiated.

Adequate sample recovery for stratigraphic logging purposes and/or headspace organic vapor testing purposes should be approximately 6 inches. Adequate sample recovery for analytical testing purposes should be a minimum of 12 inches and is somewhat dependent on the type of analytical testing required. In some cases, continuous sampling over a short interval, and compositing of the sample, may be required to satisfy analytical testing requirements. Larger diameter samplers may be used if large volumes of soil are required for analytical testing.

4.3.4 Sample Containment - General

Once retrieved, the sample will be removed from the split-spoon with a teaspoon or spatula and placed into the appropriate sample container. The sample will be split if necessary to meet sampling program requirements. Sample splitting may be necessary to provide individual samples for headspace testing, visual characterization, physical testing, analytical testing, or simply for archiving purposes. In general, most sampling programs are structured around environmental characterization needs; therefore, sample portions required for analytical testing should be collected first. The Project Sampling Plan and QAPP provides specific sample container requirements for each type of sample and should be referred to for guidance.

Once filled, the sample containers should be properly capped, cleaned, and labeled, and chain-of-custody and sample preservation procedures initiated. Sampling equipment should then be properly decontaminated.

4.3.5 Sample Containment - Volatile Organic Analyses

Collection of subsurface soil samples for volatile organic analysis (VOA) is slightly more complex than collection of samples for other routine chemical or physical testing primarily because of the concern for the potential loss of volatiles during the sample collection procedure. To limit the potential for loss of volatiles, the soil sample needs to be obtained as quickly and as directly as possible from the split-spoon. This generally means that the VOA sample is to be collected and placed into the appropriate sample container first. The VOA sample should also be obtained from a discrete portion of the entire sample interval and not composited or homogenized. The remainder of the recovered sample can then be composited, homogenized or split to meet the other testing requirements. The boring log and/or sample logbook should be filled out to indicate actual sample collection depths for both VOA samples and other portions of the sample which may have been composited over a larger vertical interval.

5.0 QUALITY CONTROL

Quality control requirements are dependent on project-specific sampling objectives. The QAPP will provide requirements for sample preservation and holding times, sample container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

6.0 DOCUMENTATION

Various forms are required to ensure that adequate documentation is made of sample collection activities. These forms include:

- Boring logs
- Field log books
- Sample collection records
- Chain-of-custody records
- Shipping labels

Boring logs (Figure 1) will provide visual and descriptive information for each sample collected and are often the most critical form of documentation generated during a sampling program. The field log book is kept as a general log of activities. Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes. Shipping labels are required if sample coolers are to be transported to the laboratory by a third party (courier service). Original copies of these records should be maintained in the appropriate project files.

7.0 REFERENCES

ASTM D 1586-84

Figure 1

R:\pubs\mw97\SOPs\7115\fig-1.doc

Sheet 1 of __

BORING LOG

Project No. ____________ Date – Start ________ Finish ________ Boring ______________

Project Name ______________________ Drilling Co. ______________________

Location ______________________ Drilling Method ______________________

Total Depth __________ Inspector __________ Reviewer ______________________

Remarks ____

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 in.	Depth Range	Rec.			

SOP NUMBER: 7121

Field and Laboratory Measurement of pH

Date: July 1998
Revision Number: 0
Author: Lori Fuller
Discipline: Water

1.0 INTRODUCTION

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) provides basic instructions for routine calibration and operation of a variety of pH meters, including the Hydrolab, Hydac Multimeter Probe, Orion SA 230, YSI Model 3500, and Horiba U-10. Although these meters may measure additional parameters (e.g., temperature, specific conductivity, etc.), this SOP addresses pH measurement only (other capabilities are outlined in the appropriate SOP and manufacturer's individual instrument manuals). This SOP is designed specifically for the measurement of pH in accordance with EPA Method 150.1 and Standard Method 4500-H B which address electrometric pH measurements of drinking, surface, and saline waters, domestic and industrial wastes, and acid rain.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan and/or Quality Assurance Project Plan (QAPP), hereafter referred to as the project plan, or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory analyses.

1.3 Health and Safety Considerations

The health and safety considerations for the laboratory or site, including both potential physical and chemical hazards, will be addressed in the site-specific Health and Safety Plan (HASP) or the laboratory QAM. In the absence of a site-specific HASP, work will be conducted according to the ENSR Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

2.0 RESPONSIBILITIES

2.1 The analyst is responsible for verifying that the pH meter is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOP and the project plan.

2.2 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.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- pH meter
- pH meter manufacturer's instruction manual
- Deionized water
- Clean glass or plastic beakers or cups
- 4.0, 7.0, and 10.0 buffer solutions
- Magnetic stirrer and Teflon-coated stirring bar
- Lint-free tissues
- Mild detergent and/or 10% hydrochloric acid (for use if samples contain oily material or particulate matter)
- National Institute of Standards and Technology (NIST)-traceable thermometer
- Calibration sheets
- Laboratory or field data sheets or logbooks

4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

4.1.1 To achieve accurate pH measurements, samples should be analyzed in the field (preferably within 15 minutes), or as soon as possible after collection. Sample should be collected in plastic or glass containers.

4.1.2 After measuring a sample containing oily material or particulate matter, the electrode must be cleaned by carefully wiping with a lint-free cloth, or washing gently in a mild detergent, followed by a deionized water rinse. If this does not suffice, an additional rinse with 10% hydrochloric acid (followed by deionized water) may be needed.

4.1.3 As temperature can affect the pH measurements obtained, both the pH and the temperature of the sample must be recorded.

4.1.4 Calibration must include a minimum of two points that bracket the expected pH of the samples to be measured. An example of a calibration sheet is presented in Figure 1.

4.1.5 Primary standard buffer salts available from NIST can be purchased and are necessary for situations where extreme accuracy is required. Secondary standard buffers may be purchased as a solution from commercial vendors and are recommended for routine use. Buffers should not be used after their expiration dates as provided by the manufacturer. If the manufacturer does not supply an expiration date or if the buffers are prepared from pH powder pillows, etc., an expiration date of one year from purchase or preparation should be used. All standards must be labeled with manufacturer, lot number, and expiration date.

4.1.6 When using the meter in the laboratory, always place the buffer/sample beaker on the magnetic stirrer, and make sure the stirring bar is rotating during measurements. Rinse the stirring bar as well as the beaker between buffers/samples. CAUTION: The magnetic stirring plate can generate heat when used for an extended period of time, and lead to increased temperature of the buffers/samples.

EXCEPTION: Do not use the magnetic stirrer for acid rain samples. It is crucial not to induce dissolved gases into the sample to be absorbed or desorbed, as this will alter the pH. Stir the sample gently for a few seconds after introducing the electrode, then allow the electrode to equilibrate prior to recording temperature and pH readings.

4.1.7 When the meter is being used in the field, move the probe in a way that creates sufficient sample movement across the sensor; this insures homogeneity of the sample and suspension of solids. If sufficient movement has occurred, the readings will not drift (<0.1 pH units). Rinse the electrode with deionized water between samples and wipe gently with a lint-free tissue.

4.1.8 When measuring the pH of hot liquids, wait for the liquid to cool to 160°F or below.

4.1.9 Fluctuating readings may indicate more frequent instrument calibrations are necessary.

4.1.10 A "low sodium error" electrode may be used for samples with a pH greater than 10, to reduce sodium error.

4.2 Calibration and Measurement Procedures

4.2.1 The pH meter must be calibrated daily before any analyses are performed. The meter should be recalibrated every 12 hours or at the frequency specified in the project plan.

4.2.2 Connect the electrode to the meter. Choose either 7.0 and 10.0 (high range) or 4.0 and 7.0 (low range) buffers, whichever will bracket the expected sample range. Place the buffer in a clean beaker. If the pH is being measured in a laboratory, place the beaker on the magnetic stirrer and place the stirring bar in the beaker. Measure and record the temperatures of the buffers using a calibrated thermometer or automatic temperature compensation (ATC).

4.2.3 Place the electrode into the 10.0 buffer or into the 7.0 buffer. (The calibration procedure described here begins with the buffer of the highest pH selected. The instrument manufacturer’s calibration instructions may suggest starting with the buffer of the lowest pH selected).

4.2.4 Adjust the instrument calibration according to the manufacturer's instructions. Discard the buffer and rinse the beaker and stirring bar thoroughly with deionized water.

4.2.5 Refill the beaker with the 7.0 buffer or the 4.0 buffer. Rinse the electrode, gently wipe it with a lint-free tissue, and place it in the selected buffer solution. If the pH is being measured in a laboratory, place the beaker on the magnetic stirrer and place the stirring bar in the beaker. Continue adjusting the instrument calibration according to the manufacturer's instructions. Record the electrode slope (if provided by the instrument) on the calibration sheet (an acceptable slope is between 92 and 102 percent). Measure and record the temperature of the buffer using a calibrated thermometer or ATC. Discard the buffer and rinse the beaker and stirring bar thoroughly with deionized water.

4.2.6 An additional check may be performed, if required by the project plan, by placing the electrode into an additional buffer solution. This buffer should be from a different source than the buffers used for the initial calibration. This buffer should read within +0.2 pH units of the buffer's true pH value.

4.2.7 Verify the calibration every 15 samples and after the last sample of the day with a buffer solution prepared from a different source than that used for initial calibration. Recalibrate the instrument if the check value varies more than 0.2 pH units from the true value.

4.2.8 The electrode will be rinsed with deionized water and wiped gently with a lint-free tissue between sample analysis.

4.2.9 Recalibrate the instrument if the buffers do not bracket the pH of the samples.

4.2.10 The meter must be recalibrated following any maintenance activities and prior to the next use.

4.3 Troubleshooting Information

If there are any performance problems with the pH meter which result in inability to achieve the acceptance criteria presented in Section 5.0, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

4.4.1 Instrument maintenance should be performed according to the procedures and frequencies required by the manufacturer.

4.4.2 The electrode must be stored and maintained according to the manufacturer's instructions.

4.4.3 If an instrument with ATC is being used, the device should be checked on a quarterly basis for accuracy with an NIST thermometer.

5.0 QUALITY CONTROL

5.1 Duplicate measurements of a single sample will be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within +0.1 pH units.

5.2 The temperature readout of the meter will be checked annually against an NIST-traceable thermometer. If the difference is greater than 0.2°C, the instrument manufacturer will be consulted for instructions. Temperature measurements will be compensated for any difference with the reference thermometer.

5.3 Some regulatory agencies may require the analysis of USEPA Water Supply (WS) or Water Pollution (WP) performance evaluation (PE) samples. These PE samples will be analyzed as required.

6.0 DOCUMENTATION

6.1 All pH meter calibration, temperature check, and maintenance information will be recorded on a daily calibration sheet (Figure 1) or equivalent. pH data may be recorded on the appropriate laboratory or field data sheets or logbooks.

6.2 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 buffer solutions
- Reading for pH 7.0 buffer before and after meter adjustment
- Reading for pH 4.0 or 10.0 buffer before and after meter adjustment
- Readings for all continuing calibration checks
- Temperature of buffers (corrected for any difference with reference thermometer), including units
- Slope reading (if provided by instrument)
- Comments

6.3 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
- Temperature (corrected for any difference with reference thermometer) and pH of sample (including units and duplicate measurements)
- Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform pH 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.

Certain state certification programs require that pH measurements in the field be taken by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

APHA-AWWA-WPCF. Standard Methods for the Examination of Water and Wastewater, 17th Edition. 1989.

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

Figure 1 Sample of Instrument Calibration Sheet

Water Quality Instrument Calibration

Parameter	Instrument		Standard		Standard Value @25°C	Ambient Temp °C/°F	Initial Measured Value	Adjusted Measured Value	Initials Date/Time	Remarks
	Manuf/Model	Serial No.	Manuf/Lot No.	Exp. Date						

All measured values must be corrected for temperature unless the instrument is operated in the ATC mode. DO measurements must also be corrected for barometric pressure.

Temp conversion: °C = 5/9(°F-32)

SOP NUMBER: 7124

Field and Laboratory Measurement of Specific Conductance

Date: July 1998
Revision Number: 0
Author: Lori Fuller
Discipline: Water

1.0 INTRODUCTION

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) provides basic instructions for routine calibration and operation of a variety of specific conductance meters, including the Hydrolab, Hydac Multimeter Probe, YSI Model 3500, Coastal Microqual, Horiba U-10 and Seabird 911 CTD. Although these meters may measure additional parameters (e.g., temperature, pH, etc.), this SOP addresses specific conductance measurement only (other capabilities are outlined in the appropriate SOP and manufacturer's individual instrument manuals). This SOP is designed specifically for the measurement of specific conductance in accordance with EPA Method 120.1 and Standard Method 2510 B which addresses specific conductance measurements of drinking, surface, and saline waters, domestic and industrial wastes, and acid rain.

1.2 Quality Assurance Planning Considerations

The end use of the data will determine the quality assurance requirements that are necessary to produce data of acceptable quality. These quality assurance requirements will be defined in the site-specific workplan and/or Quality Assurance Project Plan (QAPP), hereafter referred to as the project plan, or laboratory Quality Assurance Manual (QAM) and may include duplicate or replicate measurements or confirmatory analyses.

1.3 Health and Safety Considerations

The health and safety considerations for the laboratory or site, including both potential physical and chemical hazards, will be addressed in the site-specific Health and Safety Plan (HASP) or the laboratory QAM. In the absence of a site-specific HASP, work will be conducted according to the ENSR Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

2.0 RESPONSIBILITIES

2.1 The analyst is responsible for verifying that the specific conductance meter is in proper operating condition prior to use and for implementing the calibration and measurement procedures in accordance with this SOP and the project plan.

2.2 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.

3.0 REQUIRED MATERIALS

The following materials are necessary for this procedure:

- Specific conductance meter
- Specific conductance meter manufacturer's instruction manual
- Deionized water
- Clean glass beakers or plastic cups
- Potassium chloride (KCl) solution, 0.01M, for determination of cell constant (0.5M KCl for saline water measurements)
- KCl standard at concentration that approximates sample concentrations
- Lint-free tissues
- National Institute of Standards and Technology (NIST)-traceable thermometer
- Calibration sheets
- Laboratory or field data sheets or logbooks

4.0 4.0 METHOD

4.1 Sample Handling, Preservation, and General Measurement Procedures

4.1.1 Specific conductance measurements should be taken soon after sample collection since temperature changes, precipitation reactions, and absorption of carbon from the air can affect the specific conductance. If specific conductance measurements cannot be taken immediately (within 24 hours), samples should be filtered through a 0.45 μ filter, stored at 4^{o}C and analyzed within 28 days.

4.1.2 Report results as specific conductance, μmhos/cm at 25^{o}C.

4.1.3 As temperature can affect the specific conductance measurements obtained, record both the specific conductance and the temperature of the sample.

4.1.4 Secondary standards may be purchased as a solution from commercial vendors. These standards should not be used after their expiration dates as provided by the manufacturer. If the manufacturer does not supply an expiration date or if the standards are prepared from various salts (e.g., KCl), an expiration date of one year from purchase or preparation should be used. All standards must be labeled with manufacturer, lot number, and expiration date.

4.2 Calibration and Measurement Procedures

4.2.1 The specific conductance meter must be calibrated daily (or the calibration checked) before any analyses are performed. However, certain oceanographic instruments such as the Seabird 911 CTD and the Coastal Microqual, which, because of their sensitivity, are calibrated only by the manufacturer (at their specified frequency).

4.2.2 Set up the instrument according to the manufacturer's instructions.

4.2.3 Rinse the probe with deionized water and dry with a lint-free tissue.

4.2.4 Repeat the above procedure for the beakers or cups.

4.2.5 Pour a sufficient amount of the KCl standard (preferably at a concentration that approximates the sample concentrations) into the beaker or cup to cover the probe.

4.2.6 Immerse the probe in the standard.

4.2.7 Record the stabilized specific conductance reading of the standard and the temperature. Adjust the instrument reading (according to the manufacturer's instructions) to display the correct value of the standard. If the meter cannot be adjusted to display the correct value of the standard, the standard should read within 5% of the true value. If the meter reading is between 5% and 15% of the true value, calculate the cell constant using the formula below and correct all subsequent meter readings.

$$\textbf{Cell Constant} = \frac{\textbf{0.01M or 0.5M KCl Standard Conductance}}{\textbf{Conductance Meter Reading}}$$

If the meter reading exceeds the reference standard by greater than 15%, replace the instrument. If the meter does not have automatic temperature compensation (ATC), correct all measurements to 25°C by adding 2% of the reading per degree if the temperature is below 25°C and by subtracting 2% of the reading per degree if the temperature is above 25°C.

4.2.8 An additional check may be performed, if required by the project plan, by placing the probe into an additional KCl standard. This standard should be from a different source than the standard used for the initial calibration. This standard should read within 5% of the true value. Clean and rinse probe and cup as in Sections 4.2.3 and 4.2.4.

4.2.9 Verify the calibration every 15 samples and at the end of the day. Recalibrate or replace the instrument if the check value is not within 15% of the true value.

4.2.10 The probe will be rinsed with deionized water and wiped gently with a lint-free tissue between sample analyses.

4.2.11 The meter must be recalibrated following any maintenance activities and prior to the next use.

4.2.12 Conductivity meters designed for *in situ* field measurement will be deployed in accordance with the manufacturer's instruction manual. For water-column profiling operations the sensor readings will be recorded manually in a designated field logbook or continuously through the use of a computer. An internal data-logger will be used for recording sensor measurements during moored deployment of a sensor. The frequency of data recording will be specified in the project plan. The location, date, and time of sensor deployment, along with depth (of measurement or mooring) will be recorded in conjunction with the DO sensor data. Additional documentation requirements are listed in Section 6.0.

4.2.13 Conductivity data may be post calibrated using any of a variety of calibration data including, but not limited to field calibration points, manufacturer calibration data, and analytical results from samples collected during field deployment of the sensors. The decision criteria for post-calibration, and the technique used will be specified in the project plan, and will be consistent with the manufacturer's recommendations.

4.3 Troubleshooting Information

If there are any performance problems with the specific conductance meter which result in inability to achieve the acceptance criteria presented in Section 5.0, consult the appropriate section of the meter instruction manual for the checkout and self-test procedures. If the problem persists, consult the manufacturer's customer service department immediately for further instructions.

4.4 Maintenance

4.4.1 Instrument maintenance should be performed according to the procedures and frequencies required by the manufacturer.

4.4.2 The probe must be stored and maintained according to the manufacturer's instructions.

4.4.3 If an instrument with ATC is being used, the meter should be checked annually for accuracy with an NIST thermometer.

5.0 QUALITY CONTROL

5.1 The meter must be calibrated daily before use and recalibrated every 12 hours, and will not be used for sample determinations of specific conductance unless the initial check standard value is within 5% of the true value.

5.2 Oceanographic instruments will be calibrated every 6 months in the manufacturer's laboratory using the functional relationship between salinity and conductance, temperature and pressure as defined by the Practical Salinity Scale of 1978 (PSS-78). Post-cruise calibration records received from the manufacturer will be used to post calibrate field data.

5.3 Duplicate measurements of a single sample may be performed at the frequency specified in the project plan. In the absence of project-specific criteria, duplicate measurements should agree within 10%.

5.4 The temperature readout of the meter will be checked against an NIST-traceable thermometer at least quarterly. If the difference is greater than 0.2°C, the instrument manufacturer will be consulted for instructions. Temperature measurements will be compensated for any difference with the reference thermometer.

5.5 Some agencies may require the analysis of USEPA Water Pollution (WP) performance evaluation (PE) samples. These PE samples will be analyzed as required.

6.0 DOCUMENTATION

6.1 All specific conductance meter calibration, temperature check, and maintenance information will be recorded on the daily calibration sheet. (An example is presented as Figure 1). Specific conductivity data may be recorded on the appropriate laboratory or field data sheets or logbooks.

6.2 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 standard before and after meter adjustment
- Readings for all continuing calibration checks
- Temperature of standards (corrected for any difference with reference thermometer)
- Cell constant value
- Comments

6.3 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
- Temperature (corrected for any difference with reference thermometer) and conductance of sample (including units and duplicate measurements) Note: show all calculations for converting instrument reading to μmhos/cm if the instrument provides readings in any other units. Useful conversions are: 1 mS/m = 10 μmho/cm or 1 μmho/cm = 0.1 mS/m.
- Comments

7.0 TRAINING/QUALIFICATIONS

To properly perform specific conductance 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.

Certain state certification programs require that specific conductance measurements be taken in the field by, or in the presence of, personnel that are qualified under the certification program.

8.0 REFERENCES

APHA-AWWA-WPCF. Standard Methods for the Examination of Water and Wastewater, 17th Edition. 1989.

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

Figure 1 Example of Instrument Calibration Sheet

Water Quality Instrument Calibration

Parameter	Instrument		Standard		Standard Value @25°C	Ambient Temp °C/°F	Initial Measured Value	Adjusted Measured Value	Initials Date/Time	Remarks
	Manuf/Model	Serial No.	Manuf/Lot No.	Exp. Date						

All measured values must be corrected for temperature unless the instrument is operated in the ATC mode. DO measurements must also be corrected for barometric pressure.

Temp conversion: °C = 5/9(°F-32)

ENSR | AECOM

Field Measurement of Turbidity

SOP Number 7125

Revision Number: 0.0

January 2008

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SOP NUMBER: 7125

Field Measurement of Turbidity

Date: January 2008
Revision Number: 0.0
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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).

1. 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, 17th 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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January 23, 2008

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January 23, 2008

Groundwater Sample Collection From Monitoring Wells

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

<u>General</u>

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

d. Acceptance criteria pass/fail	Yes	No	N/A
Has required volume been removed	☐	☐	☐
Has required turbidity been reached	☐	☐	☐
Have parameters stabilized	☐	☐	☐

(continued on back)

If no or N/A - Explain below.

____

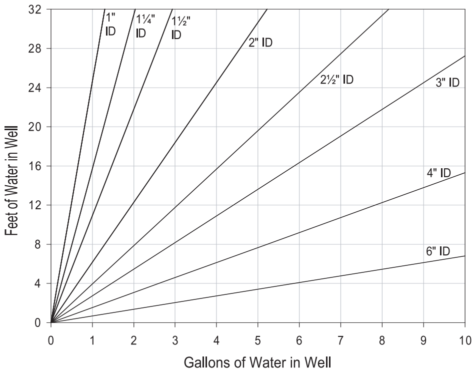
3. SAMPLE COLLECTION: Method: ____________

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

SOP NUMBER: 7220

Monitoring Well Construction and Installation

Date: 3rd Qtr., 1995
Revision Number: 4
Author: Charles Martin
Discipline: Geosciences

1.0 PURPOSE AND APPLICABILITY

1.1 Purpose and Applicability

This SOP provides guidance for installing groundwater monitoring wells. Monitoring wells are installed to monitor the depth to groundwater, to measure aquifer properties, and to obtain samples of groundwater for chemical analysis.

This SOP is applicable to installation of single monitoring wells within a borehole. The construction and installation of nested, multilevel or other special well designs is not covered within this SOP as these type of wells are not frequently constructed. This SOP applies to both overburden and bedrock monitoring wells.

Some states and EPA Regions have promulgated comprehensive guidelines for monitoring well construction and for subsurface investigation procedures. Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.2 General Principles

Monitoring well construction and installation generally involves drilling a borehole using conventional drilling equipment, installing commercially available well construction and filter/sealing materials, and development of the well prior to sampling. This SOP covers well construction and installation methods only. Borehole drilling and well development methods are covered under SOP-7115 (Subsurface Soil Sampling) and SOP-7221 (Monitoring Well Development), respectively.

1.3 Quality Assurance Planning Considerations

Field personnel should follow specific quality assurance guidelines as outlined in the site-specific QAPP.

The following aspects of monitoring well design and installation procedures depend on project-specific objectives which should be addressed in the QAPP and in the project work plan:

- Borehole drilling method and diameter,
- Type of construction materials for well screen, riser, filter pack and seals,
- Diameter of well materials,
- Length of well screen,
- Location, thickness, and composition of annular seals, and
- Well completion and surface protection requirements.

1.4 Health and Safety Considerations

Monitoring well installation may involve chemical hazards associated with materials in the soil or groundwater being investigated; and always involves physical hazards associated with drilling equipment and well construction methods. When wells are to be installed in locations where the aquifer and/or overlying materials may contain chemical hazards, a Health and Safety Plan (HASP) must be prepared and approved by the Health and Safety Officer before field work commences. This plan must be distributed to all field personnel and must be adhered to as field activities are performed.

2.0 RESPONSIBILITIES

2.1 Drilling Subcontractor

It is the responsibility of the drilling subcontractor to provide the necessary equipment for well construction and installation. Well construction materials should be consistent with project requirements.

2.2 Surveying Subcontractor

It is the responsibility of the surveying subcontractor to provide one or more of the following well measurements as specified in the project work plan: ground surface elevation, horizontal well coordinates, top of well casing elevation (i.e., top-of-casing, or measuring point elevation), and/or top of protective casing elevation.

2.3 Project Geologist/Engineer

It is the responsibility of the Project Geologist/Engineer to directly oversee the construction and installation of the monitoring well by the drilling subcontractor to ensure that the well-installation specifications defined in the project work plan are adhered to, and that all pertinent data are recorded on the appropriate forms.

2.4 Project Manager

It is the responsibility of the Project Manager to ensure that each project involving monitoring well installation is properly planned and executed.

3.0 REQUIRED MATERIAL

3.1 Well Construction Materials

Well construction materials are usually provided by the drilling subcontractor and most often consist of commercially available flush-threaded well screen and riser pipe constructed of PVC or stainless steel with a minimum 2-inch inside diameter. The length of the screen and the size of the screen slots should be specified in the project work plan.

3.2 Well Completion Materials

Well completion materials include silica sand, bentonite, cement, protective casings and locks. Completion materials are generally provided by the drilling subcontractor.

3.3 Other required materials include the following:

- Potable water supply
- Fiberglass or steel measuring tape
- Water level indicator
- Well construction diagrams (Figure 1)
- Waterproof marker or paint (to label wells)
- Health and Safety supplies

- Equipment decontamination materials
- Field project notebook/pen

4.0 METHOD

4.1 General Preparation

4.1.1 Borehole Preparation

Standard drilling methods should be used to achieve the desired drilling/well installation depths specified in the project work plan. Soil sampling, if conducted, should be conducted in accordance with ENSR SOP-7115 (Subsurface Soil Sampling).

The diameter of the borehole must be a minimum of 2 inches greater than the outside diameter of the well screen or riser pipe used to construct the well. This is necessary so that sufficient annular space is available to install filter packs, bentonite seals, and grout seals. Bedrock wells may require reaming after coring in order to provide a large enough borehole diameter for well installation.

Rotary drilling methods requiring bentonite-based drilling fluids, if selected, should be used with caution to drill boreholes that will be used for monitoring well installation. The bentonite mud builds up on the borehole walls as a filter cake and permeates the adjacent formation, potentially reducing the permeability of the material adjacent to the well screen.

If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids should be obtained and analyzed for chemical constituents that may be of interest at the site. In addition, an attempt should be made to recover the quantity of fluid or water that was introduced, either by flushing the borehole prior to well installation and/or by overpumping the well during development.

4.1.2 Well Material Decontamination

Although new well materials (well screen and riser pipe) generally arrive at the site boxed and sealed within plastic bags, it is sometimes necessary to decontaminate the materials prior to their use. Well materials should be inspected by the project geologist/engineer upon delivery to check cleanliness. If the well materials appear dirty, or if local or regional regulatory guidance requires decontamination, then well material decontamination should be performed by the drilling subcontractor in accordance with ENSR SOP-7600 (Decontamination of Equipment).

4.2 Well Construction Procedure

4.2.1 Depth Measurement

Once the target drilling depth has been reached, the drilling subcontractor will measure the total open depth of the borehole with a weighted, calibrated tape measure. Adjustments of borehole depth can be made at this time by drilling further or installing a small amount of sand filter material to achieve the desired depth. If drilling fluids were used during the drilling process, the borehole should be flushed at this time using potable water. The water table depth may also be checked with a water level indicator if this measurement cannot be obtained with the calibrated tape.

4.2.2 Centralizers

In order to install a well which is centered within the borehole, it is recommended that centralizers be used. Centralizers are especially helpful for deep well installations where it may be difficult to position the well by hand. Centralizers may not be necessary on shallow water table well installations where the well completion depth is within 25 feet of the ground surface.

4.2.3 Well Construction

The well screen and riser pipe generally are assembled by hand as they are lowered into the borehole. Before the well screen is inserted into the borehole, the full length of the slotted portion of the well screen as well as the unslotted portion of the bottom of the screen should be measured with the measuring tape. These measurements should be recorded on the well construction diagram.

After the above measurement has been taken, the drilling subcontractor may begin assembling the well. As the assembled well is lowered, care should be taken to ensure that it is centered in the hole if centralizers are not used. The well should be temporarily capped before filter sand and other annular materials are installed.

4.2.4 Filter Sand Installation

The drilling subcontractor should fill the annular space surrounding the screened section of the monitoring well to at least 1 foot above the top of the screen with an appropriately graded, clean sand or fine gravel. In general, the filter pack should not extend more than 3 feet above the top of the screen to limit the thickness of the monitoring zone. If coarse filter materials are used, an additional 1-foot thick layer of fine sand should be placed immediately above the filter pack to prevent the infiltration of sealing components (bentonite or grout) into the filter pack. As the filter pack is placed, a weighted tape should be lowered in the annular space to verify the depth to the top of the layer. Depending upon depth, some time may be required for these materials to settle. If necessary, to eliminate possible bridging or creation of voids, placement of the sand pack may require the use of a tremie pipe. Tremie pipe sandpack installations are generally suggested for deep water table wells and for wells which are screened some distance beneath the water table.

4.2.5 Bentonite Seal Installation

A minimum 2-foot thick layer of bentonite pellets or slurry seal will be installed by the drilling subcontractor immediately above the well screen filter pack in all monitoring wells. The purpose of the seal is to provide a barrier to vertical flow of water in the annular space between the borehole and the well casing. Bentonite is used because it swells significantly upon contact with water. Pellets generally can be installed in shallow boreholes by pouring them very slowly from the surface. If they are poured too quickly, they may bridge at some shallow, undesired depth. As an option, powdered bentonite may be mixed with water into a very thick slurry and a tremie pipe used to inject the seal to the desired depth.

4.2.6 Annular Grout Seal Installation

This grout seal should consist of a bentonite/cement mix with a ratio of bentonite to cement of between 1:5 and 1:20. The grout ratio should be chosen based on site conditions with a higher percentage of bentonite generally used for formations with higher porosity. A mud balance should be used if a specific mud density is required at a particular site. Grout slurry should be pumped into the annular space using a side-discharging tremie pipe located about 2 feet above the sand pack. Side discharge will help preserve the integrity of the sand pack.

In situations where the monitoring well screen straddles the water table, the seal will be in the unsaturated zone and pure bentonites (pellets or powder) will not work effectively as seals without hydration. Dry bentonite may be used if sufficient time to hydrate the seal is allowed. Seal hydration requires the periodic addition of clean water. Optionally, seals in this situation may be a cement/bentonite mixture containing up to 10 percent bentonite by weight. This type of mixture shall be tremied to the desired depth in the borehole.

The borehole annulus will be grouted with seal materials to within 3 feet of the ground surface. Drill cuttings, even those known not to be contaminated, will not be used as backfill material.

4.2.7 Well Completion

The drilling subcontractor will cut the top of the well to the desired height and install a vented (if possible), locking cap. The upper portion of the well casing can optionally be drilled to allow venting. Well casings are usually cut to be a certain height above ground surface (typically 2.5 to 3 feet) or are cut to be flush with the ground surface.

4.2.8 Protective Casing/Concrete Pad Installation

The drilling subcontractor will install a steel guard pipe on the well as a protective casing. The borehole around the guard pipe will be dug out to an approximate 2 to 3-foot radius to a minimum depth of 1 foot at the center and 6 inches at the edges. After installing the protective casing, the excavation will be filled with a concrete/sand mix. The surface of the concrete pad will be sloped so that drainage occurs away from the well. Flush-mount protective casings may not require an extensive concrete pad and should be completed such that they are slightly mounded above the surrounding surface to prevent surface water from running over or ponding on top of the casing. It should be noted, however, that in areas subject to snowfall, flush-mount casings may have to be installed so that they are entirely flush with the ground surface as they may be damaged by snow plows.

Above-ground protective casings should also be vented or should have non-air tight caps. Road box installations should not be vented. Installation of additional guard pipes may be necessary around above-ground well completions in traffic areas. Protective casings should be lockable to prevent unauthorized access.

4.2.9 Well Numbering

The project geologist/engineer will number each well casing with an indelible marker or paint to identify the well. This is particularly important with nested or paired wells to distinguish between shallow and deep wells. The well should be labeled on both the outside of the protective casing and inside beneath the protective casing lid.

4.2.10 Measuring Point Identification

The project geologist/engineer will mark the measuring point from which water level measurements will be made at a specific location along the upper edge of the well casing. PVC wells can easily be notched with a pocket knife or saw. Stainless steel wells (or PVC wells) can be marked with a waterproof marker on the outside of the well casing with an arrow pointing to the measuring point location. The measuring point is the point which will require surveying during the well elevation survey task.

4.2.11 Well Measurements

Upon completion, the following well measurements should be taken by the project geologist/engineer and recorded on the well construction diagram (Figure 1):

- Depth to static water level if water level has stabilized,
- Total length of well measured from top-of-well casing,
- Height of well casing above ground surface,
- Height of protective casing above ground surface,
- Depth of bottom of protective casing below ground surface (may be estimated).

Well screen filter pack, bentonite seal and annular seal thicknesses and depths should also be recorded on the well construction diagram.

4.2.12 Disposal of Drilling Wastes

Drill cuttings and other investigation-derived wastes such as drilling mud or well development/purge water must be properly contained and disposed of. Site-specific requirements for collection and removal of these waste materials should be outlined within the project work plan. Containment of these materials should be performed by the drilling subcontractor.

4.2.13 Well Development

At some point after installation of a well and prior to use of the well for water-level measurements or collection of water quality samples, development of the well shall be undertaken in accordance with ENSR SOP-7221 (Monitoring Well Development). Well development may be performed by the drilling subcontractor if contracted to do so, or by the project geologist/engineer or other project staff.

4.2.14 Well Elevation Survey

At the completion of the well installation program, all monitoring wells are usually surveyed to provide, at a minimum, the top-of-casing measuring point elevation for water level monitoring purposes. Other surveyed points which may be required by the project work plan include: ground surface elevation, top of protective casing elevation, and well coordinate position. Well elevation surveys are usually conducted by a surveying subcontractor.

5.0 QUALITY CONTROL

Certain quality control measures should be taken to ensure proper well completion.

5.1 The borehole will be checked for total open depth, and extended by further drilling or shortened by backfilling, if necessary, before any well construction materials are placed.

5.2 Water level and non-aqueous phase liquid (NAPL) presence will be checked during well installation to ensure that the positions of well screen, sand pack, and seal, relative to water level, conform to project requirements.

5.3 The depth to the top of each layer of packing (i.e., sand, bentonite, grout, etc.) will be verified and adjusted if necessary to conform to project requirements before the next layer is placed.

5.4 If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids may be required for analysis of chemical constituents of interest at the site.

6.0 DOCUMENTATION

All well construction data will be recorded on the Monitoring Well Construction Detail form (Figure 1). All wells will be referenced onto the appropriate site map. A field notebook and/or boring log will be used as additional means of recording data. In no case will the notebook or boring log take the place of the well construction diagram.

7.0 TRAINING/QUALIFICATIONS

Well construction and installation requires a moderate degree of training and experience as numerous drilling situations may occur which will require field decisions to be made. It is recommended that inexperienced personnel be supervised for several well installations before working on their own. Experienced drillers are also of great assistance with problem resolution in the field. Field personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials are considered to be present.

8.0 REFERENCES

1. Standard References for Monitoring Wells, Massachusetts Department of Environmental Protection, WSC-310-91, 1991.

APPENDIX: DEFINITIONS

Annulus: The measured width between the borehole wall and the outside of the well screen or riser pipe.

Bentonite Seal: A granular, chip, or pellet-size bentonite material that is often used to provide an annular seal above the well screen filter pack. This seal is typically installed dry followed by in-place hydration with or without the addition of water. Hydrated bentonite is sometimes used as a grout seal.

Bottom Cap/Plug: Threaded or slip-on cap placed at the bottom of the well prior to installation. Often serves as a sump for accumulation of silt which settles within the well. The measured length from the lowermost well screen slot to the bottom of the bottom cap is known as the sump or tail pipe portion of the well.

Centralizers: Stainless steel expansion clamps which, when fitted to well screens or riser pipe, expand to contact the borehole walls positioning the well centrally within the open borehole. Centralizers assist with even positioning and distribution of filter pack and sealant materials and assist with maintaining well plumbness.

Expansion Cap/Well Cap: Cap used to cover the opening at the top of the well riser pipe. Expansion caps are equipped with a rubber gasket and threaded wing nut which, when turned, provides a watertight seal. Expansion caps may also be locked, and generally are recommended for use with flush-constructed wells where road box protective casings are also used. Other well caps may include slip-on or threaded caps made of the same material as the well casing.

Filter Pack: A well-graded, clean sand or gravel placed around the well screen to act as a filter in preventing the entry of very fine soil particles into the well.

Grout Seal: A cement/bentonite mixture used to seal a borehole that has been drilled to a depth greater than the final well installation depth or to seal the remaining borehole annulus once the well has been installed. Occasionally, pure cement or pure bentonite is used as a grout seal.

Measuring Point: A selected point at the top of the well casing (riser pipe) used for obtaining periodic water-level measurements. The measuring point should consist of either a notch or indelibly marked point on the upper surface of the casing. Typically, the highest point on the casing (if not level) is used as the measuring point. The measuring point is also the point that is surveyed when well elevation data is obtained.

Protective Casing: A locking metal casing, placed around that portion of the well riser pipe that extends above the ground surface. The protective casing is generally cemented in place when the concrete pad is constructed around the well.

Riser Pipe: The section of unperforated well casing material used to connect the well screen with the ground surface. Frequently, it is made of the same material and has the same diameter as the well screen. Riser pipe is typically available pre-cleaned and pre-threaded for immediate use.

Road Box: A protective casing that is flush-mounted with the ground around a well installation. Road boxes are used in areas where the monitoring well cannot extend above the ground surface for traffic or security reasons. Road boxes usually require a special key to open.

Tremie Pipe: A small diameter pipe which fits in the open borehole annulus and is used to inject filter sands or hydrated seal materials under pressure.

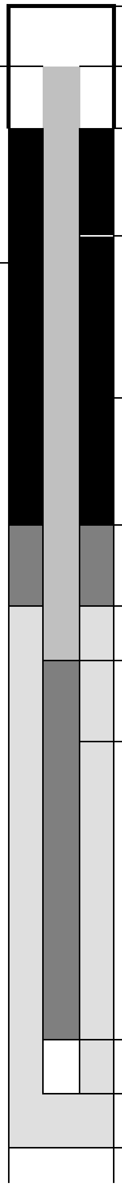
Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. Typically a well screen is purchased pre-slotted, pre-cleaned, and pre-threaded for immediate use.

Vent Hole: Small diameter hole drilled in the upper portion of the well riser pipe which provides atmospheric venting of the well. Allows for constant equilibration of the water level with changing atmospheric conditions. In flood-prone areas, or with flush-mount wells, vent holes should not be used.

Figure 1 Monitoring Well Construction Detail

ENSR		
	Client:	WELL ID:
	Project Number:	
	Site Location:	*Date installed:*
	Well Location: *Coords:*	*Inspector:*
	Method:	*Contractor:*

MONITORING WELL CONSTRUCTION DETAIL



	Depth from G.S. (feet)	Elevation(feet) Datum ________
Top of Steel Guard Pipe	________	________
Top of Riser Pipe	________	________
Ground Surface (G.S.)	0.0	________
Top of Bentonite	________	________
Top of Sand	________	________
Top of Screen	________	________
▼ Stabilized Water Level	________	________
Bottom of Screen	________	________
Bottom of Tail Pipe:	________	________
Bottom of Borehole	________	________

Measuring Point for Surveying & Water Levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

________ % Cement

________ % Bentonite

________ % Native Materials

Riser Pipe:
Length ________
Inside Diameter (ID) ________
Type of Material ________

Bottom of Steel Guard Pipe

Bentonite Seal Thickness ________

Screen:
Length ________
Inside Diameter (ID) ________
Slot Size ________
Type of Material ________

Type/Size of sand ________
Sand Pack Thickness ________

Bottom of Tail Pipe:
Length ________

Borehole Diameter ________

Approved:

________________ Signature

________________ Date

Describe Measuring Point:

____

ENSR | AECOM

Monitoring Well Development

SOP Number 7221

Revision Number: 0.0

January 2008

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January 23, 2008

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January 23, 2008

Monitoring Well Development

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^{TM} 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.

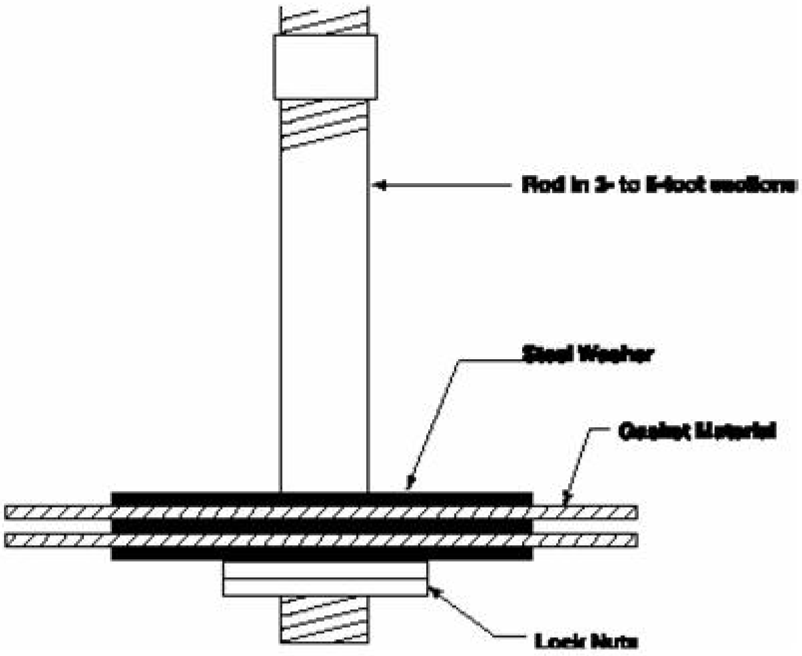
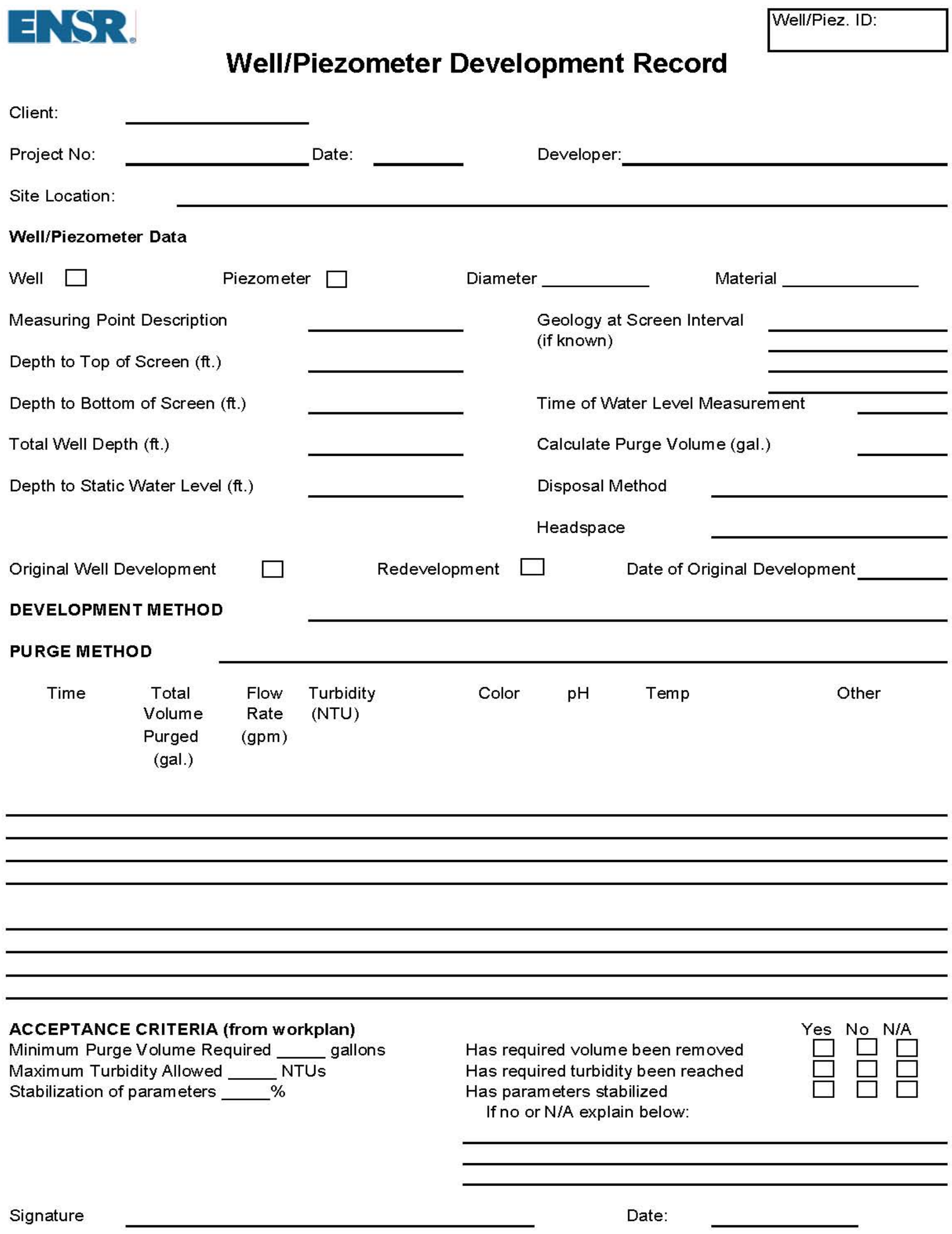


FIGURE 2 – EXAMPLE WELL DEVELOPMENT RECORD



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Well/Piez. ID:

Well/Piezometer Development Record

Client: ______

Project No: ______ Date: ______ Developer: ______

Site Location: ______

Well/Piezometer Data

Well ☐ Piezometer ☐ Diameter ______ Material ______

Measuring Point Description ______

Geology at Screen Interval (if known) ______

Depth to Top of Screen (ft.) ______

Depth to Bottom of Screen (ft.) ______

Time of Water Level Measurement ______

Total Well Depth (ft.) ______

Calculate Purge Volume (gal.) ______

Depth to Static Water Level (ft.) ______

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

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January 23, 2008

SOP NUMBER: 7315

Operation and Calibration of a Photoionization Detector (PID)

Date: January 2008
Revision Number: 0.0
Page: 1 of 9

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 – e.g., battery check, magic marker response (Section 7.5.1) or similar test.

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.

Checks of the instrument response (Section 7.5.1) should be conducted periodically and documented in the field records.

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.

Operation and Calibration of a Multi-Parameter Water Quality Monitor

SOP Number 7320

Revision Number: 0.0

January 2008

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SOP NUMBER: 7320

Operation and Calibration of a Multi-Parameter Water Quality Monitor

Date: January 2008
Revision Number: 0.0
Page: 1 of 11

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 ^{o}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.

<u>NOTE</u>: 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

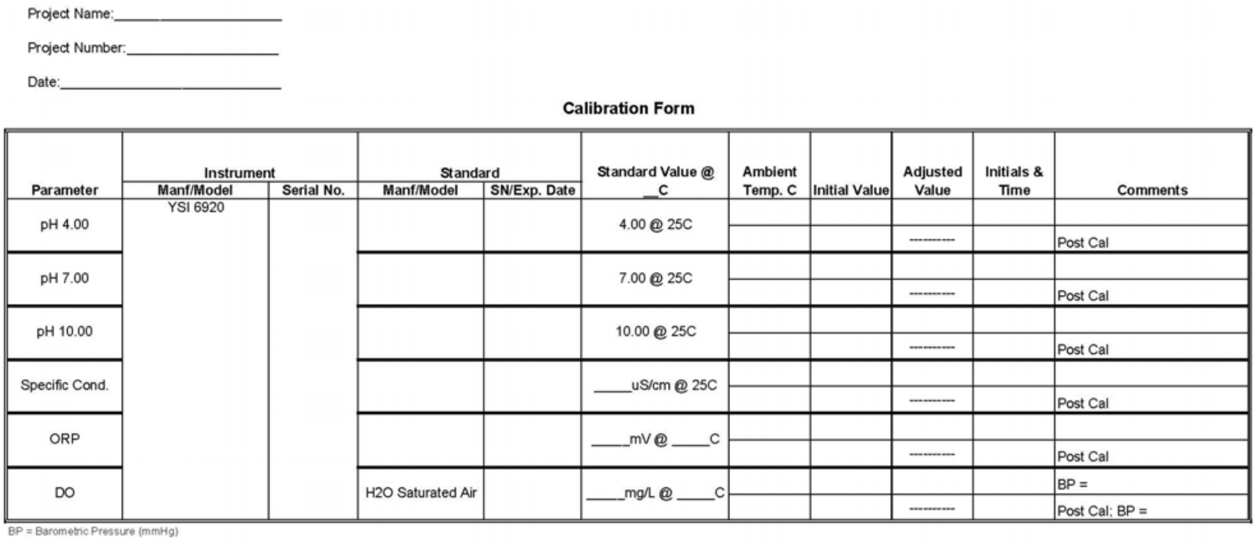
Field personnel will follow specific quality assurance guidelines as outlined in the Quality Assurance Project Plan (QAPP) and/or SAP.

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		Standard		Standard Value @ __C	Ambient Temp. C	Initial Value	Adjusted Value	Initials & Time	Comments
	Manf/Model	Serial No.	Manf/Model	SN/Exp. Date						
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

January 2008

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January 23, 2008

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Packaging and Shipment of Environmental Samples

Date: January 2008
Revision Number: 0.0
Page: 1 of 11

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.

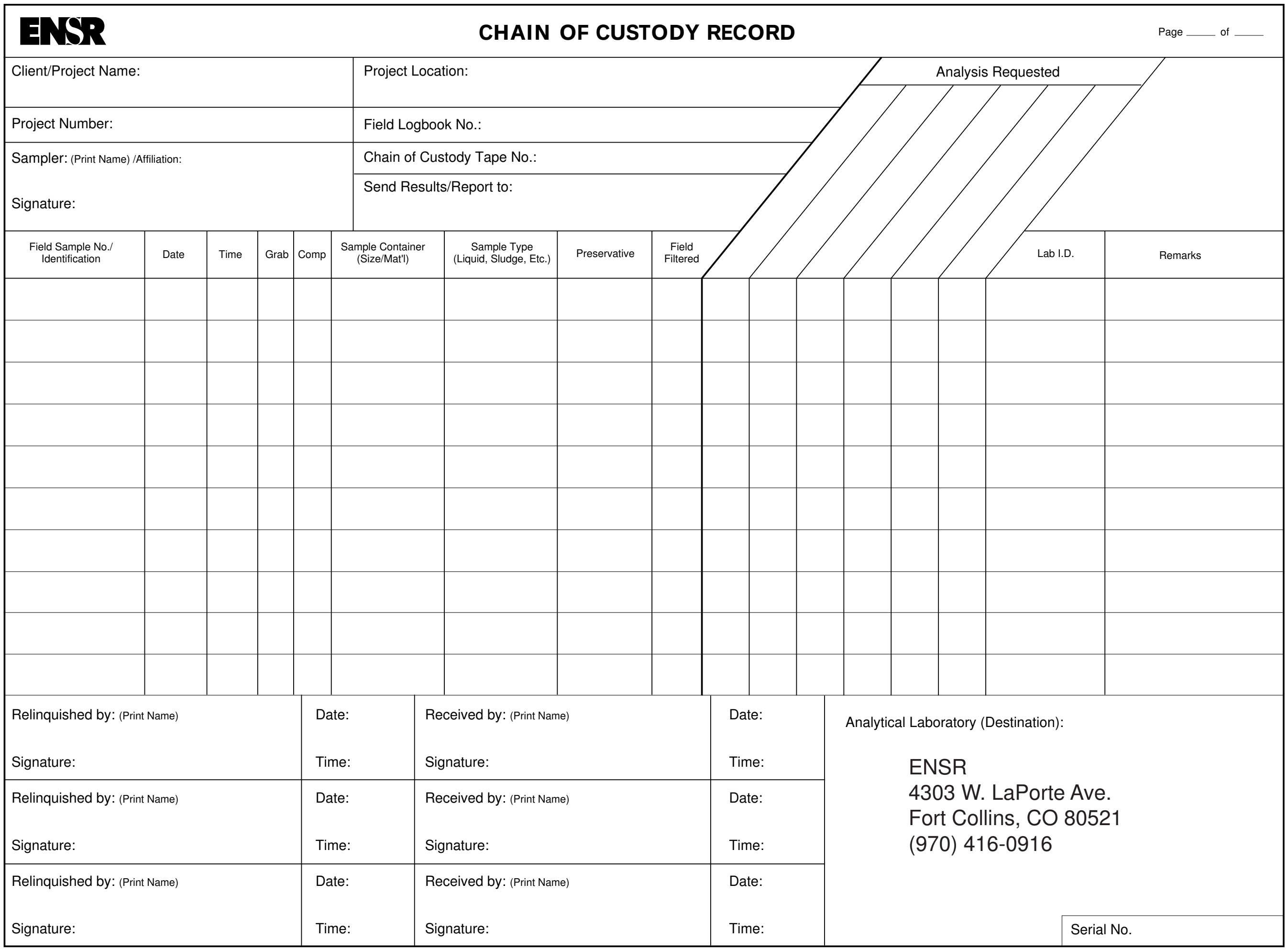
Environmental samples are generally shipped so that the samples are maintained at a temperature of approximately 4°C. Temperature blanks may be required for some projects as a quality assurance check on shipping temperature conditions. These blanks usually are supplied by the laboratory and consist of 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



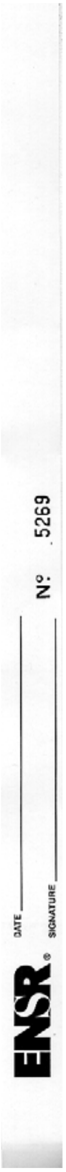
ENSR **CHAIN OF CUSTODY RECORD** Page ____ of ____

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



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

Decontamination of Field Equipment

SOP Number 7600

Revision Number: 0.0

January 2008

Original singed

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

Original singed

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

ENSR Corporation
January 23, 2008

SOP NUMBER: 7600

Decontamination of Field Equipment

Date: January 2008
Revision Number: 0.0
Page: 1 of 9

CONTENTS

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

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the methods to be used for the decontamination of field equipment used in the collection of environmental samples. Field equipment for decontamination may include a variety of items used in the field for monitoring or for collection of soil, sediment, and/or water samples, such as water level meters, water quality monitoring meters (turbidity meter, multi-parameter meter), split-spoon samplers, trowels, scoops, spoons, and pumps. Heavy equipment such as drill rigs also requires decontamination, usually in a specially constructed temporary decontamination area.

Decontamination is performed as a quality assurance measure and a safety precaution. Improperly decontaminated sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination between samples or sample locations through use of contaminated equipment. Decontamination also protects field personnel from potential exposure to hazardous materials on equipment.

This SOP emphasizes decontamination procedures to be used for decontamination of reusable field equipment. Dedicated or disposable equipment will not need to be decontaminated.

2.0 SUMMARY OF METHOD

Decontamination is accomplished by manually scrubbing, washing, or spraying equipment with detergent solutions, tap water, distilled/deionized water, and/or solvents.

Generally, decontamination of equipment is accomplished at each sampling site between collection points. Waste decontamination materials such as spent liquids and solids will be collected and managed as investigation derived waste (IDW) for later management and/or disposal (refer to procedures outlined in the Sampling Analysis Plan (SAP)). All decontamination materials, including wastes, should be stored in a central location so as to maintain control over the materials used or produced throughout the investigation program.

3.0 HEALTH AND SAFETY WARNINGS

Decontamination procedures may involve chemical exposure hazards associated with exposure to soil, water, or sediment and may involve physical hazards associated with decontamination materials. When decontamination 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

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)

- Squeeze bottles
- Plastic sheeting
- Aluminum foil
- Zipper-lock bags
- Approved plans (e.g., HASP, QAPP, SAP)
- Field project logbook/pen

7.0 METHODS

7.1 General Preparation

7.1.1 New materials, such as well materials, are generally assumed to be clean and decontamination is not anticipated. However, they should be inspected and if they appear to be dirty, should be decontaminated.

Field equipment that is not frequently used should be wrapped in aluminum foil, shiny side out, and stored in a designated "clean" area. Small field equipment can also be stored in zipper-lock plastic bags to eliminate the potential for contamination. Field equipment should be inspected and decontaminated prior to use if the equipment appears dirty.

7.1.2 Heavy equipment (drill rigs, Geoprobes®, excavators) should be decontaminated upon arrival at the Area of Investigation, prior to beginning any work.

7.1.2 A decontamination station will be established within an area that is convenient to each sampling location. If single samples will be collected from multiple locations, then a centralized decontamination station or a portable decontamination station may be established.

7.1.3 One or more IDW containment stations should be established at this time also. In general, decontamination solutions are discarded as IDW between sampling locations.

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 Decontamination of Submersible Pumps

7.3.1 This procedure will be used to decontaminate submersible pumps before and between groundwater sample collection points. This procedure applies to both electric submersible and bladder pumps. This procedure also applies to discharge tubing if it will be reused between sampling points.

7.3.2 Prepare the decontamination area if pump decontamination will be conducted next to the sampling point. If decontamination will occur at another location, the pump and tubing may be removed from the well and placed into a clean trash bag for transport to the decontamination area. Pump decontamination is easier with the use of 3-foot tall pump cleaning cylinders (i.e., Nalgene cylinder) for the various cleaning solutions, although the standard bucket rinse equipment may be used.

7.3.3 Once the decontamination station is established, the pump should be removed from the well and the discharge tubing and power cord coiled by hand as the equipment is removed. If any of the equipment needs to be put down temporarily, place it on a plastic sheet (around well) or in a clean trash bag. If a disposable discharge line is used it should be removed and discarded at this time.

7.3.4 As a first step in the decontamination procedure, use a pressure sprayer with tap water to rinse the exterior of the pump, discharge line, and power cord as necessary. Collect the rinsate and handle as IDW.

7.3.5 Place the pump into a pump cleaning cylinder or bucket containing a detergent solution (phosphate-free, borate-free detergent in tap water). Holding the tubing/power cord, pump solution through the pump system. A minimum of one gallon of detergent solution should be pumped through the system. Collect the rinsate and handle as IDW.

7.3.6 Remove the pump from the cylinder/bucket and if the pump is reversible, place the pump in the reverse mode to discharge all removable water from the system. If the pump is not reversible the pump and discharge line should be drained by hand as much as possible. Collect the rinsate and handle as IDW.

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

- Notable circumstances
- Identification of equipment rinsate blanks
- Management of decontamination fluids
- Method, date, and time of equipment blank collection
- Disposition of IDW

Repetitive decontamination of small items of equipment does not need to be logged each time the item is cleaned.

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

General guidelines for quality control check of field equipment decontamination usually require the collection of quality control (QC) samples such as equipment rinsate blanks. These requirements should be outlined in the QAPP and SAP.

Equipment rinsate blanks are generally made by pouring laboratory-supplied deionized water into, over, or through the freshly decontaminated sampling equipment and then transferring this water into a sample container. Equipment rinsate blanks should then be labeled as a sample (as per the QAPP and SAP) and submitted to the laboratory to be analyzed for the same parameters as the associated sample, or an appropriate subset thereof. Equipment rinsate blank sample numbers, as well as collection method, time and location should be recorded in the field logbook.

10.0 REFERENCES

Not applicable.