DELPHI SYSTEMS CORP.

CORRECTIVE MEASURES PROPOSAL

APPENDIX F

GROUNDWATER MNA WORK PLAN

GROUNDWATER MONITORED NATURAL ATTENUATION MONITORING AND SAMPLING WORK PLAN
DELPHI AUTOMOTIVE
FORMER ANAHEIM BATTERY FACILITY
ANAHEIM, CALIFORNIA

by

Haley & Aldrich, Inc.
Brea, California

for

Delphi Automotive
Kokomo, Indiana

File No. 32486-011
August 2007

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HALEY & ALDRICH

8 August 2007
File No. 32486-011

Department of Toxic Substances Control
Tiered Permitting and Corrective Action Branch
5796 Corporate Avenue
Cypress, CA 90630

Attention: Mr. John Geroch

Subject: Groundwater Monitored Natural Attenuation Work Plan
Delphi Automotive Group
Former Anaheim Battery Facility
Anaheim, California

Dear Mr. Geroch:

Haley & Aldrich, Inc. has prepared the enclosed Groundwater Monitored Natural Attenuation Work Plan on behalf of Delphi Automotive for the former Delphi Battery facility located at 1201 North Magnolia Avenue, Anaheim, California. This Work Plan summarizes the groundwater water monitoring activities proposed as part of the proposed Corrective Measures Proposal (CMP) beginning in September 2007.

Please contact the undersigned at (714) 984-2105 should you have any questions about the contents of this Work Plan.

Sincerely yours,
HALEY & ALDRICH, INC.

Original signed by Kelly Hoggan

Kelly Hoggan
Staff Geologist

Original signed by Thomas S. Tatnall

Thomas S. Tatnall, C.E.G. 1968, R.E.A.
Project Manager/Vice President

Enclosures

c: Delphi Corporation

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1. INTRODUCTION

This Work Plan summarizes groundwater monitoring activities to be performed for the groundwater Monitored Natural Attenuation monitoring program for the former Delphi Battery Facility (Site), in Anaheim, California (Figure 1). This groundwater monitoring plan is part of the Corrective Measures Proposal (CMP) that has been prepared by Haley & Aldrich, Inc. (Haley & Aldrich), as requested by the California Environmental Protection Agency Department of Toxic Substances Control (DTSC) Tiered Permitting Corrective Action Branch, under Corrective Action Consent Agreement (CACA) to adequately characterize Site conditions, assess potential risks to human health and the environment, and remediate the Site for commercial/industrial redevelopment. Groundwater monitoring has occurred at the Site since 2005 when twelve permanent wells were installed as part of the Current Conditions and Facility Investigation assessment. Semi-annual monitoring is proposed with events in September and March. These sampling events are discussed in Section 2.

This Work Plan identifies the groundwater monitoring wells that will be sampled and the chemicals that will be analyzed for during each monitoring event. The following sections of this Work Plan present Site background information, the proposed groundwater monitoring program, and reporting.

1.1 Site Background

1.1.1 Site Description

The Site consists of approximately 22+ acres located at 1201 North Magnolia Avenue in a commercial/industrial section of the City of Anaheim, Orange County, California (Figure 1). Prior to the 2005 decommissioning and plant demolition, the Site included the following:

- Main Production Building,
- South Building (New Charge Building),
- Three warehouses (Warehouses No. 1, No.2 and No. 3),
- Railroad siding,
- Waste Water Treatment Unit,
- Storm Water Retention Basin, as well as,
- Numerous asphalt or concrete paved areas outside the buildings.

The Site is a relatively flat rectangular property with frontage along Magnolia Avenue. The area of the Main Production Building was approximately 187,000 square feet, with smaller production and storage buildings present to the south and west.

1.1.2 History

A review of historical aerial photographs and topographic maps indicates that prior to construction of the battery manufacturing facility. The Site was agricultural and likely used as an orange grove. The original building was constructed in 1953 by Delco-Remy, a Division of General Motors, for the production of automotive batteries. A review of previous environmental reports indicates that additional major on-Site construction activities also occurred in 1963, 1974, and 1977 for a warehouse and production line buildings.

Delphi Corporation (Delphi) has entered into a Corrective Action Consent Agreement (CACA) (No. SRPD 05/06SCC-4344) with the California Department of Toxic Substance Control (DTSC). The CACA relates to thirteen solid waste management units (SWMUs) and 53 Areas of Concern (AOIs) identified during investigations performed for Phase I Environmental Site Assessment (ESA), Current Conditions Report (CCR) and Facility Investigation (FI) performed by Haley and Aldrich and others at 1201 North Magnolia Avenue, Anaheim, California (the Site). At the required by the CACA issued by DTSC, Delphi is submitting this Corrective Measures Proposal (CMP) to DTSC.

As part of the CCI and FI, twelve 2-inch-diameter Schedule 40 PVC monitoring wells were installed at the Site between August 2005 and July 2006. Monitoring wells (MW-1, -2, -3, -4, -5, -6, -7, -8, -8D -9, -10, -11) were installed. Eleven wells were advanced to between 41 and 48 feet bgs and constructed with 15 feet of 0.010 slot well screen. One deep well, MW-8D, was screened from approximately 73.75 to 78.75 feet bgs to evaluate groundwater quality at depth in the aquifer. The well construction details are presented in Table 1.

The wells were sampled on 17 August 2005, 3 February 2006, and 17 July 2006 and the samples submitted for laboratory testing. Depth to groundwater was reported between 21 and 27 feet bgs and the direction of flow was in a westerly direction.

Groundwater samples were analyzed by one or more of the following EPA Methods:

- VOCs by EPA Method 8260B
- CAM-17 Metals by EPA Method 6010B/7470A
- pH by EPA Method 150.1

1.1.3 Geology

Soils on the site have been observed to be interbedded alluvial deposits. The upper most soil, ground surface to 10 feet deep, on the Site consists of silty sand, sand, sandy silt and silt. Discrete beds of silty clay to clayey silt were noted at 7 feet, 15 feet and 22 feet below the ground surface in borings. Silty sands are the primary soil types at other intervals. The surficial soils were generally described as dry to slightly moist, various shades of brown loose to dense for sands and soft to hard for silts and clays. From approximately 23 to 78 feet the soil is primarily poorly graded fine to medium sand although silt bed were encountered from 33 to 35 feet and at 78 feet.

1.1.4 Hydrogeology

Groundwater was encountered at approximately 21 to 27 feet bgs beneath the Site during the 2005-2006 investigation activities. Groundwater flow is in a southwesterly direction beneath the Site at approximately 0.0008 ft/ft based on measurements from onsite wells (Haley & Aldrich, 2006).

1.2 Historical Groundwater Monitoring Events

Groundwater investigations began in August 2005. Since that time, 12 permanent groundwater monitoring wells have been installed, both on and off the Site (Figure 2).

2. PROPOSED GROUNDWATER MONITORING PROGRAM

The following sections present the proposed MNA groundwater monitoring program.

2.1 Health and Safety

The work will be performed under a Site-specific Health and Safety Plan (HASP) in accordance with Occupational Safety and Health Administration (OSHA) requirements. The existing HASP for the Site will be used by field staff during field activities.

2.2 Semi-Annual Monitoring Events

The MNA monitoring program consists of the following sampling events:

- Semi-annual monitoring of 14 groundwater wells;
- Sampling in September and March of each year for three years; and
- Preparation of semi-annual reports following each monitoring event.

2.3 New Groundwater Monitoring Wells

Two new wells MW-12 and MW-13 will be installed along Knollwood Circle, south of existing well MW-10. One well will be installed near the suspected core of the plume and one well will be installed farther south to prove downgradient delineate of leading edge of the plume. The wells will be installed as dual-zone wells to monitor shallow and deeper intervals in the shallow aquifer.

Wells will be installed using a hollow-stem auger drilling rig by licensed well installation contractor. Wells will be constructed in accordance with applicable California Department of Water Resources Well Standards using 2-inch diameter, 0.01-inch slotted casing and No.2 sand. Wells will be constructed with one screened interval set at approximate 33-23 feet bgs and a deeper screened interval set at approximately 60-50 feet bgs. Actual depths may vary depending on soil lithologies identified during well construction. If low permeability layers are identified the screened intervals will be set beginning at the top of the low permeability layer and the screen shortened to 5 feet, if appropriate based on lithologies. Bentonite seals will be placed across any significant low permeability layers not crossed by well screens.

The wells will be developed in accordance with the Standard Operating Procedure included in Appendix A.

2.4 Groundwater Monitoring Methodology

The groundwater monitoring methodology addresses health and safety, groundwater monitoring and sampling, and surface water sampling. The methodology is described below.

2.4.1 Fieldwork – Groundwater Monitoring and Sampling

The DTSC will be notified at least one week before a monitoring event begins. The following activities will be performed during an event.

2.4.1.1 Water Level Gauging

Prior to collecting groundwater samples depth to groundwater will be measured in each well to the nearest one-hundredth of a foot using an electronic water level indicator or free-product interface probe from a fixed point on the well. The equipment will be decontaminated between each monitoring well. Data from the well gauging will be recorded in the Groundwater Sampling Log sheet (Appendix B). To the extent possible, the groundwater monitoring wells will be gauged within a single 24-hour period with the same electronic water level indicator.

2.4.1.2 Well Purging and Sampling

Groundwater monitoring wells will be sampled in order of increasing contaminant concentrations based on the results of the previous event.

The wells purged using a low-flow purging methodology in accordance with the Standard Operating Procedure included in Appendix C.

Micropurge and sampling will consist of the following:

- Apneumatic bladder pump or peristaltic pump and "dedicated" tubing will be used to purge and sample each monitoring well.
- The pump intake or the bottom of the peristaltic pump tubing will be set at a depth approximately in the center of the monitoring well's screened interval.
- The monitoring well will be purged at a pumping rate of 200 to 400 milliliters per minute (ml/min) (i.e., 0.05 to 0.11 gallons per minute [gpm]), and to the extent possible, maintaining less than 1.0 ft of drawdown during the purging operation.
- While purging the monitoring well, water quality indicator parameters will be measured every 3 to 5 minutes, using a flow-through cell or a hand held device, and recorded on a Groundwater Sampling Data Sheet (Appendix B). Purging will be complete when a minimum of three casing volumes have been removed, and two consecutive measurements of the water quality parameters have stabilized to the values listed above for the micropurge sampling method.
- Purging will continue, if appropriate, until the parameters have stabilized for three successive measurements to the following values:
  - Turbidity ± 10%, with final reading less than 10 nephelometric turbidity units (NTU)
  - Specific Conductance ± 3%
  - pH ± 0.1
  - Dissolved Oxygen (DO) ± 10%
  - Oxidation reduction potential (ORP) ± 10 millivolts
  - Temperature ± 1 degree Celsius
- Purging will be continued until the parameters stabilize for three

consecutive measurements.

- Alternatively, purging will be complete when a volume equivalent to a minimum of three casing volumes has been removed, or until three well screen volumes (defined as the wetted well screen 5 feet above and below the pump intake) have been purged from the well, whichever occurs first.

The three-casing volume purge/sampling method consists of the following:

- The well will be purged at a pumping rate of 0.5 to 2 gpm, using the existing extraction pump, and the water level in the extraction well will be monitored. The pumping rate will be adjusted to ensure, to the extent possible, that the water level does not drop more than 1.0 ft in the extraction wells screened across the water table. For monitoring wells fully screened below the static water table, the pumping rate will be adjusted to minimize the potential for the water level to drop below the top of the screened interval, thus preventing groundwater from cascading down the interior sidewalls of the well casing.
- If parameters do not stabilize after removing five wetted casing volumes, purging will be considered complete and the groundwater sample will be collected.
- At completion of purging, the pump discharge tube will be disconnected from the flow-through cell (if used), the pumping rate will be decreased to less than 0.1 gpm, and the pump discharge will be used to fill the laboratory-supplied sample containers.
- At completion of purging, the pump discharge tube will be disconnected from the flow-through cell (if used) and the pump discharge will be used to fill the laboratory-supplied sample containers.

2.4.1.3 Analytical Testing

Collected groundwater samples will be stored on ice in a cooler and transported to a California-certified analytical laboratory for analysis under proper chain of custody. Chain of custody forms and procedures will be maintained throughout sample collection and transport. The appropriate chain of custody information will also be electronically uploaded to the project database. Field data will be collected and recorded the Groundwater Sampling Log sheet (Appendix B). The proposed sampling and analytical testing for each well is summarized below:

The wells proposed for field monitoring and groundwater quality analyses include the following:

- MW-1
- MW-2
- MW-3

- MW-5
- MW-6
- MW-7
- MW-8 Shallow
- MW-9
- MW-10
- MW-12 Shallow
- MW-12 Deep
- MW-13 Shallow
- MW-13 Deep

Parameters to be monitored in the field during purging include:

- Conductivity;
- Oxidation Reduction Potential (ORP);
- Dissolved oxygen (DO);
- Temperature;
- Turbidity; and
- pH.

Groundwater quality analysis will include:

- Volatile Organic Compounds (extended range) by EPA Method 8260B;

The wells proposed for MNA testing include:

- MW-1
- MW-3
- MW-7
- MW-8 Shallow
- MW-10
- MW-12 Shallow
- MW-12 Deep
- MW-13 Shallow

- MW-13 Deep

The proposed MNA parameters to be monitored to evaluate Natural Attenuation processes of the VOCs include:

- Total Organic Carbon (TOC) by EPA Method 415.1; (During first event);
- Biological Oxygen Demand (BOD) @ 20°C by EPA Method 405.1;
- Calcium, Potassium and Sodium by EPA Method 6010B;
- Manganese by EPA Method 3010/200;
- Ferrous Iron (Fe^{+2}) by EPA Method 6010B;
- Sulfate (SO_4^{-2}) by EPA Method 375.4
- Sulfide by EPA Method 376.2;
- Nitrate by EPA Method 352.1;
- Nitrite by EPA Method 354.1;
- Chloride by EPA Method 325.3;
- Ethene, Ethane, Methane and Carbon Dioxide by EPA Method RSK-SOP-175;

The Standard Operating Procedure for performing MNA is included in Appendix D. Other potential MNA parameters that could be analyzed, if appropriate, and preservation method and test methods are summarized in Table 2.

2.5 Quality Assurance/Quality Control

2.5.1 Duplicate Samples

One duplicate groundwater sample will be collected for approximately every 20 groundwater samples to assess laboratory precision with a minimum of one duplicate sample collected per event. Duplicates will be collected, numbered, packaged, and sealed in the same manner as the other samples. Duplicates will be assigned separate sample numbers and submitted blind to the laboratory. Duplicate samples will be analyzed using the following EPA methods:

- VOCs by EPA Method 8260B

2.5.2 Equipment Rinsate Blanks

One equipment rinsate blank (ERB) sample will be collected prior to initiation of sampling activities as a check for cross-contamination during sample collection, or after decontamination following sampling of a well with significant impacts relative to other wells being sampled. Rinsate blanks may not be collected if dedicated

equipment is used and the need for equipment blank samples is unnecessary. Deionized water will be used to fill or rinse the sampling equipment after the equipment has been cleaned, then the rinse water will be collected in appropriate sample containers. The equipment rinsate blanks will be analyzed using the following EPA methods:

- VOCs by EPA Method 8260B

2.5.3 Travel Blanks

One travel blank will be prepared in the laboratory for each day that groundwater samples are collected and shipped to the laboratory (an estimated two samples per event). The travel blanks will be prepared by the laboratory in a clean environment and kept in the cooler used to ship samples. The travel blank provides a check for cross-contamination during transport and will be analyzed for VOCs by EPA Method 8260B.

2.5.4 Data Review

Analytical data presented in laboratory reports will also be received electronically from a California-certified environmental laboratory. Haley & Aldrich will review the electronic analytical data presented for consistency with actual laboratory reports provided by the laboratory.

2.6 Decontamination

Equipment used for well monitoring, purging, and sampling will be cleaned prior to and between sampling each groundwater monitoring well with an Alconox solution (or equivalent), then double-rinsed with tap water and deionized (or distilled) water to reduce the potential for cross-contamination.

2.7 Waste Management

Well purge water and water used to decontaminate equipment will be stored in properly labeled 55-gallon drums, and stored on-Site pending disposal. The stored water will be properly manifested and disposed of at permitted TSDF.

3. GROUNDWATER MONITORING REPORTS

Groundwater monitoring reports for the annual and semiannual sampling events will contain the following:

- Groundwater elevation contour maps
- Tabulated analytical data
- Groundwater contour maps for 1,1-DCA, 1,2-DCA and 1,1-DCE
- Groundwater sampling forms and field notes documenting field activities
- Laboratory reports and chain of custody documentation
- Results of the quarterly surface water sampling events
- Appropriate descriptions of the sampling event, test results, discussion, and conclusions regarding water quality and hydrogeologic changes at the Site
- Discussion of changes in Site or well conditions that might affect future sampling events

Reports from the annual and semiannual events will be submitted to the DTSC approximately 30 days after the receipt of laboratory results from each sampling event. The results from the quarterly surface water sampling events will be presented in the subsequent annual and semiannual reports. With the annual and semiannual monitoring events occurring in March and September reports will be provided to the DTSC by 31 May and 30 November of each year.

4. ADDITIONAL REMEDIAL ACTIVITIES

Groundwater quality monitoring data will be evaluated to determine if the groundwater quality is improving due to natural attenuation.

If evaluation of long-term monitoring groundwater quality data indicates that natural attenuation is not occurring at a reasonable rate due to site-specific conditions then additional evaluation may be performed to evaluate alternatives to increase the rate of degradation and/or remove VOCs from the groundwater. One or more alternatives may be implemented to enhance degradation or remove VOCs from groundwater to obtain groundwater quality goals acceptable to the State. The additional remedial options to address groundwater could include:

- Chemical injection of hydrogen release or other compounds to enhance in-situ anaerobic bioremediation or degradation;
- Pumping and treating groundwater through a treatment system of carbon, UV oxidation or another appropriate technology
- Ozone injection; or
- Another technology appropriate for site-specific conditions and chemicals of concern in groundwater.

The selected active remedial alternative would be approved by DTSC then necessary air, waste discharge an/or well permits obtained and the system installed under DTSC oversight.

REFERENCES

1. CDWR, 1967, Progress Report of Ground Water Geology of the Coastal Plain of Orange County, 100p.

2. Haley & Aldrich, Inc., "Facility Investigation Report, Delphi Corporation – Former Anaheim Battery Operations Facility, 1201 North Magnolia Avenue, Anaheim, CA, March, 2007.

3. Haley & Aldrich, Inc., 2006. Current Conditions Report. Delphi Special Products Corporation, Former Anaheim Battery Operations, Anaheim, California, 3 February 2006.

4. Haley & Aldrich, Inc., 2006. Facility Investigation Work Plan. Delphi Corporation, Former Delphi Anaheim Battery Operations Facility, Anaheim, California, 28 April 2006.

5. U.S. Environmental Protection Agency, Office of Research and Development, "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water", EPA/600/R-98/128, September 1998.

6. U.S. Environmental Protection Agency, Solid Waste and Emergency Response, "Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action", EPA/530/R-04/030, April 2004.

7. United States Environmental Protection Agency (US EPA), April 1996. "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures," by Robert W. Puls and Michael J. Barcelona.

8. US EPA, 1999. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, EPA-540/R-99-008. October.

9. US EPA, 2002. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. July.

TABLES

TABLE 1
MONITORING WELL CONSTRUCTION DETAILS
FORMER DELPHI BATTERY PLANT, 1201 MAGNOLIA AVE.
ANAHEIM, CALIFORNIA
32486-011

Well Number	Date Installed	Casing Diameter (inches)	Casing Type	Conductor Casing	Slot Size (inches)	Total Depth (feet)	Top of Screen (feet-bgs)	Bottom of Screen (feet bgs)	Screen Length (feet)	Top of Filter Pack (feet-bgs)	Bottom of Filter Pack (feet-bgs)	Length of Filter Pack (feet)	Thickness of Bentonite Seal (feet)
1	8/11/2005	2	Sch 40 PVC	None	0.01	47	31	46	15	29.5	46	16.5	2
2	8/14/2005	2	Sch 40 PVC	None	0.01	41	25	40	15	24	41	17	5.5
3	8/11/2005	2	Sch 40 PVC	None	0.01	45	29.5	44.5	15	28	44.5	16.5	7
4	8/15/2005	2	Sch 40 PVC	None	0.01	41	25	40	15	24	41	17	4.5
5	1/31/2006	2	Sch 40 PVC	None	0.01	48.5	32.3	47.3	15	31.8	48.5	16.7	6.8
6	1/31/2006	2	Sch 40 PVC	None	0.01	52	35.5	50.5	15	34.5	52	17.5	5.5
7	2/1/2006	2	Sch 40 PVC	None	0.01	54	38.5	53.5	15	38	54	16	4
8	2/2/2006	2	Sch 40 PVC	None	0.01	51.5	36	51	15	34.75	51.5	16.75	4.5
8D	2/1/2006	2	Sch 40 PVC	None	0.01	79	73.75	78.75	5	73.5	79	5.5	4
9	2/2/2006	2	Sch 40 PVC	None	0.01	55.5	40	55	15	38.8	55.5	16.7	4.8
10	7/14/2006	2	Sch 40 PVC	None	0.01	46	29	44	15	28.5	46	17.5	3.5
11	7/14/2006	2	Sch 40 PVC	None	0.01	46	30	45	15	28.5	46	17.5	3.5

Table 2. 2007-2008 Sampling and Analysis Schedule

FIELD PARAMETERS

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed~Base Laboratory
Water	Alkalinity	Hach Alkalinity test kit model AL AP MG-L	Phenolphthalein method	General water quality parameter used (1) as a marker to verify that all site samples are obtained from the same ground-water system and (2) to measure the buffering capacity of ground water. (3) indicator of biodegradation	Each sampling round	Collect 100 mL of water in glass container.	Field
Water	Carbon Dioxide	Hach Carbon Dioxide Kit	Field	Indicator of ongoing aerobic biodegradation, should correlate with alkalinity	Each sampling round	Collect 100 mL of water in glass or plastic container and analyze as soon as possible	Field
Water	Iron (II) (Fe+2)	Colorimetric Hach Method #8146	Filter if turbid.	May indicate an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese.	Each sampling round	Collect 100 mL and analyze as soon as possible.	Field
Water	pH	Field probe with direct reading meter calibrated in the field according to the supplier's specifications.	direct reading meter	Aerobic and anaerobic biological processes are pH-sensitive. Lower pH can be indication of biodegradation.	Each sampling round	Measure immediately after purging is complete site using a flow-through cell or over-flow cell.	Field
Water	Conductivity	E120 l/SW 9050,	direct reading meter	General water quality parameter used as a marker to verify that site samples are obtained from the same ground-water system.	Each sampling round	Collect 100 to 250 mL of water in a glass or plastic container.	Field
Water	Temperature	Field probe with direct reading meter.	direct reading meter	To determine if a well is adequately purged for sampling.	Each sampling round	Read from oxygen meter,	Field
Water	Redox	Field probe with direct reading meter.	Field only, care should be taken to not aerate the sample during sampling.	To determine the redox conditions in groundwater for assessing biodegradation potential.	Each sampling round	Measure immediately after purging is complete site using a flow-through cell or over-flow cell.	Field
Water	Dissolved Oxygen	Field probe with direct reading meter.	Field only, care should be taken to not aerate the sample during sampling.	To determine the level of dissolved oxygen in groundwater (assessing biodegradation potential.)	Each sampling round	Measure dissolved oxygen on site using a flow-through cell or over-flow cell.	Field

Table 2. 2007-2008 Sampling and Analysis Schedule

FIXED LABORATORY

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Water	Chloride	EPA 325.1	Mercuric nitrate titration (Ion chromatography (IC) method E300 or method SW 9050 may also be used)	General water quality parameter used as a marker to verify that site samples are obtained from the same ground-water system. Final product of chlorinated solvent reduction.	Each sampling round	Collect 250 mL of water in a glass container. cool to 4°C	Fixed-base
Water	Nitrate	EPA 353.2		Substrate for microbial respiration if oxygen is depleted.	Each sampling round	Collect to 250 mL of water in a glass or plastic container; add H_2SO_4 to pH less than 2, cool to 4°C.	Fixed-base
Water	Sulfate (SO_4^{2-})	EPA 375.4	If this method is used for sulfate analysis, do not use the field method.	Substrate for anaerobic microbial respiration.	Each sampling round	Collect to 250 mL of water in a glass or plastic container; cool to 4°C	Fixed-base
Water	Total Iron and Dissolved and Total Manganese	SW 6010	ICP Atomic Emission Spectroscopy	To determine if anaerobic biological activity is solubilizing manganese from the aquifer matrix material. To determine the total amount of iron present in groundwater.	One round of sampling	Collect 100 ml in a glass or plastic container that is rinsed in the field with the ground water to be sampled. Adjust pH to 2 with nitric acid. Do not insert pH paper or an electrode into the sample.	Fixed Base

Table 2. 2007-2008 Sampling and Analysis Schedule

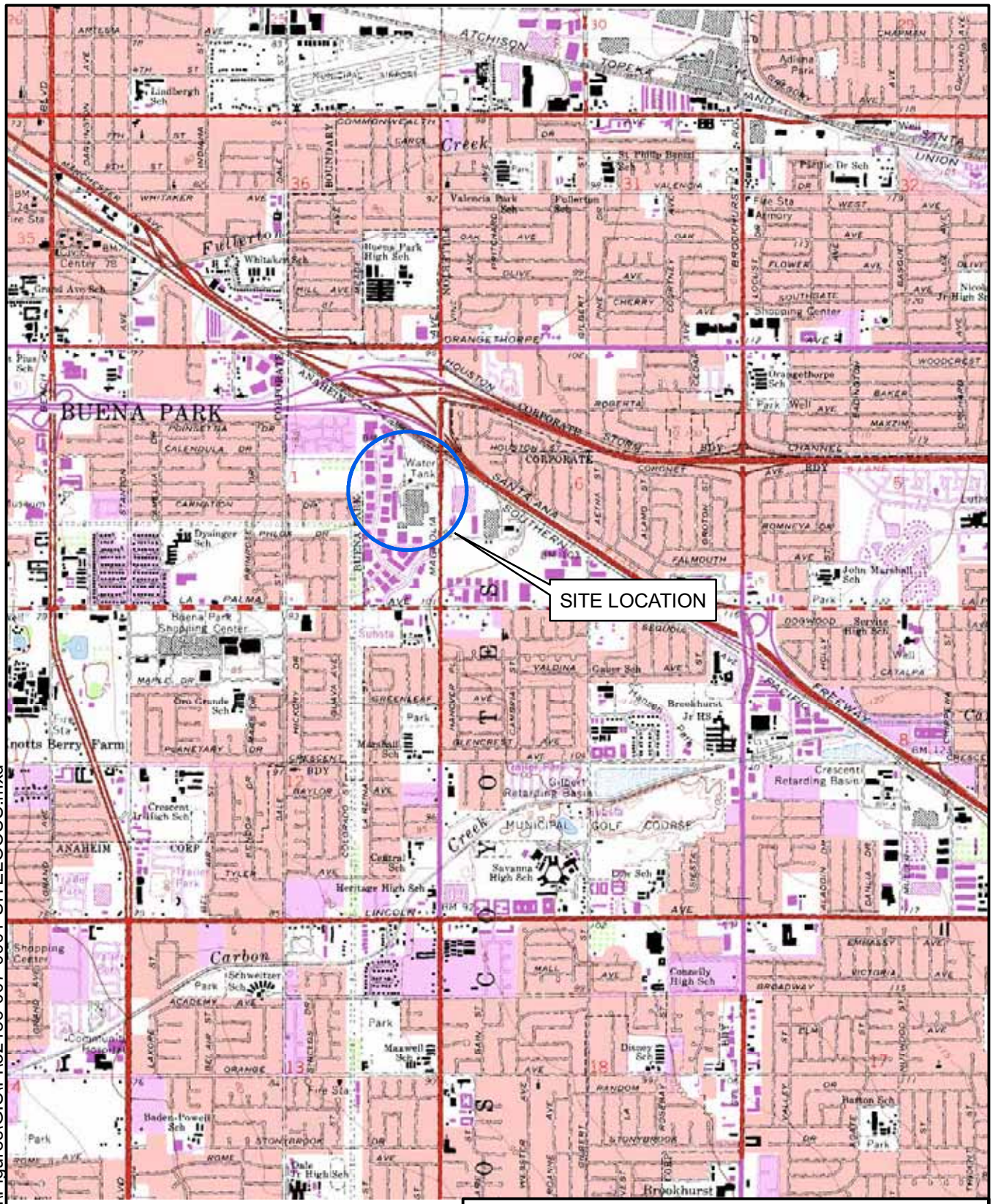
FIXED LABORATORY, CONT'D

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Water	Methane, ethane, and ethene	Kampbell et al., 1989 and 1998 or SW 3810 Modified	Method published by researchers at the U.S. Environmental Protection Agency.	The presence of CH_4 suggests BTEX degradation via methanogenesis. Ethane and ethene data are used where chlorinated solvents are suspected of undergoing biological transformation.	Each sampling round	Collect water samples in 50 mL glass serum bottles with gray butyl /Teflon-faced septa and crimp caps, cool to 4°C.	Fixed-base
Water	Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC)	EPA 415.1	UV/Persulfate Oxidation – Dohrmann Analyzer	Used to classify plume and to determine if reductive dechlorination is possible in the absence of anthropogenic carbon.	Each sampling round	Collect to two 40 mL vials, cool to 4°C.	Fixed Base

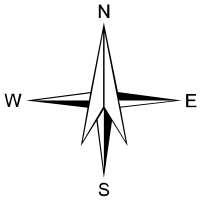
NOTES:

1. "Hach" refers to the Hach Company catalog, 1990.
2. "SW" refers to Standard Methods for the Examination of Water and Wastewater, 18th edition, 1992.
3. "EPA" refers to Methods for Chemical Analysis of Water and Wastes, U.S. EPA, 1983.
4. "SW" refers to the Test Methods for Evaluating Solid Waste, Physical, and Chemical Methods, SW-846, U.S. EPA, 3rd edition, 1986.

FIGURES



SITE COORDINATES: 33°51'8.56"N 117°58'38.17"W



U.S.G.S. QUADRANGLE: ANAHEIM, CA

HALEY & ALDRICH

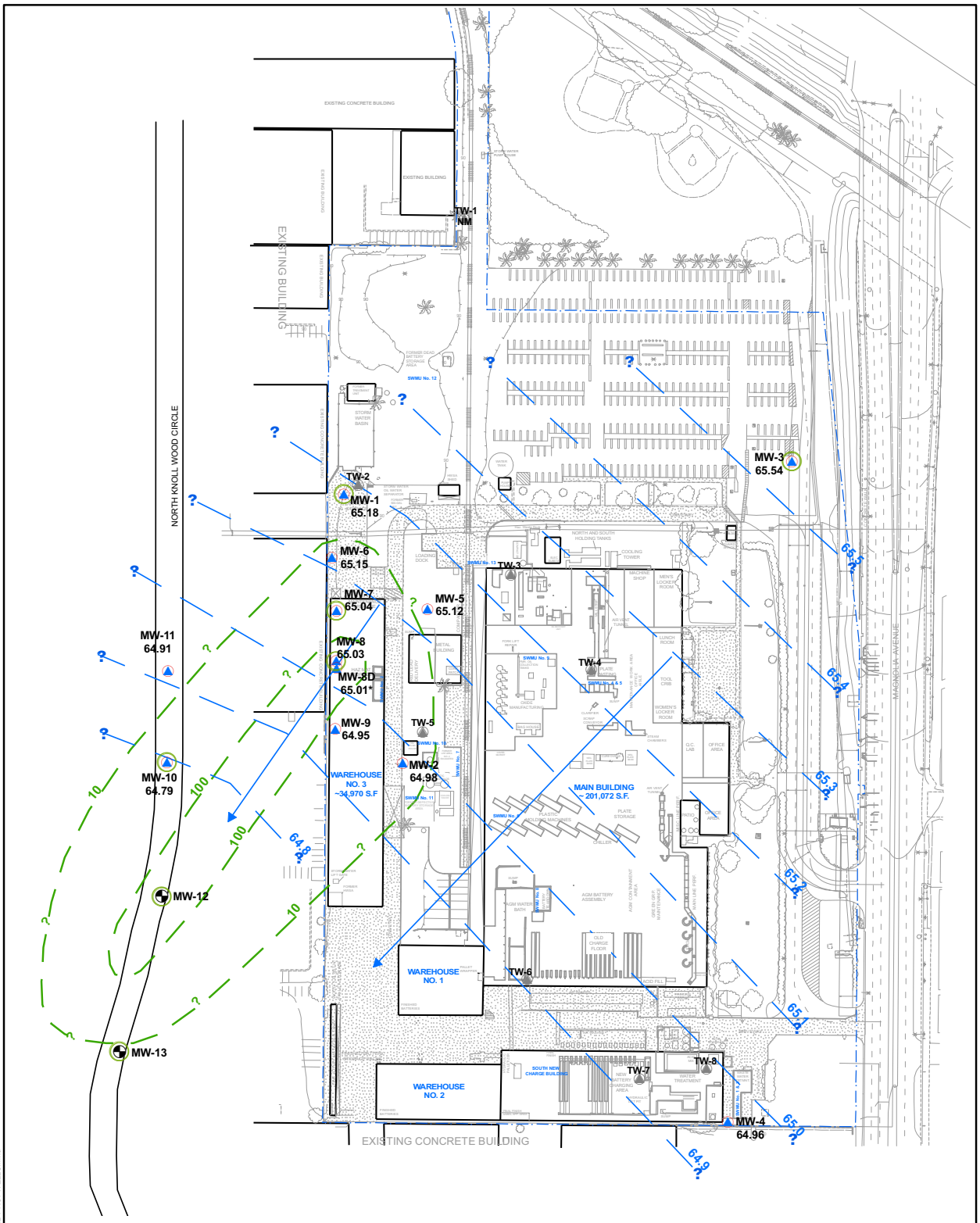
DELPHI CORPORATION
FORMER BATTERY OPERATIONS, 1201 N. MAGNOLIA
ANAHEIM, CALIFORNIA
32486-009

SITE LOCATION

SCALE: 1:24,000
MARCH 2007

FIGURE 1

G:\C&P\Delphi\Anaheim\Figures\GIS\FI\32486-007-0001-SITELOCUS.mxd



LEGEND

MW-13 PROPOSED WELLS

MW-11 64.91 MONITORING WELLS

TW-7 TEMPORARY WELLS (LEVINE-FRICKE. 25 JUNE 2005)

65.51 GROUNDWATER ELEVATION CONTOUR FEET ABOVE MEAN SEA LEVEL

ESTIMATED 1,1-DCE ISOCONCENTRATION CONTOUR

NOTE:
65.01* ELEVATION FOR MW-8D IS FOR DEEPER AQUIFER ZONE

PROPOSED MNA MONITORING WELLS

BUILDING OUTLINE

PROPERTY LINE

N
W E
S

0 70 140
SCALE IN FEET

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DELPHI CORPORATION
FORMER BATTERY OPERATIONS, 1201 N. MAGNOLIA
ANAHEIM, CALIFORNIA
32486-009

PROPOED WELLS, GROUNDWATER ELEVATION CONTOUR AND 1,1-DCE ISOCONCENTRATION MAP

SCALE: AS SHOWN
AUGUST 2007

FIGURE 2

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APPENDIX A

STANDARD OPERATING PROCEDURE FOR MONITORING WELL DEVELOPMENT

OPERATING PROCEDURE: OP3009

MONITORING WELL DEVELOPMENT PROCEDURE

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PREPARATION AND APPROVALS

VERSION	AUTHORED/DATE	REVIEWED / DATE	REVIEWED / DATE	REVIEWED / DATE	APPROVED / DATE
Ver. 0.0	BAM/ 08-02	JCP/ 08-02	GJM/ 06-03		JAK/ 06-03

Total Pages: 20

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1	Common Well Development Equipment	11

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OPERATING PROCEDURE: OP3009

MONITORING WELL DEVELOPMENT PROCEDURE

1. PURPOSE

This procedure provides guidance on methods and techniques for groundwater monitoring well development typically performed after well installation, but prior to groundwater quality sampling, specifically for instrumentation installed in overburden or bedrock for environmental monitoring and geotechnical purposes. Groundwater well development increases the yield of the well by removing fine sediments and particles from within the well and the well filter pack, enhances the hydraulic communication between the well and the screened formation, decreases turbidity, increases precision of hydrologic measurements, and increases representativeness of groundwater quality data. Well development is an integral component of a groundwater sampling program, with the objective of obtaining high quality, reproducible groundwater quality data.

The selected method and duration of groundwater well development will be dependent on a number of factors, including: well construction method and materials, depth to groundwater, anticipated groundwater testing parameters and data quality objectives, presence of contamination (i.e., degree of contamination and presence of free-phase non-aqueous phase liquids), method of borehole advancement, and site physical setting/access.

IMPORTANT NOTES:

It is not necessary to follow all of the methods in this procedure for every monitoring well development performed. The procedures may be adapted to conform to specific local practice, site-specific geologic conditions, or to support local, municipal or state regulatory requirements.

The term “groundwater monitoring well” or “well” in the procedure is used to denote groundwater monitoring wells, groundwater observation wells, piezometers, gas monitoring wells, lysimeters or other devices constructed in similar manner to a well. Certain well constructions (i.e., large-diameter pumping test wells, injection/extraction wells, commercial, residential or industrial water supply wells) may be developed using the information contained in the procedure, but are typically installed using specialized drilling equipment and are typically developed using that equipment by specific methods that are beyond the scope and intent of this field procedure.

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2. EQUIPMENT & SUPPLIES

Required

1. Water Level Indicator, Sinco or equivalent
2. Oil/Water Interface Probe
3. Thermometer
4. pH meter and buffering/calibration solutions
5. Conductivity meter and probe
   Dissolved oxygen meter and probe
7. Turbidity meter and probe
8. Oxidation/Reduction Potential meter and probe
9. Salinity meter
10. Pump (Grundfos, peristaltic, whale etc.)
11. Pump accessories (Cables, fittings, tools)
12. ½ in. or 5/8 in. HDPE or Teflon discharge tubing; also silicon tubing for peristaltic pump
13. Power source for pump (generator with fuel; automotive battery, rechargeable battery)
14. Graduated plastic bucket (5-gallon) or flow meter
15. Stopwatch
16. Standard decontamination equipment (water jug, buckets or washtubs, brushes, Alconox, distilled water, tap water, methanol, squeeze bottles)
17. Ruler, engineer's 6 ft. folding
18. Scale, engineer's
19. Graduated tape, 100 ft. length, weighted end
20. Field Logs & Forms/Field Book 6.
21. Site Plan, Maps, Boring and Well Installation Logs
22. Personal protective equipment
23. Calculator
24. Keys to well padlocks/covers
25. Paper towels
26. Trash bags

Optional:

1. Horiba MultiMeter (measures pH, temperature, conductivity, DO, turbidity, and salinity)
2. Horiba U-22 Flow Cell (measures pH, temperature, conductivity, DO, turbidity, ORP and salinity)
3. Inertial Pump Materials: Waterra Foot Valves, HDPE Tubing
4. Bailers; rope, knife

3. PROCEDURE

3.1 Summary of Procedure Purpose and Intent

The primary purpose of developing groundwater quality monitoring wells at sites containing, or potentially containing, solid or hazardous materials or their byproducts, is to create an effective filter pack around the well screen, rectify impact to the formation caused by drilling and the associated drilling fluid, remove fine

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particles from the formation near the borehole and assist in restoring the natural water quality of the aquifer in the vicinity of the well. The properly developed well ensures the reliable collection of representative ground water samples, of acceptably low turbidity.

Well development induces movement of water in two directions across the well screen and filter pack. This movement removes fines or other foreign materials from within the well, the filter pack, and the surrounding natural formation, creating a stable graded filter yielding water of relatively low turbidity.

3.2 Role of Environmental Professional or Engineer

Groundwater monitoring well development requires evaluation and consideration of a variety of site-specific characteristics, which precludes the use of one single development practice or procedure. The procedure is provided as a guide to aid the environmental professional, geologist or engineer in selecting the technical approach and methodology to effectively complete a well development program.

At the initiation of project planning, the Project Manager, Project Engineer or Scientist, and field personnel, determine any project-specific requirements for groundwater well development. Municipal, state or federal regulations, local practice, client requirements or project requirements may dictate the use of a different or modified well development method.

3.3 General Methods of Monitoring Well Development

There are three general types of well development methods typically employed on small diameter monitoring wells (equal to or less than 4 in. I.D.) installed for environmental purposes:

- Pumping and overpumping
- Bailing
- Surging with a Surge Block

Well development methods that potentially alter the chemical composition of the groundwater are not acceptable. Therefore, methods that introduce fluids (including water pumped from the well) or air, to accomplish development are generally considered unsuitable. This eliminates several methods commonly used to develop large-diameter water supply wells. These methods include backwashing, jetting, airlift pumping or air surging.

The majority of well development for environmental purposes is conducted by mechanical pumping and overpumping, use of inertial lift pumps, inertial lift pumps with surge blocks, bailers, or a combination of these methods.

3.4 Preliminary Procedures

In preparation for well development activities (and subsequent groundwater quality sampling event), the Project Manager and groundwater developer/sampler reviews project-specific requirements and considerations of the well development and groundwater sampling program.

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The information reviewed may include site map or plans, drilling methods and records, well construction records, depth to groundwater data, previous groundwater quality data, data trends, earlier sampling records and field procedures used, and preferred well sampling sequence or sampling order. Identify project documentation needs and records of well development execution.

Other information to be reviewed are specific laboratory analyses to be performed on samples to be obtained from each well, sampling glassware, need for field filtration and container preservatives. Related aspects of the procedure include site health & safety plan review, evaluation of the site physical setting, availability of electrical power, property access permission and constraints, and purge water disposal.

Design the well development program to support the data quality objectives of the chemical analyses of the groundwater samples to be obtained. Based on the types of data to be collected in the field, identify the appropriate types of mechanical purging required (by pumps or other specialized equipment), likelihood of the presence of non-aqueous phase liquid (NAPL) and accommodations for measuring NAPL. Generally, a series of wells are developed starting with the least contaminated well working towards the well exhibiting the most significant contamination, if known.

Other considerations are identifying protocol for personnel protective equipment (PPE) use and specialized handling of purged water and decontamination wastewater, as generated. Recently installed monitoring wells should not be developed before well sealant materials (bentonite annular seal, cement/bentonite grout) have set or cured, typically assumed to be approximately one week.

In some cases, groundwater obtained from wells installed and sealed with a column of cement grout has exhibited artificially high pH, due to migration and influence of the calcium carbonate from the cement. The Project Manager and field representative are cautioned of this possibility, manifested during the well development procedure by inconsistent, unstable or high pH readings.

Table I presents common well development equipment, and lists advantages/disadvantages of the equipment.

3.5 Calculate Volume of Standing Water in Well

Calculate the estimated volume of standing water in the well. Some useful formulae for calculating well volumes are provided below:

- $V = L\ r^2 (0.163)$

  Where:

  V = volume of standing water in well, in gallons
  r = internal radius of well, in inches
  L = length of standing water column, in feet
  0.163 = derived constant converting well radius in inches to feet, and cubic feet to gallons

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Other useful formulae:

- Gallons per 100 ft. = 4.08 * (D)2

  Where D = Inside well or borehole diameter, in inches

- Cubic feet of water per 100 ft. = 0.55 * (D)2

  Where D = Inside well or borehole diameter, in inches

- 7.48 gallons = 1 cubic foot

- 0.134 cubic feet = 1 gallon

3.6 Field Procedures

3.6.1 Locate Well

Locate the subject well in the field, using site plans, sketches, fixed references or other available documentation. Metal detectors may be useful in locating buried metal well casings; however, non-ferrous (i.e., aluminum or PVC) or missing well casings will not respond to metal detector signals.

Verify well designation, particularly individual wells located in closely spaced well clusters or well nests. If necessary, verify and document the location of the well to be decommissioned, referenced by taped distance to three fixed features, or acquire coordinates using global positioning system (GPS) methods or by instrument survey.

3.6.2 Evaluate Well Integrity and Construction

Evaluate and document condition of protective well casing and surface seal (padlock missing/broken, well cap missing, staining on well riser observed, concrete surface seal cracked, surface runoff entering well etc.). Record well construction material (stainless steel, PVC, fiberglass, galvanized steel, black carbon steel etc.).

Establish/verify monitoring well reference point (i.e., PVC rim, roadway box rim, protective guard pipe casing rim, ground surface).

3.7 Well Development Procedure – Mechanical Pump Method

Mechanical pumps include electrically powered submersible pumps (Grundfos and Whale brands), or suction lift surficial pumps, such as centrifugal or peristaltic types. Pumps may have variable speed controls to regulate discharge rate. Other types of suction lift surface pumps may be driven by internal combustion gasoline engines (not discussed in this procedure).

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1. Follow Preliminary Procedures above, including evaluation of well integrity and documentation of well construction details.

2. Don appropriate personnel protective equipment (PPE) as identified in project health & safety plan. Pay particular attention to splash hazards.

3. Decontaminate all downhole development equipment prior to placement within wells, between uses in either the same well, or in other wells. Clean and prepare equipment using an Alconox soapy wash, tap water rinse, methanol rinse, and distilled/deionized water rinse. Containerize decontamination rinseate, if required.

4. If warranted, measure for possible presence of non-aqueous phase liquids (NAPL), using oil/water interface probe. Modify well development program based on findings and discussion with Project Manager, including postponing/canceling well development.

5. Measure well diameter, depth to water (static water level), depth to bottom of well using water level indicator or weighted graduated tape. Calculate standing water volume (see above).

6. Verify information on the respective well record, if available, and note any discrepancies. If well logs are not available, determine screen length and depth, if possible, to determine whether the well construction will provide useful data.

7. Evaluate obstructions present within the well or material accumulated in bottom of well. The presence of substantial quantity of accumulated materials (i.e., silt > 0.5 ft.) in bottom of well may warrant modifying the well development method to remove the sediment (i.e., use of peristaltic pump or hand bailer to remove sediment).

8. Remove any unsuitable dedicated groundwater sampling devices, if present (i.e., Waterra-type inertial pumps and discharge tubing, bailers, SoakEase absorbent material). Retain and discard as solid waste.

9. Groundwater purged from the borehole may or may not require containment or may be discharged on the ground in vicinity of well head, depending on groundwater quality, site setting, regulatory considerations and project requirements. Resolve with Project Manager prior to entering field.

10. Cut a clean piece of discharge tubing for selected pump (typically ½ in. or 5/8 in. high density polyethylene (HDPE) or Teflon tubing) of sufficient length to fully penetrate the well to its screened depth and to accommodate measuring purge volumes and inorganic parameters at ground surface. Cut tubing should not fall or drop into the well.

11. For submersible pumps, attached tubing and lower pump intake into well, suspending pump intake at the approximate midpoint of the saturated zone for water table wells, or at the screen midpoint for deeper wells. Connect power cables and controller box, and operate the pump according to manufacturer's instructions.

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12. Initially operate pump at a discharge rate approximately equal to well recharge rate, using graduated bucket or flow meter and stopwatch to estimate flow, and adjust until drawdown of approximately 0.3 ft. is obtained. At the start of purging, obtain inorganic field parameters of the discharge, in the following order: pH, temperature, specific conductance (conductivity), oxidation-reduction potential (ORP), dissolved oxygen (DO) and turbidity, and record on field forms or in logbook.

13. Well development continues until representative groundwater, free from drilling fluids, drill cuttings, accumulated sediment or other materials introduced during the well construction is obtained.

    Unless determined by project specific requirements, remove approximately 3 to 5 well volumes, measuring and recording inorganic field parameters for each well volume removed. If, during removal of 3 to 5 well volumes, field parameters have stabilized within 10% for two successive readings, and turbidity has been reduced to 5 nephelometric turbidity units (NTU) or less, then well development is considered complete. Based on discussion with the Project Manager or environmental professional, consider the applicability of Step 14 below, and complete if warranted.

    In certain circumstances and based on project objectives, well development may consist of removing a fixed volume of water from the well that is predicated on the drilling method used for well installation. For wells installed without the introduction of drilling fluids (i.e., hollow stem augers, driven well points), three (3) well volumes are removed. For wells where drilling fluids were introduced (i.e., cased borings, rock coring, mud rotary methods), ten (10) well volumes are removed. In these cases, inorganic field parameter readings may be obtained for informational purposes.

14. A parallel objective of well development may be to remove drilling fluid lost to the formation(s) that was introduced during the drilling process. This aspect of development is complete when the identified volume of fluid is removed, and stabilized inorganic parameters are achieved.

15. If field parameters have not stabilized after Step 13, increase pumping rate to dislodge fine-grained materials from the filter pack, or remove sediment in suspension. It may be necessary to lower pump intake to accommodate drawdown. Avoid pulling coarse sediment into well intake to prevent pump impeller damage.

16. If slow recharge rate does not allow for continuous operation, shut off pump, allow well to recharge, and resume pumping at slower rate and well evacuation until discharge water clears. Resume measuring field parameters (Step 13) until stabilized.

17. Complete documentation as appropriate.

3.8 Well Development Procedure – Inertial Pump Methods

Inertial pumps use a dedicated pre-cleaned single ball check valve ("foot valve") and HDPE discharge tubing to manually remove water from the well.

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1. Follow Preliminary Procedures above, including evaluation of well integrity and documentation of well construction details, and Section 5.7, Steps 1 through 10.

2. Attach foot valve (i.e. Waterra type) to bottom end of HDPE tubing and lower into well. Allow approximately 2 to 4 ft. extra tubing above well casing for controlling discharge of purge water.

3. To remove groundwater from the well, manually lift and lower the HDPE tubing within the well bore by hand, approximately once every three to five seconds, timing the motion to optimize purge water volume removed with each stroke. Clean foot valve if it becomes clogged or obstructed by sediment by carefully removing tubing from well, unthreading the foot valve, and rinsing with distilled water.

4. Monitor inorganic field parameters as in Steps 12 to 14, above.

5. If slow recharge rate does not allow for continuous purging, allow well to recharge, and resume purging and well evacuation until discharge water clears. Resume measuring field parameters until stabilized. HDPE tubing and foot valves are typically dedicated and left in groundwater well following sampling.

6. Complete documentation as appropriate.

3.9 Well Development Procedure - Surge Blocks

Surge blocks can be used in conjunction with pre-cleaned, dedicated inertial pumps (single ball check valve or "foot valve") and HDPE discharge tubing.

1. Follow Preliminary Procedures above, including evaluation of well integrity and documentation of well construction details, and Section 5.7, Steps 1 through 10.

2. Press fit the surge block device securely onto foot valve (i.e. Waterra type), attach foot valve to bottom end of HDPE tubing and lower into well. Allow approximately 2 to 4 ft. extra tubing above well casing for controlling discharge of purge water.

3. To surge the groundwater, lower the surge block into the water column and use as a "plunger" by manually lifting and lowering the HDPE tubing by hand, forcing water to flow into and out of the screened portion of the aquifer. Surge each well for a minimum of 30 minutes to remove the finer material from the aquifer surrounding the borehole, providing a developed zone of uniformly graded sand of higher porosity and higher permeability surrounding the well screen, allowing the water to flow more freely into the well, and reducing potential turbidity.

4. Following the surging portion of the well development, remove the surge block from the foot valve, and purge a minimum of one well volume from the well by removing the fine particles brought into the well during surging.

5. Monitor inorganic field parameters as in Steps 12 to 14, above.

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6. If slow recharge rate does not allow for continuous purging, allow well to recharge, and resume purging and well evacuation until discharge water clears. Resume measuring field parameters until stabilized. HDPE tubing and foot valves are typically dedicated and left in well following sampling.

7. Complete documentation as appropriate.

3.10 Well Development Procedure - Bailers

Hollow, cylindrical bailers are a type of grab sampling device, and may be constructed of stainless steel, Teflon, or PTFE, typically with a single ball check valve fixed on the bottom. They are manually lowered into the well using a rope tether, allowed to collect well water, then lifted from the well. The collected water is discharged to a graduated bucket, and the process repeated until the well is deemed adequately developed. Stainless steel bailers are generally simple to decontaminate. Teflon or PTFE bailers are considered dedicated or disposable after one-time use.

In general, the use of bailers are not a preferred well development method, due to the time required to remove potentially large volumes of development water, especially in deep wells. Their use, however, creates agitation and mixing within the water column, which suspends sediment and fines, incrementally aiding in clearing the well and filter pack, thereby reducing turbidity.

PTFE ("clear") bailers are often used to collect NAPL for thickness measurements or product analysis. Although not discussed in this procedure, bailers are generally not recommended for groundwater sampling overall, and not acceptable for low-flow groundwater sampling in particular, especially sampling for volatile organic compounds (VOCs), volatile petroleum hydrocarbons (VPH), dissolved metals or other analytes requiring field filtration.

3.11 Restoration and Cleanup

The area around the well head and ground surface shall be completely cleaned up of any development materials (plastic sheeting, tubing, paper towels, litter, etc.), and the well secured.

3.12 Documentation

A complete record of the well development procedure should be documented and incorporated into the project file. Complete portions of the Groundwater Sampling Record form, recording the following information:

- Project information, date and personnel present
- Well location and designation
- Well condition inventory
- Presence of NAPL

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- Diameter, depth of well, screened interval (if known), depth to static groundwater, volume of standing water column in well
- Detailed description of well development equipment and procedure used
- Time(s) development started and ended
- Incremental and total volume of purge water removed
- Inorganic field parameter measurements
- Comments on discharge water quality
- Modifications to procedures
- Decontamination method, and discharge water management method
- Drum count of accumulated discharge water, if applicable

Appendix C contains a blank Sampling Report (Form #3004), Groundwater Sampling Record (Form #3005), Monitoring Well Development Report (Form #3006) and Low Flow Field Sampling Form (Form #3010) for reference.

3.13 Precision and Bias

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

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TABLE 1
Common Well Development Equipment

Material	Type	Power Requirement	Positive Attributes	Negative Attributes
Mechanical Pumps:				
Grundfos Pump	Submersible pump (variable speed)	120V A.C. current	-Lift height only constrained by cable length (+/- 150 ft.) -Controllable, variable flow rate from 0.01 to ≈35 L/minute -Stainless steel disassembles for simple decontamination See note 1	-Requires generator if no power source available -Risk of cross contamination of sample glassware or tubing from generator fuel -Heavy/cumbersome -Sediment may clog pump impellers -2.0 in. minimum well diameter See note 2
GeoDurham	Submersible Pump (variable speed)	12V D.C. current (Automotive battery)	-Portable power supply -Lift height only constrained by cable length (+/- 75 ft) -Controllable, variable flow rate -Stainless steel for simple decontamination See note 1	-Limit on lowest pump speed/discharge -Sediment may clog pump impellers -Power supply limits duration of pump use -2.0 in. minimum well diameter See note 2
Whale Pumps	Submersible pump (variable speed)	12V D.C. current (Automotive battery)	-Portable power supply -Lift height only constrained by cable length (+/- 30 ft.) -Disassembles for simple decontamination -1.5 in. minimum well diameter	-Power supply limits duration of pump use See note 2
Peristaltic Pumps	Suction lift surface pump (single speed)	12V D.C. current (Automotive Battery)	-Good for purging sediment from silt trap during development -Dedicated tubing -Easy to operate -0.5 in. minimum well diameter	-Not appropriate for sampling VOCs (agitation) -Lift limited to ≈25 ft. BGS -Pump rate 0.01 L/min.
Manual Methods:				
Inertial Pump	Submersible foot valve with discharge tubing	Manually operated	-Dedicated tubing -Inexpensive -Simple to operate -0.5 in. minimum well diameter	-Depth limited by manual capability to lift tubing (typically 70 to 80 ft.) -Tiring for large volumes of development water -Sediment may clog foot valve
Stainless Steel Bailer	Grab sample device with single check valve	Manually operated	-Disassembles for simple decontamination -Simple to operate	-Not appropriate for groundwater sampling (agitation) -Tiring for large volumes of development water -Splash hazard
Teflon Bailer	Grab sample device with single check valve	Manually operated	-Dedicated -Simple to operate -Inexpensive	-Not appropriate for groundwater sampling (agitation) -Tiring for large volumes of development water -Splash hazard
Clear Bailer	Grab sample device with single check valve	Manually operated	-Dedicated -Simple to operate -Inexpensive -Can collect NAPL for evaluation	-Not appropriate for groundwater sampling (agitation) -Tiring for large volumes of development water -Splash hazard

Notes and References:
1. Appropriate for low flow/low stress groundwater sampling.
2. Not appropriate if DNAPL/LNAPL present in monitoring well.

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APPENDIX A
REFERENCES

A.1 Reference Procedures

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5521-94, "Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers."

- Puls, R.W., Barcelona, M.J., 1996. "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures," US EPA Ground Water Issue, US Environmental Protection Agency. Office of Solid Waste, EPA/540/S-95/504, pp. 1 to 12.

- US Environmental Protection Agency, Region I, (30 July 1996). "Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells," SOP # GW 0001, Revision 2.

A.2 Other References

- US Environmental Protection Agency, 1992. Office of Solid Waste," RCRA Groundwater Monitoring: Draft Technical Guidance," EPA/530/R-93/001, NTIS PB 93-139350, November 1992, pp. 6-46 to 6-50.

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D6634-01, "Standard Guide for the Selection of Purging and Sampling Devices for Groundwater Monitoring Wells."

- American Society for Testing and Materials, current edition, "Annual Book of ASTM Standards," Vol.04.08, D5903-96 (Reapproved 2001), "Standard Guide for Planning and Preparing for a Groundwater Sampling Event."

- Massachusetts Department of Environmental Protection, "Standard References For Monitoring Wells," January 1991, document WSC-310-91, Section 4.5 Well Development.

A.3 COMMENTS ON REFERENCE PROCEDURES

The procedures and equipment listed in EFP No. 01a and used by Haley & Aldrich are generally as specified in the ASTM and US EPA Reference Procedures. Deviations of EFP No. 01a from the Reference Procedures are not provided. The procedure described in Section 5 has been developed to assist Haley & Aldrich personnel in performing well development, and in some cases simplifies the Reference Procedures.

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APPENDIX B
RELATED HALEY & ALDRICH PROCEDURES

- OP2020 Groundwater Monitoring (Observation) Well Abandonment
- OP2031 Groundwater Monitoring (Observation) Well Installation
- OP3000 General Environmental Field Procedures and Protocols
- OP3007 Procedures for Surface Water Sampling
- OP3008 Manual Water Level Measurement Procedure
- OP3010 Groundwater Quality Sampling Procedure
- OP3012 Low Stress/Low Flow Groundwater Sample Collection Procedure
- OP3014 NAPL Monitoring and Sampling
- OP3015 Aquifer Parameter Testing Procedure

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APPENDIX C
FORMS

- 3004 Sampling Report
- 3005 Groundwater Sampling Record
- 3006 Monitoring Well Development Report
- 3010 Low Flow Field Sampling Form

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SAMPLING RECORD

Page of

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP**	
CONTRACTOR		**DATE**	

Weather _____ **Temperature** _____

Ground surface Conditions ☐ Dry ☐ Wet ☐ Damp ☐ Standing Water ☐ Snow (_____in) ☐ Other_____

Comments _____

SOIL SAMPLING AND SURFACE WATER SAMPLING INFORMATION

Sample No.	Location	Depth (ft)	Time	Sample Description	Sampling Device	Cleaning Prodedure	Container Type

General Comments: (ie: field filtrations, persons communicated with at site, etc.)

Form 3004

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GROUNDWATER SAMPLING RECORD

Page of

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP**	
CONTRACTOR		**DATE**	

GROUNDWATER SAMPLING INFORMATION

Well No.							
Water Depth (ft)							
Time							
Product							
Depth Of Well (ft)							
Inside Diameter (in)							
Standing Water Depth (ft) (1)							
Volume Of Water In Well (gal)							
Purging Device							
Volume of Bailer/Pump Capacity							
Cleaning Procedure							
Bails Removed/ Volume Removed							
Time Purging Started							
Time Purging Stopped							
Sampling Device							
Cleaning Procedure							
TIME SAMPLES TAKEN	VOA						
	ABN						
	Metals						
PARAMETERS	Color						
	Odor						
	pH						
	Conductivity						
	Turbidity						
	Dissolved Oxygen						
	Temp, ^{0} C						
	Salinity						

Remarks: (ie: field filtrations, persons communicated with at site, etc.)

1. Standing Water Depth = Depth of Well - Water Depth

Form 3005

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MONITORING WELL DEVELOPMENT REPORT

Well No.

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		FIELD REP.	
CONTRACTOR		DATE	
ELEVATION SUBTRAHEND			

Estimated Volume of Water Lost During Drilling: _____ gallons

Comments: _____

Depth to Water Before Development: _____ feet

Comments: _____

Depth to Well Bottom Before Development: _____ feet

Comments: _____

Turubitiy of Water Before Development: _____ NTU

Comments: _____

Volume of Water Removed: _____ gallons

Comments: _____

Method of Removal (bailing, pumping): _____

Comments: _____

Depth to Well Bottom After Development: _____ feet

Comments: _____

Depth to Water After Development: _____ feet

Comments: _____

Turubitiy of Water After Development: _____ NTU

Comments: _____

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LOW FLOW/MNA FIELD SAMPLING FORM

PROJECT _____ H&A FILE NO. _____

LOCATION _____ PROJECT MGR. _____

CLIENT _____ FIELD REP _____

CONTRACTOR _____ DATE _____

Sampling Data:

Well ID: _____ Well Depth: _____ ft Initial Depth To Water: _____ ft Purging Device: _____

Start time: _____ Depth To Top Of Screen: _____ ft Depth Of Pump Intake: _____ ft Tubing Present In Well: ☐ Yes ☐ No

Finish Time: _____ Depth To Bottom Of Screen _____ ft Tubing Type: _____

Elapsed Time (24 hour)	Depth To Water From Casing (ft)	Pump Setting (ml/min) or (gal/min)	Purge Rate (ml/min) or (gal/min)	Cumulative Purge Vol. (liters) or (gal)	Temp-erature (°F) or (°C)	pH	Conduct-ivity (us/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	ORP/eH (mv)	Comments

APPENDIX B

GROUNDWATER SAMPLING LOG SHEET

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UNDERGROUND
ENGINEERING &
ENVIRONMENTAL
SOLUTIONS
Tel: 714.985.3434
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GROUNDWATER SAMPLING LOG

PROJECT NAME: _____ WELL NO. _____
PROJECT NO.: _____ SAMPLED BY: _____
DATE: _____

WELL INFORMATION			
TOP OF CASING ELEV.			(ft.)
WELL DIAMETER 2"			(inches)
DEPTH OF WELL			(ft.)
DEPTH TO WATER			(ft.)
HEIGHT OF WATER COLUMN			(ft.)
CASING VOLUME*	Hgt. x	Gal./Ft. =	(gal)
PURGE VOLUME		x 3 =	(gal)
PRODUCT THICKNESS	N/A		(ft.)

WELL CONDITION:
WEATHER CONDITIONS:
PURGING AND SAMPLING EQUIPMENT:

PURGE DATA											
Time:	Purge Volume (Gal.)	Flow Rate (Gal./Min.)	Temperature (F / C)	pH	DO mg/L	ORP	Sp.Cond. (umhos/cm)	Sal.	Turbidity NTUs	Color	Odor

Sample No.	Sample Time Time		Analyses	Container	Quantity	Preserv-ative	NOTES:

ADDITIONAL INFORMATION:
TOC = Top of well casing
*Casing Volume = r^2h(ft) x 7.48 gal/ft.^{3} 4" well = 0.66 Gal./Foot 2" well = 0.163 Gal./Foot

APPENDIX C

STANDARD OPERATING PROCEDURE FOR LOW FLOW GROUNDWATER SAMPLE COLLECTION

OPERATING PROCEDURE: OP3012

LOW STRESS/LOW FLOW GROUNDWATER SAMPLE COLLECTION PROCEDURE

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PREPARATION AND APPROVALS

VERSION	AUTHORED/DATE	REVIEWED / DATE	REVIEWED / DATE	REVIEWED / DATE	APPROVED / DATE
Ver. 0.0	SLB/GMW / 05-02	NVD/ 12-01-02	GJM/ 6-5-02		JAK/ 6-10-03

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OPERATING PROCEDURE: OP3012

LOW STRESS/LOW FLOW GROUNDWATER SAMPLE COLLECTION PROCEDURE

1. PURPOSE

This document describes procedures for collection of groundwater samples for laboratory analysis utilizing the "Low Stress/Low Flow Method". This method should be employed when it is critical to collect groundwater samples not impacted by over-purging, aeration, and sediment/colloid presence. Although the procedures described in this document are generally appropriate for obtaining groundwater samples as part of Monitored Natural Attenuation (MNA) programs, a more complete procedure for MNA programs is described in a separate document (Monitored Natural Attenuation Sample Collection Procedure).

The method described herein is most appropriate for wells that can accept a submersible pump and have a screened interval of ten feet or less. However, the procedure is flexible and can be modified for a variety of well construction and groundwater yield situations. The low-flow purging and sampling method is not appropriate for use in all hydrogeologic regimes, and certain groundwater monitoring well designs may make the method unsuitable (e.g. open hole and long screen monitoring wells in bedrock and stratified sand and clay where the water bearing zones have not been characterized).
This procedure does not address wells that contain Non-Aqueous Phase Liquids (NAPLs).

Note: The methods described in this document are provided for training use and general information. Depending upon regulatory agency and other project specific requirements, appropriate field procedures may differ from those described herein. These procedures should be confirmed with the Haley & Aldrich Project Manager prior to implementation.

1.1 BACKGROUND

Research conducted by Puls et al. (1992), Puls and Powell (1992), and Powell and Puls (1993) has shown that high-volume purging and sampling cause significant turbidity and suspended particulate artifacts that can result in an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Additionally, standard purging procedures can cause pressure changes and bailing can cause aeration that can strip volatile organic compounds from groundwater samples (Pennino, 1988) and provide misrepresentative data on aquifer conditions (such as dissolved oxygen and redox). Overpurging of a well can cause water to cascade down the well screen, causing undesirable aeration and volatilization.

The use of low-flow pumping devices for purging and sampling minimizes both the disturbance of water in well casing and the potential for mobilization of colloidal material (Barcelona et al., 1994). Low-flow purging with maintenance of water level in the well and stabilization of indicator parameters (especially turbidity) allows collection of groundwater samples that are more representative of conditions without filtering (U.S. EPA, 1993; Backhus et al., 1993). In many cases, use of a low-flow pump to purge and sample monitoring

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wells decreases sampling time, reduces the need to handle large volumes of purge water and lowers the cost associated with its disposal, and may allow collection of samples for without filtering.

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface that can be affected by flow regulators or restriction. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practicable taking into account established site sampling objectives (USEPA, Puls and Barcelona, April 1996).

2. EQUIPMENT & SUPPLIES

1. Adjustable rate, positive displacement pumps (e.g. low flow-rate submersible centrifugal or bladder pumps constructed of stainless steel or Teflon). The pump should be easily adjustable and capable of operating reliably at lower flow rates. An example is QED MicroPurge bladder pump (available for purchase or rental at US Environmental 781-899-6969, among others).

   Under most regulatory programs, peristaltic pumps may be used for collection of inorganic samples only – they are NOT appropriate for collection of VOCs. Bailers are inappropriate for use in this procedure. Waterra tubing purging and sampling is also not recommended for low-flow sampling by the USEPA.

2. Tubing: Tubing used in purging and sampling each well must be dedicated to the individual well. Once properly located, moving the pump in the well should be avoided. Consequently, the same tubing should be used for purging and sampling. The tubing wall thickness should be maximized (3/8 to ½ inch) and the tubing length should be minimized (i.e. do not have excess tubing outside of the well)

   - **Organic analysis**: Teflon or Teflon-lined polyethylene tubing must be used to collect samples.
   - **Inorganic analysis**: Teflon or Teflon lined polyethylene, PVC, Tygon or polyethylene tubing may be used to collect samples.

3. Polyethylene sheeting and sampling gloves.

4. Water level measuring device, 0.01 feet accuracy, (electronic preferred for tracking water level drawdown during all pumping operations).

5. Flow measurement supplies (e.g. graduated cylinder and stopwatch).

6. Interface probe, if needed.

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7. Power source (e.g. generator, located downwind; nitrogen tank, etc). The generator should not be oversized for the pump.

8. In-line flow-through cell containing purge criteria parameter monitoring instruments for pH, turbidity, specific conductance, temperature, Eh and dissolved oxygen (DO). The in-line device should be bypassed or disconnected during sample collection. An example is the Horiba U-22 which is a flow-through cell that comes with probes capable of measuring pH, dissolved oxygen, conductivity, salinity, TDS, temperature, turbidity and oxidation-reduction potential. Available from Ashtead Technologies, 800.242.3910, www.ashtead-technology.com or Pine Environmental, 800-301-9663, www.pine-environmental.com, among others.

9. Photoionization detector (PID), or flame ionization detector (FID) or equivalent.

10. Nylon stay-ties

11. Decontamination supplies

12. Field book or well sampling form

13. Sample Bottles. It is recommended that preservatives be added to sample bottles prior to field activities to reduce potential error or introduction of contaminants.

14. Sample preservation supplies (as required by the analytical method; see previous item)

15. Sample tags or labels, and chain of custody.

16. Well construction data, location map, field data from last sampling event.

17. Sampling Plan or Work Plan

18. Health & Safety Plan

19. pH meter

20. Conductivity meter

21. Dissolved Oxygen (DO) meter

22. Oxidation -reduction (REDOX) reaction potential (ORP) meter

23. Nephlometer (turbidity)

24. Temperature gauge

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25. Field test kits (such as Hach kits for measurement of dissolved iron (Fe^{+2}), carbon dioxide, and alkalinity). See the document "Monitored Natural Attenuation Groundwater Sample Collection Procedure" for specifications and ordering information for these types of kits.

26. Field filtration units (if required)

3. PROCEDURE

3.1 Sampling Preparatory Activities

Prior to entering the field there are several activities that should be conducted. The activities are as follows:

- Obtain and review a copy of the Sampling or Work Plan and Health & Safety Plan.
- Obtain and review previous groundwater sampling data (if available), previous water level measurements and well construction details (total depth and length of well screen).
- Locate a site map denoting the wells to be sampled.
- Obtain well wrenches, well keys and any other equipment needed to access the wells.
- Coordinate site access.
- Coordinate with laboratory to obtain sample bottles and necessary quality assurance samples.
- Perform an inventory of necessary purging, sampling, and field measurement equipment. Certain equipment may need to be purchased or rented for the sampling event. Check field measurement probes for proper calibration and ensure that the probes and kits are complete (i.e., contain calibration and analytical solutions) for the entire sampling event.

3.2 Preliminary Site Activities

Once on site the following activities should be conducted prior to beginning sampling.

- Verify well identification and location using borehole log details and location site map. Check the condition of the well and record any evidence of damage or need for repair in the field book or field sampling form. Following field activities inform the Project Manager of any necessary repair work required.
- Lay out sheet of clean polyethylene around the well for monitoring and sampling equipment.

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- Prior to opening the well cap, measure the breathing space above the well casing with a PID or FID to establish baseline levels. Repeat this measurement once the well cap is opened. If either of these measurements exceeds the air quality criteria in the health and safety plan, field personnel should adjust their PPE accordingly.

- If the well does not have a water level reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the field book or sampling form.

- Collect a round of synoptic water level measurements and well depth (in the shortest possible time) before any purging or sampling activities begin. Water levels and well depths should be measured and reported to 0.01 ft. The water levels should be obtained from the denoted reference point on the well.

- Water level and total depth measurements must be obtained to determine the well volume for hydraulic purposes. In some settings it maybe necessary to allow the water level time to equilibrate. This condition exists if a watertight seal exists at the well cap and the water level has fluctuated above the top of screen thereby creating a vacuum or pressurized area in this air space. Three water level checks will verify static water level conditions or changing conditions.

- Check newly constructed wells for the presence of light or dense aqueous phase liquids before sampling.

3.3 Sampling Procedure

It is preferable to sample the wells in order of increasing chemical concentrations (known or anticipated). The following describes the procedure for the low-flow purging and sampling method. Equipment calibration, logbook documentation, sample bottle filling and preservation, and shipping will be conducted in accordance with the site-specific Quality Assurance Project Plan (QAPjP). Personal protective equipment will be donned in accordance with the requirements of the site-specific Health and Safety Plan.

1. Attach and secure the polyethylene tubing to the low-flow pump. See the equipment and materials section for recommended pump types. As the pump is slowly lowered into the well, secure the safety drop cable, tubing, and electrical lines to each other using nylon stay-ties. It is recommended that the pump be placed in the well 12 to (preferably) 48 hours prior to purging/sampling to minimize the effects of turbidity and mixing in the well from introducing the pump.

2. Pump, safety cable, tubing and electrical lines should be lowered slowly into the well to a depth corresponding to the center of the saturated screen section of the well, or at a location determined to either be a preferential flow path or zone where contamination is present. The pump intake should be kept above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.

3. Before starting the pump, measure the water level again with the pump in the well. Start pumping water from the well at a rate of **100 to 500 milliliters per minute (mL/min) which correlates to 0.03**

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to 0.13 gallons per minute. Avoid surging. Observe air bubbles displaced from discharge tube to assess progress of steady pumping until water arrives at the surface. The pumping rate should cause little or no water level drawdown in the well (less than 0.2 ft) and the water level should stabilize.

Water level measurements should be made every three to five minutes. Precautions should be taken to avoid pump suction loss or air entrainment. Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to avoid pumping the well dry and ensure stabilization of indicator parameters. If the recharge rate of the well is very low, purging should be interrupted so as not to cause the drawdown within the well to advance below the pump intake but the operator should attempt to maintain a steady flow rate with the pump to the extent practicable. Record adjustments made to the pumping rates and water levels immediately after each adjustment.

In low-yielding wells, where 100 mL/min exceeds the entrance rate of groundwater into the well, it is important to avoid dewatering the well screen interval and purging the well dry should be avoided to the extent possible. In these cases, the pump should remain in place and the water level should be allowed to recover repeatedly until there is sufficient volume in the well to permit collection of samples. Under these low-yield conditions, it may become difficult to maintain an adequate water volume in the flow-through cell described in the next step. An alternative means of sample collection may be necessary under these conditions and should be discussed with the Project Manager.

4. While purging the well, measurements of water quality indicator parameters utilizing an in-line flow-through cell (or similar equipment) should be collected every three to five minutes until all of the parameters have stabilized. See the Equipment and Materials section for recommendations. Stabilization is achieved when three successive readings are within the following tolerances noted in the table below.

Parameter	Stabilization Level (3 successive readings within)
Turbidity	+10% and final value between 5 and 10 NTU
Specific conductance	+3%
pH	±0.1
Dissolved oxygen (DO)	±10%
Redox potential (Eh)	±10mv

In general, the order of stabilization is pH, temperature and specific conductance, followed by redox potential, dissolved oxygen, and turbidity (USEPA, 1996). A minimum subset of these parameters that can be used to determine stabilization during purging in this procedure are pH, specific conductivity and turbidity or DO. Turbidity and DO are typically the last parameters to stabilize. If the parameters have stabilized, but the turbidity is not in the range of 10 NTU, then follow step 6. For informational purposes, the following table provides typical ranges of the various field parameters. Field data collected during purging and sampling should be compared against these values and, if substantial differences exist, the accuracy of the meter should be verified to rule out potential operational problems with the equipment.

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Parameter	Typical Range of Values
Turbidity	10 – 500 NTU
Specific conductance	50 – 500 mS
pH	6 - 9
Dissolved oxygen (DO)	ND – 9 mg/L
Redox potential (Eh)	-250 - +400 mV

5. Once stabilization has been documented, go to step 8.

6. Should stabilization not be achieved for all field parameters (or turbidity only as described in Step 4), purging is continued until a maximum of 20 well screen volumes have been purged from the well. Since low-flow purging (LFP) likely will not draw groundwater from a significant distance above or below the pump intake, the screen volume is based upon a 5-foot (1.4 m) screen length. After purging 20 well screen volumes, purging is continued if the purge water remains visually turbid and appears to be clearing, or if stabilization parameters are varying slightly outside of the stabilization criteria listed above and appear to be approaching stabilization.

   - If low-turbidity samples are critical to the project goals, purging will be extended until turbidity has been reduced to 5 NTU or less.

   - The pump must not be removed from the well between purging and sampling.

7. If the turbidity measurements do not approach the range of that of natural groundwater (10 NTU), both filtered and unfiltered samples should be collected for analysis of compounds such as metals or hydrophobic compounds[1]. Filtered metal samples are to be collected with an in-line filter. A high capacity, in-line 0.45 micron particulate filter must be pre-rinsed according to the manufacturers recommendations, or with approximately 1 liter of groundwater following purging and prior to sampling. After the sample is filtered it must be preserved immediately.

8. Collect groundwater samples. All sample containers should be filled by allowing the pump discharge to gently flow down inside the container with minimal turbulence. The flow-through cell, or similar equipment, should be bypassed during sampling. As each sample bottle is collected, the bottle should be labeled with the following information then place into a cooler with the proper temperature control.

   - Sample number/ID
   - Date and time
   - Parameters to be analyzed
   - Project Reference ID
   - Samplers initials

[1] Filtering of samples for analysis is a project-specific requirement and should be confirmed with the Project Manager prior to filtration.

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After collection of the samples, the tubing from the pump should be properly discarded or dedicated to the well for re-sampling (by hanging the tubing inside the well). Avoid handling the interior of the bottle or bottle cap and don new gloves for each well sampled to avoid contamination of the sample.

VOC and gas sensitive (e.g. Fe^{+2}, CH_4, H_2S/HS) parameter samples should be collected first. Refer the project sampling and analysis plan to determine which analytes will be measured in the field (wellhead) and which will be submitted to a fixed-base laboratory. The order of sample collection is as follows:

1. Volatile organic compounds
2. Gas sensitive parameters (e.g. Fe^{+2}, CH_4, H_2S/HS)
3. Semi-volatile organic compounds
4. Total organic carbon (TOC)
5. Total organic halogens (TOX)
6. Extractable organics
7. Total metals
8. Dissolved metals
9. Phenols
10. Cyanide
11. Sulfate and chloride
12. Nitrate and ammonia
13. Radionuclides

*Note: **The pumping rate used to collect a sample for VOCs should not exceed 100 mL/min.** Samples should be transferred directly to the final container 40 mL glass vials completely full and topped with a Teflon cap. Once capped the vial must be inverted and tapped to check for headspace/air presence (bubbles). If air is present the sample vial will be discarded, and re-collected until free of air. Field filtration will be performed if dictated by the project Work Plan.*

9. Measure and record final water level and well depth.

10. Secure the well (close and lock).

3.4 Decontamination

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed from well between purging and sampling operations. The pump and tubing (including support cable and electrical wires that are in contact with the well) will be decontaminated by one of the procedures listed below.

3.4.1 Procedure 1

Decontamination solutions can be pumped from buckets through the pump, or the pump can be disassembled and flushed with the decontamination solutions. It is recommended that the detergent

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and isopropyl alcohol be used sparingly in the decontamination process and that water-flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

1. Flush the equipment/pump with potable water.

2. Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

3. Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

4. Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event shows that the level of contamination is low, then this step may be skipped.

5. Flush with distilled/deionized water. The final water rinse must not be recycled.

6. Decontaminate the in-line flow-through cell and other sampling equipment with similar procedures, as appropriate.

3.4.2 Procedure 2

1. Steam clean the outside of the submersible pump.

2. Pump hot potable water from the steam cleaner through the outside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

3. Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

4. Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.
5. Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

6. Decontaminate the in-line flow-through cell and other sampling equipment with appropriate procedures.

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3.5 Field Documentation

Field notes must document all the events, equipment used, and measurements collected during the sampling activities. The logbook or sampling form (see Appendix C Forms) should document the following for each well sampled:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Sounded well depth
- Presence of immiscible layers and detection/collection method
- Well yield - high or low
- Purge volume and pumping rate
- Time well purged
- Measured field parameters - record measurements obtained every 3-5 minutes to monitor for stabilization, see attached example record log.
- Purge/sampling device used
- Well sampling sequence
- Sampling appearance
- Sample odors
- Sample volume
- Types of sample containers and sample identification
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data and method(s)
- Sample distribution and transporter

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- Laboratory shipped to
- Chain of custody number for shipment to laboratory
- Field observations on sampling event
- Name collector(s)
- Climatic conditions including air temperature
- Problems encountered and any deviations made from the established sampling protocol.

3.6 Groundwater/Decontamination Fluid Disposal

Groundwater disposal methods will vary on a case-by-case basis and field personnel should consult the Project Manager for site-specific requirements. Disposal options may include:

- Off-site treatment at private treatment/disposal facilities or public owned treatment facilities.
- On-site treatment at Facility operated facilities.
- Direct discharge to the surrounding ground surface, allowing groundwater infiltration to the underlying subsurface regime.
- Direct discharge to impervious pavement surfaces, allowing evaporation to occur
- Decontamination fluids should be segregated and collected separately from wash waters/groundwater containers. Often small volumes of solvents used during the day can be allowed to evaporate if left in an open pail. In the event evaporation is not possible or practical, off-site disposal arrangements must be made.

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APPENDIX A
REFERENCES

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- USEPA Region 2. 1998. Ground Water Sampling Procedure, Low Stress (Low Flow) Purging and Sampling. GW Sampling SOP, Final.

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APPENDIX B
RELATED HALEY & ALDRICH PROCEDURES

- OP3000 General Environmental Field Procedures and Protocol
- OP3001 Preservation and Shipment of Environmental Samples
- OP3008 Manual Water Level Measurement Procedure
- OP3009 Monitoring Well Development Procedure
- OP3010 Groundwater Quality Sampling Procedure
- OP3013 Monitored Natural Attenuation Groundwater Sample Collection Procedure
- OP3014 NAPL Monitoring and Sampling Procedure

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APPENDIX C
FORMS

- Form 3001 Sampling Labels (Environmental)
- Form 3003 Chain of Custody
- Form 3004 Sampling Record
- Form 3005 Groundwater Sampling Record
- Form 3006 Monitoring Well Development Report

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Sample ID:	File Number:
Depth:	Project:
Date:	Analysis:
Time:	Preservative:
Collected By:	Laboratory:
Comments:	

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Form 3001

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CHAIN OF CUSTODY RECORD

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PROJECT NAME		ADDRESS		TURNAROUND TIME	
H&A CONTACT		CONTACT		PROJECT MANAGER	

Sample No.	Date	Time	Depth	Type	VOA	ABNs PAH only	Metals RCRA (8) PP(13)	Pesticides PCBs	VPH Full Suite C-ranges only	EPH Full Suite C-ranges only	TPH (specify)	TCLP (specify)	Reactivity Ignitability Corrosivity				Number of Containers	Comments (special instructions, precautions, additional method numbers, etc.)

Analysis Requested

Sampled and Relinquished by	Received by
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time
Relinquished by	**Received by**
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time
Relinquished by	**Received by**
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time

LIQUID													
													VOA Vial
													Amber Glass
													Plastic Bottle
													Preservative
													Volume

SOLID													
													VOA Vial
													Amber Glass
													Clear Glass
													Preservative
													Volume

PRESERVATION KEY

A Sample chilled	**C** NaOH	**E** H_2SO_4	**G** Methanol
B Sample filtered	**D** HNO_3	**F** HCL	**H** Sodium Bisulfate

Sampling Comments

Evidence samples were tampered with? YES NO

If YES, please explain in section below.

WHITE - Laboratory **CANARY** - Project Manager **PINK** - Haley & Aldrich Laboratory **GOLDENROD** - Haley & Aldrich Contact

Form 3003

WATER AND WASTEWATER METHODS

Analysis Description	Method No.	Preservative	Solid Sample Volume/Container	Liquid Sample Volume/Container	Holding Time
Alkalinity	310	Cool 4° C	N/A	250 mL HDPE	14 days
Amenable Cyanide	Std. Mth. 412 F.	pH>12 NaOH, Cool 4° C	N/A	1 L HDPE	14 days
Ammonia	350	pH<2 H2SO4, Cool 4° C	N/A	1 L HDPE	28 days
Base/Neutral & Acid Extractables	625	Cool 4° C	N/A	1 L Amber	7 days Ext/40 days Analyze
Biochemical Oxygen Demand (BOD)	405.1	Cool 4° C	N/A	2 L HDPE	48 hours
Chemical Oxygen Demand (COD)	410	pH<2 H2SO4, Cool 4° C	N/A	125 mL HDPE	28 days
Chloride	300.0, 325	None Required	N/A	125 mL HDPE	28 days
Chromium, Hexavalent	3500D, 218.4/5	None Required	N/A	1 L HDPE	24 hours
Fluoride	300.0, 340	None Required	N/A	500 mL HDPE	28 days
Hardness, Total (as CaCO3)	130	pH<2 H2SO4, Cool 4° C	N/A	250 mL HDPE	6 Months
Nitrate	300.0, 352.1	Cool 4° C	N/A	250 mL HDPE	48 Hours
Nitrite	300.0, 354.1	Cool 4° C	N/A	125 mL HDPE	48 Hours
Orthophosphate	300.0, 365	Filter, Cool 4° C	N/A	125 mL HDPE	48 Hours
PCBs	608	Cool 4° C	N/A	1 L Amber	7 days Ext/40 days Analyze
Pesticides	608	Cool 4° C	N/A	1 L Amber	7 days Ext/40 days Analyze
Physiologically Available Cyanid	MADEP draft	pH>12 NaOH, 4° C	N/A	1 L HDPE	14 days
Priority Pollutant Metals (13 Metals	200.7/AA, 200 Series	pH<2 HNO3, 4° C	N/A	1 L HDPE	28 days (Hg), 6 mos. (others)
Purgeable Halocarbons & Aromatics	601/602	pH 2 HCl, Cool 4° C	N/A	40 mL Glass Vial	14 days
RCRA Metals (8 Metals)	200.7/AA, 200 Series	pH<2 HNO3, 4° C	N/A	1 L HDPE	28 days (Hg), 6 mos. (others)
Sulfate	300.0, 375	Cool 4° C	N/A	250 mL HDPE	28 days
Sulfide	376	pH>9 NaOH, Zn Acetate, Cool 4° C	N/A	1 L HDPE	7 days
Sulfite	377.1	None Required	N/A	125 mL HDPE	Analyze Immediately
Total Cyanide	335	pH>12 NaOH, Cool 4° C	N/A	1 L HDPE	14 days
Total Dissolved Solids (TDS)	209	Cool 4° C	N/A	250 mL HDPE	7 days
Total Organic Carbon (TOC)	415	pH<2 HCl or H2SO4, Cool 4° C, Dark	N/A	40 mL Amber	28 days
Total Organic Halogen (TOX)	506	pH<2 HNO3, 4° C	N/A	1 L Amber	check with lab
Total Phenolics	420.1	pH<2 H2SO4, Cool 4° C	N/A	1 L Amber	28 days
Total Phosphorus	365	pH<2 H2SO4, Cool 4oC	N/A	125 mL HDPE	28 days
Total Solids (TS)	160.3	Cool 4° C	N/A	250 mL HDPE	7 days
Total Suspended Solids (TSS)	160.2	Cool 4° C	N/A	250 mL HDPE	7 days
Volatile Organics	624	pH 2 HCl, Cool 4° C	N/A	40 mL Glass Vial	14 days
Weak and Dissociable Cyanide	Std. Mth. 412 H.	pH>12 NaOH, Cool 4° C	N/A	1 L HDPE	14 days
DRINKING WATER ANALYSIS					
Volatile Organics	502.2 or 524.2	pH 2 HCl, Cool 4° C	N/A	40 mL Glass Vial	14 days
MICROBIOLOGY					
Fecal Coliform	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours
Standard Plate Count	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours
Total Coliform	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours
Yeast and Mold	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours

SOIL/SEDIMENTS/WATER

Analysis Description	Method No.	Solids (S) / Liquids (L) Preservative	Solid Sample Volume/Container	Liquid Sample Volume/Container	Holding Time
Acid Extractables/Base/Neutral Extractables	8270	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Amenable Cyanide	-	S: 4° C / L: pH>12 NaOH, 4° C	4 oz. CWM	1 L HDPE	14 days
Chromium, Hexavalent	3060A/7196	S/L: Cool 4° C	8 oz. CWM	1 L HDPE	24 hours
Extractable Hydrocarbons	8015B	S: Cool 4° C / L: pH<2 HCl, 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Herbicides	8150	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Non-Halogenated Organics	8015B	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. CWM	40 mL Glass Vial	14 days
PAH (low level)	8310 or GC/MS SIM	S/L: Cool 4° C	8 oz. AWM	1 L Amber	7 days Ext/40 days Analyze
Paint Filter Liquids Test	9095	S: Cool 4° C	8 oz. CWM	1 L Amber	Analyze ASAP
PCBs	8082	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Pesticides	8081	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Physiologically Available Cyanid	MADEP draft	S: 4° C / L: pH>12 NaOH, 4° C	4 oz. CWM	1 L HDPE	14 days
Priority Pollutant Metals(13 Metals)	6010&7000	S: 4° C / L: pH<2 HNO3, 4° C	8 oz. CWM	1 L Amber	28 days (Hg), 6 mos. (others)
RCRA Metals (8 Metals)	6010&7000	S: 4° C / L: pH<2 HNO3, 4° C	8 oz. CWM	1 L Amber	28 days (Hg), 6 mos. (others)
Total Cyanide	9010	S: 4° C / L: pH>12 NaOH, 4° C	4 oz. CWM	1 L HDPE	14 days
Volatile Hydrocarbons	8015B	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. CWM	40 mL Glass Vial	14 days
Volatile Organics	8260B, 8021	S: methanol/$NaHSO_4$, 4° C / L: pH<2 HCl, 4° C	4 oz. CWM	40 mL Glass Vial	14 days
RCRA HAZARDOUS WASTE CHARACTERIZATION					
Corrosivity (pH only)	SW846-7.2	S: Cool 4° C	4 oz. CWM	check with lab	Analyze ASAP
Ignitability/Flashpoin	SW846-7.1	S: Cool 4° C	4 oz. CWM	check with lab	Analyze ASAP
Reactivity (CN-/S2-)	SW846-7.3	S: Cool 4° C	4 oz. CWM	check with lab	Analyze ASAP
TCLP (RCRA 8) Metals (check for mercury)	1311	S: Cool 4° C	16 oz. CWM	check with lab	6 mos. Ext/6 mos. Analyze
TCLP Pesticides/Herbicides	1311	S: Cool 4° C	16 oz. CWM	check with lab	14 days Ext/40 days Analyze
TCLP Semivolatiles	1311	S: Cool 4° C	16 oz. CWM	check with lab	14 days Ext/40 days Analyze
TCLP Volatiles	1311	S: Cool 4° C	8 oz. CWM	check with lab	14 days Ext/14 days Analyze
HYDROCARBON OIL & GREASE ANALYSIS					
MADEP EPH Method	MADEP REV. 0	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. Amber	1 L Amber	S:7 days Ext / L:14 days Ext
MADEP EPH Method (C-Ranges only)	MADEP REV. 0	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. Amber	1 L Amber	S:7 days Ext / L:14 days Ext
MADEP VPH Method	MADEP REV. 0	S: methanol, 4° C / L: pH<2 HCl, 4° C	40 mL+2 oz. CWM.	40 mL Glass Vial	S: 28 days / L: 14 days
MADEP VPH Method (C-Ranges only)	MADEP REV. 0	S: methanol, 4° C / L: pH<2 HCl, 4° C	40 mL+2 oz. CWM.	40 mL Glass Vial	S: 28 days / L: 14 days
MADEP EPH Method - with selected PAHs (including acenaphthene, naphthalene, 2-methylnaphthalene, and phenanthrene	MADEP REV. 0	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. Amber	1 L Amber	S:7 days Ext / L:14 days Ext
Petroleum Identification	ASTM D3328				
Quantitative (include Chromatograms)		S: Cool 4° C / L: pH<2 H_2SO_4, 4° C	4 oz. CWM	1 L Amber	S: 7 days / L: 28 days
Total Petroleum Hydrocarbons (Infrared	418.1	S: Cool 4° C / L: pH<2 H_2SO_4, 4° C	4 oz. CWM	1 L Amber	S: 7 days / L: 28 days

AIR METHODS

Analysis Description	Method No.	Preservative	Sample Volume/Container		Holding Time
Volatile Organic Compounds	EPA T01/T02	tubes: 4° C; Tedlar Bags: dark	N/A	N/A	tube: 14 days; bag: 72 hours
Volatile Organic Compounds	EPA T014	check with lab	N/A	N/A	can: 14 days; bag: 72 hours
VPH in air	EPA T01/T02	tubes: 4° C; Tedlar Bags: dark	N/A	N/A	tube: 14 days; bag: 72 hours
VPH in air	EPA T014	check with lab	N/A	N/A	can: 14 days; bag: 72 hours

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SAMPLING RECORD

Page of

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP**	
CONTRACTOR		**DATE**	

Weather _____ **Temperature** _____

Ground surface Conditions ☐ Dry ☐ Wet ☐ Damp ☐ Standing Water ☐ Snow (_____in) ☐ Other_____

Comments _____

SOIL SAMPLING AND SURFACE WATER SAMPLING INFORMATION

Sample No.	Location	Depth (ft)	Time	Sample Description	Sampling Device	Cleaning Prodedure	Container Type

General Comments: (ie: field filtrations, persons communicated with at site, etc.)

Form 3004

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GROUNDWATER SAMPLING RECORD

Page of

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP**	
CONTRACTOR		**DATE**	

GROUNDWATER SAMPLING INFORMATION

Well No.							
Water Depth (ft)							
Time							
Product							
Depth Of Well (ft)							
Inside Diameter (in)							
Standing Water Depth (ft) (1)							
Volume Of Water In Well (gal)							
Purging Device							
Volume of Bailer/Pump Capacity							
Cleaning Procedure							
Bails Removed/ Volume Removed							
Time Purging Started							
Time Purging Stopped							
Sampling Device							
Cleaning Procedure							
TIME SAMPLES TAKEN	VOA						
	ABN						
	Metals						
PARAMETERS	Color						
	Odor						
	pH						
	Conductivity						
	Turbidity						
	Dissolved Oxygen						
	Temp, ^{0} C						
	Salinity						

Remarks: (ie: field filtrations, persons communicated with at site, etc.)

1. Standing Water Depth = Depth of Well - Water Depth

Form 3005

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MONITORING WELL DEVELOPMENT REPORT

Well No.

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		FIELD REP.	
CONTRACTOR		DATE	
ELEVATION SUBTRAHEND			

Estimated Volume of Water Lost During Drilling: _____ gallons

Comments: _____

Depth to Water Before Development: _____ feet

Comments: _____

Depth to Well Bottom Before Development: _____ feet

Comments: _____

Turubitiy of Water Before Development: _____ NTU

Comments: _____

Volume of Water Removed: _____ gallons

Comments: _____

Method of Removal (bailing, pumping): _____

Comments: _____

Depth to Well Bottom After Development: _____ feet

Comments: _____

Depth to Water After Development: _____ feet

Comments: _____

Turubitiy of Water After Development: _____ NTU

Comments: _____

APPENDIX D

STANDARD OPERATING PROCEDURE FOR PERFORMING MONITORED NATURAL ATTENUATION

OPERATING PROCEDURE: OP3013

MONITORED NATURAL ATTENUATION GROUNDWATER SAMPLE COLLECTION PROCEDURE

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PREPARATION AND APPROVALS

VERSION	AUTHORED/DATE	REVIEWED / DATE	REVIEWED / DATE	REVIEWED / DATE	APPROVED / DATE
Ver. 0.0	SLB/GMW / 05-01	NVD/ 05-01	GJM/ 06-03		JAK/ 06-03

Total Pages: 27

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OPERATING PROCEDURE: OP3013

MONITORED NATURAL ATTENUATION GROUNDWATER SAMPLE COLLECTION PROCEDURE

1. PURPOSE

This document describes procedures for collection of groundwater samples as part of Monitored Natural Attenuation (MNA) programs. In general, the procedures described in this document are similar to those described in the "Low Stress/Low Flow Groundwater Sample Procedure" document. While this document will focus on collection of samples for MNA programs, low flow sampling is often utilized for collection of samples where entrained particulates or turbidity could negatively effect the samples. This approach is also appropriate for sites where bioremediation is either being implemented or planned.

With MNA and bioremediation programs, it is very important to obtain groundwater samples that are indicative of actual aquifer conditions, particularly with respect to assessing aquifer redox conditions. Standard purging and sampling procedures can cause aeration of groundwater and cause volatilization of organic compounds. Low-flow groundwater purging and sampling procedures should be employed to avoid aquifer stress, oxygenation of the water in the monitoring well, and contaminant loss from volatilization. In-line flow-through monitoring equipment should be used to monitor aquifer stabilization during purging and for collection of many field groundwater analytical parameters. Many parameters should be obtained immediately at the wellhead (rather than at a fixed-base laboratory) to limit geochemical changes during sample transport.

A summary of natural attenuation groundwater sampling parameters is attached to this document as Table 1.

Note: The methods described in this document are provided for training use and general information. Depending upon regulatory agency and other project specific requirements, appropriate field procedures may differ from those described herein. These procedures should be confirmed with the Haley & Aldrich Project Manager prior to implementation.

1.1 Background

As defined by USEPA, Monitored Natural Attenuation (MNA) is a combination of physical, chemical and biological processes including biodegradation, sorption, dilution, diffusion, dispersion, volatilization, and chemical transformation that act to reduce measurable contaminant concentrations in the subsurface environment. Some of the processes, namely biodegradation and chemical transformation, are destructive and act to reduce contaminant mass.

These MNA processes cause geochemical shifts, or “footprints” to occur in an aquifer. MNA programs are designed to evaluate these footprints to assess how processes are acting to reduce and stabilize contaminant concentrations. MNA programs are applicable to many classes of contaminants, but this procedure is limited to assessing MNA at sites impacted by chlorinated solvents, petroleum compounds, and metals.

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To assess the extent to which the above processes are active in an aquifer, it is important to obtain groundwater samples that are representative of aquifer conditions. Research has shown that standard purging and sampling procedures (high flow rate, removal of 3-5 well volumes, sample collection with bailers) can cause pressure changes and aeration that can strip volatile organic compounds from groundwater samples (Pennino, 1988). These methods can also provide misrepresentative data on aquifer conditions particularly important in MNA evaluations, such as dissolved oxygen and redox. This document describes appropriate purging and sampling procedures, summarizes the recommended list of groundwater analytical parameters, and provides recommendations for appropriate analytical procedures including analysis of some parameters at the wellhead immediately after purging. A sampling form is included with this procedure and should be used to record water level and field parameter measurements to monitor for stabilization of groundwater conditions during purging.

Although the procedures in this document highly recommend the use of submersible pumps capable of low flow rates and in-line flow through monitoring equipment, certain project restrictions or well construction may inhibit the use of this equipment. Alternate procedures for groundwater sampling using conventional sampling equipment such as bailers are provided, but should not be used unless absolutely necessary.

2. EQUIPMENT & SUPPLIES

1. Adjustable rate, positive displacement pumps (e.g. low flow-rate submersible centrifugal or bladder pumps constructed of stainless steel or Teflon). The pump should be easily adjustable and capable of operating reliably at lower flow rates. An example is QED MicroPurge bladder pump (available for purchase or rental at US Environmental 781-899-6969, among others).

   Under some regulatory programs, peristaltic pumps may be used for collection of inorganic samples only – they are NOT viewed as appropriate for collection of VOCs (NYSDEC holds this view). Bailers are inappropriate for collection of groundwater samples for MNA programs, and should not be used unless absolutely necessary. Purging and sampling with Waterra tubing purging is also not recommended for low-flow/MNA sampling by the USEPA. Contact Sue Boyle (585-321-4222) if Waterra sampling is necessary.

2. Tubing: Tubing used in purging and sampling each well must be dedicated to the individual well. Once properly located, moving the pump in the well should be avoided. Consequently, the same tubing should be used for purging and sampling. The tubing wall thickness should be maximized (3/8 to ½ inch) and the tubing length should be minimized (i.e. do not have excess tubing outside of the well)

   - **Organic analysis**: Teflon or Teflon-lined polyethylene tubing must be used to collect samples.
   - **Inorganic analysis**: Teflon or Teflon lined polyethylene, PVC, Tygon or polyethylene tubing may be used to collect samples.

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3. Polyethylene sheeting and sampling gloves.

4. Water level measuring device, 0.01 feet accuracy, (electronic preferred for tracking water level drawdown during all pumping operations).

5. Flow measurement supplies (e.g. graduated cylinder and stopwatch).

6. Interface probe, if needed.

7. Power source (e.g. generator, located downwind; nitrogen tank, etc). The generator should not be oversized for the pump.

8. In-line flow-through cell containing purge criteria parameter monitoring instruments for pH, turbidity, specific conductance, temperature, Eh and dissolved oxygen (DO). The in-line device should be bypassed or disconnected during sample collection. An example is the Horiba U-22 which is a flow-through cell that comes with probes capable of measuring pH, dissolved oxygen, conductivity, salinity, TDS, temperature, turbidity and oxidation-reduction potential. Available from Ashtead Technologies, 800.242.3910, www.ashtead-technology.com or Pine Environmental, 800-301-9663, www.pine-environmental.com, among others.

9. Photoionization detector (PID), or equivalent.

10. Nylon stay-ties.

11. Decontamination supplies.

12. Field book or well sampling form.

13. Sample Bottles. It is recommended that preservatives be added to sample bottles prior to field activities to reduce potential error or introduction of contaminants.

14. Sample preservation supplies (as required by the analytical method; see previous item).

15. Sample tags or labels, and chain of custody.

16. Well construction data, location map, field data from last sampling event.

17. Sampling Plan or Work Plan

18. Health & Safety Plan

19. pH meter

20. Conductivity meter

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21. Dissolved Oxygen (DO) meter

22. Oxidation -reduction (REDOX) reaction potential (ORP) meter

23. Nephlometer (turbidity)

24. Temperature gauge

25. Field test kits (such as Hach kits – www.hach.com- for measurement of dissolved iron (Fe^{+2}), carbon dioxide, and alkalinity.

26. Field filtration units (if required)

3. PROCEDURE

3.1 Sampling Preparatory Activities

Prior to entering the field there are several activities that should be conducted. The activities are as follows:

1. Obtain and review a copy of the Sampling or Work Plan and Health & Safety Plan.

2. Obtain and review previous groundwater sampling data (if available), previous water level measurements and well construction details (total depth and length of well screen).

3. Obtain and review the "MNA Sampling Form".

4. Locate a site map denoting the wells to be sampled.

5. Obtain well wrenches, well keys and any other equipment needed to access the wells.

6. Coordinate site access.

7. Coordinate with laboratory to obtain sample bottles and necessary quality assurance samples.

8. Perform an inventory of necessary purging, sampling, and field measurement equipment. Certain equipment may need to be purchased or rented for the sampling event. Check field measurement probes for proper calibration and ensure that the probes and kits are complete (i.e., contain calibration and analytical solutions) for the entire sampling event.

3.2 Preliminary Site Activities

Once on-site, the following activities should be conducted prior to beginning sampling:

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- Verify well identification and location using borehole log details and location site map. Check the condition of the well and record any evidence of damage or need for repair in the field book or field sampling form. Following field activities inform the Project Manager of any necessary repair work required.

- Lay out sheet of clean polyethylene around the well for monitoring and sampling equipment.

- Prior to opening the well cap, measure the breathing space above the well casing with a PID or FID to establish baseline levels. Repeat this measurement once the well cap is opened. If either of these measurements exceeds the air quality criteria in the health and safety plan, field personnel should adjust their PPE accordingly.

- If the well does not have a water level reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the field book or sampling form.

- Obtain a round of synoptic water level measurements and well depth (in the shortest possible time) before any purging or sampling activities begin. Water levels and well depths should be measured and reported to 0.01 ft.

  Water level and total depth measurements must be obtained to determine the well volume for hydraulic purposes. In some settings it maybe necessary to allow the water level time to equilibrate. This condition exists if a watertight seal exists at the well cap and the water level has fluctuated above the top of screen thereby creating a vacuum or pressurized area in this air space. Three water level checks will verify static water level conditions or changing conditions.

- Check newly constructed wells for the presence of light or dense aqueous phase liquids before sampling.

3.3 Sampling Procedure

It is preferable to sample the wells in order of increasing chemical concentrations (known or anticipated). Equipment calibration, logbook documentation, sample bottle filling and preservation, and shipping will be conducted in accordance with the site-specific Quality Assurance Project Plan (QAPjP). Personal protective equipment will be donned in accordance with the requirements of the site-specific Health and Safety Plan.

1. Follow the procedures described in the Preliminary Site Activities section above.

2. Attach and secure the polyethylene tubing to the low-flow pump. See the equipment and materials section for recommended pump types. As the pump is slowly lowered into the well, secure the safety drop cable, tubing, and electrical lines to each other using nylon stay-ties. It is recommended that the pump be placed in the well 12 to (preferably) 48 hours prior to purging/sampling to minimize the effects of turbidity and mixing in the well from introducing the pump. This may not be feasible for many project applications.

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3. Pump, safety cable, tubing and electrical lines should be lowered slowly into the well to a depth corresponding to the center of the saturated screen section of the well, or at a location determined to either be a preferential flow path or zone where contamination is present. The pump intake should be kept above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.

4. Before starting the pump, measure and record the water level again with the pump in the well. Start pumping water from the well at a rate of **100 to 500 milliliters per minute (mL/min) which correlates to 0.03 to 0.13 gallons per minute**. Avoid surging. Observe air bubbles displaced from discharge tube to assess progress of steady pumping until water arrives at the surface. The pumping rate should cause little or no water level drawdown in the well (less than 0.2 ft) and the water level should stabilize.

   Water level measurements should be obtained and recorded every three to five minutes. Precautions should be taken to avoid pump suction loss or air entrainment. Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to avoid pumping the well dry and ensure stabilization of indicator parameters. If the recharge rate of the well is very low, purging should be interrupted so as not to cause the drawdown within the well to advance below the pump intake but the operator should attempt to maintain a steady flow rate with the pump to the extent practicable. Record adjustments made to the pumping rates and water levels immediately after each adjustment.

   In low-yielding wells, where 100 mL/min exceeds the entrance rate of groundwater into the well, it is important to avoid dewatering the well screen interval. In these cases, the pump should remain in place and the water level should be allowed to recover repeatedly until there is sufficient volume in the well to permit collection of samples. Under these low-yield conditions, it may become difficult to maintain an adequate water volume in the flow-through cell described in the next step. Often, a well recharges too slowly to adhere to these procedures, but efforts should be made to obtain a sample that is representative of aquifer conditions. An alternative means of sample collection may be necessary under these conditions and should be discussed with the Project Manager, or field oversight staff.

5. While purging the well, measurements of water quality indicator parameters utilizing an in-line flow-through cell (or similar equipment) should be collected every three to five minutes until all of the parameters have stabilized. See the Equipment and Materials section for recommendations. Stabilization is achieved when three successive readings are within the following tolerances noted in the table below.

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Table 1
Parameter Stabilization Levels

Parameter	Stabilization Level (3 successive readings within)
Turbidity	+10% and final value between 5 and 10 NTU
Specific conductance	+3%
pH	±0.1
Dissolved oxygen (DO)	±10%
Redox potential (Eh)	±10mv

In general, the order of stabilization is pH, temperature and specific conductance, followed by redox potential, dissolved oxygen, and turbidity (USEPA, 1996). A minimum subset of these parameters that can be used to determine stabilization during purging in this procedure are pH, specific conductivity and turbidity or DO. Turbidity and DO are typically the last parameters to stabilize. If the parameters have stabilized, but the turbidity is not in the range of 5-10 NTU, then follow step 6.

For informational purposes, the following table provides typical ranges of the various field parameters. Field data collected during purging and sampling should be compared against these values and, if substantial differences exist, the accuracy of the meter should be verified to rule out potential operational problems with the equipment. As a field check for accuracy of the data, compare the dissolved oxygen and redox measurements, they should correlate. For example a depressed dissolved oxygen reading (approximately <0.5 mg/L) should correlate with depressed redox reading (approximately <0 mV).

Table 2
Parameter Ranges

Parameter	Typical Range of Values
Turbidity	10 – 500 NTU
Specific conductance	50 – 500 mS
pH	6 - 9
Dissolved oxygen (DO)	ND – 9 mg/L
Redox potential (Eh)	-250 - +400 mV

6. Once stabilization has been documented, go to step 8.

7. Should stabilization not be achieved for all field parameters purging is continued until a maximum of 20 well screen volumes have been purged from the well. [Note: Because purging of this volume groundwater could negatively impact project costs, the project manager should be contacted if difficulties in attaining stabilization occur]. Since low-flow purging (LFP) likely will not draw groundwater from a significant distance above or below the pump intake, the screen volume is based

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upon a 5-foot (1.4 m) screen length. After purging 20 well screen volumes, purging is continued if the purge water remains visually turbid and appears to be clearing, or if stabilization parameters are varying slightly outside of the stabilization criteria listed above and appear to be approaching stabilization.

- If low-turbidity samples are critical to the project goals, purging will be extended until turbidity has been reduced to 5 NTU or less.
- The pump must not be removed from the well between purging and sampling.

8. If the turbidity measurements do not approach the range of that of natural groundwater (10 NTU), both filtered and unfiltered samples should be collected for analysis of compounds such as metals or hydrophobic compounds[1]. If appropriate, filtered metal samples are to be collected with an in-line filter. A high capacity, in-line 0.45 micron particulate filter must be pre-rinsed according to the manufacturers recommendations, or with approximately 1 liter of groundwater following purging and prior to sampling. After the sample is filtered it must be preserved immediately.

9. Collect groundwater samples. All sample containers should be filled by allowing the pump discharge to gently flow down inside the container with minimal turbulence. The flow-through cell, or similar equipment, should be bypassed during sampling. As each sample bottle is collected, the bottle should be labeled with the following information then place into a cooler with the proper temperature control.

   - Sample number/ID
   - Date and time
   - Parameters to be analyzed
   - Project Reference ID
   - Samplers initials

   After collection of the samples, the tubing from the pump should be properly discarded or dedicated to the well for re-sampling (by hanging the tubing inside the well). Avoid handling the interior of the bottle or bottle cap and don new gloves for each well sampled to avoid contamination of the sample.

   VOC and gas sensitive (e.g. Fe^{+2}, ethene, ethane, methane) parameter samples should be collected first. Refer to the Summary of Natural Attenuation Parameters (Table 1) attached to this document (or the project sampling and analysis plan) to determine which analytes will be measured in the field (wellhead) and which will be submitted to a fixed-base laboratory. Not all parameters will be obtained on each site, during each sampling event. The actual parameters collected will be based on the project requirements. The recommended order of sample collection is as follows:

   1. Volatile organic compounds

[1] Filtering of samples for analysis is a project-specific requirement and should be confirmed with the Project Manager prior to filtration.

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2. Gas sensitive parameters (e.g. Fe+2, ethene, ethane, methane) and other wellhead parameters. Note that for MNA programs, the method of collection of Fe+2 is at the wellhead with a colorimetric kit (i.e. Hach, www.Hach.com). Other wellhead parameters such as alkalinity and carbon dioxide should also be obtained at this time, with appropriate colorimetric kit.

3. Semi-volatile organic compounds

4. Dissolved organic carbon

5. Extractable organics

6. Total metals

7. Dissolved metals (see number 2 above)

8. Phenols

9. Cyanide

10. Sulfate, nitrate, nitrogen/ammonia, and chloride

11. Radionuclides

Note: ***The pumping rate used to collect a sample for VOCs should not exceed 100 mL/min.*** *Samples should be transferred directly to the final container 40 mL glass vials completely full and topped with a Teflon cap. Once capped the vial must be inverted and tapped to check for headspace/air presence (bubbles). If air is present the sample vial will be discarded, and re-collected until free of air. Field filtration will be performed only if dictated by the project Work Plan.*

10. Measure and record final water level and well depth.

11. Secure the well (close and lock).

3.4 Alternate Sampling Procedure

It is understood that project restrictions or well construction may not allow the use of a submersible pump for groundwater purging and sampling. This alternate procedure describes groundwater sampling with conventional equipment such as bailers. Because the use of bailers, or similar equipment, can cause collection of samples that are misrepresentative of aquifer conditions, this alternate procedure should not be used unless absolutely necessary.

1. Follow the Preliminary Site Procedures above.

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2. Attach an appropriate length of new polyethylene rope to the end of bailer. Measure and mark on the rope the depth that corresponds to the bottom of the bailer located at the middle of the well screen interval.

3. Check for light or dense non-aqueous phase liquids.

4. Slowly lower the bailer into the water column so that the intake at bottom of the bailer is located at the midpoint of the well screen. Purge 3 to 5 well volumes of groundwater, or as indicated by the project requirements. Care should be taken to perform the purging slowly and carefully, to avoid agitation and oxygenation of the groundwater in the monitoring well.

5. Once purging is completed, groundwater samples should be obtained with the bailer. The groundwater should be poured slowly into the sample collection vials, to limit oxygenation and volatilization. The order of sample collection described in the Sample Procedure section above should be followed.

6. Because in-line flow-through equipment cannot be used, collection of field parameters that are representative of aquifer conditions will require extra care. After collection of the groundwater samples is complete, groundwater should be poured slowly into a clean, small beaker/container for measurement with the various field probes.

3.5 Decontamination

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed from well between purging and sampling operations. The pump and tubing (including support cable and electrical wires that are in contact with the well) will be decontaminated by one of the procedures listed below.

3.5.1 Procedure 1

Decontamination solutions can be pumped from buckets through the pump, or the pump can be disassembled and flushed with the decontamination solutions. It is recommended that the detergent and isopropyl alcohol be used sparingly in the decontamination process and that water-flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

1. Flush the equipment/pump with potable water.

2. Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

3. Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically

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4. Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event shows that the level of contamination is low, then this step may be skipped.

5. Flush with distilled/deionized water. The final water rinse must not be recycled.
6. Decontaminate the in-line flow-through cell and other sampling equipment with similar procedures, as appropriate.

3.5.2 Procedure 2

1. Steam-clean the outside of the submersible pump.

2. Pump hot potable water from the steam cleaner through the outside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

3. Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

4. Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

5. Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

6. Decontaminate the in-line flow-through cell and other sampling equipment with appropriate procedures.

3.6 Field Documentation

Field notes must document all the events, equipment used, and measurements collected during the sampling activities. In addition to the information recorded on Table 2 – MNA Field Sampling Form, the logbook should document the following for each well sampled:

1. Identification of well

2. Well depth

3. Static water level depth and measurement technique

4. Sounded well depth

5. Presence of immiscible layers and detection/collection method

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6. Well yield - high or low
7. Purge volume and pumping rate
8. Time well purged
9. Measured field parameters - record measurements obtained every 3-5 minutes to monitor for stabilization, see attached example record log.
10. Purge/sampling device used
11. Well sampling sequence
12. Sampling appearance
13. Sample odors
14. Sample volume
15. Types of sample containers and sample identification
16. Preservative(s) used
17. Parameters requested for analysis
18. Field analysis data and method(s)
19. Sample distribution and transporter
20. Laboratory shipped to
21. Chain of custody number for shipment to laboratory
22. Field observations on sampling event
23. Name collector(s)
24. Climatic conditions including air temperature
25. Problems encountered and any deviations made from the established sampling protocol.

3.7 Groundwater/Decon Fluid Disposal

Groundwater disposal methods will vary on a case-by-case basis (consult the Project Manager) but may range from:

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Off-site treatment at private treatment/disposal facilities or public owned treatment facilities

On-site treatment at Facility operated facilities

Direct discharge to the surrounding ground surface, allowing groundwater infiltration to the underlying subsurface regime

Direct discharge to impervious pavement surfaces, allowing evaporation to occur

Decontamination fluids should be segregated and collected separately from wash waters/groundwater containers. Often small volumes of solvents used during the day can be allowed to evaporate if left in an open pail. In the event evaporation is not possible or practical, off-site disposal arrangements must be made.

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APPENDIX A
REFERENCES

- USEPA Low-flow (minimal drawdown) groundwater sampling procedures (EPA/540/S-95/504), April 1996.
- USEPA: Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater, EPA/600/R-98/128 September 1998.
- National Research Council, 2000. Natural Attenuation for Groundwater Remediation, pp. 176-77.
- Barcelona, M.J., H.A. Wehrmann, and M.D. Varljen. 1994. Reproducible Well Purging Procedures and VOC Stabilization Criteria for Ground-Water Sampling. Ground Water. V. 32, pp. 12-22.
- Pennino, J.D. 1988. There is No Such Thing as a Representative Ground Water Sample. Ground Water Monitoring Review. V 8, pp. 4-9.
- Puls, R.W. and R.M. Powell. 1992. Acquisition of Representative Ground Water Quality Samples for Metals. Ground Water Monitoring Review. V. 12, pp. 167-176.
- USEPA Region 3. 1997. Recommended Procedure for Low-Flow Purging and Sampling of Groundwater Monitoring Wells. Waste and Chemicals Management Division - Low Flow Sampling. Bulletin No. QAD023.
- USEPA Region 1. 1996. Low Stress (Low Flow) Purging and Sampling for the Collection of Groundwater Samples from Monitoring Wells. SOP #: GW 001. Revision 2. pp. 13.
- USEPA Region 2. 1998. Ground Water Sampling Procedure, Low Stress (Low Flow) Purging and Sampling. GW Sampling SOP, Final.

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Table 3 Summary of Natural Attenuation Groundwater Sampling Parameters

FIELD PARAMETERS

Analysis	Method/Reference	Minimum Level of Quantification	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed~Base Laboratory
Alkalinity	Hach Alkalinity test kit model AL AP MG-L	50 mg/L	Phenolphthalein method	General water quality parameter used (1) as a marker to verify that all site samples are obtained from the same ground-water system and (2) to measure the buffering capacity of ground water. (3) indicator of biodegradation	Each sampling round	Collect 100 mL of water in glass container.	Field
Carbon Dioxide	Hach Carbon Dioxide Kit	10 mg/L	Field	Indicator of ongoing aerobic biodegradation, should correlate with alkalinity	Each sampling round	Collect 100 mL of water in glass or plastic container and analyze as soon as possible	Field
Iron (II) (Fe+2)	Colorimetric Hach Method #8146	0.5 mg/L	Filter if turbid.	May indicate an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese.	Each sampling round	Collect 100 mL and analyze as soon as possible.	Field
pH	Field probe with direct reading meter calibrated in the field according to the supplier's specifications.	0.1 standard units	Field	Aerobic and anaerobic biological processes are pH-sensitive. Lower pH can be indication of biodegradation.	Each sampling round	Measure immediately after purging is complete site using a flow-through cell or over-flow cell.	Field
Conductivity	E120.l/SW9050,	50 μS/cm	direct reading meter	General water quality parameter used as a marker to verify that site samples are obtained from the same ground-water system.	Each sampling round	Collect 100 to 250 mL of water in a glass or plastic container.	Field
Temperature	Field probe with direct reading meter.	0 degrees Celsius	Field only	To determine if a well is adequately purged for sampling.	Each sampling round	Read from oxygen meter,	Field
Oxidation-reduction potential (ORP) or Redox	Field probe with direct reading meter.	-300 mV to 300 mV (necessary range)	Field only, care should be taken to not aerate the sample during sampling.	To determine the redox conditions in groundwater for assessing biodegradation potential.	Each sampling round	Measure immediately after purging is complete site using a flow-through cell or over-flow cell.	Field
Dissolved Oxygen	Field probe with direct reading meter.	0.1 mg/L	Field only, care should be taken to not aerate the sample during sampling.	To determine the level of dissolved oxygen in groundwater (assessing biodegradation potential.)	Each sampling round	Measure dissolved oxygen on site using a flow-through cell or over-flow cell.	Field

Table 3 Summary of Natural Attenuation Groundwater Sampling Parameters

FIXED LABORATORY

Analysis	Method/Reference	Minimum Level of Quantification	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Chloride	EPA 325.1	1 mg/L	Mercuric nitrate titration (Ion chromatography (IC) method E300 or method SW9050 may also be used)	General water quality parameter used as a marker to verify that site samples are obtained from the same ground-water system. Final product of chlorinated solvent reduction.	Each sampling round	Collect 250 mL of water in a glass container. **cool to 4°C**	Fixed-base
Nitrate	EPA 353.2	0.1 mg/L	If using E300, do not preserve with H_2SO4	Substrate for microbial respiration if oxygen is depleted.	Each sampling round	Collect to 250 mL of water in a glass or plastic container; **add H_2SO_4 to pH less than 2, cool to 4°C.**	Fixed-base
Nitrite	EPA 353.2	0.1 mg/L	E300 acceptable alternate	Substrate for microbial respiration if oxygen is depleted.	Each sampling round	Collect to 250 mL of water in a glass or plastic container, **cool to 4°C.**	Fixed-base
Nitrogen, Kjeldahl, TKN	EPA 351.2	0.1 mg/L		Determination of ammonia plus organic nitrogen for calculation of bio-available organic nitrogen	Each sampling round	Collect to 250 mL of water in a glass or plastic container **add H_2SO_4 to pH less than 2, cool to 4°C, .**	Fixed-base
Nitrogen, Ammonia	EPA 350.2	0.1 mg/L		See above	Each sampling round	Collect to 250 mL of water in a glass or plastic, **add H_2SO_4 to pH less than 2, cool to 4°C.**	Fixed-base
Sulfate (SO_4^{2-})	EPA 375.4	5 mg/L	(Ion chromatography (IC) method E300 or method SW9050 may also be used)	Substrate for anaerobic microbial respiration.	Each sampling round	Collect to 250 mL of water in a glass or plastic container; **cool to 4°C**	Fixed-base
Phosphorous	EPA 365.1	0.05 mg/L		Determination of nutrient concentration.	Each sampling round	Collect to 250 mL of water in a glass or plastic, **add H_2SO_4 to pH less than 2, cool to 4°C.**	Fixed-base

Table 3 Summary of Natural Attenuation Groundwater Sampling Parameters

FIXED LABORATORY, CONT'D

Analysis	Method/Reference	Minimum Level of Quantification	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Total Iron and Dissolved and Total Manganese	SW6010	1 mg/L	ICP Atomic Emission Spectroscopy	To determine if anaerobic biological activity is solubilizing manganese from the aquifer matrix material. To determine the total amount of iron present in groundwater.	One round of sampling	Collect 100 ml in a glass or plastic container that is rinsed in the field with the ground water to be sampled. **Field filter dissolved Mn sample and adjust pH to 2 with nitric acid.** Do not insert pH paper or an electrode into the sample.	Fixed-base
Aromatic and chlorinated hydrocarbons (BTEX, trimethylbenzene isomers, chlorinated compounds)	SW8260A	MCLs	Analysis may be extended to higher molecular weight alkyl benzenes	Method of analysis for BTEX and chlorinated solvents/byproducts, which are the primary target analytes for monitoring natural attenuation; method can be extended to higher molecular weight alkyl benzenes; trimethyl-benzenes are used to monitor plume dilution if degradation is primarily anaerobic.	Each sampling round	Collect water samples in a 40 mL VGA vial; **cool to 4°C**	Fixed-base
Methane, ethane, and ethene	Kampbell eral., 1989 and 1998 or SW3810 Modified	1 ug/L methane 5 ug/L ethane 5 ug/L ethene	Method published by researchers at the U.S. Environmental Protection Agency.	The presence of CH_4 suggests BTEX degradation via methanogenesis. Ethane and ethene data are used where chlorinated solvents are suspected of undergoing biological transformation.	Each sampling round	Collect water samples in 50 mL glass serum bottles with gray butyl /Teflon-faced septa and crimp caps. **cool to 4°C.**	Fixed-base
Dissolved Organic Carbon (DOC)	EPA 415.1	0.1 mg/L	UV/Persulfate Oxidation – Dohrmann Analyzer or equivalent	Used to classify plume and to assess the amount of carbon present to drive reductive dechlorination.	Each sampling round	Collect to two 40 mL vials, field filter and **add H_2SO_4 to pH less than 2, cool to 4°C**.	Fixed-base

NOTES:

1. "Hach" refers to the Hach Company catalog, 1990.
2. "SW" refers to *Standard Methods for the Examination of Water and Wastewater,* 1 8th edition, 1992.
3. "EPA" refers to *Methods for Chemical Analysis of Water and Wastes,* U.S. EPA, 1983.
4. "SW" refers to the *Test Methods for Evaluating Solid Waste, Physical, and Chemical Methods,* SW-846, U.S. EPA, 3rd edition, 1986.

APPENDIX B
Related Haley & Aldrich Procedures

- OP3000 General Environmental Field Procedures and Protocol
- OP3001 Preservation and Shipment of Environmental Samples
- OP3008 Manual Water Level Measurement Procedure
- OP3009 Monitoring Well Development Procedure
- OP3010 Groundwater Quality Sampling Procedure
- OP3012 Low Stress/Low Flow Groundwater Sampling Procedure
- OP3014 NAPL Monitoring and Sampling Procedure

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APPENDIX C
FORMS

- Form 3001 Sampling Labels (Environmental)
- Form 3003 Chain of Custody
- Form 3004 Sampling Record
- Form 3005 Groundwater Sampling Record
- Form 3006 Monitoring Well Development Report

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Haley & Aldrich, Inc.
465 Medford St., Suite 2200
Boston, MA 02129
Tel: 617-886-7400

Sample ID:	File Number:
Depth:	Project:
Date:	Analysis:
Time:	Preservative:
Collected By:	Laboratory:
Comments:	

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Depth:	Project:
Date:	Analysis:
Time:	Preservative:
Collected By:	Laboratory:
Comments:	

Form 3001

HALEY & ALDRICH
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465 Medford St.,
Suite 2200,
Boston, MA 02129-1400

CHAIN OF CUSTODY RECORD

Phone (617) 886-7400
Fax (617) 886-7600

Page of

H&A FILE NO.		LABORATORY		DELIVERY DATE	
PROJECT NAME		ADDRESS		TURNAROUND TIME	
H&A CONTACT		CONTACT		PROJECT MANAGER	

Sample No.	Date	Time	Depth	Type	VOA	ABNs PAH only	Metals RCRA (8) PP(13)	Pesticides PCBs	VPH Full Suite C-ranges only	EPH Full Suite C-ranges only	TPH (specify)	TCLP (specify)	Reactivity Ignitability Corrosivity				Number of Containers	Comments (special instructions, precautions, additional method numbers, etc.)

Analysis Requested

Sampled and Relinquished by	Received by
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time
Relinquished by	**Received by**
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time
Relinquished by	**Received by**
Sign	Sign
Print	Print
Firm	Firm
Date Time	Date Time

LIQUID													
													VOA Vial
													Amber Glass
													Plastic Bottle
													Preservative
													Volume

SOLID													
													VOA Vial
													Amber Glass
													Clear Glass
													Preservative
													Volume

PRESERVATION KEY

A Sample chilled	**C** NaOH	**E** H_2SO_4	**G** Methanol
B Sample filtered	**D** HNO_3	**F** HCL	**H** Sodium Bisulfate

Sampling Comments

Evidence samples were tampered with? YES NO

If YES, please explain in section below.

WHITE - Laboratory **CANARY** - Project Manager **PINK** - Haley & Aldrich Laboratory **GOLDENROD** - Haley & Aldrich Contact

Form 3003

WATER AND WASTEWATER METHODS

Analysis Description	Method No.	Preservative	Solid Sample Volume/Container	Liquid Sample Volume/Container	Holding Time
Alkalinity	310	Cool 4° C	N/A	250 mL HDPE	14 days
Amenable Cyanide	Std. Mth. 412 F.	pH>12 NaOH, Cool 4° C	N/A	1 L HDPE	14 days
Ammonia	350	pH<2 H2SO4, Cool 4° C	N/A	1 L HDPE	28 days
Base/Neutral & Acid Extractables	625	Cool 4° C	N/A	1 L Amber	7 days Ext/40 days Analyze
Biochemical Oxygen Demand (BOD)	405.1	Cool 4° C	N/A	2 L HDPE	48 hours
Chemical Oxygen Demand (COD)	410	pH<2 H2SO4, Cool 4° C	N/A	125 mL HDPE	28 days
Chloride	300.0, 325	None Required	N/A	125 mL HDPE	28 days
Chromium, Hexavalent	3500D, 218.4/5	None Required	N/A	1 L HDPE	24 hours
Fluoride	300.0, 340	None Required	N/A	500 mL HDPE	28 days
Hardness, Total (as CaCO3)	130	pH<2 H2SO4, Cool 4° C	N/A	250 mL HDPE	6 Months
Nitrate	300.0, 352.1	Cool 4° C	N/A	250 mL HDPE	48 Hours
Nitrite	300.0, 354.1	Cool 4° C	N/A	125 mL HDPE	48 Hours
Orthophosphate	300.0, 365	Filter, Cool 4° C	N/A	125 mL HDPE	48 Hours
PCBs	608	Cool 4° C	N/A	1 L Amber	7 days Ext/40 days Analyze
Pesticides	608	Cool 4° C	N/A	1 L Amber	7 days Ext/40 days Analyze
Physiologically Available Cyanid	MADEP draft	pH>12 NaOH, 4° C	N/A	1 L HDPE	14 days
Priority Pollutant Metals (13 Metals	200.7/AA, 200 Series	pH<2 HNO3, 4° C	N/A	1 L HDPE	28 days (Hg), 6 mos. (others)
Purgeable Halocarbons & Aromatics	601/602	pH 2 HCl, Cool 4° C	N/A	40 mL Glass Vial	14 days
RCRA Metals (8 Metals)	200.7/AA, 200 Series	pH<2 HNO3, 4° C	N/A	1 L HDPE	28 days (Hg), 6 mos. (others)
Sulfate	300.0, 375	Cool 4° C	N/A	250 mL HDPE	28 days
Sulfide	376	pH>9 NaOH, Zn Acetate, Cool 4° C	N/A	1 L HDPE	7 days
Sulfite	377.1	None Required	N/A	125 mL HDPE	Analyze Immediately
Total Cyanide	335	pH>12 NaOH, Cool 4° C	N/A	1 L HDPE	14 days
Total Dissolved Solids (TDS)	209	Cool 4° C	N/A	250 mL HDPE	7 days
Total Organic Carbon (TOC)	415	pH<2 HCl or H2SO4, Cool 4° C, Dark	N/A	40 mL Amber	28 days
Total Organic Halogen (TOX)	506	pH<2 HNO3, 4° C	N/A	1 L Amber	check with lab
Total Phenolics	420.1	pH<2 H2SO4, Cool 4° C	N/A	1 L Amber	28 days
Total Phosphorus	365	pH<2 H2SO4, Cool 4oC	N/A	125 mL HDPE	28 days
Total Solids (TS)	160.3	Cool 4° C	N/A	250 mL HDPE	7 days
Total Suspended Solids (TSS)	160.2	Cool 4° C	N/A	250 mL HDPE	7 days
Volatile Organics	624	pH 2 HCl, Cool 4° C	N/A	40 mL Glass Vial	14 days
Weak and Dissociable Cyanide	Std. Mth. 412 H.	pH>12 NaOH, Cool 4° C	N/A	1 L HDPE	14 days
DRINKING WATER ANALYSIS					
Volatile Organics	502.2 or 524.2	pH 2 HCl, Cool 4° C	N/A	40 mL Glass Vial	14 days
MICROBIOLOGY					
Fecal Coliform	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours
Standard Plate Count	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours
Total Coliform	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours
Yeast and Mold	STDMTH	Cool 4o C	N/A	sterile, 125 mL	6 hours

SOIL/SEDIMENTS/WATER

Analysis Description	Method No.	Solids (S) / Liquids (L) Preservative	Solid Sample Volume/Container	Liquid Sample Volume/Container	Holding Time
Acid Extractables/Base/Neutral Extractables	8270	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Amenable Cyanide	-	S: 4° C / L: pH>12 NaOH, 4° C	4 oz. CWM	1 L HDPE	14 days
Chromium, Hexavalent	3060A/7196	S/L: Cool 4° C	8 oz. CWM	1 L HDPE	24 hours
Extractable Hydrocarbons	8015B	S: Cool 4° C / L: pH<2 HCl, 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Herbicides	8150	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Non-Halogenated Organics	8015B	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. CWM	40 mL Glass Vial	14 days
PAH (low level)	8310 or GC/MS SIM	S/L: Cool 4° C	8 oz. AWM	1 L Amber	7 days Ext/40 days Analyze
Paint Filter Liquids Test	9095	S: Cool 4° C	8 oz. CWM	1 L Amber	Analyze ASAP
PCBs	8082	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Pesticides	8081	S/L: Cool 4° C	8 oz. CWM	1 L Amber	7 days Ext/40 days Analyze
Physiologically Available Cyanid	MADEP draft	S: 4° C / L: pH>12 NaOH, 4° C	4 oz. CWM	1 L HDPE	14 days
Priority Pollutant Metals(13 Metals)	6010&7000	S: 4° C / L: pH<2 HNO3, 4° C	8 oz. CWM	1 L Amber	28 days (Hg), 6 mos. (others)
RCRA Metals (8 Metals)	6010&7000	S: 4° C / L: pH<2 HNO3, 4° C	8 oz. CWM	1 L Amber	28 days (Hg), 6 mos. (others)
Total Cyanide	9010	S: 4° C / L: pH>12 NaOH, 4° C	4 oz. CWM	1 L HDPE	14 days
Volatile Hydrocarbons	8015B	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. CWM	40 mL Glass Vial	14 days
Volatile Organics	8260B, 8021	S: methanol/$NaHSO_4$, 4° C / L: pH<2 HCl, 4° C	4 oz. CWM	40 mL Glass Vial	14 days
RCRA HAZARDOUS WASTE CHARACTERIZATION					
Corrosivity (pH only)	SW846-7.2	S: Cool 4° C	4 oz. CWM	check with lab	Analyze ASAP
Ignitability/Flashpoin	SW846-7.1	S: Cool 4° C	4 oz. CWM	check with lab	Analyze ASAP
Reactivity (CN-/S2-)	SW846-7.3	S: Cool 4° C	4 oz. CWM	check with lab	Analyze ASAP
TCLP (RCRA 8) Metals (check for mercury)	1311	S: Cool 4° C	16 oz. CWM	check with lab	6 mos. Ext/6 mos. Analyze
TCLP Pesticides/Herbicides	1311	S: Cool 4° C	16 oz. CWM	check with lab	14 days Ext/40 days Analyze
TCLP Semivolatiles	1311	S: Cool 4° C	16 oz. CWM	check with lab	14 days Ext/40 days Analyze
TCLP Volatiles	1311	S: Cool 4° C	8 oz. CWM	check with lab	14 days Ext/14 days Analyze
HYDROCARBON OIL & GREASE ANALYSIS					
MADEP EPH Method	MADEP REV. 0	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. Amber	1 L Amber	S:7 days Ext / L:14 days Ext
MADEP EPH Method (C-Ranges only)	MADEP REV. 0	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. Amber	1 L Amber	S:7 days Ext / L:14 days Ext
MADEP VPH Method	MADEP REV. 0	S: methanol, 4° C / L: pH<2 HCl, 4° C	40 mL+2 oz. CWM.	40 mL Glass Vial	S: 28 days / L: 14 days
MADEP VPH Method (C-Ranges only)	MADEP REV. 0	S: methanol, 4° C / L: pH<2 HCl, 4° C	40 mL+2 oz. CWM.	40 mL Glass Vial	S: 28 days / L: 14 days
MADEP EPH Method - with selected PAHs (including acenaphthene, naphthalene, 2-methylnaphthalene, and phenanthrene	MADEP REV. 0	S: Cool 4° C / L: pH<2 HCl, 4° C	4 oz. Amber	1 L Amber	S:7 days Ext / L:14 days Ext
Petroleum Identification	ASTM D3328				
Quantitative (include Chromatograms)		S: Cool 4° C / L: pH<2 H_2SO_4, 4° C	4 oz. CWM	1 L Amber	S: 7 days / L: 28 days
Total Petroleum Hydrocarbons (Infrared	418.1	S: Cool 4° C / L: pH<2 H_2SO_4, 4° C	4 oz. CWM	1 L Amber	S: 7 days / L: 28 days

AIR METHODS

Analysis Description	Method No.	Preservative	Sample Volume/Container		Holding Time
Volatile Organic Compounds	EPA T01/T02	tubes: 4° C; Tedlar Bags: dark	N/A	N/A	tube: 14 days; bag: 72 hours
Volatile Organic Compounds	EPA T014	check with lab	N/A	N/A	can: 14 days; bag: 72 hours
VPH in air	EPA T01/T02	tubes: 4° C; Tedlar Bags: dark	N/A	N/A	tube: 14 days; bag: 72 hours
VPH in air	EPA T014	check with lab	N/A	N/A	can: 14 days; bag: 72 hours

This table is offered for informational purposes only and is intended to be followed and used by persons having related technical skills and at their own discretion and risk. Since conditions and the manner of use are outside of Haley & Aldrich's control, we make no warranties, express or implied, and accept no liability in connection with any use of this information. IT IS THE USER'S RESPONSIBILITY TO VERIFY THE SUITABILITY OF USE AND CORRECTNESS OF THE INFORMATION SUPPLIED.

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SAMPLING RECORD

Page of

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP**	
CONTRACTOR		**DATE**	

Weather _____ **Temperature** _____

Ground surface Conditions ☐ Dry ☐ Wet ☐ Damp ☐ Standing Water ☐ Snow (_____in) ☐ Other_____

Comments _____

SOIL SAMPLING AND SURFACE WATER SAMPLING INFORMATION

Sample No.	Location	Depth (ft)	Time	Sample Description	Sampling Device	Cleaning Prodedure	Container Type

General Comments: (ie: field filtrations, persons communicated with at site, etc.)

Form 3004

HALEY & ALDRICH

GROUNDWATER SAMPLING RECORD

Page of

PROJECT		**H&A FILE NO.**	
LOCATION		**PROJECT MGR.**	
CLIENT		**FIELD REP**	
CONTRACTOR		**DATE**	

GROUNDWATER SAMPLING INFORMATION

Well No.							
Water Depth (ft)							
Time							
Product							
Depth Of Well (ft)							
Inside Diameter (in)							
Standing Water Depth (ft) (1)							
Volume Of Water In Well (gal)							
Purging Device							
Volume of Bailer/Pump Capacity							
Cleaning Procedure							
Bails Removed/ Volume Removed							
Time Purging Started							
Time Purging Stopped							
Sampling Device							
Cleaning Procedure							
TIME SAMPLES TAKEN	VOA						
	ABN						
	Metals						
PARAMETERS	Color						
	Odor						
	pH						
	Conductivity						
	Turbidity						
	Dissolved Oxygen						
	Temp, ^{0} C						
	Salinity						

Remarks: (ie: field filtrations, persons communicated with at site, etc.)

1. Standing Water Depth = Depth of Well - Water Depth

Form 3005

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MONITORING WELL DEVELOPMENT REPORT

Well No.

PROJECT		H&A FILE NO.	
LOCATION		PROJECT MGR.	
CLIENT		FIELD REP.	
CONTRACTOR		DATE	
ELEVATION SUBTRAHEND			

Estimated Volume of Water Lost During Drilling: _____ gallons

Comments: _____

Depth to Water Before Development: _____ feet

Comments: _____

Depth to Well Bottom Before Development: _____ feet

Comments: _____

Turubitiy of Water Before Development: _____ NTU

Comments: _____

Volume of Water Removed: _____ gallons

Comments: _____

Method of Removal (bailing, pumping): _____

Comments: _____

Depth to Well Bottom After Development: _____ feet

Comments: _____

Depth to Water After Development: _____ feet

Comments: _____

Turubitiy of Water After Development: _____ NTU

Comments: _____

DELPHI SYSTEMS CORP.

CORRECTIVE MEASURES PROPOSAL

APPENDIX G

DTSC ADVISORY ON CLEAN IMPORTED FILL

Information Advisory
Clean Imported Fill Material

October 2001

DEPARTMENT OF TOXIC SUBSTANCES CONTROL

It is DTSC's mission to restore, protect and enhance the environment, to ensure public health, environmental quality and economic vitality, by regulating hazardous waste, conducting and overseeing cleanups, and developing and promoting pollution prevention.

State of California

California Environmental Protection Agency

Executive Summary

This fact sheet has been prepared to ensure that inappropriate fill material is not introduced onto sensitive land use properties under the oversight of the DTSC or applicable regulatory authorities. Sensitive land use properties include those that contain facilities such as hospitals, homes, day care centers, and schools. This document only focuses on human health concerns and ecological issues are not addressed. It identifies those types of land use activities that may be appropriate when determining whether a site may be used as a fill material source area. It also provides guidelines for the appropriate types of analyses that should be performed relative to the former land use, and for the number of samples that should be collected and analyzed based on the estimated volume of fill material that will need to be used. The information provided in this fact sheet is not regulatory in nature, rather is to be used as a guide, and in most situations the final decision as to the acceptability of fill material for a sensitive land use property is made on a case-by-case basis by the appropriate regulatory agency.

Introduction

The use of imported fill material has recently come under scrutiny because of the instances where contaminated soil has been brought onto an otherwise clean site. However, there are currently no established standards in the statutes or regulations that address environmental requirements for imported fill material. Therefore, the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) has prepared this fact sheet to identify procedures that can be used to minimize the possibility of introducing contaminated soil onto a site that requires imported fill material. Such sites include those that are undergoing site remediation, corrective action, and closure activities overseen by DTSC or the appropriate regulatory agency. These procedures may also apply to construction projects that will result in sensitive land uses. The intent of this fact sheet is to protect people who live on or otherwise use a sensitive land use property. By using this fact sheet as a guide, the reader will minimize the chance of introducing fill material that may result in potential risk to human health or the environment at some future time.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our website at www.dtsc.ca.gov.

Overview

Both natural and manmade fill materials are used for a variety of purposes. Fill material properties are commonly controlled to meet the necessary site specific engineering specifications. Because most sites requiring fill material are located in or near urban areas, the fill materials are often obtained from construction projects that generate an excess of soil, and from demolition debris (asphalt, broken concrete, etc.). However, materials from those types of sites may or may not be appropriate, depending on the proposed use of the fill, and the quality of the assessment and/or mitigation measures, if necessary. Therefore, unless material from construction projects can be demonstrated to be free of contamination and/or appropriate for the proposed use, the use of that material as fill should be avoided.

Selecting Fill Material

In general, the fill source area should be located in nonindustrial areas, and not from sites undergoing an environmental cleanup. Nonindustrial sites include those that were previously undeveloped, or used solely for residential or agricultural purposes. If the source is from an agricultural area, care should be taken to insure that the fill does not include former agricultural waste process byproducts such as manure or other decomposed organic material. Undesirable sources of fill material include industrial and/or commercial sites where hazardous ma-

Potential Contaminants Based on the Fill Source Area

Fill Source:	Target Compounds
Land near to an existing freeway	Lead (EPA methods 6010B or 7471A), PAHs (EPA method 8310)
Land near a mining area or rock quarry	Heavy Metals (EPA methods 6010B and 7471A), asbestos (polarized light microscopy), pH
Agricultural land	Pesticides (Organochlorine Pesticides: EPA method 8081A or 8080A; Organophosphorus Pesticides: EPA method 8141A; Chlorinated Herbicides: EPA method 8151A), heavy metals (EPA methods 6010B and 7471A)
Residential/acceptable commercial land	VOCs (EPA method 8021 or 8260B, as appropriate and combined with collection by EPA Method 5035), semi-VOCs (EPA method 8270C), TPH (modified EPA method 8015), PCBs (EPA method 8082 or 8080A), heavy metals including lead (EPA methods 6010B and 7471A), asbestos (OSHA Method ID-191)

**The recommended analyses should be performed in accordance with USEPA SW-846 methods (1996). Other possible analyses include Hexavalent Chromium: EPA method 7199*

Recommended Fill Material Sampling Schedule

Area of Individual Borrow Area	Sampling Requirements
2 acres or less	Minimum of 4 samples
2 to 4 acres	Minimum of 1 sample every 1/2 acre
4 to 10 acres	Minimum of 8 samples
Greater than 10 acres	Minimum of 8 locations with 4 subsamples per location

Volume of Borrow Area Stockpile	Samples per Volume
Up to 1,000 cubic yards	1 sample per 250 cubic yards
1,000 to 5,000 cubic yards	4 samples for first 1000 cubic yards +1 sample per each additional 500 cubic yards
Greater than 5,000 cubic yards	12 samples for first 5,000 cubic yards + 1 sample per each additional 1,000 cubic yards

terials were used, handled or stored as part of the business operations, or unpaved parking areas where petroleum hydrocarbons could have been spilled or leaked into the soil. Undesirable commercial sites include former gasoline service stations, retail strip malls that contained dry cleaners or photographic processing facilities, paint stores, auto repair and/or painting facilities. Undesirable industrial facilities include metal processing shops, manufacturing facilities, aerospace facilities, oil refineries, waste treatment plants, etc. Alternatives to using fill from construction sites include the use of fill material obtained from a commercial supplier of fill material or from soil pits in rural or suburban areas. However, care should be taken to ensure that those materials are also uncontaminated.

Documentation and Analysis

In order to minimize the potential of introducing contaminated fill material onto a site, it is necessary to verify through documentation that the fill source is appropriate and/or to have the fill material analyzed for potential contaminants based on the location and history of the source area. Fill documentation should include detailed information on the previous use of the land from where the fill is taken, whether an environmental site assessment was performed and its findings, and the results of any testing performed. It is recommended that any such documentation should be signed by an appropriately licensed (CA-registered) individual. If such documentation is not available or is inadequate, samples of the fill material should be chemically analyzed. Analysis of the fill material should be based on the source of the fill and knowledge of the prior land use.

Detectable amounts of compounds of concern within the fill material should be evaluated for risk in accordance with the DTSC Preliminary Endangerment Assessment (PEA) Guidance Manual. If

metal analyses are performed, only those metals (CAM 17 / Title 22) to which risk levels have been assigned need to be evaluated. At present, the DTSC is working to establish California Screening Levels (CSL) to determine whether some compounds of concern pose a risk. Until such time as these CSL values are established, DTSC recommends that the DTSC PEA Guidance Manual or an equivalent process be referenced. This guidance may include the Regional Water Quality Control Board's (RWQCB) guidelines for reuse of non-hazardous petroleum hydrocarbon contaminated soil as applied to Total Petroleum Hydrocarbons (TPH) only. The RWQCB guidelines should not be used for volatile organic compounds (VOCs) or semi-volatile organic compounds (SVOCS). In addition, a standard laboratory data package, including a summary of the QA/QC (Quality Assurance/Quality Control) sample results should also accompany all analytical reports.

When possible, representative samples should be collected at the borrow area while the potential fill material is still in place, and analyzed prior to removal from the borrow area. In addition to performing the appropriate analyses of the fill material, an appropriate number of samples should also be determined based on the approximate volume or area of soil to be used as fill material. The table above can be used as a guide to determine the number of samples needed to adequately characterize the fill material when sampled at the borrow site.

Alternative Sampling

A Phase I or PEA may be conducted prior to sampling to determine whether the borrow area may have been impacted by previous activities on the property. After the property has been evaluated, any sampling that may be required can be determined during a meeting with DTSC or appropriate regulatory agency. However, if it is not possible to analyze the fill material at the borrow area or determine that it is appropriate for use via a Phase I or PEA, it is recommended that one (1) sample per truckload be collected and analyzed for all compounds of concern to ensure that the imported soil is uncontaminated and acceptable. (See chart on Potential Contaminants Based on the Fill Source Area for appropriate analyses). This sampling frequency may be modified upon consultation with the DTSC or appropriate regulatory agency if all of the fill material is derived from a common borrow area. However, fill material that is not characterized at the borrow area will need to be stockpiled either on or off-site until the analyses have been completed. In addition, should contaminants exceeding acceptance criteria be identified in the stockpiled fill material, that material will be deemed unacceptable and new fill material will need to be obtained, sampled and analyzed. Therefore, the DTSC recommends that all sampling and analyses should be completed prior to delivery to the site to ensure the soil is free of contamination, and to eliminate unnecessary transportation charges for unacceptable fill material.

Composite sampling for fill material characterization may or may not be appropriate, depending on quality and homogeneity of source/borrow area, and compounds of concern. Compositing samples for volatile and semivolatile constituents is not acceptable. Composite sampling for heavy metals, pesticides, herbicides or PAH's from unanalyzed stockpiled soil is also unacceptable, unless it is stockpiled at the borrow area and originates from the same source area. In addition, if samples are composited, they should be from the same soil layer, and not from different soil layers.

When very large volumes of fill material are anticipated, or when larger areas are being considered as borrow areas, the DTSC recommends that a Phase I or PEA be conducted on the area to ensure that the borrow area has not been impacted by previous activities on the property. After the property has been evaluated, any sampling that may be required can be determined during a meeting with the DTSC.

For further information, call Richard Coffman, Ph.D., R.G., at (818) 551-2175.