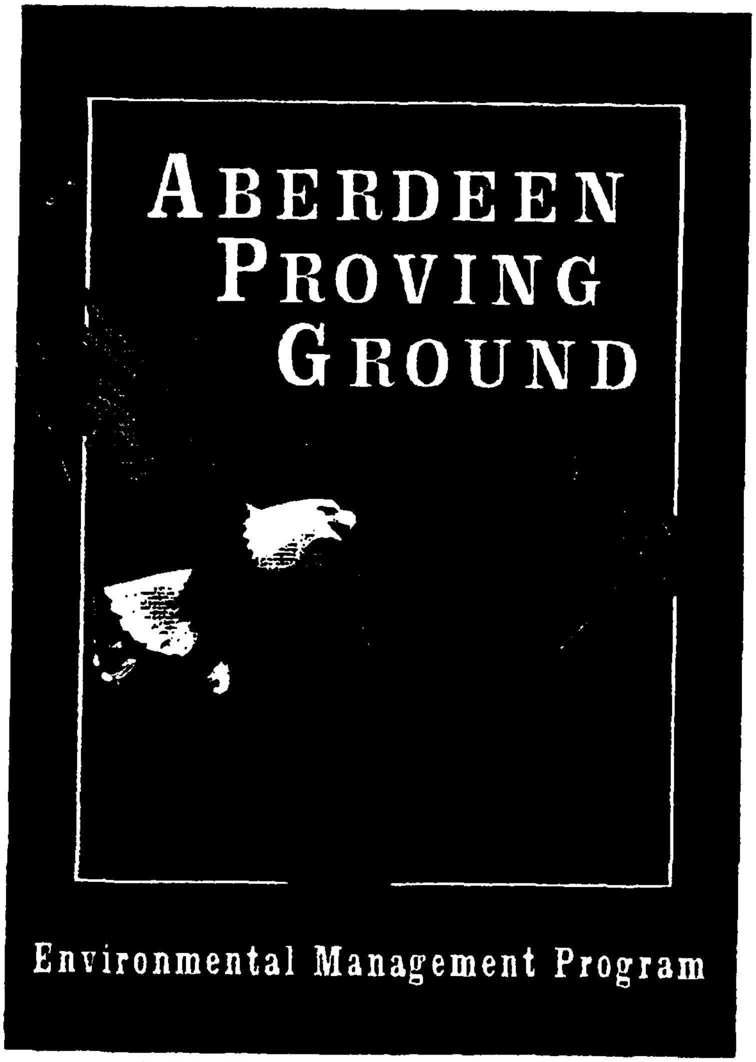
Canal Creek Study Area
Aberdeen Proving Ground - Edgewood Area, Maryland

APPENDIX A

GROUNDWATER MONITORING PLAN
FINAL QUALITY ASSURANCE PROJECT PLAN
STANDARD OPERATING PROCEDURES (SOPs)



OCTOBER 1993

STANDARD OPERATING PROCEDURES*

DISTRIBUTION RESTRICTION STATEMENT
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0238-A-1

*Shadow areas represent recent changes by WES

INDEX STANDARD OPERATING PROCEDURES

* Denotes SOP in draft. Not available for review at this time.

STANDARD OPERATING PROCEDURE 001
SAMPLE LABELS

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for the use of sample labels. Every sample will have a sample label uniquely identifying the sampling point and analysis parameters. An example label is included as Figure 001-1. Other formats with similar levels of detail are acceptable.

2.0 Material

a. Sample Label
b. Indelible lab marker

3.0 Procedure

The following steps describe how to use the sample labelling system:

3.1 As each sample is collected/selected, fill out a sample label. Enter the following information on each label:

a. Project Name

b. Project Number

c. Location/Site I.D. - enter the well # or surface water sampling #, and other pertinent information concerning where the sample was taken.

d. Date of Sample Collection

e. Time of Sample Collection

f. Analyses to be Performed (Note: due to number of analytes, details of analysis should be arranged with lab *a priori.)*

g. Whether Filtered or Unfiltered (water samples only)

h. Preservatives (water samples only)

i. The Number of Containers for the Sample (*e.g.* 1 of 2, 2 of 2)

3.2 Double-check the label information to make sure it is correct. Detach the label, remove the backing and apply the label to the sample container. Cover the label with clear tape, ensuring that the tape completely encircles the container.

3.3 Record the Sample Number and designated sampling point in the field logbook, along with the following sample information:

a. Time of sample collection (each logbook page should be dated)

b. The location of the sample

c. Organic vapor meter or photoionization meter readings for the sample (when appropriate)

d. Any unusual or pertinent observations (oily sheen on groundwater sample, incidental odors, soil color, grain size, plasticity, etc.)

e. Number of containers required for each sample

f. Whether the sample is a QA sample (split, duplicate or blank)

3.3.1 A typical logbook entry might look like this:

7:35 AM Sample No. MW-3. PID = 35 PPM
Petroleum odor present. Sample designated MW-3-001.

Note: Duplicate samples will be given a non-existent well number rather than simply using the actual well number with an added prefix or suffix. This will prevent any indication to the lab that this is a duplicate sample. This fictitious well number will be listed in the logbook along with the actual location of the sample.

3.4 Place the sample upright in the designated sample cooler. Make sure there is plenty of ice in the cooler at all times.

4.0 Maintenance

Not Applicable.

5.0 Precautions

5.1 Note that although incidental odors should be noted in the logbook, it is unwise from a health and safety standpoint to routinely "sniff test" samples for contaminants.

5.2 No indication of which samples are duplicates is to be provided to the lab.

6.0 References

U.S. EPA. 1980, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80

FIGURE 001-1
SAMPLE LABEL

PROJECT NAME ___________ PROJECT NUM. _________
SAMPLE LOCATION/SITE ID ______________________
DATE: ___/___/___ TIME: ____:____
ANALYTES: METALS VOC EXPLOSIVES ORGANICS OTHER
FILTERED: [NO] [YES]
PRESERVATIVE: [NONE] [HNO_3] [OTHER _____]
SAMPLER: ________________

STANDARD OPERATING PROCEDURE 002
CHAIN-OF-CUSTODY FORM

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for use of the Chain-of-Custody (COC) Form. An example is provided as part of this SOP. Other formats with similar levels of detail are acceptable.

2.0 Material

a. Chain-of-Custody Form
b. Indelible ink pen

3.0 Procedure

3.1 Give the site name and project name/number.

3.2 Enter the sample identification code.

3.3 Indicate the sampling dates for all samples.

3.4 List the sampling times (military format) for all samples.

3.5 Indicate "grab" or "composite" sample with an "X."

3.6 Specify the sample location.

3.7 Enter the total number of containers per cooler.

3.8 List the analyses/container volume.

3.9 Obtain the [illegible]ture of sample team leader.

3.10 State the carrier service and airbill number, analytical laboratory, and custody seal numbers.

3.11 Sign, date, and time the "relinquished by" section.

3.12 Upon completion of the form, retain the shipper copy, and affix the other copies to the inside of the sample cooler, in a zip seal bag to protect from moisture, to be sent to the designated laboratory.

4.0 Maintenance

Not Applicable.

5.0 Precautions

None.

6.0 References

U.S. EPA. 1990. Sampler's Guide to the Contract Laboratory Program. EPA/540/P-90/006, Directive 9240.0-06,Office of Emergency and Remedial Response, Washington, D.C., December 1990.

U.S. EPA. 1991. User's Guide to the Contract Laboratory Program. EPA/540/O-91/002, Directive 9240.0-01D, Office of Emergency and Remedial Response, January 1991.

U.S. EPA. 1980, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80

Proj. no.	Site Name				Num. of Containers										LAB : AIRBILL No: Courier:
Samplers:															
Date	Time	Comp	Grab	Field Sample No.											REMARKS
				TOTAL											

Relinquished by:	Date/ time	Received by:	Relinquished by:	Date/ Time	Received by:
Relinquished by:	Date/ time	Received by: (for lab)	Date/Time	Remarks	

FIGURE 002-1
EXAMPLE CHAIN-OF-CUSTODY FORM

STANDARD OPERATING PROCEDURE 003
FIELD LOGBOOK

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for recording field survey and sampling information in the Field Logbook.

2.0 Material

a. Field Logbook (Teledyne 415 Level Book, or equivalent) [1]
b. Indelible ink pen

3.0 Procedure

All information pertinent to a field survey or sampling effort will be recorded in a bound logbook. Each page/form will be consecutively numbered, dated, and signed. All entries will be made in indelible ink and all corrections will consist of line-out deletions that are initialed and dated. The person making the correction will provide a brief explanation for the change. There should be no blank lines on a page. A single blank line or a partial blank line (such as at the end of a paragraph) should be lined to the end of the page. If only part of a page is used, the remainder of the page should have an "X" drawn across it. At a minimum, entries in the logbook will include but not be limited to the following:

a. Project number.

b. Unique, sequential field sample number.

c. Purpose of sampling.

d. Location, description, and log of photographs of each sampling point.

e. Details of the sample site (for example, the elevation of the casing, casing diameter and depth, integrity of the casing, etc.)

f. Name and address of field contact.

g. Documentation of procedures for preparation of reagents or supplies which become an integral part of the sample (e.g., filters and absorbing reagents).

[1] Pre-printed, bound forms are approved as well. See SOP 016 for recommended content and format.

h. Identification of sample crew members.

i. Type of sample (for example, groundwater or surface water).

j. Suspected waste composition.

k. Number and volume of sample taken.

l. Sampling methodology, including distinction between grab and composite sample.

m. Sample preservation.

n. Date and time of collection.

o. Collector's sample identification number(s).

p. Sample shipment (for example, name of the laboratory and cartage agent: Federal Express, United Parcel Service, etc.)

q. References such as maps of the sampling site.

r. Field observations (*e.g.* oily sheen on groundwater sample, incidental odors, soil color, grain size, plasticity, moisture content, layering, U.S.C.S.classification, etc.)

s. Any field measurements made (for example, pH, conductivity, explosivity, water depth, OVA readings, etc.)

t. Signature and date by the personnel responsible for observations.

u. Decontamination procedures.

Sampling situations vary widely. No general rules can specify the extent of information that must be entered in a logbook. However, records should contain sufficient information so that someone can reconstruct the sampling activity without relying on the collector's memory. The Project Manager will keep a master list of all field logbooks assigned to the Sampling Team Leaders. One logbook kept by the Project Manager will be a master site log of daily activities and will contain the list of field logbooks assigned to Sampling Team Leaders.

4.0 Maintenance

Not Applicable.

5.0 Precautions

None.

6.0 Refe ences

U.S. EPA. 1990. Sampler's Guide to the Contract Laboratory Program. EPA/540/P-90/006, Directive 9240.0-06, Office of Emergency and Remedial Response, Washington, D.C., December 1990.

U.S. EPA. 1991. User's Guide to the Contract Laboratory Program. EPA/540/O-91/002, Directive 9240.0-01D, Office of Emergency and Remedial Response, January 1991.

U.S. EPA. 1980, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80

STANDARD OPERATING PROCEDURE 004
SAMPLE PACKING AND SHIPPING

1.0 Scope and Application

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for the packing and shipping of samples to the laboratory for analysis.

2.0 Material

a. Waterproof coolers (hard plastic or metal)
b. Metal cans with friction-seal lids (*e.g.* paint cans)
c. Custody seals
d. ~~Non-absorbent~~ Packing material [2]
e. Sample Documentation
f. Ice
g. Plastic Garbage Bags
h. Clear Tape
~~i. Bubble wrap or closed cell foam packing sheets~~
j. Zip seal plastic bags

3.0 Procedure

3.1 Check cap tightness and verify that clear tape covers label and encircles container.

3.2 Wrap sample container in bubble wrap or closed cell foam sheets.

3.3 Enclose each sample in a clear zip-seal plastic bag.

3.4 Place several layers of bubble wrap, or at least 1" of vermiculite on the bottom of the cooler. Line cooler with open garbage bag, place all the samples upright inside a garbage bag and tie the bag.

3.5 Double bag and seal loose ice to prevent melting ice from soaking the packing material. Place the ice outside the garbage bags containing the samples.

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[2] Permissible packing materials are: a) (non-absorbent) bubble wrap or closed cell foam packing sheets; b) (absorbent) vermiculite. Organic materials such as paper, wood shavings (excelsior), and cornstarch packing "peanuts" will not be used.

3.6 Pack shipping containers with packing material (~~styrofoam "peanuts" in plastic bags, or closed-cell foam, vermiculite, or~~ bubble wrap). Place this packing material around the sample bottles or metal cans to avoid breakage during shipment.

3.7 Enclose all sample documentation (i.e., Field Parameter Forms, COCs) in a waterproof plastic bag and tape the bag to the underside of the cooler lid. If more than one cooler is being used, each cooler will have its own documentation.

3.8 Seal the coolers with signed and dated custody seals so that if the cooler were opened, the custody seal would be broken. Place clear tape over the custody seal to prevent damage to the seal.

3.8.1 Refer to SOPs 001, 002, 003, 016 and 39.

3.9 Tape the cooler shut with packing tape over the hinges and place tape over the cooler drain.

3.10 Ship all samples via overnight delivery on the same day they are collected if possible.

4.0 Maintenance

Not Applicable.

5.0 Precautions

5.1 Any samples suspected to be of medium/high contaminant concentration or containing dioxin must be enclosed in a metal can with a clipped or sealable lid (e.g., paint cans). Label the outer metal container with the sample number of the sample inside.

5.2 If the sample is suspected of being contaminated with chemical agent, DO NOT use this SOP for packing and shipping methods USE ONLY the packing and shipping methods prescribed in SOP035.

6.0 References

U.S. EPA. 1990. Sampler's Guide to the Contract Laboratory Program. EPA/540/P-90/006, Directive 9240.0-06, Office of Emergency and Remedial Response, Washington, D.C., December 1990.

U.S. EPA. 1991. User's Guide to the Contract Laboratory Program. EPA/540/O-91/002, Directive 9240.0-01D, Office of Emergency and Remedial Response, January 1991.

U.S. EPA. 1980, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80

STANDARD OPERATING PROCEDURE 005
DECONTAMINATION

1.0 Scope and Application

All personnel or equipment involved in intrusive sampling, or which enter a hazardous waste site during intrusive sampling must be thoroughly decontaminated prior to leaving the site to minimize the spread of contamination and prevent adverse health effects. This procedure describes the normal decontamination of sampling equipment and site personnel.

2.0 Material

a. Plastic sheeting, buckets, etc. to collect wash water and rinsates.
b. Approved water.
c. HPLC-grade water.[3]
d. 0.10N Nitric Acid.
e. Non-phosphate laboratory detergent.
f. Reagent grade alcohol [4]
g. Aluminum foil or clean plastic sheeting.
h. Pressure sprayer, rinse bottles, brushes.
i. Plastic garbage bags.
j. 0.01N HCl

3.0 Procedure

3.1 Sample Bottles

At the completion of each sampling activity the exterior surfaces of the sample bottles must be decontaminated as follows:

3.1.1 Be sure that the bottle lids are on tight.

3.1.2 Wipe the outside of the bottle with a paper towel to remove gross contamination.

---

[3] For the purposes of this SOP, HPLC-grade water is considered equivalent to "Deionized ultra filtered water", "Reagent-grade distilled water", and "Deionized organic-free water". The end product being water which is pure with no spurious ions or organics to contaminate the sample. The method of generation is left to the individual contractor.

[4] For the purposes of this SOP, the term "reagent grade alcohol" refers to either pesticide grade isopropanol or reagent grade methanol.

3.2 Personnel Decontamination

Review the project Health and Safety Plan for the appropriate decontamination procedures.

3.3 Equipment Decontamination

3.3.1 Water Samplers

3.3.1.1 Bailers.

After each use, Polytetrafluoroethelyne (PTFE) double check valve bailers used for groundwater sampling will be decontaminated as follows:

a. Discard all ropes used in sampling in properly marked sealable container, or as directed by the health and safety plan. Note: no tubing is to be used in conjunction with a bailer in collecting samples.

b. Scrub the bailer to remove gross(visible) contamination, using appropriate brush(es), approved water, and non-phosphate detergent.

c. Rinse off detergent with approved water.

d. Rinse bailer with reagent grade alcohol.

e. Rinse bailer with HPLC-grade water.

f. Rinse bailer with 0.10N Nitric Acid solution.

g. Rinse bailer with HPLC-grade water.

h. Allow bailer to air dry.[5]

i. Wrap bailer in aluminum foil or clean plastic sheeting, or store in a clean, dedicated PVC or PTFE storage container.

j. Dispose of used decon solutions with drummed purge water.

k. Rinse bailer with HPLC-grade water immediately prior to re-use.

[5] If the bailer has just been used for purging and is being decontaminated prior to sampling do not air dry. Double rinse with HPLC-grade water and proceed to collect samples.

3.3.1.2 Pumps

Submersible pumps will be decontaminated as follows:

a. Scrub the exterior of the pump to remove gross (visible) contamination, using appropriate brush(es), approved water, and non-phosphate detergent. (Steam cleaning may be substituted for detergent scrub).

b. Calculate the volume of pump plus any tubing which is not disposable and not dedicated to a single well. Pump 3 volumes of non-phosphate laboratory detergent solution to purge and clean the interior of the pump.

c. Rinse by pumping no less than 9 volumes of approved water to rinse.

d. Rinse pump exterior with reagent grade alcohol.

e. Rinse pump exterior with HPLC-grade water.

f. Allow pump to air dry.

g. Wrap pump in aluminum foil or clean plastic sheeting, or store in a clean, dedicated PVC or PTFE storage container.

h. Prior to reusing pump rinse exterior again with HPLC-grade water. (Double rinse in step "e" above may be substituted for this step).

3.3.1.3 Dip samplers

All dip samplers, whether bucket, long-handled, or short-handled (see SOP-007 "Surface Water Sampling") will be decontaminated in the same manner as given in section 3.3.1.1 "bailers" above.

3.3.1.4 Labware

Labware such as beakers which are used to hold samples for field measurements, water chemistry, etc. will be decontaminated according to the procedures in 3.3.1.1"bailers" above.

3.3.1.5 Water level indicators

Electric water level indicators, weighted measuring tapes, or piezometers used in the determination of water levels, well depths, and/or NAPL levels will be decontaminated in accordance with section 3.3.1.1"bailers" above. Clean laboratory wipes may be substituted for brushes. Tapes, probes, and piezometers should be wiped dry with clean laboratory wipes, and coiled on spools or clean plastic sheeting rather than allowed to air dry.

3.3.2 Solid materials samplers

Solid materials samplers include soil sampling probes, augers, trowels, shovels, sludge samplers, and sediment samplers. All will be decontaminated as follows:

a. Scrub the sampler to remove gross(visible) contamination, using appropriate brush(es), approved water, and non-phosphate laboratory detergent.

b. Rinse off detergent with approved water.

c. Rinse sampler with reagent grade alcohol.

d. Rinse sampler with HPLC-grade water.

e. (Non-metallic samplers only) Rinse sampler with 0.10N Nitric Acid solution.

f. (Non-metallic samplers only) Rinse sampler with HPLC-grade water.

g. Allow sampler to air dry.

h. Wrap sampler in aluminum foil clean plastic sheeting, or store in a new zip-seal bag (size permitting) or clean, dedicated PVC or PTFE storage container.

i. Dispose used decon solutions properly according to the site health and safety plan.

j. Rinse sampler with HPLC-grade water immediately prior to re-use.

3.3.3 Other sampling and measurement probes

3.3.3.1 Soil gas sampling probes will be decontaminated as solids sampling devices.

3.3.3.2 Temperature, pH, conductivity, Redox, and dissolved oxygen probes will be decontaminated according to manufacturer's specifications. If no such soecifications exist, remove gross contaminant and triple rinse probe with HPLC-grade water. A summary of the decontamination procedures to be used must be included in the instrument-specific SOP.

3.3.3.3 Measuring tapes which become contaminated through contact with soil during field use will be decontaminated as follows:

a. Wipe tape with a clean cloth or laboratory wipe which has been soaked with non-phosphate laboratory detergent solution to remove gross contamination. Rinse cloth in the solution and continue wiping until tape is clean.

b. Wipe tape with a second clean, wet cloth (or lab wipe) to remove soap residues.

c. Dry tape with a third cloth (or lab wipe) and rewind into case, or re-coil tape.

3.3.4 Drilling Rigs

All drilling rigs and associated equipment such as augers, drill casing, rods, samplers, tools, recirculation tank, and water tank (inside and out) will be decontaminated prior to site entry after over-the-road mobilization and immediately upon departure from a site after drilling a hole. Supplementary cleaning will be performed prior to site entry there is a likelihood that contamination has accumulated on tires and as spatter or dust enroute from one site to the next (see also Field Investigation Plan, § 6.3.7).

a. Place contaminated equipment in an enclosure designed to contain all decontamination residues (water, sludge, etc.).

b. Steam clean equipment until all dirt, mud, grease, asphaltic, bituminous, or other encrusting coating materials (with the exception of manufacturer-applied paint) have been removed.

c. Water used will be taken from an approved source.

d. Containerize, sample, characterize, and dispose of all decontamination residues properly.

3.3.5 HPLC-grade water Storage

Dedicated glass storage containers will be used solely for dispensing HPLC-grade water. New HPLC-grade water containers will be decontaminated as follows:

a. Clean with hot tapwater from approved source and non-phosphate laboratory detergent while scrubbing the exterior and interior of the container with a stiff-bristled brush.

b. Rinse thoroughly with approved water.

c. Rinse with 0.01N Nitric acid.

d. Rinse with approved water.

e. Rinse thoroughly with HPLC-grade water.

f. Fill clean container with HPLC-grade water. Cap with one layer of PTFE-lined paper and one layer of aluminum foil. Secure cap with rubber band and date the container.

Used HPLC-grade water containers will be decontaminated as follows:

a. Clean the exterior with hot tapwater from an approved source, non-phosphate laboratory detergent, and a stiff-bristled brush.

b. Rinse the exterior thoroughly with HPLC-grade water

c. Rinse the interior twice with pesticide-grade isopropanol.

d. Rinse interior thoroughly with HPLC-grade water.

e. Fill clean container with HPLC-grade water. Cap with one layer of PTFE-lined paper and one layer of aluminum foil. Secure cap with rubber band and date the container.

4.0 Maintenance

4.1 HPLC-grade water will be stored only in decontaminated glass containers with aluminum foil lids as stipulated above. The water may not be stored for more than, nor used more than three days after manufacture.

4.2 HPLC-grade water will be manufactured on-site. An approved tap water source will be used as the influent to the system. Procedures for system set-up, operation and maintenance will conform to manufacturer's specifications.

5.0 Precautions

5.1 Dispose of all wash water, rinse water, rinsates, and other sampling wastes (tubing, plastic sheeting, etc.) in properly marked, sealable containers, or as directed by the health and safety plan.

5.2 Once a piece of equipment has been decontaminated, be careful to keep it in such condition until needed.

5.3 Do not eat, smoke or drink on site.

6.0 References

Site-specific health and safety plan.

STANDARD OPERATING PROCEDURES 006
USE OF THE IRDMS NETWORK

1.0 LOGIN/LOGOUT OF THE IRDMS (PRI) NETWORK

1.1 Files may be transferred to, or copied from; the PRI LAN through remote terminals. The connection requires a Hayes-compatible modem operating at 1200 baud, and 3COM network software. The contractor will purchase the 3COM 3+ Remote package, and PRI will supply a "Remote Login Disk" which contains DOS startup files (AUTOEXEC.BAT, COMMAND.COM, IBMBIO.COM, IBMDOS.COM, etc.) and 3COM network programs for startup, remote dialing, etc.

1.2 To connect to the PRI LAN, the PC must be rebooted from the Remote Login Disk #1. After the standard DOS startup routines are completed, you will get the A> prompt. Change to the drive containing the IRDMS files (C or D).

Type	D: <CR>
Get	D>

Next, you will start the 3COM linking program.

Type: 3COM XXX (include the space) (where XXX is the contractor i.d.) <CR> Get (after pauses - you will hear the phone ring and data transmission):

```
Login 1.1 - Copyright (etc.) 3COM
XXX:PRI:IRDMS logged in
D> 3f link e:
E: Linked to \\XXX:PRI:IRDMS
D>
```

(NOTE: The Remote Login Disk may now be removed from the A: drive)

You are now linked to the E: drive on the PRI LAN, which can be treated as any other drive. For example, you can switch to the E: drive by typing E: <CR>. After a pause (sometimes several seconds), you should get the E> prompt.

Under E: is a subdirectory \TRANSFER where all files are sent (*.TRN) to be transferred. To copy a file SEMAP.TRN from drive D and directory DATA to the network,

Type	E: <CR>
Get	E>
Type	CD\TRANSFER <CR>
Get	E> (The subdirectories do not show on the prompt)

Type	copy D:\DATA\SEMAP.TRN <CR>

(NOTE: any valid DOS COPY format can be used)

After a while, you may get a message saying that the network is still trying, and allows you to do an abort. Eventually, you should get a file(s) copied message:

Get	1 file(s) copied

To verify that the file was transmitted, you can print the directory listings.
If you are not on the E> (actually E\TRANSFER) prompt, type E: <CR>,then

CD\TRANSFER <CR>,then

Type	DIR <CR>
Get	(a listing of the \TRANSFER directory contents. SEMAP.TRN should be in the listing.)

To log out after all files have been transmitted:

Type	D; <CR>
Get	D>
Type	LOGOUT <CR>
Get	a "logged out" message

You can now (a) do other things with the IRDMS programs, or (b) reboot the machine with the Remote Login Disk removed, to return the PC to local control.

AFTER EVERY TRANSFER OF DATA TO THE PRI LAN, call PRI at (410) 679-3030 (ask for the contact for the specific installation) and give them the installation and file type (e.g., SL map file data) and the DOS name of the file that was transmitted. The contractor should receive by Fax a confirmation that the data was received; if not, call PRI and ask for it.

STANDARD OPERATING PROCEDURE 007
SURFACE WATER SAMPLING

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for sampling surface water. This procedure can be applied to the collection of surface water samples from streams, rivers, ditches, lakes, ponds and lagoons. Surface water samples provide an indication of the amount of contaminant in the surface water. It is therefore important to collect a representative sample.

2.0 Material

a. Sample bottles
b. Stainless steel or PTFE-lined bucket
c. Long-handled dip sampler (PTFE or stainless steel)
d. Short-handled dip sampler (PTFE or stainless steel)
e. Peristaltic pump with 0.451M filters and disposable tygon tubing
f. 0.451 disposable filters
g. Cooler with ice

3.0 Procedure

3.1 For all surface water samples, mark the sampling locations on a site map. Photograph and describe each location, and place a numbered stake above the visible high water mark on the bank closest to the sampling location, and/or mark adjacent trees with surveyor's flagging. The photographs and descriptions must be adequate to allow the sampling station to be relocated at some future date by someone other than the original sampling crew. Use the long handled dip sampler where access is poor or non-contact with water is suggested in the health and safety plan.

3.2 Sampling should performed deliberately and methodically to minimize disturbance of bottom sediments, yet as quickly as possible to ensure a representative sample. To prevent contamination of the exterior of the sample container, and/or potential contamination of the surface water sample by laboratory contaminants on the exterior of the bottle, the sample container should never be dipped into the water, rather a decontaminated, long-handled or measuring cup-type PTFE or stainless steel sampler, or a sampling bucket should be used to collect unfiltered samples.

3.3 **Sampling with the PTFE or stainless steel sampler** (long-handled or measuring cup-type):

3.3.1 Remove the cap from the sample bottle.

3.3.2 Dip a sample of surface water using the sampler.

3.3.3 Tilt sample bottle and gently pour sample from sampler into the bottle. Allow the sample to trickle down the side of the bottle. Avoid aerating the sample.

3.3.4 Add preservative as required by SOP039. Replace cap, and place in cooler immediately.

3.4 Sampling with stainless steel or PTFE-lined bucket:

3.4.1 Remove cap from sample bottle.

3.4.2 Gently dip collection bucket in the water. Fill bucket and carefully lift from water body.

3.4.3 Tilt sample bottle and gently pour sample from sampler into the bottle. Allow the sample to trickle down the side of the bottle. Avoid aerating the sample.

3.4.4 Add preservative as required by SOP039. Replace cap, and place in cooler immediately.

– OR –

3.4.5 Use smaller sampling cup to transfer sample from bucket to sample bottle as in section 3.3 above.

3.5 Both filtered and unfiltered samples will be taken for metals analyses. Bulk samples for filtration will be collected using the stainless steel or PTFE-lined bucket method described in section 3.4 above. Sample filtration must be performed immediately upon retrieval of the bulk sample as follows:

3.6 Filtration will be performed immediately after collecting sample. Set up filtration equipment prior to collecting sample. Filtration may be accomplished by gravity (see 3.7), or if necessary, due to slow filtering, a peristaltic pump will be used to pressure filter the sample (see 3.8). Vacuum filtration will not be used due to the possibility of analyte volatilization.

3.7 Gravity filtration will be accomplished as follows:

3.7.1 Using decontaminated forceps, place a 0.45lM membrane in a decontaminated filter funnel.

3.7.2 Slowly pour sample into the funnel and collect filtrate directly into appropriate sample container(s).

3.7.3 Add preservative(s) as required by SOP039. Immediately cap container and place in cooler.

3.7.3 Dispose of filter membrane.

3.8 Pressure filtration will be accomplished as follows:

3.8.1 Using previously assembled disposable tubing, 451 in-line filter, and peristaltic pump, filter sample from collection bucket into appropriate container.

3.8.2 Adjust pump rate to avoid aeration of sample.

3.8.3 Fill container, preserve as indicated in SOP0039, immediately cap container and place in cooler.

3.8.4 Dispose of filter and tubing.

3.9 Refer to SOP 1-5, 16, and 39.

4.0 Maintenance

Refer to manufacturer's specifications for maintenance procedures on generators and pumps.

5.0 Precautions

5.1 Avoid disturbing bottom sediments.

5.2 Consult the health and safety plan (HASP) prior to collecting any samples for PPE such as dermal and respiratory protection and personal flotation devices when sampling in or near deep water or from boats.

5.3 Always decontaminate the sampling and filtration equipment, and change gloves between sampling locations to minimize the risk of cross contamination.

5.4 Always set up generators downwind of working area. Never service generators onsite.

6.0 References

None.

STANDARD OPERATING PROCEDURE 008
pH MEASUREMENT USING BECKMAN .™ 12 pH/ISE METER

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for measuring the pH of all types of aqueous solutions, including drinking water, saline water, industrial and domestic wastes. pH is a measure of the hydrogen ion content of a solution, and thus gives a general indication of the acidity or alkalinity of a water sample.

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

2.0 Material

a. . 12 pH Meter
b. Combination (pH) electrode
c. Automatic temperature compensator (ATC) probe
d. Commercial Buffer solutions (standards) of pH 4.00, 7.00, and 10.00
e. HPLC-grade water
f. Beakers
g. Wash bottle
h. Laboratory wipes for blotting electrodes

3.0 Procedure

3.1 **Calibration check.** Calibration of the pH meter will be checked on a daily basis. A two point calibration should be used as follows:

3.1.1 Prepare beakers of buffer solutions of pH 4.00, 7.00, and 10.00.

3.1.2 Calibration should closely bracket the expected pH range of the samples to be taken.

3.1.3 Turn on instrument, clear instrument

3.1.4 Rinse the electrode with distilled water and blot excess.

3.1.5 Immerse probes in beaker of pH 4.00 or 7.00 standard, swirl gently.

3.1.6 Press pH key, then STD key.

3.1.7 Keep the probes in the sample until the reading stabilizes. The reading should be the pH of the standard.

3.1.8 Rinse the electrode with distilled water and blot excess.

3.1.9 Repeat the procedure with pH 7.00 and 10.00 standards

3.1.10 Record the initial readings.

3.1.11 If the measured values vary from the expected value by greater than 0.2 pH units, recalibrate the instrument with fresh aliquots of buffer solution. If the discrepancy persists, alert the Field Operations Leader, who has the option of trying to fix the meter or obtaining a second pH meter.

3.1.12 Record all measurements in the field logbook.

3.1.13 Verify calibration by reading the pH of the third buffer solution.

3.1.14 Refer to SOP 003 and 016.

3.2 **pH measurements** will be taken using the two-point standardization method as follows:

3.2.1 Connect the ATC and pH electrodes to the appropriate inputs.

3.2.2 Turn on instrument, clear instrument.

3.2.3 Prepare two small beakers of standard buffer solutions. Ideally the pH values of these standards will "bracket" the expected pH value of the sample and be as close as possible to the pH of the sample.

3.2.4 Rinse a small beaker with distilled water, then sample water. Fill the beaker with sample water.

3.2.5 Rinse the probes with distilled water. Blot excess.

3.2.6 Immerse electrode and ATC in first standard. Swirl gently. Press pH key and STD key. Wait for display to stop flashing.

3.2.7 Rinse the probes with distilled water. Blot excess.

3.2.8 Immerse electrode and ATC in second standard. Swirl gently. Press STD key. Wait for display to stop flashing.

Blot excess.

l swirl gently, keeping the probes in the

'e after stabilization. Note any problems such

Blot excess.

additional samples.

er's specifications.

ection 3.3.1.4"labware".

nete

:d.

ı adjusted to pH 4 when the meter is not in
l with deionized water and the protective cap
o not blot the electrode dry prior to putting

matter that can impair electrode response by
distilled water rinsing.

:s may not apply to alternate manufacturers'

7.00 and one end point (pH 4.00 or 11.00)
vo end points only.

›H Meter, .™ 11 pH meter, and .™ 12-

Analysis of Water and Wastes, March, 1983.

:andard Methods for the Examination of Water and
'ublic Health Assn., American Water Works Assn., and Water

STANDARD OPERATING PROCEDURE 009
TEMPERATURE MEASUREMENTS

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for measuring the temperature of a solid or liquid sample, in particular, for measuring water temperature. Groundwater temperature does not vary dramatically over the course of a year. Therefore, groundwater temperature can be used to help identify an aquifer, identify stream reaches where groundwater inflow is occurring, identify thermal gradients in lakes or ponds, and also indicate when sufficient water has been removed from a well during purging.

2.0 Material

Digital reading, thermocouple thermometer in combination meter or in a stick. Accuracy = +/- 0.5°C

3.0 Procedure

3.1 Rinse the probe with distilled water.

3.2 Insert the probe into the sample, and leave it in the sample until the temperature stabilizes.

3.3 Record the temperature reading, being sure to indicate °C or °F.

3.4 Decontaminate the probe according to SOP005 "Decontamination" section 3.3.1.4 "Labware."

3.5 Refer to SOP 003, 005, and 016.

NOTE: $°C = (°F - 32)(5/9)$
$°F = ((9/5)C°) + 32$

4.0 Maintenance

Not Applicable.

5.0 Precautions

None

6.0 References

Methods for Chemical Analysis of Water and Wastes, U.S. EPA, March, 1983.

STANDARD OPERATING PROCEDURE 010
WATER LEVEL AND WELL-DEPTH MEASUREMENTS

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for measuring water level and well-depth. This procedure is applicable to the sampling of monitoring wells and must be performed prior to any activities which may disturb the water level, such as purging or aquifer testing.

2.0 Material

a. Electric Water Level Indicator (dipmeter) with cable measured at 0.01 foot increments.

-or-

Weighted Steel Tape and chalk.

-or-

Transducer and datalogger.

b. Oil-water interface probe
c. *Plastic Sheeting*
d. Photoionization detector (PID) or intrinsically safe flame ionization detector (FID)

3.0 Procedure

3.1 Preliminary Steps

3.1.1 Locate the well and verify its position on the site map. Record whether positive identification was obtained, including the well number and any identifying marks or codes contained on the well casing or protective casing. Gain access to the top of the well casing.

3.1.2 Locate the permanent reference mark at the top of the casing. This reference point will be scribed, notched or otherwise noted on the top of the casing. If no such marks are present, measure to the top of the highest point of the well casing and so note this fact in field logbook. Determine from the records and record in the notebook the elevation of this point.

3.1.3 Record any observations and remarks regarding the completion characteristics and well condition, such as evidence of cracked casing or surface seals, security of the well (locked cap), and evidence of tampering.

3.1.4 Keep all equipment and supplies protected from gross contamination; use clean plastic sheeting. Keep the water level indicator probe in its protective case when not in use.

3.2 Operation

3.2.1 Sample the air in the well head for gross organic vapors by lifting the well cap only high enough for an organic vapor meter (PID or FID) probe to be entered into the well casing. This will indicate the presence of gross volatile contaminants as well as indicating potential sampler exposure.
Remove cap. Allow well to vent for 60 to 90 seconds. Resample headspace.
Record both readings. If the second reading is lower than the first, use the second reading to determining whether respiratory protection will be required during subsequent water level and well depth determinations, and sampling.
Note that all headspace sampling must be performed at arm's length and from the upwind side of the well if possible.

3.2.1.1 Refer to SOP 011, 023, or 024 as appropriate.

3.2.2 If non-aqueous phase liquid (NAPL) contamination is suspected [6], use an interface probe to determine the existence and thickness of NAPLs.

3.2.2.1 Open the probe housing, turn the probe on, and test the alarm. Slowly lower the probe into the well until the alarm sounds. A continuous alarm indicates a NAPL while an intermittent alarm indicates water. If a NAPL is detected, record the initial level (first alarm). Mark the spot by grasping the cable with the thumb and forefingers at the top of the casing. If a mark is present on the casing, use the mark as the reference point. If no mark is present, use the highest point on the casing as the reference point. Withdraw the cable sufficiently to record the depth.

3.2.2.2 Continue to slowly lower the probe until it passes into the water phase. Slowly retract the probe until the NAPL alarm sounds and record that level in the manner as described above.

3.2.2.3 Record the thickness of the LNAPL (see section 3.3.1).

3.2.2.4 Continue to slowly lower the interface probe through the water column to check for the presence of DNAPL.

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[6] Interface probes will be used in all wells for first round sampling, regardless of site history. If no NAPLs are detected during the first round of sampling, this step may be omitted during subsequent sampling events unless conditions such as site history or headspace vapors would indicate otherwise.

3.2.2.5 Measure and record the thickness of the DNAPL layer (if any) as described above.

3.2.2.6 Slowly raise the interface probe, recording the depth to each interface as the probe is withdrawn. If there is a discrepancy in depths, clean the probe sensors and re-check the depths.

3.2.2.7 NOTE: Air/liquid interface depth is more reliable if probe is lowered into liquid. NAPL/water drepths are more accurate if probe is moved from water into NAPL.

3.2.2.8 Always lower and raise interface probe slowly to prevent undue mixing of media.

3.2.2.9 Always perform NAPL check in wells installed in areas with suspected NAPL contamination. Always perform NAPL check if headspace test reveals presence of volatiles. Always perform NAPL check the first time a well is sampled. If a well has been sampled previously and no NAPLs were present and none of the preceding conditions are met, the NAPL check may be omitted.

3.2.3 If no NAPL is present use an *electronic water level detector* as follows.

3.2.3.1 Remove the water level indicator probe from the case, turn on the sounder, and test check the battery and sensitivity scale by pushing the red button. Adjust the sensitivity scale until you can hear the buzzer.

3.2.3.2 Slowly lower the probe and cable into the well, allowing the cable reel to unwind. Continue lowering until the meter buzzes. Very slowly, raise and lower the probe until the point is reached where the meter <u>just</u> buzzes. Marking the spot by grasping the cable with the thumb and forefingers at the top of the casing. If a mark is present on the casing, use the mark as the reference point. If no mark is present, use the highest point on the casing as the reference point. Withdraw the cable and record the depth.

3.2.4 Alternatively use a steel tape with an attached weight if aquifer gradients are lower than 0.05 ft/ft. Due to the possibility of adding unknown contaminants from chalk colorants, only white chalk is permitted.

3.2.4.1 Rub chalk onto the first 1 foot of the steel tape and slowly lower the chalked end into the well until the weighted end is below the water surface. (A small splash can be heard when the weighted end hits the water surface.)

3.2.4.2 Using the method described above read and record the length from the steel tape.

3.2.4.3 Remove the steel tape. The chalk will be wet or absent where the tape was below the water surface. Locate, read, and record this length. Subtract wetted length from total length and record the difference. This is the depth to water table.

3.2.5 Transducers and dataloggers will be used where water level fluctuations over time are to be measured, such as tidal fluctuation studies (SOP043) and slug tests (SOP033). Note that transducers are inappropriate for measuring well depth.

3.2.5.1 Slowly lower the transducer into the well until it is below the lowest possible piezometric level (typically 2-3 ft below the water table).

3.2.5.2 Tape the umbilical to the protective casing to prevent the transducer from falling further.

3.2.5.3 Attach the umbilical leads to the datalogger.

3.2.5.4 Turn datalogger on.

3.2.6 To measure the well depth, lower electric water level indicator probe or tape until slack is noted. Very slowly raise and lower the cable until the exact bottom of the well is "felt." *Measure (cable) or read the length :(tape)* and record the depth. Note that if the electric water level indicator is used to determine depth of well, the offset distance between the tip of the probe and the electrode must be added to the reading to determine actual depth.

3.2.7 Withdraw the probe or tape.

3.2.8 Decontaminate the probe(s) and cable(s).

3.3 Data Recording and Manipulation

3.3.1 Record the following computations:

date and time
weather
method of measurement
casing elevation
NAPL surface elevation = casing elevation - depth to NAPL
NAPL thickness = depth to bottom of NAPL - depth to top of NAPL
water level elevation = casing elevation - depth to water
well bottom elevation = casing elevation - depth to bottom (or read directly from tape)

3.4 Refer to SOPs 3, 5, and 16.

4.0 Calibration

No calibration is needed.

5.0 Precautions

5.1 Depending upon the device used, correction factors may be required for some measurements.

5.2 Check instrument batteries prior to each use.

5.3 Exercise care not to break the seals at the top of the electric water level indicator probe.

6.0 References

M^{c}Alary, T. A., and Barker, J. F., 1987. "Volitalization Losses of Organics During Ground Water Sampling from Low Permeability Materials" in Ground Water Monitoring Review, Fall, 1987

Thornhill, Jerry T., 1989. Accuracy of Depth to Groundwater Measurements ; In "EPA Superfund Ground Water Issue" EPA/540/4-89/002

STANDARD OPERATING PROCEDURE 011
PHOTOIONIZATION DETECTOR (HNu Model PI-101 and HW-101)

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for field operations with a photoionization detector (HNu Systems Model PI-101 or HW-101). The photoionization detector (PID) detects total ionizables, hence it is used to monitor both organic and inorganic vapors and gases to determine relative concentrations of air contaminants. This information is used to establish level of protection and other control measures such as action levels. The PID cannot effectively detect compounds having ionization potentials above the photon energy level of the lamp used; therefore, methane, which has an ionization potential of 12.98 eV, is undetectable by PIDs, whose lamps are capable of producing 9.5, 10.2, or 11.7 eV.

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

2.0 Material

a. HNu Systems Model PI-101 or HW-101 survey probe with 9.5, 10.2, or 11.7 eV lamp.
b. Lead-acid gel-cell battery
c. Calibration Gas (*e.g.* isobutylene - 101 ppm) w/regulator
d. Tygon tubing
e. Tedlar bag (optional)
f. Instrument logbook

3.0 Procedure

These procedures are to be followed when using the HNu in the field.

3.1 Start Up Procedures

3.1.1 Before attaching the probe, check the function switch on the control panel to ensure that it is in the off position. Attach the probe by plugging it into the interface on the top of the readout module.

3.1.2 Turn the function switch to the battery check position. The needle on the meter should read within or above the green battery arc on the scale. If not, recharge the battery. If the red indicator light comes on, the battery needs recharging or service may be indicated.

3.1.3 Turn the function switch to any range setting. Listen for the hum of the fan motor. Check meter function by holding a solvent based marker pen near the sample intake. If there is no needle deflection, look briefly into the end of the probe (no more than one or two seconds) to see if the lamp is on. If it is on, it will give a purple glow. Do not stare into the probe any longer than two seconds. Long term exposure to UV light can damage the eyes. (See also note 5.4)

3.1.4 To ZERO the instrument, turn the function switch to the standby position and rotate the zero adjustment until the meter reads zero. A calibration gas is not needed since this is an electronic zero adjustment. If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted, if necessary. Allow the instrument to warm up for 3-5 minutes to ensure that the zero reading is stable. If necessary, readjust the zero.

3.2 Operational Check

3.2.1 Follow the start up procedure in section 3.1

3.2.2 With the instrument set on the 0-20 range, hold a solvent-based magic marker near the probe tip. If the meter deflects upscale, the instrument is working.

3.3 Field Calibration Procedure

3.3.1 Follow the start-up procedures in section 3.1 and the operational check in section 3.2.

3.3.2 Set the function switch to the range setting for the concentration of the calibration gas.

3.3.3 Attach a regulator HNu P/N 101-351 or equivalent (flow = 200 to 300 ml/min) to a disposable cylinder of isobutylene (HNu 101-351 or equivalent). Connect the regulator to the probe of the HNu with a piece of clean Tygon tubing. Turn on the valve of the regulator.

3.3.4 After five seconds, adjust the span dial until the meter reading equals the benzene concentration of the calibration gas used, corrected to its equivalence which should be marked on the canister (Isobutylene ~0.7Xbenzene).

3.3.5 Record in the field log: the instrument ID No.; serial number; the initial and final span settings; the date; time; location; concentration and type of calibration gas used; and the signature of the person who calibrated the instrument.

3.3.6 If the HNu does not function, check-out, or calibrate properly, the project equipment manager is to be notified as soon as possible. Under no circumstances is work requiring monitoring with a PI-101 or HW-101 to be done with a malfunctioning instrument.

3.4 Calibration to a Gas Other Than Isobutylene

The HNu may be calibrated to any certified calibration gas. However, after calibration all subsequent instrument readings will be relative to the calibration gas used.

3.4.1 Calibrate according to procedure 3.3

3.4.2 Partially fill and flush to two times a gas bag (Tedlar recommended) with the certified National Institute of Standards and Technology (NIST) (formerly NBS) traceable calibration gas. Then fill the bag with one to three liters of the calibration gas. If the gas is toxic, this must be done in a fume hood.

3.4.3 Feed the calibration gas into the probe with the range set for the value of the gas. After five seconds, adjust the span control until the meter reads the value of the calibration gas.

3.4.4 Record the results of the calibration on the calibration/maintenance log and attach a new calibration sticker (if available) or correct the existing sticker to reflect the new calibration data. All subsequent readings will be relative to the new calibration gas.

3.5 Operation

3.5.1 Follow the start up procedure, operational check and calibration check (refer to 3.1).

3.5.2 Set the function switch to the appropriate range. If the concentration of gases of vapors is unknown, set the function switch to 0-20 ppm range. Adjust if necessary.

3.5.3 While taking care not to permit the HNu to be exposed to excessive moisture, dirt, or contaminants, monitor the work activity as specified in the Site Health and Safety Plan.

3.5.4 When the activity is completed or at the end of the day, carefully clean the outside of the HNu with a damp disposable towel to remove all visible dirt. Return the HNu to a secure area and place on charge. Place the instrument on charge after each use; the lead acid batteries cannot be ruined by over charging.

3.5.5 With the exception of the probe's inlet and exhaust, the HNu can be wrapped in clear plastic to prevent it from becoming contaminated and to prevent water from getting inside in the event of precipitation. If the instrument becomes contaminated, make sure to take necessary steps to decontaminate it. Call the Equipment Administrator if necessary; under no circumstances should and instrument be returned from the field in a contaminated condition.

3.6 Refer to SOP 3 and 16.

4.0 Maintenance

The following sections cover basic maintenance and servicing procedures; they are to be performed only by persons who have been specifically trained in the procedures. In general, disassembly procedures not covered in this text are to be left to trained service personnel, including the contractor's equipment administrator or equipment managers as appropriate.

The appropriate calibration/maintenance logs are to be filled in completely whenever a PI-101 or HW-101 receives servicing. This is true of both contractor-owned and rental instruments.

The equipment manager should be called to arrange for a fresh instrument when necessary. The contractor's equipment facility is responsible for arranging all repairs which cannot be performed by the project equipment manager.

4.1 Routine Service

The PID's performance is affected by a number of factors. These include but are not limited to the decay of the UV lamp output over time and the accumulation of dust and other particulate material and contaminates on the lamp and in the ion chamber. Because of these factors, the PID should not be left in the field for a period of more than two weeks before being replaced with a fresh instrument. If a site is going to be inactive for a period of more than a week, all monitoring instruments are to be returned to the project equipment manager or his trained designee for servicing and/or reassignment. The following procedures are to be performed at the designated intervals for routine service.

Procedure	Frequency
Operational Check	Prior to use and at instrument return
Field Calibration	Prior to use and at instrument return
Full Calibration	Bi-weekly (return instrument to equipment manager for replacement with a fresh unit)
Clean UV Lamp and Ion Chamber	Bi-weekly or as needed
Replace UV Lamp	As needed

4.1.1 UV Lamp and Ion Chamber Cleaning

During periods of analyzer operation, dust and other foreign materials are drawn into the probe forming deposits on the surface of the UV lamp and in the ion chamber. This condition is indicated by meter readings that are low, erratic, unstable, non-repeatable, drifting, and which show apparent moisture sensitivity. These deposits interfere with the ionization process and cause erroneous readings.

Check for this condition regularly to insure that the HNu is functioning properly. If the instrument is malfunctioning, call your respective equipment manager to arrange to have a fresh replacement.

4.1.2 Lamp eV Change

If different applications for the analyzer would require different eV lamps, separate probes, each with its own eV lamp, must be used. A single readout assembly will serve for any of the probes (9.5, 10.2 and 11.7 eV). A change in probe will require resetting of the zero control and recalibrating the instrument. The 11.7 eV lamp will detect more compounds than either of the two lower eV lamps. However, the 11.7 eV probe needs more frequent calibration, it burns out much faster than the lower eV lamps.

5.0 Precautions

5.1 The HNu PI-101 and HW-101 are designed to sample air or vapors only. DO NOT allow any liquids or low boiling vapors to get into the probe or meter assembly.

5.2 High concentrations of any gas can cause erroneous readings. High humidity can also cause the instrument readings to vary significantly from the actual concentration of gases or vapors present. This is true even through the HNu cannot react to water vapor.

5.3 High humidity, dust, and exposure to concentrations of low boiling vapors will contaminate the ion chamber, causing a steady decrease in sensitivity.

5.4 Continued exposure to ultraviolet light generated by the light source can be harmful to eyesight. If a visual check of the UV lamp is performed: Do not look at the light source from a distance closer than 6 inches with unprotected eyes. Use eye protection (UV-blocking sunglasses or safety glasses). Only look briefly - never more than about 2 seconds.

5.5 Place the instrument on charge after each use; the lead batteries cannot be ruined by over charging.

5.6 If at any time the instrument does not check out or calibrate properly in the field, the equipment manager is to be notified immediately and a replacement provided for the malfunctioning instrument. Under no circumstances should field work requiring continuous air monitoring for organic vapors and/or gases be done with a malfunctioning HNu, without a HNu or an approved comparable instrument.

6.0 References

Manufacturer's Equipment Manual(s).

STANDARD OPERATING PROCEDURE 012
SPECIFIC CONDUCTANCE MEASUREMENTS

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for measuring the specific conductance of any aqueous solution, including drinking water, saline water, industrial and domestic wastes. Conductivity is the ability of an aqueous solution to pass an electrical current. The current is primarily carried by dissolved inorganic ions such as chlorides, nitrates, sulfates, along with cations such as sodium, calcium, magnesium and others. Organic compounds do not carry current and therefore have almost no conductivity.

2.0 Material

a. Conductivity meter with integral temperature compensation - Accuracy = ± 2% at 25°C (77°F)
b. Conductivity cell
c. Appropriate conductivity reference solution
d. HPLC-grade water (see SOP005 footnote 2)
e. Thermometer (optional, see 5.2)

3.0 Procedure

3.1 Calibration

The specific conductivity meter should be calibrated at the beginning of each day[7] as follows:

3.1.1 Thoroughly rinse the probe with Appropriate conductivity reference solution

3.1.2 Zero meter if appropriate.

3.1.3 Measure the specific conductance of fresh Appropriate conductivity reference solution record it in the field notebook, and adjust the calibration knob until the meter reads properly.

3.1.4 Rinse probe with HPLC-grade water.

3.1.5 Measure the specific conductance of HPLC-grade water and record in the field logbook. If Specific conductivity of HPLC-grade water is not 0 (±2%) recalibrate instrument.

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[7] The meter should be recalibrated any time the readings are suspect (e.g. out of expected range)

3.2 Operation

The specific conductivity meter will be operated as follows:

3.2.1 Thoroughly rinse the probe and sample beaker with sample water.

3.2.2 Measure the temperature of the sample water. Convert Fahrenheit temperature readings to Celsius using C = 5/9 (F - 32) if Celsius temperature is not obtained directly.

3.2.3 Place the probe in the sample beaker with sufficient sample to completely submerge the probe. Swirl the probe to remove any air bubbles trapped in the probe.

3.2.4 Select the highest multiplier scale on the meter and turn the instrument on. Progressively use lower multiplier scales until a mid-scale deflection is obtained.

3.2.5 If appropriate, check probe accuracy by pressing cell test button. If value change is > 10% check probe.

3.2.6 Record the temperature and conductivity values.

3.2.7 *Specific conductivity values are corrected for temperature using:*

$$K_{25°C} = \frac{K\ measured}{1 + 0.0191\ (t - 25)}$$

where:

K = conductivity in μmhos
t = temperature, °C

3.2.8 Decontaminate the probe. (See SOP005 § 3.3.3.2)

3.3 Refer to SOPs 003, 005, and 016.

4.0 Maintenance

The following steps will be taken to properly maintain the conductivity meter:

4.1 Check the batteries each time the instrument is used.

4.2 Inspect the probe on a daily basis for damage or loss of platinum black plating from the electrode. If the platinum is damaged, alert the Field Team Leader and arrange to get a new cell.

4.3 Follow manufacturers specifications regarding storage of probe between uses.

5.0 Precautions

5.1 Be certain there is no air in the cell before taking a reading.

5.2 If conductivity meter does not have integral temperature compensation, use a thermometer to determine temperature of the sample.

6.0 References

USEPA, 1983. Methods for Chemical Analysis of Water and Wastes, March, 1983.

Manufacturer's Manual

STANDARD OPERATING PROCEDURE 013
COLLECTION OF MONITORING WELL SAMPLES

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for the collection of groundwater samples from monitoring wells.

2.0 Material

a. Conductivity meter
b. Thermometer (optional) [8]
c. pH meter with ORD probe
d. Turbidity meter
e. Dissolved Oxygen meter
f. Water-level indicator
g. Transparent bailer with a double check valve
h. PVC bailer (for purging only)
i. Stainless steel bailer (for purging and sampling)
j. Polytetrafluoroethelyne (PTFE) bailer with PTFE-coated stainless steel cable, double check valve top and controlled *flow bottom discharge attachment* [9] for VOC sampling (40-mL vials), and top discharge attachment for collecting larger samples (1-L bottles) (for purging and sampling)
k. Polypropylene rope
l. Submersible pump and hose (for purging only)
m. Peristaltic pump with tubing for filtering samples
n. Variable speed, low flow submersible pump (*e.g.* Grundfos MP1 ground-water sampling pump) (for purging and sampling)
o. Bladder pump (dedicated to one well only)
p. 0.451M filters
q. Sample bottles and labels
r. Logbook or book of field parameter forms
s. Generator
t. Tygon tubing
u. Plastic sheeting
v. Photoionization Detector (PID) Organic Vapor Analyzer

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[8] Temperature compensation and measurement capabilities are generally available as integral functions of pH meters and conductivity meters. If this is the case, a separate thermometer is not required.

[9] Although use of a controlled flow bottom discharge valve is historically preferred, use of such a device can cause aeration of the sample.

3.0 Procedure

3.1 General: Ground-water sampling will follow these general steps:

- Arrive on site
- Set up apparatus (generators, pumps, etc.)
- Glove
- Perform all steps of SOP 010 - orgânic vapor check, water level and well depth measurements
- Sample NAPLs (as required)
- Begin purge procedure
  - If using bailer to purge and sample see § 3.6.
  - If using pump to purge and bailer to sample see § 3.7.
  - If using bladder or low-flow pump to purge and sample see § 3.8.
- Decon/reglove
- Take samples
  - If with bailer see § 3.6.5
  - If with bladder or low flow pumps see §3.8
- Decon/dispose of wastes, move equipment to next site.

3.2 General Rules for *Groundwater Field Parameter* Logbook (see SOP 016 for further procedures):

3.2.1 Only one site or installation per logbook, and only one sampling location per page or form (if using pre-printed forms). The same book maybe used for more than one sampling event.

3.2.2 First five pages will be reserved for index, general notes, etc. Sign and date each entry.

3.2.3 Last five pages will be reserved for recording calibration data for the pH, temperature, turbidity, ORD, DO, and conductivity meters. Use the page number or a separately recorded "Cal Reference Number" to refer to each calibration.

3.2.4 (As appropriate). Insert the cardboard flap under the form being filled out, so that writing does not go through to the pages below.

3.2.5 (As appropriate). Fill in the forms from front to back of the logbook, tearing out the white copy for each sample when the sample has been collected. This copy goes in the cooler with the sample, directly to the laboratory. The original copy must be torn out before you write on the back of the duplicate form.

3.2.6 (As appropriate). Duplicate copies, index pages, and calibratiou sheets remain intact.

3.3 Groundwater Sampling General Rules

3.3.1 Refer to SOPs 001-005, 008-012, 036, 037, and 039

3.3.2 Groundwater samples will be collected from the least contaminated wells first, progressing to the most contaminated [10].

3.3.3 Upon arrival at the well site, immediately set up and organize the purging, sampling, and filtration equipment. If needed, due to muddy or contaminated ground, remoteness from sampling vehicle, and\or for placement of hose(s) and\or power cord if a pump is used, place clean plastic sheeting at, or around the well, to serve as a clean staging area for purging and sampling equipment, as conditions warrant. Care must be exercised not to step on plastic sheeting.

3.3.4 If the well is remote from the sampling vehicle set up the filtration equipment and place rope, wrapped bailer, and pre-labeled sample containers on the plastic sheet, uphill from the well.

3.3.5 When a pump is to be used situate the portable generator on level ground approximately 15 feet away from and downwind from the well. All generator maintenance (oil and fueling) is to be performed off site. If the hose(s) and/or power cord of the pump are not on a reel, place the pump with its hose and power cord on the plastic sheeting downhill from the well.

3.3.6 Glove. Check well headspace for organic vapor which may pose a health and safety hazard and indicate the presence of NAPL. Measure depth(s) to and thickness(es) of NAPL(s) as appropriate. Measure the depth to water and depth of well. From the water depth, well diameter, sand pack length, etc., calculate the equivalent volume (1 EV) of water in the well.

1 EV = volume in casing + volume in saturated sand pack. Therefore; if the water **table lies below the top of the sandpack**, use the following equation:

$$1\ EV = (\pi R_w^2 h_w) + (0.30\pi(R_s^2 - R_w^2)h_s) * (0.0043)$$

If the water table lies above the top of the sandpack use this equation:

$$1\ EV = [(\pi R_w^2 h_w) + (0.30\pi(R_s^2 - R_w^2)h_s)] * (0.0043)$$

where: R_s = radius of sandpack in inches

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[10] First round samples are to be collected from upgradient wells first, moving to downgradient wells under the assumption that upgradient wells will be less contaminated than downgradient wells. Results of first round analysis may mandate a change in sampling sequence.

R_w = radius of well casing in inches
h_s = height of sandpack in inches
h_w = water depth in inches

0.0043 gal/in ^{3}
Assumed filter pack porosity = 30%

Tables and graphs showing equivalent volumes for typical well constructions are available.

Alternate equations for calculating EV are acceptable, two alternates are given in SOP 010

3.3.7 Samples will always be collected in order of decreasing volatility (*i.e.*, the samples to be analyzed for the volatile constituents should be collected first.) Deliver the VOC sample to the vial by allowing the water to trickle down the inside wall of the vial at a rate no greater than approximately 100 ml/min. Other samples may be delivered at a faster rate. Sampling rates will at no time exceed 1 L/min. Procedures for each class of samples are contained in Appendix A of the GWP, the QAPP, and SOP 039.

3.3.8 When *collecting* samples for volatile analysis care should be taken to prevent analyte loss by volatilization. The following procedures should be adhered to when collecting these samples [11]:

3.3.8.1 Avoid excessive aeration and agitation of sample.

3.3.8.2 Fill vial so that a reverse meniscus is present by adjusting the flow rate from the sampling device.

3.3.8.3 Place septum on vial so that the PTFE side is in contact with the sample. After the cap is on the bottle, check for air bubbles in the sample. If air bubbles are present, properly dispose of that sample and recollect the sample in the same vial.

3.3.8.4 Make sure vial is labeled and immediately transfer the vial to the cooler with ice.

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11 Although EPA Region III policy is to preserve VOA samples by acidifying to pH < 2, the possibility of generating mustard agent by reverse hydrolyzation of thyodiglycol mandates that at the Edgewood Area, APG this not be done. Instead, the holding time on all VOA samples shall not exceed 7 days.

3.3.9 Filtered and unfiltered samples will be taken for inorganics (metals) analyses. The samples will be filtered through an in-line 0.451M filter (preferred method), or by gravity through a 0.451M membrane placed in a filter funnel. Use forceps to place the membrane into the funnel and pour sample through funnel until appropriate volumes have been filtered.

If necessary, due to slow filtering, a peristaltic pump may be used to filter the sample through an in-line filter. Connect the pump to the generator, attach tygon tubing to the bottom discharge valve on the bailer. Start pump and collect sample from the end of the in-line filter directly into the proper container, preserved (as required by SOP 039), and placed in the cooler. Filtered samples will be preserved in the field with acid to a pH of less than 2. Make sure sample bottle is labeled and the cap is on tightly. Then place in cooler with ice immediately.

– OR –

If a low flow pump is used collect the samples, filtered samples will be taken by installing a 0.451M filter in-line and pumping the water through the filter. Collect sample from the end of the in-line filter directly into the proper container, preserved (as required by SOP 039), and placed in the cooler. Filtered samples will be preserved in the field with acid to a pH of less than 2. Make sure sample bottle is labeled and the cap is on tightly. Then place in cooler with ice immediately.

3.3.10 Unfiltered samples will be collected by slowly pouring the sample water into the appropriate sample container, being careful not to agitate or cause bubbles to form. Do not overfill bottles. Make sure sample bottle is labeled and the cap is on tightly. Then place the sample in cooler with ice immediately.

3.3.11 All samples will be delivered to the laboratory as soon as possible. If possible, samples will be shipped on the same day as they are collected. If samples must be retained due to weekend sampling (Friday through Sunday), the lab shall be notified as to the time sensitive nature of the samples.

3.3.12 Refer to SOP 1-5, 16, 31, and 39.

3.4 Sampling of Non-Aqueous Phase Liquids

3.4.1 If NAPLs are detected in the well, a sample from all layers must be collected prior to any purging activities. Non-aqueous phase liquids (NAPLs) may be indicated by the presence of volatiles in the well headspace, and confirmed by the oil/water interface probe (see SOP 10 § 3.2 - 3.2.2.3).

3.4.1.1 Collecting LNAPLs will be accomplished using a transparent bailer with a double check valve. This bailer will be slowly lowered until the bottom of the bailer is 1-2 in. below the LNAPL-water interface, as determined in SOP 010 then slowly withdrawn. Verify that the interface was sampled by visual inspection of the bailer contents through the side of the bailer. Measure the thickness of the LNAPL in the bailer and note in the Field Notebook. Sample for laboratory analysis. An additional field verification may be performed by decanting the remainder of the contents of the bailer into a glass jar, adding a hydrophobic dye such as Sudan IV, or Redoil, shaking the sample and looking for coloration of NAPL. Alternate field tests are: examine the sample under ultra violet light (many floresce), or allow the sample to stand overnight, and examine for interface and/or volatiles in the headspace the following day. Refer to following sections on purging and sample collection for set up and general operation.

3.4.1.2 Collecting dense non-aqueous phase liquids (DNAPLs) will be accomplished using a transparent bailer with a double check valve. The bailer must be lowered very slowly to the bottom of the well and raised slowly out of the well in a controlled fashion. Sample for analysis as above. The same field check described above may be employed for DNAPL. Refer to following sections on purging and sample collection for set up, and general operation.

3.4.1.3 If NAPLs are present in the well, and a low-flow pump is to be used for purging and sampling, the well will be allowed to re-equilibrate prior to purging and sampling. This will be accomplished by allowing the well to stand undisturbed for at least 8 hours prior to purging and sample collection.

3.5 Well Purging - General Rules

Water within the casing of a well will stagnate, degas, lose volatiles, possibly precipitate metals due to changes in redox potential, and may react with the screen and/or casing material. It is therefore necessary to purge a sufficient volume of this stagnant water from the well and/or casing to ensure that a representative sample of formation water can be obtained. Traditionally, the volume of water to be purged was arbitrarily set at 3 to 5 equivalent volumes. Recent advances in sampling technologies have caused a re-thinking of such arbitrary purge volumes. It is for this reason that Monitoring of select chemical and physical properties of the sample medium will be used instead of strict volumes to determine when a representative sample may be taken from a well.

3.5.1 Acceptable purge/sampling devices include: bailers, high-discharge submersible pumps (purge only), and variable speed, low-flow pumps which include both submersible pumps (purge and sample), and dedicated bladder pumps (purge and sampling). It is recommended to purge and sample at similar rates with one type device per well. An acceptable exception to this general rule is to use a high-discharge submersible pump to purge a deep, fast-recharging well, and a bailer to sample the same well.

3.5.2 Peristaltic, gas-lift, and centrifugal pumps can cause volatilization, produce high pressure differentials, and can result in variability in the analysis of some analytes of interest. These types of pumps shall not be used to purge or sample wells.

3.5.3 To prevent ground-water from cascading down the sides of the screen in to an open hole, thereby aerating the sample, purge rates will closely match recharge rates. If the static water level is within the casing, the initial purge rates may be set high enough to lower the water level to the top of the screen, then reduced to maintain that level.

3.5.4 Purging will be accomplished with either a submersible pump, a low-flow (submersible or bladder) pump, or bailer. The choice of bailer or pump will be based on depth to water table, volume to be purged, and permeability of the aquifer. If the well recharges rapidly and/or has greater than 20 gallons (estimated EV) to be purged, water may be removed with a submersible pump or a low-flow pump. If the well recharges slowly and/or has less than 20 gallons to be purged, water will be removed with a bailer or a low-flow pump.

3.5.5 Purging will be accomplished with as minimal disturbance to the surrounding formation as possible.

3.5.6 Purge water will be containerized [12] on site until analysis of samples is completed. At that time, if the samples are non-hazardous, the water may be disposed of through the waste water treatment plant on-post. If the purge water is found to be hazardous, it will be disposed of as hazardous waste in a licensed TSDF.

3.5.7 If the water level is within the screened interval and the well recharge rate is less than 0.1 L/min purge the well using a low-flow pump as follows:

3.5.7.1 Draw the water down to within 1 foot of the top of the pump.

3.5.7.2 Allow the well to recover.

3.5.7.3 Check and record field parameters (§ 3.7.3).

[12] If, after two rounds of quarterly samples, the water has proven to be uncontaminated, and the purge volume does not exceed 10,000 Gal/day, the purge water may be discharged on the surface, at least 50 ft downhill from the well. If the water is contaminated but does not exceed 100 ppm total VOC, and other contaminants are non toxic to aquatic life as defined in COMAR 26.08.02.03-2, Table 1, MDE may be petitioned on a case-by case basis for a waiver for surface discharge. This letter will be drafted by the contractor for DSHE signature.

3.5.7.4 Repeat steps 3.5.7.1through 3.5.7.3then collect samples for metals analysis only [13].

3.5.7.5 Note the event in the field log book, and report the problem to the APG project manager. If this extremely low recharge problem consistently occurs in a given well, the well may be considered for re-development and/or replacement.

3.5.7.6 If adjacent wells have elevated VOC levels, additional soil gas surveys will be considered in the vicinity of the low recharge well to help determine the need for replacement.

3.6 Purging and Sampling With Bailers

3.6.1 Bailers may be used for both purging and sampling wells if: a) the well recharge rate is less than 4 L/min, b) depth to the water table is less than 50 ft, and c) less then 20 gal are to be purged (5 EV < 20 gal) [14].

3.6.2 When purging with a bailer, either a PVC, PTFE, or stainless steel bailer may be used. The bailer will be attached to either a spool of PTFE-coated stainless steel cable or polypropylene rope. If using cable, attach it to the bailer using stainless steel cable clamps. Thoroughly decon the cable after each use, prior to rewinding cable onto spool. Cable clamps and raw cable ends may serve to trap contamination. Exercise particular caution in deconning these areas. If using rope, attach the rope to the bailer using a bowline knot, dispense the needed length (a few feet more than the well depth) and cut the remainder away, then, at the end opposite the bailer, make a slip knot and place it around the well casing or protective posts to prevent losing the bailer and rope down the well. The polypropylene rope will be not reused, it will be properly disposed of. Either type of bailer will be repeatedly lowered gently into the well until it fills with water, removed, and the water will be discharged into an appropriate container until purging is complete. Care must be taken not to unduly agitate the water, as this tends to aerate the sample, increase turbidity, makes stabilization of required parameters (3.6.3) difficult to achieve, and generally prolongs purging.

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[13] Analyte losses due to volatilization in a drained well are too high for valid VOC sampling (M^c^Alary and Barker, 1987).

[14] These numbers are based on the following assumptions: 1) In purging, it is preferable to remove water at approximately the recharge rate. 2) Four L/min is estimated as the approximate maximum rate at which water can be removed with a bailer from depths of 20-50 feet. 3) Twenty gallons is estimated to be at the limit of the sampler's endurance, at which point fatigue and sloppiness of technique begin.

3.6.3 After purging 2 EV, obtain a sample of groundwater and measure the following stabilization parameters: temperature (SOP 009), conductivity (SOP 012), pH (SOP 008), turbidity (SOP 036), redox potential (Eh) (SOP 038), and dissolved oxygen level (SOP 037) at each successive half-well volume. When three of these stabilization parameters are in agreement within approximately 10% in three consecutive half-well volume samples, sufficient water has been purged from the well. The results of these tests should be recorded in the sampling logbook. Should these parameters not reach agreement, no more than five well volumes will be purged.

3.6.4 Immediately upon completion of purging, collect samples for laboratory analysis using a PTFE bailer on a PTFE-coated stainless steel cable. The bailer will be equipped with double check valve top and controlled flow bottom discharge attachments for VOC sampling (40-mL vials), and top discharge attachment for collecting larger samples (1-L bottles).

3.6.5 Slowly, so as not to agitate the water, lower the bailer into the well, using a spool of PTFE-coated cable. Allow bailer to fill, withdraw smoothly. Refill bailer as needed.

3.6.5.1 Please see footnote 2. If the controlled flow bottom discharge attachment is used for VOC sampling, attach it to the bottom of the bailer. Using the stopcock valve on the bailer to control the flow, fill sample vials as described above in § 3.3.8.

3.6.5.2 Remove check valve top and pour unfiltered sample into inorganics sample bottles.

3.6.5.3 Collect filtered samples as described in § 3.3.9(above).

3.6.6 Decon bailer and cable in accordance with SOP 005 § 3.3.1.1

3.7 Purging With Pump, Sampling With Bailer

3.7.1 If the recharge rate of the well is greater than 30 L/min, or the water level is deeper than 50 ft, or more than 20 gal or purge water will be generated (5 EV > 20 gal), then purging and sampling may be accomplished using a submersible pump / bailer combination.

3.7.2 When purging with a pump, gradually lower the intake until it is submerged within the screened interval. Lower an electronic water level probe to the top of the screen (as determined from completion records) to the monitor water level, start pump, and slowly lower the pump as the water level continues to fall. Care should be exercised to lower the water column to the top of the screened interval (water level probe will stop beeping) but not below the top of the screen if possible. This will ensure that the stagnant layer has been removed, but should minimize the detrimental effects of over pumping the well. Secure hose(s) and/or power cord to casing and place discharge hose into the proper container, downhill and as far away from the well as possible Determine and record the discharge rate.

Discharge rate = volume of container/time to fill container

The discharge rate will be established at approximately equal to or just greater than the well's recharge rate (determined from well development). If well development records are incomplete, recharge rate can be determined by monitoring the rise/fall of the water level within the casing as one purges the well. If the water level is static at a given pumping rate, but fluctuates up or down as pumping rate is decreased or increased, the pumping rate at which the water level is static is the recharge rate.

3.7.3 After purging 2 EV, obtain a sample of groundwater and measure the following stabilization parameters: temperature, conductivity, pH, turbidity, redox potential (Eh), and dissolved oxygen level at each successive half-well volume. When three of these stabilization parameters are in agreement within approximately 10% in three consecutive half-well volume samples, sufficient water has been purged from the well. The results of these tests should be recorded in the sampling logbook. Should these parameters not reach agreement, no more than five well volumes will be purged.

3.7.4 Immediately upon completion of purging, collect samples for laboratory analysis using a PTFE bailer on a PTFE-coated stainless steel cable. The bailer will be equipped with double check valve top and controlled flow bottom discharge attachments for VOC sampling (40-mL vials), and top discharge attachment for collecting larger samples (1-L bottles). Filtration of metals samples will be accomplished using either an in-line filter attached to the bottom of the bailer, or a funnel and appropriate filter (see § 3.3.9above).

3.7.5 Slowly, so as not to agitate the water, lower the bailer into the well, using a spool of PTFE-coated cable. Allow bailer to fill, withdraw smoothly, fill sample containers as described above in § 3.6.5

3.7.6 Decon bailer and cable in accordance with SOP 005 § 3.3.1.1. Decon pump in accordance with SOP 005 § 3.3.1.2.

3.8 Purging and Sampling With Low-Flow Pump

To obtain representative samples, subsurface disturbances should be kept to a minimum, thereby preventing sample alteration due to sampling actions. The reasoning behind the use of low-flow pumps to purge and sample monitoring wells is that these pumps minimize physical disturbance (turbulence) at the sampling point and chemical changes (aeration) in the medium. For these reasons, the low-flow pump is the preferred method for both purging and sampling in most cases. For the purposes of this SOP, "low-flowpumps" are defined as either dedicated bladder pumps or variable speed submersible pumps. Practical operational flow rates for these sampling devices range from 0.1 L/min to 30 L/min.

3.8.1 Low-flow pumps may be used for purging and sampling any well having recharge greater than 0.1 L/min, which is the practical lower limit of pump performance. Below that pumping rate, pump inefficiencies and/or overheating may alter the physical and chemical properties of the sample. If the pump is continuously operated at sampling rates higher than the well recharge rate, the water level will be lowered in the well, possibly allowing aeration of the sample which is unacceptable sampling procedure. Low-flow pumps are suitable for sampling wells with recharge rates lower than 0.1 L/min if precautions are taken to avoid aeration of the sample.

3.8.2 Low flow submersible pumps will be used as follows:

3.8.2.1 Lower the pump into the well, slowly so as not to agitate the water, until the pump is at the mid-point of the screened interval or the mid-point of the water column if the static water table lies below the top of the screen [15]

3.8.2.2 Attach the pump's umbilical cord (which will consist of power cord and sampling tubing) to the protective casing, or lock the cord spool so that the pump cannot move vertically in the well during sampling.

3.8.2.3 Lower the water level probe into the well behind the pump until it just touches water. This will allow the sampler to monitor the water level while purging and sampling, and prevent the inadvertent drying of the well.

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[15] This assumes a 10-ft. screened interval. If the screened interval is greater than 10-ft., multiple samples should be taken as follows:

- L If the screen is 10 - 12 ft., sample the canter of the water column, as outlined above.
- L If the screen is longer than 12-ft., and the water column is 10-ft or less, sample the center of the water column.
- L If the screen is longer than 12-ft., and the water column fills the screen, or extends above the screen, sample at 1/3 and 2/3 the height of the water column, or about every 6-ft.

3.8.2.4 Begin purging at the pump's lowest setting, then gradually increase rate [16] until the pumping rate matches the aquifer recharge rate. **If the water level is above the top of the screen**, the pumping rate may be allowed to slightly exceed recharge rate, lowering the water level to no less than 1 foot above the screen, then reduced until it matches recharge rate and purging continued. **If the water level is below the top of the screen**, always keep the purge rate lower than well's recharge rate.

3.8.2.5 Monitor stabilization parameters listed in § 3.6.3beginning immediately, using an in-line monitoring system. Record parameters regularly, at a rate of one set of parameters per each 1-3 liters of water removed from the well. When these parameters stabilize to within 10% over 3 consecutive readings, reduce [17] flow rate to 0.1 L/min (if needed) and begin collecting VOC samples directly from the discharge line.

3.8.2.6 If the well recharges at a rate less than 0.1 L/min, purge until the water level is even with the top of the screen, allow the well to recover and sample immediately.

3.8.2.7 Remove and decon water level probe (SOP 005 § 3.3.1.5)and pump (SOP 005 § 3.3.1.2).

3.8.3 The length of tubing used in conjunction with the low-flow pump will be appropriate to the depth of the well (*i.e.* A 100 ft roll of tubing may not be used in sampling a 30 ft well. A 50 ft roll would be used instead, thereby generating less decon solution, and providing less opportunity for physical and chemical changes in the sample due to contact with the spooled tubing (see § 3.8.4)). This means that the contractor will have on hand: a) spools of varying length (*e.g.* 25, 50, 75, and 100 ft spools) or b) several short *e.g.* 10 ft lengths of tubing with a secure means of connecting them end-to-end.

3.8.4 When a sampling event occurs during summer months, in full sun, shade will be provided for the spooled tubing. Otherwise the tubing will be an effective water heater, warming the ground-water sample, creating the potential for volatilization of organics.

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[16] Some sources indicate that the pumping rate should not exceed 1 L/min, with 0.5 L/min being preferable. The optimal purge rate is highly aquifer dependent, and may range from less than 0.5 L/min to greater than 10 L/min. The purge rate for a given well will; therefore, be a field decision, based on well development, purge, and sampling records rather than SOP mandate.

[17] Sampling should occur at the same rate as purging as long as aeration of sample does not occur.

3.8.5 Spooled tubing will be monitored to ensure that no air bubbles are trapped at the top of a coil. Trapped air bubbles can enhance volatilization of organics.

3.8.6 If a dedicated bladder pump is used, follow steps 3.8.2.3through 3.8.2.5for purging and sampling.

4.0 Maintenance

Refer to manufacturer's requirements for maintenance of pumps and generators.

5.0 Precautions

Refer to the HASP for appropriate PPE.

6.0 References

Gass, Taylor E.; Barker, James F.; Dickhout, R.; Fyfe, J. S.; 1991, Test Results of the Grundfos Ground-water Sampling Pump, From: "Proceedings of the Fifth National Symposium on Aquifer Restoration and Ground Water Monitoring"

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STANDARD OPERATING PROCEDURE 014
COLLECTION OF PRODUCTION WELL SAMPLES

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for the collection of groundwater samples from production wells. This protocol will allow for collection of samples from both active production wells (§ 3.4) and inactive production wells (§ 3.10).

2.0 Material

a. Conductivity meter
b. Temperature meter
c. pH meter
d. Turbidity meter
e. ORD probe
f. Dissolved oxygen meter
g. Sample bottles and labels
h. Logbook or field parameter form

3.0 Procedure

3.1 Upon arrival at the well site, immediately set up and organize the sampling and ancillary equipment. If needed, due to muddy or contaminated ground and/or remoteness from sampling vehicle place plastic sheeting at, or around the sampling location as conditions warrant. Exercise caution not to step on and contaminate the sheeting.

3.2 If the well is remote from the sampling vehicle set up the filtration equipment and place sample containers on the plastic sheet, uphill of the sampling location.

3.3 If a pump is to be used for filtration, situate the portable generator on level ground approximately 15 feet away from and downwind from the sampling location. All generator maintenance (oil and fueling) is to be preformed off site.

3.4 If the well is currently in use. As close as possible to the well, open a tap to a high flow rate and allow the well to purge.

3.5 Obtain a sample of groundwater for temperature, conductivity, ORD, DO, turbidity, and pH measurements. Record values in sampling logbook.

3.6 Take samples for physical stabilization (water quality) parameters every 5 minutes during the well purging process.

3.7 Allow the well to purge until the water quality parameters of pH, temperature, conductivity, turbidity, oxidation-reduction potential, and dissolved oxygen measurements stabilize within 10% in three consecutive 5-minute sampling periods, purging will be considered complete and sampling may proceed.

3.8 Slow water flow rate to a trickle.

3.9 For procedures for collecting samples, with the exception of the sample source being a bailer: Refer to SOP 013 3.2.1;3.5.1 and 3.5.3 through 3.5.8.

3.10 If the well is not currently in use. Use a pump and bailer, or low-flow pump for sampling. Refer to SOP 013 for purging and sampling protocol.

3.11 decontaminate equipment

3.12 Refer to SOP 1-5, 13, and 16.

4.0 Maintenance

Not applicable.

5.0 Precautions

Not applicable.

6.0 References

USATHAMA. 1990. Installation Restoration Quality Assurance Program, December 1985, 1st edition, March 1987, 2nd edition).

STANDARD OPERATING PROCEDURE 015
DOCUMENT CONTROL SYSTEM

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for identifying and storing a complete set of documents relating to project tasks. Each document will receive a unique identification number made up of elements describing the document.

2.0 Materials

Not applicable.

3.0 Procedure

3.1 Each project-related document will be given to the Document Control Officer.

3.2 The Document Control Officer will record information for each document on a Document Control Sheet which will be retained as a backup record.

3.3 The information from each Document Control Sheet will be maintained in a computer database.

3.4 The individual Document Control Number will be entered on the Document Log Sheet and will be written on the document.

3.5 The storage location for each document will be recorded on the Document Control Logsheet and the documents will be stored in the recorded location.

3.6 The database file will be backed up on a regular basis to prevent accidental loss of the data.

4.0 Maintenance

Not Applicable.

5.0 Precautions

None.

6.0 References

None.

STANDARD OPERATING PROCEDURE 016
SURFACE WATER, GROUNDWATER, AND SOIL/SEDIMENT FIELD LOGBOOKS

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure is to delineate protocols for recording surface water, groundwater, soil/sediment sampling information, as well as instrument calibration data in the Field Logbooks. Example forms are given. Alternate, equivalent forms are acceptable.

2.0 MATERIAL

a. Applicable Field Logbook
b. Indelible ink pen

3.0 PROCEDURE

All information pertinent to soil/sediment, groundwater, or surface water sampling will be recorded in the appropriate logbook. Each page/form of the logbook is consecutively numbered. All entries will be made with an indelible ink pen. All corrections will consist of line-out deletions that are initialed and dated.

A. Soil/Sediment Logbook

1. Field Parameters (refer to forms 16-a and b)

a. If using carbon paper or self-duplicating forms, before entering data in logbook, insert a sheet protector between form sets to isolate first blank form from remaining forms.

b. HIGH CONCENTRATION EXPECTED?: answer "Yes" or "No."

c. HIGH HAZARD?: answer "Yes" or "No."

d. INSTALLATION/SITE: record the complete name of the installation or site.

e. AREA: record the area designation of the sample site.

f. INST CODE: record the 2 letter installation code appropriate for the installation or site. Correct abbreviations can be found on pages 3-6 of the IRDMS User's Guide for chemical data entry.

g. FILE NAME: record "CSO" for a soil sample or "CSE" for a sediment sample.

h. SITE TYPE: record the abbreviation appropriate for where the sample was taken. Correct abbreviations can be found on pages 18-21 of the IRDMS User's Guide for chemical data entry. This entry must match the Site Type on the map file form.

i. SITE ID: record a code up to 10 characters or numbers which is unique to the site.

j. FIELD SAMPLE NUMBER: record a code specific for the sample.

k. DATE: enter the date the sample was taken.

l. TIME: enter the time (12 hour or 24 hour clock acceptable as long as internally consistent) the sample was taken.

m. AM PM: circle "AM" or "PM" to designate morning or afternoon (12 hour clock).

n. SAMPLE PROG: record "GQA" (Groundwater Quality Assessment) or other appropriate sample program.

o. DEPTH (TOP): record the total depth sampled.

p. DEPTH INTERVAL: record the intervals at which the plug will be sampled.

q. UNITS: record the units of depth (feet, meters)

r. SAMPLE MEASUREMENTS: check the appropriate sampling method.

s. CHK: check off each container released to a laboratory.

t. ANALYSIS: record the type of analysis to be performed on each sample container.

u. SAMPLE CONTAINER: record the sample container type and size.

v. NO.: record the number of containers.

w. REMARKS: record any remarks about the sample

x. TOTAL NUMBER OF CONTAINERS FOR SAMPLE: record the total number of containers.

y. SITE DESCRIPTION: describe the location where the sample was collected.

z. SAMPLE FORM: record the form of the sample (i.e., clay, loam, etc.) using The Unified Soil Classification System (USCS).

aa. COLOR: record the color of the sample as determined from standard Munsell Color Charts.

bb. ODOR: record the odor of the sample or "none". See SOP 001 § 5.0 "Precautions".

cc. PID (HNu): record the measured PID(HNu) values.

dd. UNUSUAL FEATURES: record anything unusual about the site or sample.

ee. WEATHER/TEMPERATURE: record the weather and temperature.

ff. SAMPLER: record your name.

2. Map File Form (refer to form 16-c)

a. The mapfile logbook form will be located on the reverse of the field parameter logbook form, or on an adjoining page of the field logbook (if level book is used)

b. SITE ID: record the Site ID from the field parameter form.

c. POINTER: record the field sample number for the sample being pointed to.

d. DESCRIPTION/MEASUREMENTS: describe the location where the sample was taken, along with distances to landmarks.

e. SKETCH/DIMENSIONS: diagram the surroundings and record the distances to landmarks.

f. MAP REFERENCE: record which U.S.G.S. Quad Map references the site.

g. COORDINATE DEFINITION: write the compass directions the X- and Y-Coordinates of the map run.

h. COORDINATE SYSTEM: write "UTM" (Universal Transverse Mercator).

i. SOURCE: record the 1 digit code representing the Map Reference.

j. ACCURACY: give units (*e.g.* write "1-M" for 1 meter).

k. X-COORDINATE: record the X-Coordinate of the sample site location.

l. Y-COORDINATE: record the Y-Coordinate of the sample site location.

m. UNITS: record the units map sections are measured in.

n. ELEVATION REFERENCE: record whether topography was determined from a map or a topographical survey.

o. ELEVATION SOURCE: record the 1 digit code representing the elevation reference.

p. ACCURACY: record the accuracy of the map or survey providing the topographical information.

q. ELEVATION: record the elevation of the sampling site.

r. UNITS: write the units in which the elevation is recorded.

s. SAMPLER: write your name.

B. Surface Water Logbook (refer to form 16-b and c)

1. Field Parameter Logbook

a. CAL REF: record the calibration reference for the pH meter.

b. pH: record the pH of the sample.

c. TEMP: record the temperature of the sample in degrees Celsius.

d. COND: record the conductivity of the water.

e. For all other sections, see 3.B.1.

2. Map File Form - See 3.A.2.

C. Groundwater Logbook (refer to form 16-b and d)

1. Field Parameter form - See 3.B.1.

2. Map File form (refer to form 16-c)

a. WELL NO. OR ID: record the abbreviation appropriate for where the sample was taken. Correct abbreviations can be found on pages 18-21 of the IRDMS User's Guide for chemical data entry.

b. SAMPLE NO.: record the reference number of the sample.

c. WELL/SITE DESCRIPTION: describe the location where the sample was taken, along with distances to landmarks.

d. X-COORD and Y-COORD: record the survey coordinates for the sampling site.

e. ELEV: record the elevation where the sample was taken.

f. UNITS: record the units the elevation was recorded in.

g. DATE: record the date in the form MM/DD/YY.

h. TIME: record the time, including a designation of AM or PM.

i. AIR TEMP.: record the air temperature, including a designation of C or F (Celsius or Fahrenheit).

j. WELL DEPTH: record the depth of the well in feet and inches.

k. CASING HT.: record the height of the casing in feet and inches.

l. WATER DEPTH: record the depth (underground) of the water in feet and inches.

m. WELL DIAMETER: record the diameter of the well in inches.

n. WATER COLUMN HEIGHT: record the height of the water column in feet and inches.

o. SANDPACK DIAM.: record the diameter of the sandpack. Generally, this will be the same as the bore diameter.

p. EQUIVALENT VOLUME OF STANDING WATER: use one of the following equations, to determine one equivalent volume (EV):

1 EV = volume in casing + volume in saturated sand pack. Or to restate:

$$1\ EV = (\pi R_w^2 h_w + 0.30\pi(R_s^2 - R_w^2)h_s) * (0.0043)$$

where: R_s = radius of sandpack in inches
R_w = radius of well casing in inches
h_s = height of sandpack in inches
h_w = water depth in inches

$$0.0043 = gal/in^3$$

and filter pack porosity is assumed as 30%

– OR –

$$\text{Volume in casing} = (0.0043\ \text{gal/in}^3)(\pi)(12\ \text{in/ft})(R_c^2)(W_h)$$

where R_c = radius of casing in inches, and
W_h = water column height in feet

$$\text{Vol. in sandpack} = (0.0043\ \text{gal/in}^3)(\pi)(12\ \text{in/ft})(R_b^2 - R_c^2)(W_h)(0.30)$$

(if W_h is less than the length of the sandpack),

– PLUS –

$$\text{Vol. in sandpack} = (0.0043\ \text{gal/in}^3)(\pi)(12\ \text{in/ft})(R_b^2 - R_c^2)(S_h)(0.30)$$

(if W_h is greater than the length of the sandpack).

where R_b = radius of the borehole, and
S_h = length of the sandpack.

Show this calculation in the comments section.

q. VOLUME OF BAILER OR PUMP RATE: record bailer volume or pump rate.

r. TOTAL NUMBER OF BAILERS OR PUMP TIME: record the number of bailers required to remove 3 equivalent volumes (EV) of water from the well or the total purge time and volume as applicable.

s. WELL WENT DRY? write "YES" OR "NO."

t. NUMBER OF BAILERS OR PUMP TIME: record the number of bailers or pump time which made the well go dry.

u. VOLUME REMOVED: record the volume of water (gal) removed before the well went dry.

v. RECOVERY TIME: recor[illegible]e time required for the well to refill.

w. PURGE AGAIN?: answer "YES" or "NO."

x. TOTAL VOL. REMOVED: record the total volume of water (in gallons) removed from the well.

y. CAL REF.: record the calibration reference for the pH meter.

z. TIME: record time started (INITIAL T(0)), 2 times DURING the sampling and the time sampling ended (FINAL).

aa. pH: record the pH at start of sampling (INITIAL), twice DURING the sampling and at the end of sampling (FINAL).

bb. TEMP: record the water temperature (Celsius) at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

cc. COND: record the conductivity of the water at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

dd. D.O.: record the dissolved oxygen level in the water at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

ee. TURBIDITY: record the readings from the turbidity meter (nephelometer) and units at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

ff. ORD: record the oxidation/reduction(RedOx) potential of the water sample at the start of sampling, twice DURING the sampling and at the end of sampling (FINAL).

gg. HEAD SPACE: record any positive readings from organic vapor meter reading taken in well headspace prior to sampling.

hh. NAPL: Record the presence and thickness of any non aqueous phase liquids (LNAPL and DNAPL)

ii. COMMENTS: record any pertinent information not already covered in the form.

jj. SIGNATURE: sign the form.

D. Field Calibration Forms (refer to form 16-e)

a. Record time and date of calibration.

b. Record calibration standard reference number.

c. Record meter I.D. number

d. Record initial instrument reading, recalibration reading (if necessary), and final calibration reading on appropriate line.

e. Record value of reference standard (as required).

f. COMMENTS: Record any pertinent information not already covered on form.

g. SIGNATURE: sign form.

4.0 MAINTENANCE

Not Applicable.

5.0 PRECAUTIONS

None.

6.0 REFERENCES

User's Guide to the Contract Laboratory Program, USEPA, July, 1984.

FIELD PARAMETER/LOGBOOK FORM 16-a
SOIL AND SEDIMENT SAMPLES

HIGH CONCENTRATION EXPECTED? ____________________ HIGH HAZARD? ______

INSTALLATION/SITE ____________________ AREA __________

INST CODE __________ FILE NAME ____.__________

SITE TYPE __________ SITE ID ____________________

FIELD SAMPLE NUMBER ____________________

DATE (MM/DD/YY) ___/___/___ TIME __________ AM PM SAMPLE PROG. ______

DEPTH (TOP) ______ DEPTH INTERVAL __________ UNIT ______

SAMPLING METHOD:

SPLIT SPOON ____ AUGER ____ SHELBY TUBE ____ SCOOP ____ OTHER __________

CHK	ANALYSIS	SAMPLE CONTAINER	NO.	REMARKS

TOTAL NUMBER OF CONTAINERS FOR SAMPLE __________

DESCRIPTION OF SITE AND SAMPLE CONDITIONS

SITE DESCRIPTION : ______________________________

____

____

SAMPLE FORM __________ COLOR ______ ODOR ______

PID (HNu) __________ UNUSUAL FEATURES __________

____

WEATHER/TEMPERATURE ____________________

SAMPLER ______________

FIELD PARAMETER/LOGBOOK FORM 16-b
GROUNDWATER AND SURFACE WATER SAMPLES

HIGH CONCENTRATION EXPECTED? ____________________ HIGH HAZARD? __________

INSTALLATION/SITE ____________________ AREA __________

INST CODE __________ FILE NAME ____________________

SITE TYPE __________

SITE ID ____________________ FIELD SAMPLE NUMBER __________

DATE (MM/DD/YY) ___/___/___ TIME __________ AM PM SAMPLE PROG. ______

DEPTH (TOP) __________ DEPTH INTERVAL __________ UNITS ______

SAMPLING MEASUREMENTS

CAL REF. ______ pH ______ TEMPERATURE °C ______ CONDUCTIVITY ______

OTHER __________

CHK	ANALYSIS	SAMPLE CONTAINER	NO.	REMARKS

TOTAL NUMBER OF CONTAINERS FOR SAMPLE __________

DESCRIPTION OF SITE AND SAMPLE CONDITIONS

SITE DESCRIPTION ____

____

____

SAMPLING METHOD ____

SAMPLE FORM ____________________ COLOR __________ ODOR ______

PID (HNu) ____

UNUSUAL FEATURES ____

WEATHER/TEMPERATURE ____________________ SAMPLER __________

MAP FILE LOGBOOK FORM 16-c
SURFACE WATER, SOIL, AND SEDIMENT SAMPLES

SITE ID ______________________ POINTER ______________

DESCRIPTION/MEASUREMENTS ____

____

____

____

SKETCH/DIMENSIONS :

MAP REFERENCE ____

COORDINATE DEFINITION (X is ______________________ Y is ______________)

COORDINATE SYSTEM ______________________ SOURCE ______________________

ACCURACY ______________

X-COORDINATE ______________ Y-COORDINATE ______________ UNITS ________

ELEVATION REFERENCE ____

ELEVATION SOURCE ______________________ ACCURACY ______________________

ELEVATION ______________________ UNITS ______________________

SAMPLER ______________________________

WELL COORD. OR ID ______________________ SAMPLE NO. __________
WELL/SITE DESCRIPTION ______________________________________

X-COORD. __________ Y-COORD. __________ ELEV. __________ UNITS ______
DATE ___/___/___ TIME __________ AIR TEMP. __________

WELL DEPTH ________ FT. ________ IN. CASING HT. ________ FT. ________ IN.
WATER DEPTH ________ FT. ________ IN. WELL DIAMETER __________ IN.
WATER COLUMN HEIGHT ________ FT. ________ IN. SANDPACK DIAM. ________ IN.
EQUIVALENT VOLUME OF STANDING WATER ______________ (GAL) (L)
VOLUME OF BAILER __________ (GAL) (L) or PUMP RATE __________ (GPM) (LPM)
TOTAL NO. OF BAILERS (5 EV) __________ or PUMP TIME __________ MIN.
WELL WENT DRY? [Yes] [No] NUM. OF BAILERS __________ or PUMP TIME __________
VOL. REMOVED ______________ (GAL) (L) RECOVERY TIME __________
PURGE AGAIN? [Yes] [No] TOTAL VOL. REMOVED __________ (GAL) (L)

DATE & TIME	QUANTITY REMOVED	TIME REQ'D	pH	Cond	Temp	ORD	Turb	DO	Character of water (color / clarity / odor / partic.)
(before)									
(during)									
(during)									
(during									
(after)									

COMMENTS ______________________________________

SIGNATURE ______________________________

EXAMPLE
FIELD CALIBRATION FORM 16-e
FOR
pH, CONDUCTIVITY, TEMPERATURE, TURBIDITY, ORD, AND DISSOLVED OXYGEN METERS

INITIAL CALIBRATION	FINAL CALIBRATION
DATE:	DATE:
TIME:	TIME:

pH METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: ____________

METER ID

pH STANDARD	INITIAL READING	RECALIB. READING	FINAL READING
7.0			
10.0			
4.0			

CONDUCTIVITY METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: ____________

METER ID

COND. STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

TEMPERATURE METER CALIBRATION

METER ID

TEMP. STANDARD	INITIAL READING	RECALIB. READING	FINAL READING
ICE WATER			
BOILING WATER			
OTHER			

EXAMPLE
FIELD CALIBRATION FORM 16-e
FOR
pH, CONDUCTIVITY, TEMPERATURE, TURBIDITY, ORD, AND DISSOLVED OXYGEN METERS

TURBIDITY METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: ____________

METER ID

STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

ORD METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: ____________

METER ID

STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

DISSOLVED OXYGEN METER CALIBRATION

CALIBRATION STANDARD REFERENCE NO: ____________

METER ID

STANDARD	INITIAL READING	RECALIB. READING	FINAL READING

COMMENTS ____

____

____

____

SIGNATURE ____________________________

STANDARD OPERATING PROCEDURE 017
GROUND PENETRATING RADAR SURVEY

1.0 PURPOSE

This guideline provides a description of, and technical management guidance on the use of Ground Penetrating Radar surveys during hazardous waste site investigations at U.S. Army installations.

2.0 SCOPE

This guideline provides a description of and the principles of operation, instrumentation, applicability, and implementation of ground penetrating radar (GPR) geophysical surveys. GPR surveys can be used to map subsurface stratigraphy; to rapidly locate buried metallic objects, such as pipes, drums, ordnance, and tanks; to locate buried waste disposal structures; to locate voids within the subsurface; and in some cases can directly detect contaminants.

The document is intended to be used by a site manager to develop an understanding of the method sufficient to permit work planning and scheduling, resource planning, subcontractor procurement and evaluation, and manipulation and use of the technical data during remedial investigations and feasibility studies. This guidance is not intended to provide a detailed description of methodology and operation, which will vary between sites, between target depths and characteristics, and between instruments. The description focuses on methods and equipment that are readily available and typically applied; it is not intended to provide a complete discussion of the state of the art. Specialized expertise is required during both planning and execution of geophysical surveys to develop a target-specific, site-specific, and instrument-specific scope of work, with detailed operating procedures. which will best achieve the goals of the survey.

3.0 DEFINITIONS

Dielectric Constant. The measure of the ability of a material to store a charge when an electromagnetic field is applied. This is the measure of the property which determines the reflection, adsorption, and transmission characteristics of the radar signal in the subsurface. Dielectric constants for common materials are listed in Table 017-1.

Ground Penetrating Radar (GPR) Survey. A geophysical survey technique where an (electromagnetic) radar pulse is transmitted into the subsurface and the reflected pulse is measured and recorded.

Penetration or Exploration Depth. The maximum depth at which an object of interest can be detected using a given GPR configuration. The penetration depth is a function of the electrical properties of the subsurface materials and of the GPR signal strength and antenna design.

Radar Trace. The display of reflected signal strength on a graph of lateral distance along the ground-vs-travel time.

Transceiver. Antenna design consisting of a transmitter mounted on or within the antenna - also known as a monostatic configuration. A bistatic antenna configuration consists of the transmitter in a separate housing from the antenna.

Travel Time. The time required for a radar signal to travel from the antenna to a target, reflect, and return to the antenna. Travel time is a function of the depth of the target and the electromagnetic characteristics of the subsurface.

4.0 RESPONSIBILITIES

Site Manager. Responsible for the scoping of geophysical surveys during development of the work plan, with the help of the RI leader, site geologist, and site geophysicist.

Site Geophysicist. As a specialist in this field, the site geophysicist plays a central role in determining the appropriateness of these techniques for providing necessary data. Field work for these surveys is supervised by the site geophysicist, with support from geophysical technical specialists and other personnel as needed. Data reduction and interpretation are performed by the site geophysicist or technical specialists.

Field Operations. Leader responsible for the overall management and coordination of the field work and enforcement of proper work and Health and Safety practices - including coordination, observation, or supervision of Explosive Ordnance Disposal (EOD) or military personnel, subcontractors, or co-contractors as required.

5.0 THEORY AND PRINCIPLES OF OPERATION

5.1 Description of the Ground Penetrating Radar (GPR) Method

Commercially-available GPR units operate on the principle of time-domain reflectometry, in which the difference in strength and the time delay between a transmitted electromagnetic pulse and its reflection from an object are measured. The time delay, t, is directly related to the propagation velocity of the electromagnetic waves, v, and to the distance between the transmitter and the subsurface object or reflector, D, as follows:

$$t = \frac{2D}{v}$$

Because GPR antenna are generally placed near the ground surface, the distance, D, corresponds to the depth of buried targets that reflect the radar signals.

The strength of a radar signal is a complex function of the distance traveled through the medium and the dielectric constant, the magnetic permeability, and the electrical conductivity of the medium. Radar signals are attenuated rapidly in materials with high dielectric constants. The attenuation of radar signals in subsurface media is dependent on their mineralogy and the water content. Thus, materials such as dry sands and gravels are least absorptive of radar signals, whereas wet clays are highly absorptive. The absorptive properties of the medium limits the penetration depth, i.e., the depth at which targets may be detected. The strength of a radar reflection is also a function of the composition, size shape, and depth of the target. Reflections are strong not only from objects exhibiting large difference in dielectric constant from the surrounding medium, but also which are large in size compared to the radar signal wave length.

The GPR repetitively transmits very short-duration (typically 5 to 10 nanosecond) pulses of high-frequency (typically 80 MHz to 1 GHz) electromagnetic energy through an antenna that is moved along the ground surface at a constant speed. Reflected pulses are detected by the same antenna at a location corresponding to the distance traveled by the antenna during the transmission and reflection of the pulse, at which point another pulse is transmitted. At a typical antenna speed of 2 miles per hour (3 feet per second), a complete pulse transmit/receive cycle occurs about every 2 inches along the path of the antenna. GPR antenna may have either a monostatic or bistatic configuration. In the monostatic configuration, the antenna is a transceiver that utilizes a fast acting switch changing it to a receiving antenna immediately following pulse transmission and back to transmitting antenna for generation of the next pulse. The bistatic configuration utilizes separate transmitter and receiver antennas. The received signal is transmitted to the central control unit where the initial signal processing takes place and the pulse is typically recorded with digital tape recorders and displayed on an oscilloscope and/or graphic recorder. The reflected data may also be run through a video display units for real-time viewing. Recording enables the geophysicist to play back data later for further processing or analysis.

Common radar antennas operate at approximate center frequencies of between 80 and 1000 MHz. The higher frequencies provide the best resolution for smaller targets, however, the penetration depth is roughly inversely proportional to frequency. Thus, the design of any GPR survey requires an analysis of the trade-off between target resolution and depth of penetration so that the optimal antenna frequency may be selected.

5.2 Applicability

The antenna frequency and equipment configuration used for ground penetrating radar (GPR) surveys, as well as the survey methodology, is dependent upon site-specific conditions and the particular objectives of the survey. In addition, analysis of data requires interpretive skills developed through extensive training in the geosciences/geophysics and exposure to the application of GPR to a variety of field problems. The supervising geophysicist should have experience applying the technique at sites presenting a wide range of soil conditions and where the objectives of surveys have involved identification of subsurface features that include distinct targets such as buried metal objects and more subtle features such as back-filled excavations. Because of the highly interpretative nature of the GPR work it is difficult, therefore, to establish a standard operating procedure that would apply to all site surveys. The following material, however, offers some general guidelines for the conduct of GPR surveys, including information on the principles of operation, instrumentation, application and interpretation associated with standard GPR methods.

Because the GPR method utilizes high-frequency radio waves that are of higher frequency than the wave frequencies associated with seismic surveys or resistivity soundings, target resolution is better than that provided by these other two techniques. However high frequencies are more susceptible to signal attenuation. In typical clay materials, for example, the useful penetration depth is about 3 feet using a 100 megahertz (MHz) antenna. The same antenna used to survey over an area of dry sand soils (< 20 percent moisture); however, will allow for a penetration depth of about 30 feet.

Ground penetrating radar (GPR) is typically useful in detecting three classes of subsurface anomalies - metallic objects, layers/areas/objects of differing electrical properties, and disruptions in the layering of the subsurface materials. Buried metallic objects, such as pipes, barrels, bomb casings, and underground storage tanks, typically show prominent hyperbolic signatures due to the high contrast in electrical conductivity between metals and soil materials. Buried materials of differing electrical properties, such as concrete or brick walls, or water or air-filled pvc pipes, can also be detected. In some cases, contamination in the soils or floating on the water table can be directly detected using GPR. For example, free petroleum product strongly attenuates the radar signal and can often be detected floating on the water table. GPR is also useful for delineating disruptions in the natural soil layering, due to excavations, disposal trenches, or voids.

Characterization of the subsurface with GPR involves the generation of plots of distance along a survey line vs. reflected wave travel time and signal strength (amplitude) for return pulses from subsurface reflectors. The "reflective" property of subsurface materials or objects is associated with strong contrasts in the electrical properties between materials or objects that are in contact. These strong contrasts may be associated with naturally occurring stratigraphic or structural boundaries or from the disruption of natural materials and/or the presence of man-made materials (i.e., buried drums or contaminants). The dielectric constants for natural and man-made materials provide a parameter for quantifying and comparing electrical properties of subsurface materials. Disruptions of natural earth materials (e.g., excavation of and back-filling of trenches or formation of voids through subsidence) change the materials bulk physical and chemical properties, and, consequently, their electrical properties. These contrasts make GPR an effective means for identifying the boundaries of abandoned landfills or locating drums or subsurface contaminant plumes. Depending on the depth of penetration that may be achieved, the method may be used to map the interface between the saturated and unsaturated zones, map the depth to bedrock, locate sinkholes, or map fracture systems more efficiently than may be accomplished with other conventional methods such as soil boring programs.

A major limitation of GPR is subjective process involved in data interpretive. Weak reflections from objects of interest may be indistinguishable from noise in the radar record or masked by stronger reflections from other objects. However, special computerized signal processing and enhancing routines originally developed for seismic processing now enable the geophysicist to enhance weaker signals, but the success of the data interpretative process ultimately depends heavily on the experience of the geophysicist.

6.0 INSTRUMENTATION

The standard array of GPR instrumentation consists of a transmitter/antenna unit(s), a DC power supply, a control unit and the signal processing circuitry connected to the antenna by a cable; an oscillograph or video display unit, and a plotter or an analog or digital recording device. The field equipment may be vehicle mounted but is small enough that it may be hand carried into areas not having vehicle access. Examples of GPR units are Geophysical Survey Systems, Incorporated's (GSSI) SIR System 8 and System 10 ground-penetrating radar systems. Both GSSI systems utilize impulse radar technology to sense and record continuous, high resolution profiles of subsurface materials.

The primary variable in GPR instruments is the antenna configuration. Antennas are urrently available in both monostatic (one-piece) and bistatic (two-piece) configurations and are generally designed to detect radar signals ranging from about 80 to 1000 MHz.

7.0 DATA ACQUISITION

7.1 Field Procedures

7.1.1 Planning. The planning phase of a GPR survey requires the development of information pertaining to the geophysical characteristics of the site and how they might vary across the area to be surveyed. The type and structure of soils, geologic formations, and the approximate elevation of the water table are critical factors that should be established. In addition to developing information about the characteristics of earth materials that are present at the site, the geophysicist needs to develop information about the targets of interest and factors that may interfere with execution of the survey or cause excessive noise in the acquired data. If possible, it is useful to know the depth, size and shape, and type of potential targets to be detected. The depth and size of the objects are very important such that the appropriate antenna configuration and spacing between survey lines may be selected. Surveys over known objects on site are useful to cross-check the survey detection limit and depth calculations; however, they are not absolutely necessary. Other specifications include accuracy of locational resolution desired, probable weather conditions during site activities, and the type and sophistication of data processing required for data interpretation and presentation.

The time and effort required to perform GPR field surveys depends on several factors including the sophistication of the equipment used, the type of target, and logistical considerations. Additional time and effort are required to process and interpret data. Sophisticated data processing, detailed interpretations, and high-quality displays require considerable computer usage and may require more time to complete than the actual field survey.

7.1.2 Site Layout. GPR surveys are performed by establishing a grid of parallel survey lines across the site and moving the radar antenna along each of these lines. The spacing between the lines is dependent upon the size and depth of the targets of interest and the objectives of the survey (i.e. reconnaissance or detailed survey). GSSI systems employ an electronic marking device that records a mark on direct field graphic records or within digital radar files. Generally, double marks or clicks are made at the beginning and end of the survey lines and single clicks are recorded as the antenna passes over predetermined distance intervals. Following acquisition of data in the field the data is downloaded from digital tape to PC storage for subsequent processing and analysis in the office.

7.1.3 Depth Determination. To determine the depth of anomalies noted on radar profiles, it is necessary to convert the data from recorded travel times, to depths. This is done by determining the transmission velocity(ies) associated with the earth materials. The velocity of electromagnetic waves within the subsurface at the site may be determined through excavation of observed targets to determine their depth of burial. Several excavations may be made and an average or range of transmission velocities for materials at a given site may be determined. Once velocity values are determined, interpretations or determinations concerning the depths of other signatures or anomalies may be made. Two other simpler methods, discussed in the following section, provide a simple means of determining the radar-wave velocities through subsurface materials and, therefore a means for converting travel-times to depths. These are two graphical approaches, one involving examination of hyperbolic signatures and the other involving the examination of changes in the travel-time within a given subsurface section as the transmitter and receiver antenna (bistatic configuration) are moved away from each other. The later is referred to as wide angle radar reflection (WARR) measurements.

7.1.4 GPR Survey Measurements. Once an optimal GPR survey configuration has been decided upon, The survey itself is straightforward, barring changes in the subsurface electrical characteristics. The unit is activated and the antenna is towed along one of the prearranged grid lines. An electronic mark is placed on the data at the beginning and end of each survey line, and every 10 or 20 feet along the line, so that the position of the data and anomalies on each radar line is readily apparent. The locations of surface metal, utilities, walkways, etc. should be noted on the field logs during the survey.

7.2 Data Format

Although much of the data obtained in GPR surveys are automatically recorded by the instrumentation, additional information to unambiguously identify and to interpret each trace should be recorded in the field logbook. At a minimum, the field logbook should contain the following information:

- Project name, number and location
- Company or organization
- Date and time of day
- Operator's name
- Line and trace designation (also recorded directly on the signal recording medium)
- Equipment serial numbers
- Antenna frequency
- Direction and speed of antenna movement
- Weather and temperature
- Site map coordinates at the beginning and end of the trace
- Other pertinent notes, remarks or comments
- Electromagnetic velocity in the subsurface medium at the nearest calibration point.
- Map of grid and survey lines referenced to permanent features (wells, buildings, etc.)
- Data acquisition parameters (gain, range, filters used)

8.0 DATA PROCESSING AND INTERPRETATION

8.1 General

Reflected radar signals are electronically processed and displayed as an intensity-modulated time spectrum, where the time corresponds to target depth as described above. The series of signals corresponding to the reflected pulses as the antenna moves along a path forms a three-dimensional data set containing distance of traverse, depth, and intensity information.

Typically, the data are recorded on magnetic tape and/or displayed on a graphic recorder with distance displayed along the X-axis, time (i.e., depth) displayed along the Y-axis, and the intensity given by the degree of darkness of the trace. In a typical survey, a series of parallel traverses are made with the GPR, and the series of graphical traces provide X-Y-Z locational, as well as intensity of reflection information for targets of interest. Interpretation of anomalies in GPR traces requires considerable subjective evaluation by a trained geophysicist. Extensive experience is essential to distinguishing target reflections from inherent system noise and interferences. In many cases, the anomalies due to targets of interest are small compared to varying reflections from the antenna system, the ground surface, geologic perturbations, and other interferences. Similarly, an acceptable interpretation of target depth from travel-time data requires knowledge of the varying geophysical characteristics across the site area surveyed.

A radar antenna transmits a "cone" rather than a thin beam of electromagnetic energy. The result is that reflections are obtained from objects not directly below the antenna. As the antenna moves across the plane of an object, reflections are obtained for a considerable distance along the antenna path. The radar reflections will generate a hyperbolic signature pattern. The size and shape of this hyperbolic signature varies as a function of the wave velocity within the subsurface materials, the size and the orientation of the object relative to the radar wave pulse, and the rate, t, at which the antenna configuration is moved along the surveyed line. The signal travel times will vary corresponding to the distance between the antenna and the object.

8.2 Hyperbolic reflectors

A discrete spherical target, therefore, will generate a hyperbolic reflection patterns with the apex of the hyperbola corresponding to the location and depth of the object. Multiple or odd-shaped targets or targets of considerable size in comparison to the radar wavelength) will generate complex reflection patterns consisting of overlapping hyperbolas. Thus, a true "picture" of subsurface objects is not obtained, and experience is necessary to translate the complex tracings into information concerning target depths, size, or shape.

8.3 Depth Determination

The calculation of the depth of exploration for a particular GPR configuration may be accomplished by knowing the dielectric constant of the earth materials or the depth to a particular reflector that is clearly visible on the radar record. In addition, the depth may be calculated through identification and graphical measurement of hyperbolic signatures or through the development wide angle refraction and reflection (WARR) data. The values for resistivity (inverse of conductivity), dielectric constant, and wave velocity in Table 017-1 are typical values; however, the real values for subsurface materials may change significantly over short lateral distances. The use of the published values exclusively may not yield depth calculations of sufficient precision.

8.3.1 <u>WARR Method.</u> The WARR measurement requires the use of actual data from the surveys conducted at each of the areas, are used to determine the velocities of the pulse, depth to significant reflectors, and the total depth of penetration. WARR measurements are performed with a bistatic (separate transmitter and receiver) antenna configuration. The two antennae are moved away from each other at a constant rate as a record is developed. By knowing the distance between the transmitter and receiver at a given time during the development of the record, the geophysicist may calculate the electromagnetic wave velocity(ies) using a t^2-x^2 plot. The recorded reflections are graphically plotted with the square of the distance between transmitter and receiver on the x-axis and the square of the time period on the y-axis. The inverse of the slope of the line of the reflection is the velocity of propagation. A simple calculation relating distance versus time will yield a velocity of the propagated pulse. Once the transmission velocity is known, depths to reflectors may be determined. The WARR measurements require the presence of good horizontal reflectors.

8.3.2 <u>Hyperbola Geometry Method.</u> The second method, the identification and measurement of hyperbolas, also provides good estimates of GPR penetration depth. The shape and position of the hyperbolic signatures, caused by cylindrical objects (e.g. pipes or drums), is a function of the wave velocity within the subsurface, the size of the object, and the rate at which the antenna is moved. This type of calculation is possible because the GPR pulse has a broad cone-shaped radiation pattern and cylindrical objects have numerous surfaces that are normal to the pulse as the antenna is moved along a survey line: first approaching, directly over, and then away from the buried object.

The cone-shaped radiation pattern has an included angle of approximately 90 degrees. For flat or horizontal reflectors, only the vertical component of the pulse is reflected back to the receiver and the other sub-vertical components of the pulse are reflected or refracted away from the antenna not producing a record. Therefore, the two-way reflection sensitivity, or field of view, for flat surfaces is small. For cylindrical objects in the subsurface the sub-vertical components of the pulse may also be reflected back to the receiver as the antenna approaches the object. Because the round trip travel-time for the reflected pulse decreases as the antenna approaches the object, reaches a minimum directly over the object, and then increases again as the antenna moves away from the object, the record that is produced has a hyperbolic (inverted horse shoe) signature or pattern. The hyperbolic pattern generated on a radar record, distance (x) vs time (y), is a representation of the maximum round trip travel for the pulse when it first intersects the pipe, decreasing as the antenna approaches the axis of the pipe, and then increasing to a maximum again as it moves away from the pipe. Therefore, the position and shape of the hyperbola in the radar record are directly related to the wave transmission characteristics of the subsurface materials. Utilizing this simple geometric relationship the geophysicist may calculate transmission velocities for the various areas and the depths of penetration for the pulse and the depth to significant anomalies. Essentially, this results in a conversion of time on the y-axis of the GPR records to depth.

(T_z) represents the time of travel (or distance once velocity is known) for the "first" or "last" reflection that is produced when the center axis of the antenna is 45 degrees from the curved object (e.g. pipe). This reflection is recorded in the GPR record as the ends of the limbs of the parabola. This value is also referred to as the slant range or distance between the target and the antenna. The distance represented by (T_z) is greater than the actual depth of the target. As the antenna approaches the object the radar signature (top of the hyperbola) approaches the actual depth of the object. (T_y) represents the time of travel (or distance once the velocity is known) when the antenna is directly over the reflector.

If it is assumed that the subsurface materials over path distance (Z) have on average the same electrical properties as those for path distance (Y) and the dimensions of the pipe are considered insignificant relative to the other dimensions, then following geometric relations are true:

$$X^2 + Y^2 = Z^2$$

and

$$\frac{T_y}{T_z} = \frac{Y}{Z}$$

Combining these equations and solving for Y (the actual depth of the pipe), the following equation may be derived:

$$Y = X * (1/((T_z/T_y)^2 - 1)^{0.5})$$

X = distance along the ground in any convenient unit.
Y = depth of pipe in distance units.
T_z= travel time or "slant range" to pipe in any units.
T_y= travel time when the antenna is directly over the pipe.

The distance along the surface and the lengths of the T_z and T_y scaled directly from the record are all that are needed to calculate the depth to the object causing the hyperbola. While these graphical measurements and calculations are relatively simple, they may become tedious when performed on all of the hyperbolae. This process has been automated with RADAN software available from GSSI.

9.0 SURVEY DESIGN

9.1 Prerequisites

Appropriate planning of GPR surveys requires a basic understanding of the site subsurface and hydrogeologic features, including the probable lateral variability. A statement of work should be generated that describes, in as much detail as possible, the known site conditions that may affect the subsurface electrical properties and the objectives of the proposed survey efforts, and allows for changing the survey parameters if the subsurface conditions change or are not found to be as described. The type and degree of data interpretation and the desired format for data presentation should also be specified if possible.

9.2 Instrument Selection

The important instrument selection decision for the survey lies in the determination of the optimal antenna. Generally, the higher the antenna frequency, the smaller the object that it can resolve, and the smaller its depth of penetration. The optimal antenna is the one with the highest resolution that will have sufficient depth of exploration. However, the depth of penetration for a given antenna will vary widely between sites, primarily due to soil moisture content and the amount of clay/sand ratio of the soils. Overnight rainfall can often elevate the soil moisture content such that an antennas depth of penetration can be degraded by 30% in a few hours. No one antenna configuration is suitable for all cases, even at the same site. Ideally, the survey crew should carry multiple antennas to the site for the survey so that an optimal configuration will always be available.

9.3 Grid Design

The survey grid should be designed such that the GPR measurements are spaced to adequately define the distribution and extent of the exploration targets. For convenience, an orthogonal survey grid, located relative to a known location, is usually established over the survey area and the GPR measurements and anomalies are located by their grid coordinates (x,y). This is a convenient method for recording the data in an organized manner, for graphically displaying the data, and for ease of locating the anomalies detected. For determination of geologic features or to detect large targets, reconnaissance-type, low-resolution surveys are typically performed with a track spacing of 5 to 20 feet. Surveys to detect small discrete targets or to resolve target details require a track spacing of 1 to 5 feet.

10.0 QUALITY CONTROL

The application of quality control principles to GPR surveys involves:

10.1 General

Requiring that trained geophysicists be utilized in all aspects of the survey including the preparation of the project workplans and survey designs, conduct of the survey, interpretation of the data, and presentation of the results. Workplans need to be written such that some degree of latitude is given to the survey team so that they may adjust to site conditions.

- Clearly defining the objectives of the survey in terms of the: (a) degree of detail needed and the size of the area to be surveyed; (b) type, depth, size and composition, of targets of interest (if known); (c) resolution required; (d) schedule limitations; (e) degree of sophistication required for data presentation and interpretation; and (f) specific deliverables required.

- Defining specific field quality control procedures.

- Justifying rejection of any data from a data set. Field data sheets should contain all observed data and the conditions that could impact data validation.

- Recording all field data in permanent ink in a bound logbook and tape logs with each page signed and dated by the survey team leader.

- Properly calibrating the GPR unit. In general, the objectives of most geophysical surveys may be achieved by obtaining relative measurements across the area surveyed. Absolute calibration is, therefore, of lesser importance. However, a properly calibrated instrument provides an added measure of data validity.

- Evaluating all sources of noise, interference, and obstructions at a site and noting their potential effects on certain measurements made along a surveyed line. These real-time field observations later allow for correcting the data results for noise, validating suspected external sources, and in detecting problems that may jeopardize the objectives of the survey.

10.2 Calibration

Calibration of the radar traces for depth determinations is performed as follows:

- For reconnaissance surveys or for surveys where lateral resolution is more important than depth, the traces may be roughly calibrated by estimating the velocity of electromagnetic waves in the media at the site from published values for similar materials. The crudeness of the calibration is evidenced by considering that the velocity may vary by more than an order of magnitude, depending on the soil/rock properties and the moisture content.

- For surveys requiring reasonable resolution of target depth, the travel time to targets of known depths must be determined at each site. As the radar trace is made over the known targets, the reflection patterns provide direct depth-calibration points on the trace. Sites with uniform lithology may require only a few depth calibrations, but generally it is necessary to perform these calibrations at several locations and at several depths throughout the area of interest. Each radar trace should be referenced to the calibration most representative of the trace coordinates at the site. The preferred method is to use buried objects of known depth as calibration targets, or to excavate to detected objects and measure their depth below ground surface. A less desirable (but often necessary) procedure is to bury standard targets at various depths within the area of interest.

- In addition, WARR measurements may be conducted at several locations over the entire area of the site to determine how the transmission velocities change. If necessary specific transmission velocities may be determined for each subarea within the surveyed area.

10.3 Daily Quality Control

All radar traces and interpreted data sets should be accompanied by quality control data that indicate the level of quality of the data. Periodic replicate measurements should be made so that measurement precision may be established. Time and/or depth calibrations should be performed on a daily basis.

A calibration that yields significant changes in instrument parameters or travel time may indicate the need for repetition of data or increased density of travel time calibrations in the area of interest. Graphical data should be reviewed during the field activities to determine that data quality is adequate, and whether the survey results appear to be consistent with conceptual models.

11.0 HEALTH AND SAFETY CONSIDERATIONS

11.1 General

All procedures for hazardous waste site entrance, traverse, and egress that apply to general field operations established in the Site Health and Safety Plan also apply to conduct of geophysical surveys. Because GPR surveys are non-intrusive, the potential for exposure to chemicals of concern is generally low. Conducting GPR surveys consists of traversing the site on foot or in vehicles, and there are extended periods during which personnel are subject to adverse environments at the site. Geophysics survey personnel will adhere to the guidelines of the Site Health and Safety Plan for field activities.

Towing the GPR antenna by hand may involve considerable physical activity or hazards, especially on sloping or rough terrain. The geophysical methods discussed herein do not require extremely strenuous activity, and exposure to heat or cold is similar to that during other field activities. Extreme weather conditions will have adverse effects on the time required to obtain validated data, there by increasing the duration of personal exposure to the elements and to hazardous site influences.

11.2 Explosive Ordnance Disposal (EOD)

For surveys in areas where ordnance disposal or the presence of ordnance is suspected, EOD personnel will clear site access and survey areas prior to survey activities as per the Health and Safety Plan. The GPR methods described here involve the transmission of a weak electromagnetic radar signal whose characteristics vary between antenna transceivers. These transceivers generally emit a total electromagnetic signal of 0.1-4.0milliwatts over a frequency spectrum ranging from 80-1000 MHz. These signal strengths are total output strengths measured at the transceiver. The signal strength at any given frequency is measured in microwatts and falls off rapidly with depth in the subsurface. It is possible that this signal may not be safely broadcast in the vicinity of certain types of (live) ordnance, particularly those which may have active radar proximity detonators. The individual GPR instruments proposed for the survey(s) will be cleared for use, for each site where ordnance may be present, by the facility Health and Safety officer.

12.0 POTENTIAL PROBLEMS

GPR surveys are subject to a wide variety of potential problems that may impact conduct of the survey and/or proper interpretation of the survey results. The two most significant problems include:

- Noise and Interferences. GPR measurements may be affected severely both by natural and by man-made sources of electromagnetic interference. Sources of system noise that degrade the quality of radar traces include improper spacing of antennas above ground, improper cable placement, location of antennas too close to other system components, and facility instrument operation. Because reflections are obtained from any object with a dielectric constant differing from the surroundings, large masses or a high density of buried or surface rocks, metal, debris, wet soil. or structures can mask targets of interest. Some antennas are not shielded on their top surface and, as a result, are subject to interfering reflections obtained from overhead objects such as trees, power lines, and buildings. Topographic and geologic features can also interfere with acquisition of high-quality target detection data. Small depressions in the ground surface, the presence of boulders, clay lenses and moist soil zones affect both the capability to detect the target and determine its depth. Sources of electromagnetic energy in the vicinity, such as radio or television transmitters, or navigational radar antennas may result in spurious signals in the radar traces. In some cases, these problems may be minimized by judicious selection of radar and/or data communications frequency, and by scheduling the surveys during period of transmission inactivity.

- Rebar. The presence of steel reinforcing mesh or concrete rods in concrete(rebar) is a common problem for GPR surveys. The rebar generates regularly spaced hyperbolas in the data. If the rebar is thick and closely spaced, the reflections from the rebar can completely obscure the underlying material.

- Weather Conditions. Because water absorbs radar signals, wet weather has a very serious effect on the ability to perform GPR surveys. Physical difficulties in executing a survey over wet terrain also may be expected. Therefore, survey activities should be planned, if at all possible, during periods when dry weather can be expected. The survey schedule should also account for moist soil conditions and changes in these conditions.

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TABLE 017-1

	Resistivity (ohm/meter)	Relative Dielectric Constant	Electromagnetic Wave Vel. (cm/ns)
Air	----	1	30
Asphalt	~10	2.5-3.5	16-19
Concrete	~10	3-9	10-17
Conglomeratic soil	100-1000	9-14	8-10
Sandy soil	50-400	11-18	7-9
Silty soil	20-200	14-36	5-8
Clayey soil	1-30	25-56	4-6
Sandstone	200-1000	9-14	8-10
Limestone	2000-10000	6-11	9-12
Ice	----	3.2	17
Water	----	81	3.3
Sea Water	5x10-2	81	3.3

*Reference: 1987, Operation Manual, Model 2441 GeoRadar-I, OYO Corporation.

STANDARD OPERATING PROCEDURE 018
ELECTROMAGNETIC INDUCTION (TERRAIN CONDUCTIVITY) SURVEYS

1.0 PURPOSE

The purpose of this standard operating procedure is to provide a general description and technical management guidance on the use of electromagnetic induction (terrain conductivity) surveys during hazardous waste site investigations at U.S. Army installations.

2.0 SCOPE

This guideline provides a description of the principles of operation, instrumentation, applicability, and implementation of electromagnetic induction methods used during hazardous waste site investigations to determine subsurface conductivity. Measurements of subsurface conductivity can be used to determine the presence and approximate extent of subsurface contaminants, buried drums, and metal containers, along with depth to the water table and structural characteristics of the subsurface environment.

The document is intended to be used by a site manager to develop an understanding of the method sufficient to permit work planning and scheduling, resource planning, subcontractor procurement and evaluation, and manipulation and use of the technical data during remedial investigations and feasibility studies. This guidance is not intended to provide a detailed description of methodology and operation, which will vary between sites, between target depths and characteristics, and between instruments. The description focuses on methods and equipment that readily available and typically applied; it is not intended to provide a complete discussion of the state of the art. Specialized expertise is required during both planning and execution of geophysical surveys to develop a target-specific, site-specific, and instrument-specific scope of work, with detailed operating procedures, which will best achieve the goals of the survey.

3.0 DEFINITIONS

Apparent Cor .tivity. The quantity measured during an electromagnetic induction survey; proportional to the actual conductivities of subsurface materials.

Conductivity. The property of a material to conduct an electric current, roughly equal to the reciprocal of resistivity.

Current. The quantity of charge transmitted per unit time.

Electromagnetic Induction (EMI). The process of transmitting a primary electromagnetic field which induces a secondary magnetic field in magnetic or paramagnetic objects or volume.

Electromagnetic Induction Survey. A geophysical exploration method whereby secondary electromagnetic fields are induced in the subsurface and whose strength is a measure of ground conductivity.

Horizontal Dipole Coil Orientation. The horizontal dipole coil orientation induces a field response which is greatest in the near-surface and falls off monotonically with depth.

In-phase Signal Component. The 180 degree (in-phase) component of the induced electromagnetic field. The in-phase component is highly sensitive to buried metal, but has no direct relationship to the earth conductivity.

Potential. Intensive property of electric fields, equating to the ability to do work.

Profiling. A survey technique where the EMI instrument, using a fixed coil spacing, takes measurements along a survey line to determine how the readings vary with location.

Quadrature Phase Signal Component. The 90 degree component of the induced electromagnetic field which is linearly proportional to the earth conductivity.

Resistivity. The property of a material which resists the flow of an electric current.

Sounding. A survey technique which measures the conductivities from progressively greater depths by increasing the coil spacings of the EMI instrument about a given location.

Vertical Dipole Coil Orientation. In the vertical dipole coil orientation, the EMI instrument has a greater depth of exploration than in the horizontal dipole mode, and the near-surface materials add relatively little to the total measurement.

4.0 RESPONSIBILITIES

Site Manager. Responsible for the scoping of geophysical surveys during development of the work plan, with the help of the RI leader, site geologist, and site geophysicist.

Site Geophysicist. As a specialist in this field, the site geophysicist plays a central role in determining the appropriateness of these techniques for providing necessary data. Field work for these surveys is supervised by the site geophysicist, with support from geophysical technical specialist and other personnel as needed. Data reduction and interpretation are performed by the site geophysicist or technical specialists.

Field Operations. Leader responsible for the overall management and coordination of the field work and enforcement of proper work and Health and Safety practices - including coordination, observation, or supervision of Explosive Ordnance Disposal (EOD) or military personnel, subcontractors, or co-contractors as required.

5.0 THEORY AND PRINCIPALS OF OPERATION

5.1 Description of Electromagnetic Induction (EMI) Method

In the Electromagnetic Induction (EMI) method, the electrical conductivity of a geohydrologic section is measured by transmitting a high-frequency electromagnetic field into the earth, which induces eddy currents that generate secondary electromagnetic fields. These secondary electromagnetic fields can then be detected by a receiver. The primary electromagnetic field is transmitted by an aboveground transmitter coil, and the resulting secondary electromagnetic fields are detected by an aboveground receiver coil. Thus, EMI measurements do not required direct ground contact, as is the case for resistivity measurements, and surveys across a line or area may be performed quite rapidly.

EMI instruments are calibrated to read subsurface conductivity directly in units of millimhos per meter, where

1000 millimo per meter = 1 / ohm-meter

This relation indicates that the conductivity obtained from EMI measurements varies inversely with the resistivity measured using a resistivity survey. However, because the subsurface sections associated with the two methods are generally of different depth or cross-sectional area, there is not an exactly inverse relationship between conductivity and resistivity surveys.

The conductivity value obtained by an EMI instrument depends on the combined effects of the number of soil and rock layers, their thicknesses and depths, and the inherent conductivities of the materials. The quantity actually measured is an apparent conductivity of the earth volume between the ground surface and an effective penetration depth, which is defined as the depth at which variations in conductivity no longer have a significant effect on the measurement. The sampling depth is related to the spacing between the transmitter and receiver coils of the instrument, approximately as follows:

Sampling depth = 1.5 (coil spacing)

Vertical profiling can be accomplished by multiple measurements about a point, with varying coil spacings. Horizontal profiling is performed by making measurements along traverses with a fixed coil spacing.

5.2 Applicability

The measurement of subsurface conductivity at a hazardous waste site provides a valuable contribution to site characterization for the following reasons:

- Conductivity is a function of the geohydrologic section and is overwhelmingly influenced by the presence of water (where buried metal is not present). Therefore, conductivity can provide indirect evidence on the porosity and permeability of subsurface materials and the degree of saturation. These parameters, in turn, are directly related to subsurface lithology and to the potential for infiltration/migration of contaminants from a source area.

- Conductivity is influenced by the presence of dissolved electrolytes in soil or rock pore fluids. Contaminant plumes in the vadose (unsaturated) and saturated zones can be mapped if there is sufficient change in conductivity to be detected by EMI measurements. In general, contaminant plumes of inorganic wastes are most easily detected because conductivity may be increased by one to three orders of magnitude above background values. The limit of detection is a change from a background of 10%–20%. Plumes of non-polar organic constituents from spills or leaking containers may be detected if sufficient soil moisture has been displaced to affect the ground conductivity to a measurable degree.

- Conductivity can be used to detect the presence of buried wastes if the degree of saturation, containerization, or inherent electrical properties of the wastes produce sufficient variation from the soil matrix. Practically, only large sources, such as a buried disposal trench or a group of buried drums, can be detected by these methods. The degree of detail provided by typical surveys cannot distinguish the size, shape, or mass of sources except in a qualitative manner.

For these reasons, conductivity surveys should be investigated as potentially appropriate site characterization tools when any of the following information is desirable:

- Detection and mapping of contaminant plumes; the rate of plume movement may also be deduced from measurements made over time.
- Estimates of depth, thickness and resistivity of subsurface layers, depth to the water table, or probable geologic composition of a layer.
- Detection, mapping an depths of burial pits, landfills, clay caps or lenses, or deposits of buried waste.
- Determination of locations for drilling to intercept contamination or to investigate aquifer properties.
- Corroboration of limited chemical and geohydrologic data at a site.

6.0 INSTRUMENTATION

EMI instruments are available in two forms:

6.1 Fixed Coil

Single-piece models operable by *one person*, with fixed coil spacings of 1, 4, and 12 feet; these provide sampling depths on the order of 1.5, 6, and 15 feet, respectively. The Geonics EM-38 (1 foot coil spacing) and EM-31 (12 foot coil spacing) are examples of this type of instrument.

6.2 Variable-coil

Dual-coil models, operable by two persons, with variable coil spacing up to about 40 feet (sampling depth up to about 60 feet). The Geonics EM-34 is an example of this type of instrument.

The 12-foot fixed coil and the dual-coil apparatus are most commonly used in hazardous wastes site investigations. In either case, an additional person to record data and identify measurement locations is highly desirable and more time efficient. The instruments are calibrated to read directly in conductivity units, and values are typically read and recorded on a data sheet. Some units have been modified to provide direct digital recording on magnetic tape.

7.0 DATA ACQUISITION

7.1 Field Procedures

7.1.1 Planning. Known or assumed geohydrologic features of the site, potential source locations and migration characteristics of hazardous constituents, are used to select specific techniques and equipment to establish appropriate locations and depths for geophysical measurements. The level of detail necessary (data quality objectives) determines the amount of effort and, in simple terms, the required number and density of data points. The data quality will depend on the method and specific equipment selected, the supporting hardware and software capabilities, and site-specific conditions.

Most of the details can be planned prior to site activities; however, some leeway must be accorded to the field procedures to account for variable site conditions and weather.

7.1.2 Site Layout. One of the most labor-intensive and time-consuming aspects of the field work involves layout of grids, and surveying or careful measurement of locations to allow geophysical surveys to be accomplished is a systematic, documentable manner. Every data point must be uniquely identified by locational coordinates of sufficient resolution to accomplish the objectives of the survey. Where possible, a cartesian (X,Y) grid should be established to provide these coordinates.

7.1.3 Electromagnetic Induction Measurements. At a given site grid location, the specified orientation of the apparatus is established, i.e., with the axis of the coils either parallel or perpendicular to the direction of the survey line. The meter reading is recorded and the apparatus moved to the next site grid location.

For the dual-coil method, both the intercoil spacing and coplanarity of the coils must be established prior to recording the data. Surveys are normally conducted with the coil axes horizontal and at right angles to the survey direction.

EMI profiles can be accomplished in a continuous manner using vehicle-mounted equipment and strip chart or digital recorders. Location information must be appended by tic marks or voice-over and some means provided to reference written field logs in a consistent manner.

7.2 Data Format

7.2.1 General. Information obtained during an EMI survey should be presented according to a standard data format, using standardized data sheets with original field entries. As a minimum, this should include the following information:

- Project, task, site, and location identification;
- Company or organization;
- Date (and time, if applicable);
- Operator's name and signature;
- Method/technique identification;
- Instrument make, model, serial number, and calibration date/frequency (if applicable);
- Coil type and configuration;
- Line or site grid location(s);

- Weather and site conditions and temperatures;
- Identification of relevant calibration and QC data; and
- Data for each sounding or profile should be recorded on a single sheet, if possible.
- Presence and location of cultural or topographic features which could affect the data.

7.2.2 Survey data. Survey data should include, in a tabular format, the following information:

- Coil location, per the survey plan;
- Coil spacing and configuration (unless specified in the heading); and
- Meter reading in millimhos per meter (quadrature phase) or parts per thousand (in-phase).

Special precautions to systematize and preserve data will be required for data that are recorded continuously on strip charts, magnetic tape, or in the memory of a recording device (such as an Omnidata Polycorder). Identifying header information must be recorded directly on the chart, tape, or file. Strip charts should be permanently affixed to the field logbook. Magnetic tapes or memory devices should be downloaded at least daily and hardcopy obtained. The original hard copy of output should be similarly secured/stored.

8.0 DATA INTERPRETATION

Corrections may be applied to EMI data for accuracy and drift, variation in location from pre-established coordinates, changes in scale, and nonlinearities associated with high conductivity values. In all cases, such corrections must be fully supported by data originally recorded or annotated in the field. Profile data along traverses are obtained as plots of conductivity versus distance. Parallel traverse data may be combined to provide conductivity contour maps of a site. Two or more profiles at different sampling depths, as well as sounding data at a given location, provide information on the relative conductivities of shallow and deeper layers. Contour plots can provide valuable information on the extent and direction of groundwater flow and contaminant transport.

Detailed comparison of EMI sounding measurements with layer models of the site can be made. This type of interpretation has been used at sites with relatively simple, uniform geohydrology to determine overburden-bedrock spatial and depth relationships. In some cases, very detailed interpretations, including aquifer flow properties, location of permeable zones, and interaquifer transfer, are possible.

9.0 SURVEY DESIGN

9.1 Prerequisites

Appropriate planning of EMI surveys requires at least a basic understanding of general site features and geohydrologic characteristics, including the probable variability in conditions. A statement of work should be generated that describes, in as much detail as possible, the known site conditions that may affect subsurface conductivity and the objectives of proposed survey efforts. The type and degree of data interpretation and the desired format for data presentation should be specified if possible.

9.2 Instrument Selection

For a given exploration target, the selection of the proper EMI instrument will primarily depend on the target depth. In general, the sampling depth of an EMI instrument is about 1.5 times the coil spacing. Some EMI instruments have adjustable coil orientations which allow the exploration depth to be somewhat modified by altering the orientation of the coils. For example, the Geonics EM-31 (coil spacing of 12 feet) has an exploration depth of about 0-15 feet in the horizontal dipole orientation and 5-20 feet in the vertical dipole orientation. Since fixed coil instruments do not generally offer coil spacing much greater than 12 feet, exploration targets greater than 20 feet deep require the use of a variable coil instrument.

9.3 Profiling vs Sounding

If it is necessary to determine the location and lateral extent of an exploration target (or targets), then the profiling method is indicated. If the survey needs to determine the changes of conductivity with depth (stratigraphic characterization) or the depths of conductivity changes, then EMI soundings are indicated.

9.4 Grid Design

The survey grid should be designed such that there are sufficient measurement points to adequately locate and define the distribution and extent of the exploration targets. For convenience, an orthogonal sampling grid, relative to a known location, is usually established over the survey area and the sampling points located by their grid coordinates (x,y). This is a convenient method for recording the data in an organized manner, for graphically displaying the data, and for ease of locating sampling points. Conductivity measurements are then taken at regular intervals along the gridlines, commonly every 5, 10, 20, or 50 feet - depending on the size of the exploration targets.

9.5 Work Planning and Scheduling

Conductivity surveys may be performed concurrently with field geotechnical investigations. In this case, on-site interpretation of data may provide real-time guidance for well drilling, sampling, or testing activities. Ideally, however, the geophysical surveys should be conducted in advance, allowing sufficient time for data interpretation and use of the results in planning other field exercises.

The time and effort required by conductivity surveys vary greatly depending on the site-specific objectives and site conditions. Typically, 1,000 – 10,000 feet of EMI profiling or 20-200 EMI soundings can be accomplished per day by a two-person team. Data reduction and interpretation will require at least an equivalent amount of time to the field work. Weather conditions, terrain, and obstructive site features cause considerable variability in these estimates.

10.0 QUALITY CONTROL

10.1 General

Geophysical surveys are subject to misapplication, erroneous interpretations, and use of incomplete or inadequate data. All of these avoidable errors can severely impact both the cost of subsequent site investigations and the validity of the site characterization. This susceptibility to misuse and potential for negative impact demands in assurance that appropriate quality control measures have been implemented. Quality control aspects common to most types of geophysical field programs are as follows:

- Program management personnel with technical expertise in preparing of statements of work, reviewing of proposals, work plans and reports, and technical supervision of subcontracts and field-related programs.
- Insistence on a defined scope of work, clear specifications, and data validation procedures.
- Requirement of a field quality control program.
- Appropriate justification before rejection of data points from a data set. Field data sheets should contain all observed data and the conditions that could impact data validity.
- Field data should be recorded in permanent ink in a bound logbook and each page signed and dated by the operator. Original unaltered logbooks should be retained in the site file.
- Proper calibration of instrumentation. In general, the objectives of geophysical surveys can be met by relative measurements across an area or with depth and , therefore, absolute calibration is of lesser importance than precision of measurements. However, a properly calibrated instrument provides an added measure of data validity. Furthermore, proper calibration permits correlation and comparison of the associated data with site features and geohydrologic characteristics not evident at the time of the field effort.
- An evaluation should be made of noise, interferences, and obstructions at a site. Such measurements, inferences, and explanations should be recorded in the field. These real-time quality control procedures aid field personnel in correction of noise sources over which they have control, in validating suspected external sources, and in early detection of problems that may jeopardize the survey objectives.

10.2 Instrument Quality Control

10.2.1 Calibration. EMI instruments are calibrated by the manufacturer over massive rock outcrops of known characteristic that are used as a geologic standard to measure the absolute conductivity over a uniform section of earth. The EMI apparatus should be maintained in calibration by the user, by noting drift in the readings at a stable "secondary standard" site. A secondary standard site is a location established in the field that is used to check the accuracy (calibration of the instrument and the drift (precision of the instrument. A secondary standard site is a location that the user of the instrument uses daily on large projects, much the same way the manufacturer uses massive rock outcrops for precision and accuracy determination.

Unacceptable drift or erratic operation shall be corrected by replacement with an instrument in proper working order. Values that are obtained from measurements over the stable secondary standard site that vary by more than 10%−15% are considered to be unacceptable drift.

10.2.2 Daily Quality Control. All aspects of the daily quality control measures for resistivity measurements apply also to EMI measurements. Repeated periodic measurements (at least three times a day) should be made at one or more locations and orientations at the site to determine the precision of measurements and to detect instrument drift.

11.0 HEALTH AND SAFETY CONSIDERATIONS

11.1 General

All procedures for hazardous waste site entrance, traverse, and egress that apply to general field operations also apply to conduct of geophysical surveys. Conductivity surveys depend on traverse of the site on foot or in vehicles, and there are extended periods during which personnel are subject to adverse environments at the site. Geophysics survey personnel will adhere to the guidelines of the Site Health and Safety Plan for field activities.

The geophysical methods discussed herein do not require extremely strenuous activity, and exposure to heat or cold is similar to that during other field activities. Extreme weather conditions will have adverse effects on the time required to obtain validated data, there by increasing the duration of personal exposure to the elements and to hazardous site influences.

11.2 Explosive Ordnance Disposal (EOD)

For surveys in areas where ordnance disposal or the presence of ordnance is suspected, EOD personnel will clear site access and survey areas prior to survey activities as per the Health and Safety Plan. The EMI methods described here involve the transmission of a weak electromagnetic signal whose characteristics are instrument dependent. Variable coil instruments generally emit an electromagnetic signal of 1-10 watts strength at variable frequencies ranging from 6.5-0.4kHz (for the Geonics EM-34). Fixed coil instruments emit signals of about 0.5-1.2watts strength at frequencies from 9-15 kHz (for the Geonics EM-31 and EM-38). These signal strengths are maximum strengths measured at the transmitting coil and fall off rapidly with depth in the subsurface. It is possible that this signal may not be safely broadcast in the vicinity of certain types of (live) ordnance detonators. The individual EMI instruments proposed for the survey(s) will be cleared for use, for each site where ordnance may be present, by the facility Health and Safety officer.

12.0 POTENTIAL PROBLEMS

EMI surveys are geophysical methods that, although standardized and frequently applied, are subject to a wide variety of problems. Problems can be expected to arise in the following areas:

12.1 **Planning and Execution.** Rarely is a survey accomplished exactly according to the original plan. Site features not previously specified and myriad other variations can occur that force changes in the details of the approach. However, the data quality objectives of the survey, the general methodology, the amount of data required, and the degree of data interpretation requested should remain unchanged. Project work scopes should be written with some degree of latitude to allow a change in plans whenever justified.

12.2 **Noise and Interferences.** Measurements can be affected severely both by natural and by man-made sources of electrical and electromagnetic noise. Nearby power lines, stray ground currents, and atmospheric discharges adversely effect both types of surveys. Large masses of buried metal, fences, railroad tracks and underground pipes or cables can strongly distort measurements and reduce instrument sensitivity to features of interest. These problems generally can be accounted for or overcome but must be recognized early in the program so that appropriate avoidance measures can be implemented. Known or suspected sources of interference should be included in the initial planning for a project.

12.3 **Weather Conditions.** It is possible to conduct the surveys under almost any conditions that permit traverse of the site. However, snow cover, standing water, heavy rainfall, or thoroughly saturated surface soils may severely restrict the ability to meet project objectives and schedules. Scheduling contingencies should be included whenever possible, especially during periods when inclement weather is expected.

12.4 **Technical Difficulties.** Preventable difficulties include equipment malfunction or misapplication; poor operator training, and lack of applications experience. Other difficulties may arise because the behavior of the site is not as initially conceptualized. The effect of these problems can be minimized by early recognition of their cause and severity and responsive and responsible technical management. Interim, real-time scrutiny of the data by the site geophysicist and management personnel is essential. The geophysical subcontractor must be responsive regarding equipment replacement, repair, or changes in personnel. The site manager and the site geologist should be cognizant of technical difficulties beyond the control of the field personnel and should recognize the need to change plans, field personnel, or cancel a survey, as appropriate.

13.0 REFERENCES

Good discussions of various survey techniques and applications are found in the following references.

Benson, Richard C., Robert A. Glaccum and Michael R. Noel, 1982. Geophysical Techniques for Sensing Buried Wastes and Waste Migration, Technos, Inc., Miami, FL., Contract No. 68-03-3050, USEPA Environmental Monitoring Systems Laboratory, Las Vegas, NV.

Costello, Robert L., 1980. Identification and Description of Geophysical Techniques, Report No. DRXTH-TE-CR-80084, US Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD; Defense Technical Information System No. ADA 123939.

McKown, G.L., G.A. Sandness and G.W. Dawson, 1980. Detection and Identification of Buried Waste and Munitions, Proceedings of the 11th American Defense Preparedness Association Environmental Systems Symposium, Arlington, VA.

Ward, Stanley H., ed., 1990. Volume I - Review and Tutorial, Geotechnical and Environmental Geophysics, Society of Exploration Geophysicists Investigations in Geophysics No. 5.; SEG, Tulsa, OK.

Ward, Stanley H., ed., 1990. Volume II - Environmental and Groundwater, Geotechnical and Environmental Geophysics, Society of Exploration Geophysicists Investigations in Geophysics No. 5.; SEG, Tulsa, OK.

STANDARD OPERATING PROCEDURE 019
MONITORING WELL INSTALLATION

1.0 Scope and Application

The installation of monitoring wells is contingent upon the existing conditions at the project site. The purpose of this Standard Operating Procedure is to delineate the quality control measures required to ensure the accurate installation of monitoring wells. The applicable Cluster Work Plan or site Sampling Design Plan should be consulted for specific installation instructions. The term "monitoring wells", as used herein is defined to denote any environmental sampling well. Subsections 6.7 *et seq.* and 6.8 *et seq.* of the Field Investigation Plan, as well as sections 1, 2, 3, and 6 of the Field Sampling Plan (Appendix A) are included by reference. Example well log forms are given at the end of this SOP. Alternate, equivalent forms are acceptable.

2.0 Material

2.1 Drilling Equipment

a. Appropriately sized drill adequately equipped with augers, bits, drill stem, etc.
b. Steam cleaner and water obtained from approved source for decontaminating drilling equipment.
c. PID: Microtip HL-200 (or equivalent)
d. Water level indicator
e. Weighted Steel tape measure
f. LEL-Oxygen monitor
g. Steel drums for intrusion derived wastes (drill cuttings, contaminated PPE, decon solutions, etc.)
h. Source of approved water
i. Heavy plastic sheeting
j. Sorbent pads and/or logs

2.2 Well Installation Materials [18]

a. Well screen : [19]

PVC: JOHNSON (or equivalent); PVC Vee Wire Continuous slot, wire wrapped screen; 4-inch diam.; SCH 40; flush-threaded (leak-proof) joints; PVC complies with ASTM D2665, ASTM D1784, and ASTM F480; free of ink markings; cleaned and prepackaged by manufacturer

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18 Technical information on all installed materials (screens, riser pipe, filter pack, bentonite, cement, etc.) and representative samples of the proposed filter pack, bentonite powder, and bentonite pellets will be supplied to the Contracting Officer's Representative (COR).

19 Well screen slot size and filter pack gradation will be determined from sieve analysis of aquifer materials. Screen and calling material type will be determined based on field tests of groundwater chemistry and contaminants.

Stainless Steel: JOHNSON (or equivalent); Brainless steel Vee-Wire ContinuOUs BlOt, wire wrapped screen; 304 stainless steel [20]; ASTM F480 flush threads; cleaned, wrapped, and heat sealed by manufacturer.

b. Riser pipe:

PVC: JOHNSON (or equivalent); STD. PVC; 4-inch diam.; SCH 40; flush-threaded (leak-proof) joints; PVC complies with ASTM D2665, ASTM D1784, and ASTM F480; free of ink markings; cleaned and prepackaged by manufacturer

Stainless Steel: JOHNSON (or equivalent); SCH 5; 304 stainless steel; ASTM type A312 material; 4-inch diam.; cleaned, wrapped and heat sealed by manufacturer.

c. Plugs/Caps: JOHNSON (or equivalent); standard PVC or stainless steel
d. Filter pack: MORIE, 100 well gravel (or equivalent) Note: final gradation may vary as a function of the gradation of the formation (see footnote 2)
e. Fine Ottawa sand
f. Bentonite seal: BAROID, bentonite pellets (3/8-inch diam.)
g. Cement: Type II Portland Cement [21]
h. Bentonite powder: BAROID, Aquagel Gold Seal
i. Steel Protective Casing: BRAINARD-KILMAN (or equivalent) zinc-plated steel, lockable, painted. [22]
j. Geotextile: MIRAFI (or equivalent); GTF 130; non-woven; 4 oz.
k. Coarse (blanket) gravel: Crushed stone aggregate
l. Containers for purged water, as required.
m. Submersible pump or bailer of appropriate capacity, and surge block sized to fit well
n. Hach DREL 2000 portable laboratory (or equivalent)
o. Conductivity, pH, ORD, turbidity, dissolved oxygen, and temperature meters
p. Electric well sounder and measuring tape.
q. Portland Type II cement (see footnote)
r. Steel Posts (pickets), Painted (see footnote)

2.3 Documentation

a. Copy of appropriate Cluster Work Plan
b. Copy of Section 6 "Field Investigation Plan'
c. Copy of Appendix A 'Field Sampling Plan"
d. Copy of approved Health And Safety Plan
e. Copies of well and excavation permits
f. Copies of SOPs 003, 005, 008-012, 019(this SOP), 023, 024, and 028

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[20] Unless the sum od Cl^-, F^-, and Br^- is >1000ppm, in which case type 316 should be used (see also "Field Investigation Plan" Section 6.8.6 and Appendix A, "Field Sampling Plan" § 3.3.2.)

[21] If sulfates are higher than 1500ppm type IV Portland Cement will be used

[22] All painted components (protector casing, steel pickets) will be painted high-visibility orange and allowed to dry completely prior to being brought onsite.

g. Boring log forms
h. Well completion diagram form
i. Well development form

2.4 Geologist's personal equipment

a. 1OX handlens
b. Unified Soil classification System chart
c. Munsell color chart
d. Sieve set (Keck model SS-81 or equivalent)
e. PPE as required by HASP

3.0 Procedure

3.1 Materials Approval

3.1.1 Water sources for drilling, grouting, sealing, filter placement, well installation, and equipment decontamination must be approved by the COR prior to arrival of the drilling equipment. Information required for the water source includes: water source, manufacturer/owner, address and telephone number, type of treatment and filtration prior to tap, time of access, Cost per gallon (if applicable), dates and results associated with all available chemical analyses over the past two years, and the name and address of the analytical laboratory (if applicable).

3.1.2 Pure sodium bentonite with no additives (bentonite) will be the only drilling fluid additive allowed, and its use must be approved by the COR prior to the arrival of the drilling equipment. The information required for evaluation includes: brand name, manufacturer, manufacturer's address and telephone number, product description, and intended use for the product.

3.1.3 Granular Filter Pack material must be approved by the COR prior to drilling. A one-pint representative sample must be supplied to the COR. Information required includes: lithology, grain size distribution, brand name, source, processing method, and BlOt size of intended screen.

3.1.4 Portland Type II cement will be used for grout (see footnote).

3.2 Drilling

3.2.1 The objective of the selected drilling technique is To ensure that the drilling method provides representative data while minimizing subsurface contamination, cross contamination, and drilling costs. The drilling method used will be hollow stem auger or water/mud rotary[23]. No other methods will be considered as

[23] Due to the potential for aquifer contamination and plugging, mud rotary drilling is not recommended for monitoring wells. If; however, the well is a deep monitoring well and/or is screened in a "running sand" , and the aquifer is expected to have a relatively high flow rate, then mud rotary may be approved on a case-by-case basis.

available without approval of EPA and MDE. The method used at a specific site will be proposed in the work plan and evaluated by the COR.

3.2.2 A Site Geologist will be present during all well drilling and installation activities and will fully characterize all tasks performed in support of these activities into the monitoring well logbook. The Site Geologist will be responsible at only one operating rig for the logging of samples, monitoring of drilling operations, recording of water losses/gains and groundwater data, preparing the boring logs and well diagrams, and recording the well installation procedures of the rig. The Site Geologist will have onsite sufficient equipment in operable condition to perform efficiently his/her duties as outlined in the Field Investigation Plan (Section 6), and the Field Sampling Plan (Appendix A), and other contractual documents. Items in the possession of each Site Geologist will include, copies of Section 6, Appendix A, the approved HASP, this SOP, a hand lens (10X), a standard color chart, grain-size chart, and a weighted (with steel or iron) steel tape long enough to measure the deepest well, heavy enough to reach that depth, and small enough to fit readily within the annulus between the well and drill casing. The Site Geologist will also have onsite, a water level measuring device, preferably electrical.

3.2.3 No lubricants will be used on downhole drilling equipment. Additives containing either lead or copper will not be allowed. In addition, polychlorinated biphenyls will not be permitted in hydraulic fluids or other fluids used in the drilling rig, pumps, or other field equipment and vehicles.

3.2.4 Surface runoff or other fluids will not be allowed to enter any boring or well during or after drilling/construction.

3.2.5 Antifreeze used to keep equipment from freezing will not contain rust inhibitors and sealants. Antifreeze is prohibited in an areas in contact with drilling fluid. The ground surface at the well site will be protected from possible coolant, fuel, and hydraulic fluid spills and/or leakage by placement of plastic sheeting with raised edges, draining into a lined catch basin large enough to contain spills and/or leakage from motors, radiators, or vehicle tanks. Sorbent pillows will be placed to catch obvious leaks from the drill rig. Sorbent logs may be used instead of, or in conjunction with a lined catch basin to contain spills.

3.2.6 An accurate measurement of the water level will be made upon encountering water in the borehole and later upon stabilization. Levels will be periodically checked throughout the course of drilling. Any unusual change in the water level in the hole such as a sudden rise of a few inches may indicate artesian pressure in a confined aquifer will be the basis for cessation of drilling. The geologist will immediately contact his/her supervisor [24]. Particular attention for such water-level changes will be given after penetrating any clay or silt bed, regardless of thickness, which has the potential to act as a confining layer.

[24] The USACE Waterways Experiment Station (WES) may also be contacted for guidance. The WES project manager is Dr. James May (601) 634-3395. He also exercises direct technical oversight of the Lauderick Creek Study Area. Mr. Danny Harrelson (601) 634-2685 has technical oversight of the Westwood Study Area. Dr. Robert Larson (601) 634-3201 has technical oversight of the Bush River Study Area.

Anticipated depths of wells are given in well specific work plans (*e.g.* Appendix I). In case the previously defined criteria have not been met before the depth range for a given hole is reached, the geologist will stop the drilling and confer with her/his supervisor. The current boring conditions (depth, nature of the stratigraphic unit, and water-table depth) will be compared to those of other wells nearby to decide to continue drilling or to terminate and complete the well.

3.2.7 **If the well is to be installed in the surficial aquifer:** Drilling will be terminated before penetrating the basal aquitard. The basal aquitard is defined as the first 2 foot-thick clay below the water table, or below 5 feet in the case of a shallow aquifer (Field Investigation Plan, § 6.7.3)

3.2.8 **If the well is to be installed in a lower, confined aquifer:**

3.2.8.1 Penetrations of aquifers located lower than the watertable aquifer will be limited to avoid cross-contamination.

3.2.8.2 Placement of new upper confined aquifer wells will be initially limited to those areas where contamination has been confirmed.

3.2.8.3 The location of upper confined aquifer wells will be based upon the findings of the water-table aquifer investigation. Areas of known contamination will be targeted for installing upper confined aquifer wells for the purposes of delineating vertical contamination.

3.2.8.4 Where possible, upper-confined aquifer wells will be located such that they afford triangulation with other wells within the same aquifer to allow for a determination of ground-water flow direction.

3.2.8.5 Some upper-confined aquifer wells will be installed approximately 10-15 ft from water-table wells to enable the accurate assessment of vertical hydraulic gradients. If the direction of ground-water flow is known, wells within a group will be located sidegradient of each other.

3.2.8.6 The boring will be advanced until the base of the surficial aquifer is reached (see § 3.2.7).

3.2.8.7 An outer, surface casing will be set 2 to 5 ft into the confining layer to minimize the potential for cross-contamination from the unconfined aquifer during drilling activities.

3.2.8.8 The surface casing will be driven into the confining bed and grouted into place. A grout plug at least 2 feet thick will be tremied into the bottom of the surface casing. The grout will be permitted to cure for 24 hours. All drilling fluids within the surface calling will then be removed, and the casing will be flushed with clean potable water.

3.2.8.9 The drilling equipment will be decontaminated, a smaller bit or auger selected, and the hole will be continued through the grout plug into the confined aquifer.

3.2.8.10 If deeper aquifers are to be screened, repeat preceding steps until total depth is reached.

3.2.9 <u>If DNAPL contamination is detected during drilling,</u> the well will be terminated and completed at the base of the aquifer. Drilling will not continue through the confining unit.

3.2.9.1 Stainless steel screens will be used in DNAPL wells. Screen size selection will be according to criteria set forth in § 3.4.3.2(below). The formation grain size will be multiplied by the higher factor (6) to determine filterpack grain size. This will ensure that the filterpack is sufficiently coarse to permit DNAPL to pass freely from the formation into the coarser filterpack, then into the open well (Cohen and Mercer, 1993).

3.2.9.2 DNAPL sampling cups are prohibited. The well screen will be capped, and set 0.3 ft (0.5 ft. max.) into the top of the confining bed and rest on the bottom of the hole or bentonite backfill (if used). No sand will be placed below the screen.

3.2.9.3 The remainder of the well installation and completion will be accomplished according to section 3.4.

3.3 Logging

3.3.1 All borings for monitoring wells will be logged by a geologist. Logs will be recorded in a field logbook and/or a boring log. If the information is recorded in a logbook, it will be transferred to Boring Log Forms on a daily basis. Field notes are to include, as a minimum:

a. Boring Number
b. Material Description (as discussed below)
c. Weather conditions
d. Evidence of Contamination
e. Water Conditions (including measured water levels)
f. Daily Drilling Footage and Quantities (for billing purposes)
g. Notations on Man-Placed Materials
h. Drilling Method and Bore Hole Diameter
i. Any Deviations from Established Field Plans
i. Blow Counts for Standard Penetration Tests
k. Core and Split-Spoon Recoveries

3.3.2 Material description for soil samples must include:

a. Classification
b. Unified Soil Classification Symbol
c. Secondary Components and Estimated Percentages
d. Color
e. Plasticity
f. Consistency
g. Density
h. Moisture Content
i. Texture/Fabric/Bedding and Orientation
j. Grain Angularity

k. Depositional Environment and Formation
l. Incidental odors
m. OVA reading(s)
n. Staining

3.3.3 Material description for rock samples must include:

a. Classification
b. Lithologic Characteristics
c. Bedding/Banding Characteristics
d. Color
e. Hardness
f. Degree of Cementation
g. Texture
h. Structure and Orientation
i. Degree of Weathering
i. Solution or Void Conditions
k. Primary and Secondary Permeability
l. Sample Recovery
m. Incidental odors
n. OVA reading(s)
o. Staining

See also SOP003 and SOP016 for details on logbook entries.

3.4 Well Construction and Installation

After the hole is drilled and logged, backfill hole as required for proper screen placement. The integrity of the aquitard will be restored by placing a bentonite plug of an appropriate thickness, either to the top of the aquitard (normal well installation) or to within 0.3 ft. of the top of the aqitard (DNAPL well). Aquifer fill will be clean filter pack.

Normal screen placement for the water table (surficial) aquifer will be with 2 ft. of the screen extending above the static water level. The bottom of the screen will rest no more than 6 in. from the bottom of the hole or backfill material, whichever is applicable.

Note: the end cap in DNAPL wells will rest on the bottom of the bottom of the hole, or bentonite backfill if applicable. (see § 3.2.9.2above)

Screen placement for a confined aquifer well will normally be at the top of the confined aquifer.

3.4.1 Screen lengths will not normally exceed 10 feet. If it appears advantageous in a given situation (e.a. to screen an entire aquifer which is thicker than 10 feet, approval must be sought on a case-by-case basis from MDE and EPA. Otherwise, wells will be screened as follows:

Thickness of Aquifer:	Action:

< 10'	Screen entire aquifer
> 10' < 30'	screen top 10' consider vertically nested well cluster
> 30'	install vertically nested well cluster

3.4.2 The installation of monitoring wells in uncased or partially cased holes will begin within 12 hours of completion of drilling, or if the hole is to be logged, within 12 hours of well logging, and within 48 hours for holes fully cased with temporary drill casings. once installation hall begun, work will continue until the well has been grouted and the drill casing has been removed. Exceptions MUST be requested in writing by the contractor to the Contracting officer's Representative prior to drilling. Unscheduled delays attributable to unforeseeable site occurrences will not require advance approval.

3.4.3 Well screens, casings, and fittings will conform to National Sanitation Foundation Standard 14 or American Society for Testing and Materials (ASTM) equivalent for potable water usage. These materials will bear the appropriate rating logo. If the logos are not present, a written statement from the manufacturer/supplier stating that the materials contain the appropriate rating must be obtained. Material used will be new and essentially chemically inert to the site environment.

3.4.3.1 Well screen and casing should be inert with respect to the ground water; therefore, the selection Of screen and casing material will be based on select field tests of aquifer chemistry and potential contaminants. The screen will be capped without sediment trap or DNAPL sampling cup, and lowered into the hole. The well casing will be pre- cut to extend 2 to 2.5 ft above the ground surface. Prior to placement of the last piece of well casing, a notch or other permanent reference point will be cut, filed, or scribed into the top edge of the casing.

3.4.3.2 Screen slot size will be appropriately sized to retain 90 to 100% of the filter pack material, the size of which will be determined by sieve analysis of formational material (See § 3.4.3.2).

3.4.3.3 The tops of all well casing will be capped with covers composed of materials compatible with the products used in the well installation. Caps may either be vented, or a telescopic fit, constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions. In either case it should be secure enough to preclude the introduction of foreign material into the well, yet allow pressure equalization between the well and the atmosphere.

3.4.4 Filter pack material will be tremied into place, and lightly tamped and leveled. Filter pack will extend from the bottom of the hole to a height of 1-2 ft above the top of the screen. The filter pack will be capped with 1 ft of fine (Ottawa) sand to prevent the bentonite seal from infiltrating the filter pack.

3.4.4.1 Granular filter packs will be chemically and texturally clean, inert, and siliceous.

3.4.4.2 Filter pack grain size will be based on formation grain-size analysis. The D30 (70% retained) sieve size multiplied by a factor of not less than 3 nor greater than 6 will be used to determine the appropriate grain size.

3.4.4.3 Calculations regarding filter pack volumes will be entered into the Field Logbook along with any discrepancies between calculated and actual volumes used. If a discrepancy of greater than 10% exists between calculated and actual volumes exists, an explanation for the discrepancy will also be entered in the Logbook.

3.4.5 Bentonite seals will be no less than two feet nor more than five feet thick as measured immediately after placement. The normal installation will include a five foot seal. Thinner seals may be used in special cases as defined in Section 3.12 of Appendix A. The final depth to the top of the bentonite seal will be measured and recorded.

3.4.6 **GROUT**

Grout used in construction will be composed by weight of:

- 20 parts cement (Portland cement, type II)(see footnote)
- 0.4 to 1 part (max.)(2-5%) bentonite
- 8-gallons (max.) approved water per 94-lb bag of cement.

Neither additives nor borehoie cuttings will be mixed with the grout. Bentonite will be added after the required amount of cement is mixed with the water.

3.4.6.1 All grout material will be combined in an above-ground container and mechanically blended to produce a thick, lump-free mixture. The mixed grout will be recirculated through the grout pump prior to placement.

3.4.6.2 Grout placement will be performed using a commercially available grout pump and a rigid, side discharge tremie pipe.

3.4.6.3 The following will be noted in the Field Logbook: 1) calculations of predicted grout volumes, 2) exact amounts of cement, bentonite, and water used in mixing grout, c) actual volume of grout placed in the hole, d) any discrepancies between calculated and actual volumes used. If a discrepancy of greater than 10% exists between calculated and actual volumes exists, an explanation for the discrepancy will also be entered in the Logbook.

3.4.7 Well protective casings will be installed around all monitoring wells on the same day as the initial grout placement around the well. Any annulus formed between the outside of the protective casing and the borehole will be filled to ground surface with cement.

3.4.8 The construction of each well will be depicted as built in a well construction diagram. The diagram will be attached to the boring log and will graphically denote:

a. Screen location, length
b. Joint location
c. Granular filter pack

d. Seal
e. Grout
f. Cave-in
g. Centralizers
h. Height of riser
i. Protective casing detail

3.5 Monitoring well completion

3.5.1 Assemble appropriate decontaminated lengths of pipe and screen. Make sure these are clean and free of grease, soil, and residue.

3.5.2 Lower each section of pipe and screen into the borehole, one at a time, screwing each section securely into the section below it. No grease, lubricant, polytetrafluoroethelyne (PTFE) tape or glue, may be used in joining the pipe and screen sections.

3.5.3 Centralizers will be used every 50 ft below the top 50 ft. (except within screened interval and bentonite seal). Centralizer material will be PVC, PTFE, or stainless steel. Determination of centralizer material will be based on the same criteria as screen and calling selection (see Field Investigation Plan, Section 6.8)

3.5.4 Prior to installation, cut the riser so that it will extend approximately 2-2.5 ft. above grade. Notch, file, or otherwise permanently mark a reference point on the top of the casing. All pipe cuts MUST be square to ensure that the elevation between the highest and lowest point of the well casing is less than or equal to 0.02 ft.

3.5.5 When the well is set to the bottom of the hole, temporarily place a cap on top of the pipe to keep the well interior clean.

3.5.6 Place the appropriate filter pack into using a tremie pipe. Monitor the rise annulus with a weighted tape to assure that bridging is not occurring.

3.5.7 After the pack is in place, wait three to five minutes for the material to settle, tamp and level a capped PVC pipe, and check its depth weighted steel tape.

3.5.8 Add a 1-2 foot cap of fine-grained (Ottawa) sand to prevent infiltration of the filterpack by overlying bentonite seal.

3.5.9 Install the bentonite seal by dropping bentonite pellets into the hole gradually. If the well is deeper than 30 feet, a tremie pipe will be used to place the pellets. Tamp and level the pellets with a capped PVC pipe, and check depth with a weighted tape as above.

3.5.10 Wait a for the pellets to hydrate and swell. Hydration times will be determined by field test or by manufacturer's instructions. Normally this will be 30 to 60 minutes. Document the hydration time in the field notebook. If the pellets are above the water level in the hole, add several buckets of clean water to the boring. Document the amount of water added to the hole.

3.5.11 Mix an appropriate cement-bentonite slurry (§ 3.4.6). Be sure the mixture is thoroughly mixed and as thick as is practicable.

3.5.12 Lower a side discharge tremie pipe into the annulus to the level of the pellet seal.

3.5.13 Pump the grout slurry into the annulus while withdrawing the tremie pipe and temporary casing.

3.4.14 Stop the grout fill at 5 feet below the ground surface. Allow to cure for not less than 12 hours. If grout settles more than 6-in., add grout to bring level back up to within 5-ft. of ground surface. Place approximately 2 ft. of bentonite pellets (minimum 0.5 ft) in annulus. Seat the protective casing in the bentonite seal, allowing no more than 0.2 ft between the top of the well casing and the bottom of the protective casing cap. Fill inner annulus (between well casing and protective casing) with bentonite pellets to the level of the ground surface. Cover bentonite pellets with 1 ft. of clean granular material (coarse sand or pea gravel filter pack). Fill the outer annulus (between the protective casing and the borehole) with neat cement. Allow the cement to mound above ground level and finish to slope away from the casing. Lock the cap.

-or-

3.5.15 Continue the grout fill to the ground surface. Seat the protective casing in the grout, allowing no more than 0.2 - ft between the top of the well casing and the bottom of the protective casing cap. Lock the cap.

-and-

3.5.16 Allow the grout slurry to set overnight.

3.5.17 Fill the outer annulus (between the casing and the borehole) with neat cement. Allow the cement to mound above ground level and finish to slope away from the casing.

3.5.18 Slope the ground surface away from the casing for a distance of two feet, at a rate of no less than 1 inch in two feet. Surface this sloping pad with a geotextile mat covered by 3 in. of coarse gravel.

3.5.19 Set pre-painted protective steel pickets (3 or 4) evenly around and 4 feet out from well.

3.6 Well Development

3.6.1 Well development is the process by which drilling fluids, solids, and other mobile particulates within the vicinity of the newly installed monitoring well have been removed while restoring the aquifer hydraulic conductivity. Development corrects any damage to or clogging of the aquifer caused by drilling, increases the porosity of the aquifer in the vicinity of the well, and stabilizes the formation and filter pack sands around the well screen.

3.6.2 Well development will be initiated after 48 consecutive hours but no longer than 7 calendar days following grouting and.or placement Of surface protection. The record of well development will be submitted to the Contracting Officer's Representative within three working days after well development is completed.

3.6.3 Two well development techniques - over pumping and surging will be employed in tandem. over pumping is simply pumping the well at a rate higher than recharge. Surging is the operation of a plunger up and down within the well casing similar to a piston in a cylinder.

3.6.4 Materials Required

a. Well Development Form
b. Boring Log and Well Completion Diagram for the well
c. Submersible pump or bailer of appropriate capacity, and surge block
d. Conductivity, pH, ORD, turbidity, dissolved oxygen, and temperature meters
e. Electric well sounder and measuring tape.
f. Containers for purged water, if required.

3.6.5 Summary of Procedures and Data Requirements.

3.6.5.1 Pump or bail the well to ensure that water flows into it, and to remove some of the fine materials from the well. Removal of a minimum of one equivalent volume (EV) is recommended at this point. The rate of removal should be high enough to stress the well by lowering the water level to approximately 1/2 its original level.

3.6.5.2 Slowly lower a close-fitting surge block into the well until it rests below the static water level, but above the screened interval. (Note: this latter is not required in the case of an LNAPL well.)

3.6.5.3 Begin a gentle surging motion which will allow any material blocking the screen to break up, go into suspension, and move into the well. Continue surging for 5-10 minutes, remove surge block, and pump or bail the well, rapidly removing at least one EV.

3.6.5.4 Repeat previous step at successively lower levels within the well screen until the bottom of the well is reached. Note that development should always begin above, or at the top of, the screen and move progressively downward to prevent the surge block from becoming sand locked in the well casing. As development progresses, successive surging can be more vigorous and of longer duration as long as the amount of sediment in the screen is kept to a minimum.

3.6.5.5 Development is expected to take at least 2 hours in a small well installed in a clean sand, and may last several days in large wells, or in wells set in silts with low permeabilities.

3.6.5.6 Development will continue until little or no sediment can be pulled into the well, and target values for parameters listed in 3.6.4.9(e.) (below) are met.

3.6.5.7 At a minimum, development will remove 3 to 5 EV, plus 3 to 5 times the amount of fluid lost during drilling, and 3 to 5 times the volume used in filter pack placement.

3.6.5.8 All water removed must be disposed of as directed by the Sampling Design Plan.

3.6.5.9 Record all data as required on a Well Development Record Form (see example), which is made a part of the complete Well Record. These data include:

a. Depths and dimensions of the well, the casing, and the screen, obtained from the Well Diagram.

b. Water losses and uses during drilling, obtained from the boring log for the well.

c. Water contained in the well, obtained from calculations using the depth of the water column and the well radius, plus the radius and height of the filter pack and an assumed 30% porosity.

d. Measurements of the following indicator parameters: turbidity, pH, conductivity, oxidation-reduction (ORD, Redox) potential, dissolved oxygen, and temperature before, twice during, and after development.

e. Target values for the indicator parameters listed above are as follows: pH - stabilize, conductivity - stabilize, ORD - stabilize, DO stabilize, temperature - stabilize, turbidity - NTU 5 or stabilize

f. Notes on characteristics of the development water.

g. Data on the equipment and technique Used for development.

h. Estimated recharge rate and rate/quantity of water removal during development. (See SOP 013 section 3.2.)

3.7 Refer to SOP003 (Field Logbook), 005 (Decontamination), 008 - 012 and 036 038 (Instrumentation for Groundwater Parameters).

4.0 Maintenance

Not Applicable.

5.0 Precautions

Refer to the site-specific Health and Safety Plan for discussion of hazards and preventive measures during well development activities.

6.0 References

Aller, Linda, *et al.*, 1989. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, National Water Well Association

Cohen, Robert M., and Mercer, James W. 1993. DNAPL Site Evaluation, CRC Press, Inc.

COMAR 26.04.04Well Construction

EPA Groundwater Handbook 1989

Nielsen, David M., 1993. Correct Well Design Improves Monitoring, in "Environmental Protection", Vol.4, No.7, July, 1993.

USATHAMA. 1987. Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports, March 1987.

WELL DESIGNATION: ____________________ DATE(S) OF INSTALLATION: ____/____/____

SITE GEOLOGIST: ________________________ DEVELOPMENT DATE(S): ____/____/____

STATIC WATER LEVELS BEFORE AND AFTER DEVELOPMENT *:

BEFORE ____________ DATE __________ 24 HR. AFTER __________ DATE __________

DEPTH TO SEDIMENT BEFORE AND AFTER DEVELOPMENT *:

BEFORE ____________ DATE __________ 24 HR. AFTER __________ DATE __________

DEPTH TO WELL BOTTOM *: _______________ SCREEN LENGTH _____________

HEIGHT OF WELL CASING ABOVE GROUND SURFACE: __________________

QUANTITY OF MUD/WATER:

LOST DURING DRILLING	(+) ____________________	gallons
REMOVED PRIOR TO WELL INSERTION	(-) ____________________	gallons
LOST DURING THICK FLUID DISPLACEMENT	(+) ____________________	gallons
ADDED DURING FILTER PACK PLACEMENT	(+) ____________________	gallons
TOTAL LOSSES	____________________	gallons

(a) Water column ht. (ft.) _____________ (b) Well radius (in.) ____________

(c) Screen length (ft.) _____________ (d) Borehole radius (in.) ____________

(e) QUANTITY OF FLUID STANDING IN WELL

$(12 * a * \pi * b^2 * 0.0043) =$

__________ gallons
(Show Calculation)

(f) QUANTITY OF FLUID IN ANNULUS

$[12 * c * \pi 8(d^2 - b^2) * 0.0043 * 0.30]$

__________ gallons
(Show Calculation)

DEVELOPMENT VOLUME = (5 * TOTAL LOSSES) + [5 * (e + f)] = ____________ gallons
(Show Calculation)

*** ALL DEPTHS MEASURED FROM TOP OF WELL CASING**

EXAMPLE WELL DEVELOPMENT RECORD
(PAGE 2 OF 2)

WELL DESIGNATION ____________ DATE(S) OF DEVELOPMENT:
____/____/____

TYPE AND SIZE OF PUMP: ______________________________

TYPE AND SIZE OF BAILER: ______________________________

DESCRIPTION OF SURGE TECHNIQUE:
____
____

RECORD OF DEVELOPMENT

DATE & TIME	QUANTITY REMOVED	TIME REQ'D	pH	Cond	Temp	ORD	Turb	DO	Character of water (color / clarity / odor / partic.)
(before)									
(during)									
(during)									
(during									
(after)									

TYPICAL PUMPING RATE ________GAL./HR. EST. RECHARGE RATE ____________

TOTAL QUANTITY OF WATER REMOVED ___________ TIME REQUIRED ____________

REMARKS____
____
____

SIGNATURE OF SITE GEOLOGIST ______________________

Hole No.

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

STANDARD OPERATING PROCEDURE 020
ACTIVE SOIL GAS SAMPLING

1.0 Scope and Application

This standard operating procedure is applicable when conducting soil gas sampling. A soil gas survey is an effective screening tool in locating areas contaminated with volatile organic compounds.

2.0 Material

a. Probe set, including probe jack
b. Rotary hammer with 1"* 36" drill bit
c. Disposable shield points
d. 3/16" o.d. polyethylene tubing
e. Extension cord
f. Portable generator or other power source
g. 1L Tedlar bags [25]
h. Sample labels
i. Vacuum box and vacuum pump
j. Tygon tubing for vacuum box
k. Clean sand
l. Powdered bentonite
m. Two measuring cups
n. Tools: vise grips, 3/4" and ⅝" wrenches, scissors

3.0 Procedure

3.1 Soil Gas Point Installation

3.1.1 Assemble clean probe sections to the desired sampling depth.

3.1.2 Cut polyethylene tubing to at least 1' longer than the depth of the hole.

3.1.3 Insert one end of the tubing approximately ¼" inside of aluminum shield point. Crimp the shield point tightly around the tubing with vise grips and insert the tube and shield point inside of the clean KV probe.

3.1.4 Using rotary drill and 36" drill bit, bore down 30" at the location desired for sampling. Be sure to clear the hole well so that soil does not fall back into hole.

3.1.5 Drive stainless steel probe and attached shield point and polyethylene tubing down the hole with a rotary hammer to about 4', or above the saturation zone. (It is desired to obtain a sample of the soil gas, not the ground water.) If samples are needed from greater than 4', drive the steel probe with a solid tip to the desired depth, extract, and insert a probe fitted with a disposable shield point and tubing.

---

[25] Tedlar bags and on-site analysis is preferred. Glass vials and offsite analysis will be acceptable. An equivalent SOP for glass vials and offsite analysis will be submitted by the contractor prior to sampling. Holding times for either sample container will be kept to a minimum.

3.1.6 Extract the probe by hand or with the jack. Be sure that shield point and tubing stays in the ground and attached to the shield point.

3.1.7 Pour ½ cup of sand down sampling hole. Gently shake the tubing to ensure that the sand settles and no bridged spaces remain.

3.1.8 Pour ½ cup bentonite down sampling hole, add ¼ cup distilled water, add another ½ cup bentonite down hole and another ¼ cup water. Continue until bentonite seal reaches the surface.

3.1.9 Allow at least 20 minutes before extracting sample.

3.1.10 Take sample (see 3.2 below)

3.1.11 Remove probe and backfill hole with bentonite.

3.2 Soil Gas Sample Collection Using Tedlar Bags

3.2.1 Cut at least 1" off the end of the tubing to ensure a clean sample.

3.2.2 Attach tubing to the vacuum box and pump.

3.2.3 Open valve on a clean, dry Tedlar bag and attach inside the vacuum box.

3.2.4 Close the vacuum box, close stopcock (3-way valve) between vacuum box and pump and then turn the pump on.

3.2.5 Allow Tedlar bag to fill 90% (do not overfill bag), shut off, crimp Tygon tubing (to prevent release of sample back down hole), open stopcock, and remove Tedlar bag from box.

3.2.5.1 If the bag is filled with air only, squeeze the air out completely to purge air that was in the tubing and sand and reattach inside the box. Repeat steps 3.2.4and 3.2.5.Close the valve on the Tedlar bag upon removal, label it accordingly, and put it in a cool, dark area. Note: not so cool as to cause condensation.

3.2.5.2 If Tedlar bag is filled with water and air, be sure to close valve on Tedlar bag before removing it, label the bag accordingly, and put it in a cool, dark area. Note: not so cool as to cause condensation.

3.2.5.3 If water is pulled into the Tedlar bag, Tygon tubing inside the vacuum box must be replaced.

3.2.6 Remove and decon probes.

3.2.7 Repeat the above procedures for each additional soil gas point.

3.3 Sampling with glass vials.

4.0 Maintenance

None

5.0 Field Quality Control Measures

5.1 To ensure that the equipment is free of volatile contaminants, collect at least two QC samples per day by drawing uncontaminated air through an unused representative sampling apparatus (assembled shield point and tubing). One sample should be taken at the beginning of the day, prior to collecting any samples, the other at the end of the day, after decontaminating the equipment. Ambient air may usually be assumed to be uncontaminated. If site ambient air is assumed to be contaminated, it should be sampled for contaminant levels.

5.2 To ensure that the analyzed samples are representative of the collected samples, and that the Tedlar bags are not losing volatile samples, spiked samples of known volatile concentration will be prepared. These samples will be stored and handled in the same manner as other field samples. Spiked samples will be the first collected and last analyzed.

Selected low level samples should also be duplicated at a different time and analyzed immediately to verify that analyte loss is not occurring.

Alternatively, samples may be analyzed in the field, using either Tedlar bags or syringe samplers to collect and transport the samples to the gas chromatograph.

5.3 Note sampling times for each sample in field notebook and on sample bag (if bags are used).

5.4 No more that 4 hours should elapse between sampling and analysis 15 minutes is preferable.

6.0 References

None

STANDARD OPERATING PROCEDURE 021
SEDIMENT SAMPLING

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure is to delineate protocols for sampling sediments. Sediments include solid matter derived from rocks or biological materials which are suspended in, or settled from, water. This procedure can be applied to the collection of sediment samples from areas of deposition such as streams, rivers, ditches, lakes, ponds and lagoons. Sediment samples indicate the amount of contamination adsorbed on sediment particles and/or the amount of wastes transported from the site. It is therefore important to collect a representative sample.

2.0 MATERIAL

a. Stainless steel, Polytetrafluoroethelyne (PTFE), or PTFE-lined sampling tray or bowl
b. Stainless steel or PTFE dip sampler, scoops, trowels, spoons, ladles
c. PVC pipe, 2 in. diameter
d. Hand core sediment sampler, liners (optional) and extensions
e. Pipe dredge sampler
f. Jaw type sampler
g. Sample bottles
h. Rubber boots/waders
i. Plastic sheeting
j. Utility knife
k. Rope
l. Boat
m. PPE
n. Personal flotation devices (PFDs)

3.0 PROCEDURE

The water content of the sediment may vary greatly. Likewise, the sediments themselves may range from very soft to dense. It may be necessary to use a variety of equipment to obtain the required samples, even at a single site.

3.1 Upon arrival at the site, immediately set up and organize the equipment downstream (where applicable) from sampling point.

3.1.1 Cut a section of plastic sheet approximately 6 ft. x 6 ft. Place plastic on ground to use as a clean staging area for sampling equipment.

3.1.2 Arrange sample containers, samplers, preservatives, and decon equipment on the plastic sheet. Exercise caution not to step on, or otherwise contaminate this clean working surface.

3.1.4 Don personal protective equipment in accordance with the site safety and health plan.

3.1.5 Collect surface water sample.

3.1.6 Collect sediment sample. The preferred method of collecting sediment samples will be by hand corer (section 3.2), or PVC pipe (section 3.3). If using a scoop, trowel, spoon, or ladle, refer to section 3.5. If using a dredge sampler see section 3.4.

3.2 If using a hand corer, proceed as follows:

3.2.1 Ensure that the corers and (optional) liners are properly cleaned.

3.2.2 Force the corer into the sediment with a smooth continuous motion to a depth of approximately 9 inches.

3.2.3 Twist the corer to detach the sample; then withdraw the corer in a single smooth motion.

3.2.4 Remove top of corer and decant excess water into a 1-L sample bottle. This water sample will be labelled and analyzed as an additional unfiltered surface water sample.

3.2.5 Remove the nosepiece and deposit the sample onto a stainless steel, PTFE, or PTFE-lined tray.

3.2.6 Transfer the sample into sample containers (see 3.3.6) using a stainless steel laboratory spoon (or equivalent device). The transfer equipment may be disposable to avoid decontamination costs, and the risk of cross-contamination.

3.2.7 The top 6 inches of the core will be sampled into 3 separate containers - 2 inches per container to ensure that an accurate chronology of contamination can be determined.[26]

3.2.8 Ensure each container will be properly labeled, appropriate preservatives added (see SOP 039), and placed in cooler with ice packs.

3.2.9 Decontaminate equipment according to SOP 005.

[26] If specific data quality objectives mandate, the sample may be homogenized in bowl using sampling spoon, then samples will placed in containers, preserved (as required) and packed on ice.

3.3 **A two-inch diameter PVC pipe can be effectively used instead of a hand corer in very soft sediments as follows:**

3.3.1 Force pipe into sediment with a smooth continuous motion to a depth of approximately 9 inches

3.3.2 Cap the pipe, forming an airtight seal, to create a vacuum as it is withdrawn from the water

3.3.3 Decant excess water as in 3.2.4 above.

3.3.4 Deposit the sample onto a stainless steel or PTFE tray, and sample as in steps 3.2.5 through 3.2.7 above.

3.3.5 Decontaminate equipment according to SOP 005.

3.4 In deeper water, sampling will be accomplished from a boat.

3.4.1 **If a pipe dredge is used**, it will be thrown outward, then dragged across the bottom to collect sediment. The sampler will be emptied into a stainless steel or PTFE tray. The composite sample will be placed in the sample bottle by pouring, or through the use of a stainless steel spoon or trowel.

3.4.2 If a **jaw type bottom sampler is used**, refer to SOP 022 for details.

3.4.3 Decontaminate equipment according to SOP 005 § 3.3.2 "Solid materials samplers".

3.5 If using a scoop, trowel, spoon, or ladle, sample as follows:

3.5.1 Insert the sampling device into the material at the selected point and slowly remove the sample. Care should be taken to retain as much of the clay component as possible.

3.5.2 Transfer the sample into the appropriate container, add preservative as required in SOP 039, cap the container, and place in ice chest.

3.5.3 Decontaminate equipment according to SOP 005 § 3.3.2 "Solid materials samplers".

3.6 Refer to SOP 1-5, 16, 31, and 39.

3.7 For all samples, mark the sampling location on a site map. Photograph (optional, recommended) and describe each location, and place a numbered stake above the visible high water mark on the bank closest to the sampling location. The photographs and description must be adequate to allow the sampling station to be relocated at some future date.

3.8 Dispose of all sampling wastes in properly labelled containers.

4.0 MAINTENANCE

Not Applicable.

5.0 PRECAUTIONS

5.1 Both surface water and sediment samples are to be collected at the same location.

5.2 Take the surface water sample first (SOP 007). Sediment sampling usually results in disturbance of the sediments which may influence the analytical results of the surface water samples.

5.3 Wear gloves when collecting sediment samples. Be sure to consult the health and safety plan for the proper dermal and respiratory protection prior to collecting any samples.

5.4 Higher levels of personal protective equipment may be required by the HASP.

5.5 If sampling from a boat or near water bodies with a depth of four feet or more, the sampling team shall wear personal flotation devices (life jackets).

5.6 Collect samples first from those areas that are suspected of being the least contaminated, thus minimizing the risk of cross contamination.

5.7 Collecting sediment samples directly into sample bottles is not recommended.

6.0 REFERENCES

EPA/540/P-87/001, A Compendium of Superfund Field Operations Methods.

STANDARD OPERATING PROCEDURE 022
SEDIMENT AND BENTHIC MACROINVERTEBRATESAMPLING WITH ECKMAN GRAB

1.0 Scope and Application

This standard operating procedure covers the protocol for obtaining qualitative or quantitative samples of soft sediments and macroinvertebrates inhabiting soft sediments in lakes, reservoirs, and other water bodies. The Eckman grab sampler is well suited to collecting samples in deeper (up to 100 feet) water bodies.

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

2.0 Materials

a. Eckman grab sampler: a box-shaped device with two scoop-like jaws.
b. Boat
c. Sample containers
d. Sieve - 500 1 (U.S. std. #30)
e. Stainless steel spoon or trowel
f. Personal protective equipment (PPE)
g. Personal flotation devices (PFDs)

3.0 Procedure

3.1 Cock the sampler by raising each jaw upward into the cocked position using the attached cable and secure the cable to the catch pin located at the top of the sampler.

3.2 Once cocked, lift the sampler overboard and lower slowly but steadily to the bottom.

3.3 Once on the bottom, indicated by a slack line, the weighted messenger is sent down the line tripping the catch mechanism, causing the spring loaded jaws to close the bottom of the sampler, containing the sediment.

3.4 Raise the sample at a slow but steady rate to prevent sample loss or washout.

3.5 Once the sample is on board, empty the sample into a stainless steel, PTFE, or PTFE-lined bowl or tray for processing.

3.5.1 If the sediment will be analyzed for VOCs, transfer the sample into the appropriate sample sontainers immediately.

3.5.2 If the sediment will not be analyzed for VOCs, use Stainless steel spoon to thoroughly homogenize sample, then transfer sample into appropriate containers. Add preservative as directed in SOP 039. Place in ice-filled chest.

3.5.3 If benthic macroinvertebrates are to be collected, sieve sample and transfer macroinvertebrates into appropriate container. Preserve sample as directed in SOP 039.

3.6 Thoroughly decontaminate the device as described in SOP 005 § 3.3.2 "Solid Materials Samplers".

4.0 Maintenance

Maintain according to manufacturers suggestions.

5.0 Precautions

5.1 Inspect the device for mechanical deficiencies prior to its use.

5.2 This sampler is inefficient in waters deeper than approximately 75 to 100 feet, under adverse weather conditions, and in waters of moderate to strong currents or wave action.

5.3 Exercise caution at all times once the grab is loaded or cocked because a safety lock is not part of the standard design.

5.4 Operate the sampler from a boat with a winch and cable.

5.5 Wear gloves when collecting sediment samples. Be sure to consult the health and safety plan for the proper dermal and respiratory protection prior to collecting any samples.

5.6 Higher levels of personal protective equipment may be required by the HASP.

5.7 While sampling from a boat in water bodies with a depth of five feet or more, the sampling team shall wear personal flotation devices (life jackets).

5.8 Collect samples first from those areas that are suspected of being the least contaminated, thus minimizing the risk of cross contamination.

6.0 References

ASTM Standard 2.1. D4387 Guide for Selecting Grab Sampling Devices for Collecting Benthic Macroinvertebrates

USEPA. 1990. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters. Office of Research and Development. EPA/600/4-90/030. November, 1990.

STANDARD OPERATING PROCEDURE 023
ORGANIC VAPOR ANALYZER(FOXBORO 128 GC)

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for field operations with the organic vapor analyzer (Foxboro Model 128 GC). The organic vapor analyzer (OVA) is an intrinsically safe, flame ionization detector designed to detect and measure organic vapor concentrations by producing a response to an unknown sample, which can be related to a gas of known composition to which the instrument has previously been calibrated. This information is used to determine control measures such as protection and action levels.

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

2.0 Material

a. probe/readout assembly
b. sidepack assembly
c. tedlar bag
d. calibration gas (*e.g.* methane 90 - 100ppm)
e. fuel (zero grade hydrogen - 99.999%)
f. tygon tubing
g. regulator

3.0 Startup Procedure

3.1 Connect the Probe/Readout Assembly to the Sidepack Assembly by attaching the sample line and the electronic jack to their respective receptacles located on the side of the Sidepack.

3.2 Check the battery condition by moving the INSTRUMENT toggle switch to the "BATT." position and ensure that the meter needle is beyond the white BATTERY OK line.

3.3 Move the INSTRUMENT toggle switch to the ON position, and allow a 5 minute warm-up.

3.4 Adjust the CALIBRATION ADJUST knob to set the meter needle to the level desired for activating the audible alarm. If the alarm level is other than zero, the CALIBRATION range toggle switch must be set to the appropriate range (i.e., X1, X10, or X100).

3.5 Turn the ALARM VOLUME knob fully clockwise.

3.6 Using the ALARM LEVEL ADJUST knob (located on the back of the Probe/Readout Assembly), turn the knob until the audible alarm is activated.

3.7 Move the CALIBRATION range toggle switch to the X1 position and adjust the meter reading to zero using the CALIBRATION ADJUST knob.

3.8 Turn the PUMP toggle switch ON. Place the instrument in the vertical position. Observe the SAMPLE FLOW RATE tube. Ensure flow rate is between 1-1/2 - 2-1/2 units.

3.9 Open the H_2 TANK valve and the H_2 SUPPLY valve, wait one minute for hydrogen to purge the system.

3.10 Press the red IGNITER BUTTON (located on the side of the Sidepack Assembly) until the alarm sounds and the needle on the Probe/Readout Assembly jumps upscale. CAUTION: THE IGNITER BUTTON SHOULD NOT BE DEPRESSED FOR MORE THAN 8 SECONDS. IF FLAME DOES NOT LIGHT WITHIN 8 SECONDS, WAIT 1 MINUTE AND TRY AGAIN.

3.11 The instrument is ready for use. Use the CALIBRATION ADJUST knob to zero out ambient background organics.

4.0 SHUT DOWN PROCEDURE

4.1 Close H_2 TANK VALVE

4.2 Close H_2 SUPPLY VALVE

4.3 Move "INSTRUMENT" BATT./OFF/ON toggle switch to OFF.

4.4 Wait 5 seconds and move the "PUMP" toggle switch to OFF.

5.0 FUEL REFILLING

WARNING: THERE SHOULD BE NO POTENTIAL IGNITERS OR FLAMES IN THE AREA.

5.1 The instrument and the charger should be completely shut down prior to hydrogen tank refilling operations. Refilling should be done in a well ventilated non-hazardous area.

5.2 If this is the first filling of the instrument or if the filling hose has been allowed to fill with air, the filling hose should be purged with hydrogen prior to filling the instrument tank.

5.3 The filling hose should be left attached to the hydrogen supply tank when possible. Ensure that the FILL/BLEED valve on the instrument end of the hose is in the OFF position. Connect the hose to the refill connection on the Sidepack Assembly.

5.4 Open the hydrogen supply bottle valve slightly. Open the H_2 REFILL VALVE and the H_2 TANK VALVE on the instrument and place the FILL/BLEED valve on the filling hose assembly to the FILL position.

5.5 After the fuel tank is filled, close the H_2 REFILL VALVE on the instrument, close the FILL/BLEED valve on the refill hose, and close the valve on the hydrogen supply bottle.

5.6 The hydrogen trapped in the refill hose must now be bled off. CAUTION: THE REFILL HOSE WILL CONTAIN A SIGNIFICANT AMOUNT OF HYDROGEN AT HIGH PRESSURE. Turn the FILL/BLEED valve on the filling hose to the BLEED position. After the hose is bled down to atmospheric pressure, the FILL/BLEED valve should be turned to the FILL position to allow the hydrogen trapped in the connector fittings to move into the hose assembly. Turn the FILL/BLEED valve to the BLEED position and exhaust the trapped hydrogen. Then turn the FILL/BLEED valve to the OFF position to keep the remaining hydrogen in the hose at one atmosphere to ensure no air will be trapped in the hose for the next filling.

5.7 Close the H_2 TANK VALVE.

5.8 Observe the H_2 TANK PRESSURE meter and ensure that the pressure reading does not decrease rapidly.

6.0 CALIBRATION

Field calibration is accomplished using a single known sample of methane in air in the range of 90ppm to 100ppm. This may not provide the accuracy stated under specifications but is adequate for field survey work.

6.1 Place instrument in normal operation with the CALIBRATION range toggle switch set to X10 and the GAS SELECT KNOB SET TO 300.

6.2 Use the "CALIBRATION" ADJUST knob to adjust the meter reading to zero.

6.3 Fill a tedlar bag with methane sample of known concentration (between 90ppm and 100ppm) and connect to the OVA sample probe.

6.4 Adjust the CALIBRATION GAS SELECT KNOB until the meter reading is equivalent to the value of the gas standard.

6.5 Record in a field log book: date, time, location, instrument ID number, calibration gas and concentration, final GAS SELECT setting, and the name of the person calibrating the instrument.

7.0 BATTERYCHARGING

WARNING:NEVER CHARGE BATTERYIN A HAZARDOUS ENVIRONMENT

7.1 Insert battery charger cable into the battery pack RECHARGER receptacle. Plug battery charger into 115 VAC outlet.

7.2 Turn battery charger on.

7.3 Approximately one hour of charging is required for each hour of use. However, an overnight charge is recommended. The charger can be left on indefinitely without damage to the batteries. When finished, turn the charger off and disconnect the charger from the battery.

8.0 PRECAUTIONS

8.1 Keep battery on charger when not in use, and recharge battery as soon as possible after use.

8.2 Avoid intake of boiling vapors and liquids.

8.3 Avoid over-tightening of valves.

8.4 Use zero grade H_2 (99.999%, certified total hydrocarbons as methane < 0.5 ppm recommended).

8.5 Calibration gas mixture must be balanced in air.

8.6 Do not over tighten valves.

9.0 REFERENCES

Foxboro OVA 128 Reference Manual, December, 1985.
ICF Field Equipment Manual, November, 1988.

STANDARD OPERATING PROCEDURE 024
PHOTOIONIZATION DETECTOR (MICROTIP HL-200)

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for field operations with the photoionization detector (Microtip HL-200). The photoionization detector (PID) uses an ultraviolet emitting lamp designed to detect, measure and display the total concentration of airborne ionizable gases and vapors. This information is used to determine control measures such as protection and action levels.

Use of brand names in this SOP is in no wise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

2.0 Material

a. Microtip
b. Battery Pack
c. Calibration Gas (100ppm Isobutylene)
d. Tedlar Bag
e. Tygon Tubing
f. Regulator

3.0 Startup/Calibration Procedure

3.1 Turn the instrument on by pressing the back of the power switch located on the handle of the Microtip.

3.2 The message "Warming up now, please wait" will be displayed for up to three minutes. After normal display appears, the Microtip is ready for calibration.

3.3 Fill a tedlar bag with the desired calibration gas (usually 100ppm Isobutylene).

3.4 Press SETUP button and select the desired Cal Memory using the arrow keys (normally set to 200ppm). Press EXIT button to leave setup function.

3.5 Press CAL button and expose Microtip to Zero Gas. (Usually clean outdoor air will be suitable. If any doubt exists as to the cleanliness of the background air a commercial source of zero gas should be used.).

3.6 The Microtip then asks for the Span Gas concentration. Enter the known span gas concentration and then connect the tedlar bag containing the Span Gas.

NOTE: THE SPAN GAS CONCENTRATIONIS DEPENDENT UPON BOTH THE CONCENTRATIONOF THE SPAN GAS USED AND THE RATING OF THE UV LAMP IN THE MICROTIP AT TIME OF CALIBRATION.IF USING 100ppm ISOBUTYLENEAND THE STANDARD 10.6 eV LAMP, THE SPAN GAS CONCENTRATIONWILL BE 56ppm.

3.7 Press enter and the Microtip sets its sensitivity. Once the display reverts to normal the Microtip is calibrated and ready for use. Remove the Span Gas from the inlet probe. The instrument should be calibrated at least once a day.

4.0 Battery charging

4.1 Ensure Microtip is off.

4.2 Set the voltage selector switch on the bottom of the battery charger to the appropriate AC line voltage.

4.3 Press the release button on the bottom of the Microtip and remove the battery pack by sliding it backwards.

4.4 Plug charger into the battery pack and then into an AC outlet and allow the battery to charge for at least 8 hours.

4.5 After charging, remove the charger, *first from the outlet* then from the battery pack, and slide the battery pack back onto the Microtip.

5.0 Precautions

5.1 Microtip does not carry an Intrinsic Safety Rating and must not be used in a hazardous location where flammable concentrations of gases or vapors are constantly present.

5.2 All calibration, maintenance and servicing of this device, including battery charging, must be performed in a safe area away from hazardous locations.

5.3 Do not open or mutilate battery cells

5.4 Do not defeat proper polarity orientation between the battery pack and battery charger.

5.5 Substitution of components may affect safety rating.

6.0 References

Microtip HL-200 User's Manual, February, 1990.

STANDARD OPERATING PROCEDURE 025
SOIL SAMPLING

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for sampling surface and subsurface soils. Soil samples give an indication of the area and depth of site contamination, so a representative sample is very important.

2.0 Materials

a. Stainless steel spoon, trowel, knife, spatula, (as needed)
b. Split-spoon, Shelby tube, or core barrel sampler
c. Bucket auger or push tube sampler
d. Drill rig and associated equipment
e. Stainless steel bowl
f. PPE as required by the HASP

3.0 Procedure

3.1 Subsurface Samples

3.1.1 Don PPE. Collect split-spoon, core barrel, or Shelby Tube samples during drilling.

3.1.2 Upon opening sampler, or extruding sample, immediately screen soil for volatile organic compounds using either a PID or FID. If sampling for VOCs, determing the area of highest concentration, use a stainless steel knife, trowel or lab spatula to peel and sample this area.

3.1.3 Log the sample in field notebook in accordance with SOP 003, while it is still in the sampler.

3.1.4 Peel and transfer the remaining sample in a decontaminated stainless steel bowl. Mix thoroughly with a decontaminated stainless steel spoon or trowel.

3.1.5 Place the sample into the required number of sample jars.

3.1.6 Preserve samples as required in SOP 039.

3.1.7 Discard any remaining sample into the drums being used for collection of cuttings.

3.1.8 Decon sampling implements according to SOP 005 § 3.3.2.

3.1.9 All borings will be abandoned according to procedures in SOP 028.

NOTES: If sample recoveries are poor, it may be necessary to composite samples before placing them in jars. In this case, the procedure will be the same, except that two split-spoon samples will be mixed together. The field logbook should clearly state that the samples have been composited, which samples were composited, and why the compositing was done.

Samples taken for geotechnical analysis will be undisturbed samples, collected using a thin-walled (shelby tube) sampler.

3.2 Surficial Soil Samples

3.2.1 Don PPE. Remove vegetative mat. Collect a sample from under the vegetative mat with a stainless steel trowel, push tube sampler, or bucket auger.

3.2.2 If a representative sample is desired over the depth of a shallow hole or if several shallow samples are to be taken to represent an area, composite as follows·

3.2.2.1 As each sample is collected, place a standard volume in a stainless steel bowl.

3.2.2.2 After all samples from each hole or area are in the bucket, homogenize the sample thoroughly with a decontaminated stainless steel spoon, trowel or spatula.

3.2.3 If no compositing is to occur place sample directly into the sample jars.

3.2.4 Place the leftover soil in the auger borings and holes left by sampling. If necessary, add clean sand to bring the subsampling areas back to original grade. Replace the vegetative mat over the disturbed areas.

3.2.5 Samples for VOCs will not be composited. A separate sample will be taken from a central location of the area being composited and transferred directly from the sampler to the sample container.

3.2.6 Preserve samples as required in SOP 039.

3.2.7 Decon sampling implements according to SOP 005 § 3.3.2

3.3 Refer to SOP 1-5, and 16.

4.0 Maintenance

Not Applicable.

5.0 Precautions

5.1 Refer to the Health and Safety Plan.

5.2 Soil samples will not include vegetative matter, rocks, or pebbles, unless the latter are part of the overall soil matrix.

6.0 References

ASTM Method D1586-84, Penetration Test and Split-Barrel Sampling of Soils.

ASTM Method D1587-83, Thin Walled Sampling of Soils.

Department of the Army, Office of the Chief of Engineers, Engineer Manual 1110-2-1907 Soil Sampling, 31 March 1972

STANDARD OPERATING PROCEDURE 026
ACTIVE SOIL GAS ANALYSIS

1.0 Scope and Application

The purpose of this standard operating procedures is to describe protocols for using the Sentex Scentograph Portable Gas Chromatograph (GC) to analyze soil gas samples for volatile organic compounds. The primary method described here for introducing samples into the GC uses an absorbent tube to concentrate samples prior to analysis, although sample loop and direct injection methods may also be used. Operation of the GC should not be attempted without first reading the operation manual.

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

2.0 Material

a. Sentex Scentograph Portable GC with argon ionization detector (AID)/electron capture detector (ECD)
b. Toshiba T 1200 laptop personal computer
c. Battery charger for Scentograph GC
d. Battery charger for Toshiba PC
e. Industrial Solvents Calibration Library software and empty data disks
f. Argon (high purity) carrier gas
g. Calibration gases, as needed
h. Regulator for carrier gas
i. Regulator for calibration gas
j. Copper gas transfer tubing and fittings
k. Three 1L Tedlar bags
l. Multimeter
m. Spare analytical column
n. Spare Septa
o. Sample loop assembly and loops
p. Spare preconcentrator assembly
q. Other spare parts (e.g., tubing, swagelock fittings)
r. Syringes (1 1L, 5 1L, 10 1L, 100 1L, 1 mL, 5 mL, 50 mL
s. Syringe cleaner
t. Vacuum pump for syringe cleaner
u. Tools (Allen wrench, large adjustable wrench, small adjustable wrench, ¼" wrench, small screwdrivers)
v. Paperwork (applicable regulations and NRC license, Scentograph Operators' Manual, GC log book, table of ionization potentials)

3.0 Setup

3.1 The GC should preferably be operated in a clean environment, without significant concentrations of volatile organic compounds in the atmosphere. Batteries and internal gas canisters allow self-contained operation of up to six to eight hours, but longer continuous operation requires a 110-v power supply and external source of ultra-high-purity argon carrier gas. After each portable operation, the instrument must be recharged for at least 8 hours, preferably overnight, before resuming operations. When the instrument is not in use, it should be connected to the battery charger.

3.2 Install regulator on the carrier gas cylinder, attach ⅛" copper tubing to the outlet of the regulator and briefly purge the tubing by carefully opening the cylinder valve slightly. Connect the free end of the copper tubing with quick connector to the fitting marked carrier on the back of the GC, being careful to insert the connector straight. Open cylinder valve and carrier gas valve on GC to fill the internal tank. The maximum pressure is 1,800 psi, and severe damage can result from over pressuring the internal tanks. Repeat this process for calibration gas, connecting tubing to fitting marked calibration. Do not operate the GC if the carrier gas pressure is less than 200 psi.

3.3 Set column pressure to desired value (typically 30 psi) by adjusting carrier gas regulator inside the GC with an Allen wrench. Do not use a column pressure of less than 10 psi. After at least five minutes, turn on the PC (with Sentex software disk in A drive and blank data disk in the B drive) and set initial conditions at the operating parameters menu. For the industrial solvents calibration library, the operating conditions should be as follows:

Sample time: Adjust as needed, generally 10−20 sec.
Delay time: 0.5 sec.
Desorption time: 4.0 sec.
Inhibit time: 80 sec.
Oven temperature: 100ÆC
Chart duration: 20 min.
Analyses/calibration: Adjust as needed (used in automatic mode only)
Column: 12' 10% SP1000
Column pressure: 30 psi
Retention time window: Typically 3%
Noise threshold: Typically 50−100

Other operating conditions should be selected as needed depending on project needs if the Industrial Solvents Calibration Library is not being used.

4.0 Calibration

4.1 Using the Industrial Calibration Library software, it is only necessary to calibrate with benzene. Otherwise, calibration gases containing the compounds of interest are needed. A calibration standard near the expected sample concentration should be used.

4.2 At the operating parameters menu, name the calibration mixture, identify the peaks, and specify their concentrations. Recheck operating parameters.

4.3 Calibration gas from the internal cylinder or from an external source may be used. If using the internal tank, turn on the calibration gas valve on the rear of the GC. If an external source is used, turn off the carrier gas valve, run calibrations until the calibration gas pressure is zero, and attach the carrier gas source (at atmospheric pressure) to the calibration port on the side of the GC.

4.4 Initiate the calibration run by pressing 4 [enter] at the main menu. If using the industrial solvents calibration library, the benzene peak must be the first peak and must fall between 230 and 242 seconds. If not, make small adjustments to the temperature or column pressure and repeat.

5.0 Operation

5.1 After satisfactory calibration of the instrument, attach a Tedlar bag or similar sample container to the analysis port on the instrument and open the inlet valve on the container. Type 3 followed by a return at the main menu to initiate a sample run. If manual operation is selected after a change in operating parameters before a calibration run, the instrument will automatically start a calibration cycle before the analysis run.

5.2 The instrument will match observed peaks with those in the calibration gas and in the calibration library (if used), identify the peaks, and calculate concentrations based on peak area. Peak data as well as operating conditions are stored on a data disk in the B drive.

6.0 Quality Control

At a minimum, a quality control (GC) sample containing constituents of interest should be analyzed at the beginning and end of each batch of samples. The instrument should be calibrated before each sample batch, after any change in operation conditions, and when any changes in instrument response is noted. Duplicate samples should be analyzed every 10 to 20 samples.

7.0 Recall and Display of Results

To recall results, type 5 followed by a return at the operations menu. The analysis summary, listing trace number, analysis date, analysis time, peak identification, concentration, retention time, peak area, and sample (or calibrant) name, will be displayed. To view a particular trace, type 6 followed by a return at the operation menu, then specify the trace number.

8.0 Shutdown

After the last analysis, turn off the PC. Allow the column and detector to cool before shutting off the carrier gas supply. Turn off carrier and calibration gas valves on the back of the GC and turn off cylinder valves. Bleed excess pressure from the copper tubing and disconnect from the GC.

9.0 Precautions

The argon ionization detector uses a 150-mCi tritium source on a thin metal foil. The source is sealed in a steel cylinder. Any repairs of the detector must be made by the manufacturer. The detector housing and the sealed source must never be opened.

To prevent damage to the instrument, the following precautions must be observed:

- Do not operate the GC with less Than 200 psi carrier gas pressure.
- Do not fill the internal tanks to over 1,800 psi.
- Allow at least 5 minutes of carrier gas flow through the column before turning off the instrument.
- Do not replace the preconcentrator assembly without instructions from the manufacturer.
- Do not select a column pressure less than 10 psi or greater than 30 psi.
- Use only carrier grade argon as a carrier gas (at least 99.995%, preferably 99.999% pure). Industrial grade argon (*e.g., from a welding shop*) will cause contamination.
- Use only high purity regulators for the gas supply.
- If problems occur, call Sentex at (201) 945−3694.

STANDARD OPERATING PROCEDURE 027
PASSIVE SOIL GAS SURVEYS

1.0 Scope and Application

The steps and information herein are the "Standard Procedures" for carrying out a Petrex environmental survey. Possible deviations from standard procedures may occasionally be implemented on-site by our field staff to adjust for unique survey conditions. The Petrex Technique is also frequently used for oil and gas, geothermal, and mineral exploration which force slight variations on these "Standard Operating Procedures." Also, surveys performed in winter in frozen ground offer a unique situation and slightly different field practices.

The fact that the standard procedures may occasionally be altered is done to maintain quality service while using the Petrex Technique. It must also be understood that the ion flux data from one survey at a given site and a given time interval should not be compared to the flux numbers from another survey. Since the data is semi-quantitative, only the flux patterns of a survey or the relative difference between flux values of two samples from the same survey should be considered during interpretation.

If any questions arise upon review of this document, please address your questions to NERI technical staff at:

Northeast Research Institute, Inc.
309 Farmington Avenue. Suite A-100 Farmington. Connecticut
06032
(203) 677-9666

-or-

Northeast Research Institute, Inc. 605 Parfet Street, Suite
100, Lakewood, Colorado 80215
(303) 238-0090

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

2.0 Sample Production and Preparation

2.1 Charcoal Sieving

The static VOC (Volatile Organic Compound) collector is prepared by applying pre-sieved activated charcoal to the end of a ferromagnetic wire.

2.2 Charcoal Bonding

The details of the procedure for preparing the activated charcoal is proprietary information. The procedure results in the production of a collector consisting of size-sorted activated charcoal bonded to the area within 1 cm of the end of a ferromagnetic wire with a Curie point of 358£C.

2.3 Collector Containers

Culture tubes, measuring 25 mm x 125 mm and having a screw cap closure, are washed in a biodegradable detergent, rinsed in methanol, and baked at 180 £C for one hour.

2.4 Wire Cleaning

The previously constructed wires are cleaned by heating in a special apparatus at 358 £C a total of 35 times under high vacuum. The wires are cleaned in lots of 32 wires. From each lot, two wires are removed for immediate analysis to verify the cleanliness of the lot. The remaining 30 wires are then sealed in one clean culture tube under an inert atmosphere and placed in inventory.

2.5 Packaging for Client

Immediately prior to shipping the wires to the field, the tubes containing 30 wires are removed from inventory and the wires are repackaged under an inert atmosphere in individual tubes. All of the repackaged tubes contain two wires. Ten percent of these have three wires. The collectors are packaged by bagging in zip-seal plastic bags in an inert atmosphere. These bags are then placed in inventory in a temperature-controlled room. The basis for having two wires in each tube is that it allows NERI to analyze one wire by standard Thermal Desorption-Mass Spectrometry (TD-MS) while the second sample is available for TD-GC/MS or as a backup to the TD-MS. The third wire in selected samples from each survey is used to establish optimum instrument parameters.

2.6 Quality Control and Quality Assurance

Prior to releasing stocked wires for a field survey, two single wires from each lot are checked for cleanliness and collecting potential. This QA/QC phase measures and documents collector preparedness when leaving the laboratory. One of these wires is analyzed without exposure in order to demonstrate that the lot is clean, and the other wire is exposed to hexane vapor for two seconds and then analyzed in order to verify that the charcoal is highly adsorptive. The triplicate wires are used when the wires return from the field. These wires help determine the required machine sensitivity and act as a measure of reproducibility.

2.7 Custody Document

A "custody document" accompanies each group of collectors leaving the laboratory and remains with the group until the collectors have been exposed, analyzed, and disposed of.

3.0 Field Operations

3.1 Locating Sample Sites

Sample placement sites, usually predetermined on an accepted survey proposal, are located from a nearby, surveyable landmark using a compass and pacing or some other measuring device (e.g., pacing wheel, hip chain, or tape measure). A transit may be used for more accurate placement, but such accuracy is seldom required.

3.2 Soil Coring

Once a sample site has been established, a hole is cored to a predetermined depth (sample placement depth is held constant for a given survey). This is accomplished using a variety of tools depending on the nature of the material to be cored. The holes should be vertical and as free from debris as possible. When the sampling is performed in areas covered by asphalt or concrete, a generator-powered rotary hammer drill with a carbide-tipped bit is used to drill a 1½ inch diameter hole in the cover. A hand auger is used to remove the cuttings and road base from the hole.

3.3 Collector Placement

Immediately after the hole is cored, a collector tube is removed from the zip-seal plastic bag and the bag is resealed. The cap is then removed from the tube, and the tube is placed vertically, open end down, into the hole. The hole is then back-filled with the soil core which was removed. The cap is placed in a clean zip-seal plastic bag and stored until collector retrieval. Collectors placed under asphalt or concrete are treated the same as those in uncovered soil, except for modifications to permit easy retrieval and to avoid potential down-hole contamination from surface cuttings. To allow retrieval of these collectors, a piece of galvanized wire is twisted around the neck of the tube and run to the surface so that the sample may be recovered by pulling the retrieval wire. An aluminum plug is then placed near the top of the hole, and the remainder of the hole is plugged with quick setting hydraulic cement.

3.4 Site Identification

Each site is flagged using pin flags, spray paint or ribbon flagging, and the site location is marked and numbered on a base map. A field notebook is used to record the date, collector number, site location description, soil type, and general observations.

3.5 Exposure Time

Time calibration collectors are included as part of every survey. These are QA collectors used to monitor sample loading during the survey. These collectors are placed in an area of known or suspected contamination, and sets are retrieved and analyzed at intervals to indicate the appropriate residence time for survey samples. Separate "travel blank" collectors are also included as a QC measure in every survey. These collectors are transported along with the survey collectors but the tubes are never opened. These control collectors monitor for potential contamination during transport or placement.

3.6 Collector Retrieval

The collectors are retrieved when the time calibration collectors reveal that there has been sufficient loading of gases on the charcoal absorbent. In the field, the soil is removed until the tube is exposed. A cap is taken from the sealed zip-seal plastic bag. The Viton seal is checked to make sure it is seated inside the cap. The culture tube is removed from the hole and any dirt that is on the threads of the tube is wiped off with a clean cloth. In the event the tube is broken or cracked, the collector wire is transferred to a new tube using forceps. The tube is capped and sealed. All flagging material is retrieved.

3.7 Collector Numbering

Each tube is immediately numbered according to the scheme established in the field notes and on the base map. The collector number is written on adhesive labels which are applied to the tube cap. No two sites may have the same number.

3.8 Collector Shipment

Once the collectors have been retrieved, they are sealed in zip-seal plastic bags and then wrapped with bubble packing. Material such as styrofoam peanuts or newsprint can introduce possible contaminants to the collectors and should not be used for packaging. The collectors, field notes, base map, and chain-of-custody document are either hand carried back to NERI's analytical laboratories, or are shipped by overnight carrier service.

3.9 Decontamination

All down-hole equipment and tool parts which contact excavated soil are constructed of heavy gauge steel and have no natural or synthetic components which could absorb and retain most soil-borne organic contaminants. These tools are decontaminated between use at each sampling location by rotation through a four step cleaning process. These steps are:

a. Immersion and vigorous scrubbing in a mild solution of laboratory grade detergent until all visual accumulations of soil are removed.

b. Thorough rinsing with potable water.

c. Spray rinsing with methyl alcohol.

d. Air Dry.

All derived liquids (and sediment) are contained in dedicated disposable vessels.

4.0 Collector Analysis

4.1 Numbering Check

Upon receipt of the collectors, the number on each tube is recorded and any missing or duplicated numbers are noted. A missing number generally indicates that the collector could not be retrieved. Samples with identical numbers generally cannot be used unless their true site location can be established.

4.2 Sample Holding

A Petrex soil gas sample consists of a minute quantity of various volatile organic compounds sorbed onto a charcoal element and enclosed in a protective container with a near impervious Viton seal.

Maximum sample holding time is a function of both the chemical stability of the sorbed compounds and the integrity of the seal of the container.

It has been the experience of Northeast Research Institute, Inc. (NERI) that Petrex soil gas samples that are properly repackaged after retrieval from the field and stored under environmentally controlled conditions typically remain compositionally and quantitatively unchanged through periods of greater than four months.

All samples scheduled for analysis via Curie-point pyrolysis/mass spectrometry are analyzed within three weeks of retrieval from the field.

4.3 Instrumentation

Thermal desorption is accomplished using a Fisher radio frequency power supply and a Curie point pyrolizer designed by NERI and Extrel. The mass spectrometer used is an Extrel Spectrel quadrapole mass spectrometer. The analysis is controlled and recorded by a DEC PDP 11/23 microcomputer. Following the analysis, all data are collected and archived on a PDP 11/73 microcomputer. Data for all active jobs are stored on both of the PDP 11 computers, as well as on magnetic tape. Data for all completed jobs are stored on magnetic tape in perpetuity.

4.4 Calibration

An Extranuclear Quadrupole Spectrometer equipped with a Curie-point pyrolysis/thermal desorption inlet is used for collector analysis. Mass assignment and resolution are manually adjusted using a Perfluorotributylamine (PFTBA) standard. A linear correction, based on the known spectrum of PFTBA, is calculated. This correction is applied to a second

PFTBA spectrum. If correct mass (M/Z) values are obtained, the operator proceeds to the next turning step. If not, Step 1 is repeated until correct masses are obtained.

Peak intensity ratios are set from the major peaks in the PFTBA spectrum using the following values:

Mass (M/Z)		Spectrum Intensities
69	-	100%
131	-	25% ~5%
219	-	35% ~5%
502	-	5% ~2%

At the standard mass (M/Z = 69), PFTBA is measured at a preset sample pressure and detector voltage and compared to previous values at the same setting.

Electron energy is set to 70 electron volts and emission is set at 12 milliseconds. All other operating parameters, such as scans, scan range, mass offset are established in the computer program. These values may only be changed by the laboratory manager.

Tuning is performed at the beginning of a run, so that an individual survey is analyzed at the same set of instrument conditions. The samples are analyzed in random order.

4.5 Instrument Parameters

The instrument is operated with the following parameters.

Vacuum - $<3 \times 10^{-6}$ torr
Ionization Energy - 70.0 eV
Ionization Current - 12.0 mA
Desorption Time - 5.0 sec
Desorption Temperature - 358 ℃
Number of Scans/Sample - 30
Scan Rate - 1,250 amu/sec

4.6 Mass Spectrometer Analysis and QA/QC

Each collector wire is analyzed in random order. The entire group of survey collectors are analyzed as one run without interruption from other surveys.

The organic gases adsorbed on the carbon are thermally desorbed from the carbon, separated according to ion mass, counted, and a mass spectrum of masses from 29 to 240 is obtained.

Periodic (approximately every 20 samples) machine background analyses are performed as a QC measure to assure minimal influence from internal communication. If there are peaks that are not related to atmospheric gases, the supervisor is notified and the mass spectrometer is shut down and cleaned as necessary.

A written sample number record is kept during the analysis to prevent accidental cross numbering.

The mass spectrometer control program prompts the operator with a warning if a sample number is entered that has already been used. The operator then checks the current number, along with the disk storage location of the previously entered number, to resolve the true numbering situation.

4.7 Data Filing

The raw data file generated by the sample analysis is labeled and stored under a unique file name.

4.8 Schedule of Maintenance

1,000 Samples: Cleaning of sample introduction area, ion source, and expansion chamber by in-house technicians.

4,000 Samples: Above noted procedures plus cleaning of lenses and quadrapoles

Annually: Preventative maintenance program conducted by manufacture's service representative.

5.0 Data Interpretation and Presentation

5.1 Map Generation

The sample location maps are created by placing the field base map on a digitizing board and entering each site as an X-Y coordinate relative to an origin. The relative ion counts for each compound can then be plotted at the sample locations. Cultural and topographic features can also be digitized onto the map as reference points.

5.2 Compound Identification

The mass spectrum that is drawn for each sample is compared to a library of mass spectra derived from known volatile organic compounds. Several thousand pure compound spectra have been developed by the Bureau of Standards and are available for spectra comparison. NERI has also developed its own library of spectra through headspace analysis of pure compounds using the Petrex wires. Once a compound has been identified in this manner, the ion current or "flux"for this compound is defined as the total ion current for the "parent peak" or least interfered peak of that compound.

5.3 Relative Flux Determination

The process of determining ion currents (relative intensities) of indicator peaks is computerized. All ion current data are extracted from the original data file and are processed for identification.

The relative ion current intensity (relative intensities) of the gases that are desorbed from the collectors are matched with sample locations on a map of the survey area. These relative intensities are useful for inferring the areal extent of contamination and relative differences in the concentrations of the compounds in the soil or groundwater. This can aid in determining the location of source areas or direction of movement of contamination.

These surface collections and analyses <u>cannot</u> be used to determine the depth to the source contaminants or the precise concentration at depth.

Because compounds can be differentiated by their spectra, analyses from the carbon collectors can be used to help differentiate multiple compounds and multiple source areas within a single survey.

5.4 Data Interpretation

Once the relative intensities for a compound are mapped, the data can be contoured to reveal those areas with "hot spots" and the orientation of plume migration. All other available data, such as geologic setting, soil types, groundwater conditions, type of contaminant, site history, and other factors are taken into account as the interpreter draws his conclusions.

5.5 Additional Uses of Petrex Collectors

Some of the other uses of the Petrex Technique that are utilized in surveys are headspacing of soil and water samples and depth profiling.

5.5.1 Headspace

A headspace soil sample is analyzed by collecting approximately 25 grams of soil, which are transferred to a thermochemically cleaned headspace container. Several adsorption wires are added and the headspace container is sealed and allowed to equilibrate for up to 24 hours, depending on the level of contamination. The wires are then removed and prepared for desorption mass spectrometric analysis as described earlier. An identical process is performed for screening water samples.

5.5.2 Depth Profiling

In order to determine if the source of the soil gas signal is near surface or in a deeper vadose/saturated zone, depth profiling can be used.

At each selected location, shallow bore holes are drilling a few feet apart to depths such as 1, 2, 4, and 6 feet deep. After all the loose cuttings and carvings have been removed from the bottom of the hole, a core of soil may be taken for headspace analysis. Next, a Petrex collector is lowered into the hole and back-filled. The collectors remain in place for the same length of time as the survey wires.

Each of the sampling methods addresses a different aspect that will help indicate the nature of the VOC source. In the case of composite soil sampling, detection of VOCs during analysis implies that the VOCs are actually contained within the soil matrix. When the VOC is anthropogenic in nature, the VOC presence is indicative of soil contamination of that depth interval.

When performing an <u>in situ</u> time-integrated sampling program with Petrex collectors, the collector serves as both an extended headspace sampler relative to the soil matrix in its immediate vicinity, as well as measuring the soil gas flux though that zone during the exposure period.

Soil gas movement through the vadose zone is theorized to be a diffusion process. If the headspace data indicate that the VOC is not present in the soil matrix, then the <u>in situ</u> depth profiling collectors should show a relative increase of ion counts as the depth increases. By combining both pieces of data, the nature of the VOC source (near surface or deep vadose/saturated) can be inferred.

5.6 Data Presentation

Once the data have been compiled, interpreted, and mapped, a report is produced for the client's use. Also, the maps are printed which display the relative intensity of the compounds of the client's specifications. These reports and maps are for the client's use only, and no report or map is released to anyone else without prior written consent of the client. This confidentiality policy is never breached.

6.0 Interpretation of Petrex Maps

The policies outlined in this Standard Operating Procedure are strictly followed on each survey. It should be noted that the relative intensities for any compound at one sample location can only be compared to another location within the same survey for the same compound. Relative intensities of different compounds cannot be compared to each other. Also, the relative intensities of one survey cannot be compared to the relative intensities of any other survey, even between two surveys at different times of the year over the same site. However, the same "hot spots" and plumes should contour in the same place over multiple surveys at a given site, allowing for migration.

STANDARD OPERATING PROCEDURE 028
WELL AND BORING ABANDONMENT

1.0 Scope and Application

The purpose of this standard operating procedure is to establish the protocols by which all borings and wells will be safely abandoned. The primary objective of well abandonment is to ensure that the abandoned well or boring does not provide a conduit for the vertical migration of contamination between aquifers.

2.0 Materials

a. Drill Rig
b. Filter Pack Material
c. Pure Sodium Bentonite With no Additives (bentonite) Powder (grout)
d. Bentonite Pellets (seal)
e. Cement (Portland Type II)
f. Approved Water

3.0 Procedure

The procedures used in boring abandonment will ideally accomplish two objectives: 1) protect aquifers from cross-contamination by sealing the borehole 2) restore the strata in the borehole to nearly original conditions by selective placement of fill material.

Any casing will be pulled, drilled out, or thoroughly pierced. Using tremie pipe, grout will be placed from the bottom of the hole to within 3 feet of the ground surface, and allowed to settle for 24 hours. The remainder of the hole will be filled with concrete. The surface of the concrete will be mounded, smoothed, and inscribed with "ABD", for abandoned, any assigned well or boring designation, and the date the hole was abandoned. All boring logs, samples, completion records, and abandonment procedures will be included in the records of work on the site or cluster.

If the hole is within 15 ft. of a monitoring well in the same aquifer, or a replacement well is to be installed within 15 ft. of the well, any temporary casing will be pulled, drilled out, or thoroughly pierced. Using tremie pipe, the hole will then be back-filled with filter pack material opposite sand strata and bentonite or grout opposite substantial (2-feet or thicker) clay and silt strata. Where sand as backfill approaches the ground surface, two feet of bentonite will be placed above the sand and a 3-foot concrete plug will be placed at the surface. Otherwise, backfill materials will be placed from the bottom of the hole to within 3 feet of the ground surface. These materials will be allowed to settle for 24 hours. The remainder of the hole will be filled with concrete. The surface of the concrete will be mounded, smoothed, and inscribed with "ABD", for abandoned, any assigned well or boring designation, and the date the hole was abandoned. All boring logs, samples, completion records, and abandonment procedures will be included in the records of work on the site cluster.

If the well is not within 15 ft. of another monitoring well, or if there are no substantial, continuous sand bodies, and no replacement well is planned within 15 feet of the original well location then the hole may be grouted from the bottom to the top.

3.1 Grout

Grout used in construction will be composed by weight of:

- 20 parts cement (Portland cement, type II or V);
- 0.4 to 1 part (max.)(2-5%) bentonite; and
- 8-gallons (max.) approved water per 94-lb bag of cement.

Neither additives nor borehole cuttings will be mixed with the grout. Bentonite will be added after the required amount of cement is mixed with the water.

All grout material will be combined in an above-ground container and mechanically blended to produce a thick, lump-free mixture. The mixed grout will be recirculated through the grout pump prior to placement.

Grout placement will be performed using a commercially available grout pump and a rigid tremie pipe removal and grouting will be accomplished in stages, aquifer by aquifer, sealing the boring from the bottom to ground surface. This will be accomplished by placing a grout pipe to the bottom and pumping grout through the pipe until undiluted grout reaches the bottom of the next higher section of casing or, for the top-most section, until grout flows from the boring at ground surface. Efforts will be made to grout incrementally as the temporary casing is removed.

After 24 hours, the abandoned drilling site will be checked for grout settlement. On that day, any settlement depression will be filled with grout and rechecked 24 hours later. This process will be repeated until firm grout remains at the ground surface.

3.2 Borings

The term "Borings" as used in this SOP applies to any drilled hole made during the course of RI which is not completed as a well. This includes soil test borings, soil sampling borings, and deep stratigraphic borings. Whether completed to the planned depth or aborted for any reason prior to reaching that depth, borings will be grouted and will normally be closed within 4 hours, or within 4 hours or completion of logging of completion of logging.

3.2.1 Shallow Borings NOT Penetrating Water Table

Shallow borings made for the collection of subsurface soil samples will be abandoned by backfilling the hole with cuttings from the hole, **if and only if the**

boring does not penetrate the water table. Clean sand will be used to make up any volume not filled by the cuttings.

3.2.2 Borings Penetrating the Water Table

Shallow borings made for the collection of subsurface soil samples **which penetrate the water table** will be abandoned by grouting the hole from the bottom to the top.

3.2.3 Deep Stratigraphic Borings

Deep stratigraphic borings will normally be located in areas which, by virtue of the historical record, are presumed relatively uncontaminated. Therefore, these borings are usually over 100 feet from any sampling well locations. Any boring located within 15 feet of a proposed well location, or located directly upgradient or downgradient (on anticipated flow line) of a proposed well location will be abandoned by placing clean sand in the aquifer intervals and bentonite or grout in aquitard intervals as described above. If the boring is over 15 feet from and/or not upgradient of a proposed well location, the boring will be completely filled with grout.

3.3 Wells

The following procedure applies to wells aborted prior to completion and existing wells determined to be ineffective or otherwise in need of closure.

Prior to abandoning any developed well, MDE will be provided written notification along with an abandonment plan for that well.

If the well is within 15 ft. of another monitoring well in the same aquifer, or a replacement well is to be installed within 15 ft. of the well, casing will be pulled, drilled out, or thoroughly pierced. Using tremie pipe, the hole will then be back-filled with filter pack material opposite sand strata and bentonite or grout opposite substantial (2-feet or thicker) clay and silt strata. Where sand as backfill approaches the ground surface, two feet of bentonite will be placed above the sand and below the concrete plug near the surface. Backfill materials will be placed from the bottom of the hole to within 3 feet of the ground surface. These materials will be allowed to settle for 24 hours. The remainder of the hole will be filled with concrete. The surface of the concrete will be mounded, smoothed, and inscribed with "ABD", for abandoned, any assigned well or boring designation, and the date the hole was abandoned. All boring logs, samples, completion records, and abandonment procedures will be included in the records of work on the site cluster.

If the well is not within 15 ft. of another monitoring well, and is not to be replaced by another well within 15 ft. of the original location, casing will be pulled, drilled out, or thoroughly pierced. Using tremie pipe, grout will be placed from the bottom of the hole to within 3 feet of the ground surface, and allowed to settle for 24 hours. The remainder of the hole will be filled with concrete. The surface of the concrete will be mounded, smoothed, and inscribed with "ABD", for abandoned, any assigned well or boring designation, and the date the hole was abandoned. All boring logs, samples, completion records, and abandonment procedures will be included in the records of work on the site cluster.

5.0 Replacement Wells

Replacement wells (if any) will normally be offset at least 15 feet from any abandoned well in a presumed up- or cross-gradient ground-water direction. Site-specific conditions may necessitate variation to this placement.

6.0 Precautions

None.

7.0 References

COMAR 26.04.04 Regulation of Water Supply, Sewage Disposal, and Solid Waste § .11 Abandonment Standards

STANDARD OPERATING PROCEDURE 029
EXTRACTION WELLS

1.0 Purpose

The purpose of this standard operating procedure is to delineate the protocol to be used in installing wells which will be used for ground-water extraction rather than monitoring. Examples of such uses are pump tests, water supply wells, and wells used in pump-and-treat remediation systems.

2.0 Materials

2.1 Drilling Equipment

a. Appropriately sized drill adequately equipped with augers, bits, drill stem, etc.
b. Steam cleaner and water obtained from approved source for decontaminating drilling equipment.
c. PID: Microtip HL-200 (or equivalent)
d. Water level indicator
e. Weighted steel tape measure
f. LEL-Oxygen monitor
g. Steel drums for intrusion derived wastes (drill cuttings, contaminated PPE, decon solutions, etc.)
h. Source of approved water
i. Heavy plastic sheeting
j. Sorbent pads and/or logs

2.2 Well Installation [27]

a. Well screen: [28]

PVC: JOHNSON (or equivalent); PVC Vee Wire Continuous slot, wire wrapped screen; SCH 40; flush-threaded (leak-proof) joints; PVC complies with ASTM D2665, ASTM D1784, and ASTM F480; free of ink markings; cleaned and prepackaged by manufacturer

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[27] Technical information on all installed materials (screens, riser pipe, filter pack, bentonite, cement, etc.) and representative samples of the proposed filter pack, bentonite powder, and bentonite pellets will be supplied to the Contracting Officer's Representative (COR).

[28] Well screen slot size and filter pack gradation will be determined on case by case basis. Material type will be determined based on field tests of groundwater chemistry and contaminants, as well as planned rehabilitation technique(s) (e.g. acid wash or oxidizer to eliminate Fe slimes, etc.).

Stainless Steel: JOHNSON (or equivalent); stainless steel Vee-Wire Continuous slot, wire wrapped screen; 304 stainless steel; ASTM F480 flush threads; cleaned, wrapped, and heat sealed by manufacturer.

b. Riser pipe:

PVC: JOHNSON (or equivalent); std. PVC; SCH 40; flush-threaded (leak-proof) joints; PVC complies with ASTM D2665, ASTM D1784, and ASTM F480; free of ink markings; cleaned and pre-packaged by manufacturer

Stainless Steel: JOHNSON (or equivalent); SCH 5; 304 stainless steel; ASTM type A312 material; 4-inch diam.; cleaned, wrapped and heat sealed by manufacturer.

c. Plugs/Caps: JOHNSON (or equivalent); standard PVC or stainless steel
d. Filter pack: MORIE, #00 well gravel (or equivalent) Note: final gradation may vary as a function of the gradation of the formation (see footnote 2)
e. Fine Ottawa sand
f. Bentonite seal: BAROID, bentonite pellets (3/8-inch diam.)
g. Cement: Type II Portland Cement [29]
h. Bentonite powder: BAROID, Aquagel Gold Seal
i. Steel Protective Casing: BRAINARD-KILMAN (or equivalent) zinc-plated steel, lockable
j. Geotextile: MIRAFI (or equivalent); GTF 130; non-woven; 4 oz.
k. Coarse (blanket) gravel: Crushed stone aggregate
l. Containers for purged water, as required.
m. Submersible pump or bailer of appropriate capacity, and surge block sized to fit well
n. Hach DREL 2000 portable laboratory (or equivalent)
o. Conductivity, pH, ORD, turbidity, dissolved oxygen, and temperature meters
p. Electric well sounder and measuring tape.
q. Portland Type II cement

2.3 Documentation

a. Copy of appropriate Cluster Work Plan
b. Copy of Appendix A of the Generic Work Plan
c. Copy of approved Health And Safety Plan
d. Copies of well and excavation permits
e. Copies of SOPs 3, 5, 8-12, 19(this SOP), 23, 24, and 28
f. Boring log forms
g. Well completion diagram form

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[29] If ground-water sulfate content is greater than 1500ppm, Type V cement is required for greater sulfate resistance.

h. Well development form

2.4 **Geologist's personal equipment**

a. 10X handlens
b. Unified Soil Classification System chart
c. Munsell color chart
d. Sieve set (Keck model SS-81 or equivalent)
e. PPE as required by HASP

3.0 Procedure

3.1 Materials Approval

3.1.1 Water sources for drilling, grouting, sealing, filter placement, well installation, and equipment decontamination must be approved by the COR prior to arrival of the drilling equipment. Information required for the water source includes: water source, manufacturer/owner, address and telephone number, type of treatment and filtration prior to tap, time of access, cost per gallon (if applicable), dates and results associated with all available chemical analyses over the past two years, and the name and address of the analytical laboratory (if applicable).

3.1.2 Pure sodium bentonite with no additives (bentonite) will be the only drilling fluid additive allowed, and its use must be approved by the COR prior to the arrival of the drilling equipment. The information required for evaluation includes: brand name, manufacturer, manufacturer's address and telephone number, product description, and intended use for the product.

3.1.3 Granular Filter Pack material must be approved by the COR prior to drilling. A one-pint representative sample must be supplied to the COR. Information required includes: lithology, grain size distribution, brand name, source, processing method, and slot size of intended screen.

3.1.4 Portland Type II cement will be used for grout (see previous footnote).

3.2 Drilling

3.2.1 The objective of the selected drilling technique is to ensure that the drilling method provides representative data while minimizing subsurface contamination, cross contamination, and drilling costs. The drilling method used will be hollow stem auger or water/mud rotary. No other methods will be considered as available without approval of EPA. The method used at a specific site will be proposed in the work plan and evaluated by the COR.

3.2.2 A Site Geologist will be present during all well drilling and installation activities and will fully characterize all tasks performed in support of these activities into the monitoring well logbook. The Site Geologist will be responsible at only one operating rig for the logging of samples, monitoring of drilling operations, recording of water losses/gains and groundwater data, preparing the boring logs and well diagrams, and recording the well installation procedures of the rig. The Site Geologist will have onsite sufficient equipment in operable condition to perform efficiently his/her duties as outlined in the Generic Work Plan (GWP) and other contractual documents. Items in the possession of each Site Geologist will include, copies of Appendix A of the GWP, the approved HASP, this SOP, a hand lens (10X), a standard color chart, grain-size chart, and a weighted (with steel or iron) steel tape long enough to measure the deepest well, heavy enough to reach that depth, and small enough to fit readily within the annulus between the well and drill casing. The Site Geologist will also have onsite, a water level measuring device, preferably electrical.

3.2.3 No lubricants will be used on downhole drilling equipment. Additives containing either lead or copper will not be allowed. In addition, polychlorinated biphenyls will not be contained in hydraulic fluids or other fluids used in the drilling rig, pumps, or other field equipment and vehicles.

3.2.4 Surface runoff or other fluids will not be allowed to enter any boring or well during or after drilling/construction.

3.2.5 Antifreeze used to keep equipment from freezing will not contain rust inhibitors and sealants. Antifreeze is prohibited in an areas in contact with drilling fluid. The ground surface at the wellsite will be protected from possible coolant, fuel, and hydraulic fluid spills and/or leakage by placement of plastic sheeting with raised edges, draining into a lined catch basin large enough to contain spills and/or leakage from motors, radiators, or vehicle tanks. Sorbent pillows will be placed to catch obvious leaks from the drill rig. Sorbent logs may be used instead of, or in conjunction with a lined catch basin to contain spills.

3.2.6 An accurate measurement of the water level will be made upon encountering water in the borehole and later upon stabilization. Levels will be periodically checked throughout the course of drilling. Any unusual change in the water level in the hole such as a sudden rise of a few inches indicating artesian pressure in a confined aquifer will be noted. Appropriate action will be taken as required in the work plan for that well. Particular attention for such water-level changes will be given after penetrating any clay or silt bed, regardless of thickness, which has the potential to act as a confining layer.

3.3 Well Construction and Installation

After the hole is drilled and logged, backfill hole as required for proper screen placement.

3.3.1 Well screen and casing should be inert with respect to the ground water; therefore, the selection of screen and casing material will be based on select field tests of aquifer chemistry and potential contaminants. Screen slot size will be determined by sieve analysis of formational material. The screen will be capped without sediment trap or DNAPL sampling cup, and lowered into the hole. The well casing will be pre-cut to extend 2 to 2.5 ft above the ground surface. Prior to placement of the last piece of well casing, a notch or other permanent reference point will be cut, filed, or scribed into the top edge of the casing.

3.3.2 Filter pack material will be tremied into place, lightly tamped, and leveled. Filter pack will extend from the bottom of the hole to a height of 1 ft above the top of the screen. The filter pack will be capped with 1 ft of fine (Ottawa) sand to prevent the bentonite seal from infiltrating the filter pack.

4.0 Maintenance

Not Applicable.

5.0 Precautions

Not Applicable.

6.0 References

COMAR 26.04.04 Regulation of Water Supply, Sewage Disposal, and Solid Waste § .11 Abandonment Standards

STANDARD OPERATING PROCEDURE 030
RADIOACTIVITY SURVEYS

1.0 Scope and Application

This protocol is developed to serve as guidance to personnel performing radiological environmental surveys of surface soil, water bodies, or other environmental media which may be potentially contaminated with alpha, beta and beta- gamma radioisotopes.

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

The following assumptions will be made:

1. Radiological contamination is present at the site.

2. All radioisotopes are present, unless historical documentation is available to help identify the specific radioisotope(s) present.

3. A potential health hazard exists from external and internal radiation exposure until instrumentation survey data and appropriate environmental samples indicate otherwise.

2.0 Material

a. Eberline Model PAC-1SAG survey meter mated with an alpha scintillation detector (or equivalent)

b. Eberline Model E-520 survey meter (or equivalent), mated with a HP-210 hand held detector (or equivalent)

c. Eberline Smart Portable (ESP-2) survey meter (or equivalent) mated with a SPA-3 low energy gamma scintillation detector (or equivalent)

3.0 Survey Procedures

3.1 Survey Site Preparation.

3.1.1 All survey instrumentation and sampling equipment will remain outside the potentially contaminated area until the boundaries of the contaminated site can be established. Upon establishing the contaminated boundaries, entry and exit routes will be designated for ingress and egress into the area. Cold and hot lines should be established to control the spread of potential radiological contamination from hot to cold areas.

3.1.2 A cartesian grid (X-Y) of the survey site will be developed. The Project Officer in charge of the survey will develop a specific methodology to accomplish this framework. The grid pattern should also be usable in locating sampling points for clean-up and in reproducing the sampling data. The grid of the survey site should be used in planning for the collection of other environmental samples from the site. UTM coordinates are preferred but not mandated.

3.1.3 The Project Officer in charge should note the following observations:

- Any standing water on the survey site

- Water run-off areas and where the run-off water is leading to i.e., streams, lakes, marshes, etc. these areas must be considered during the pathway analysis

- A pathway analysis will be performed to assist in determining the number and type of environmental samples needed to assess the potential health hazard.

3.2 Instrumentation survey.

3.2.1 Calibration and Operational Checks.

(a) All portable survey meters will be calibrated at quarterly intervals. All Instruments will be properly labeled with the calibration date posted on the label.

(b) All portable survey meters will be checked for operability prior to packing and shipping the instruments to the survey site. The operability check will consist of checking the operation of the survey meter with an appropriate radiation check source at a known distance from the instrument detector. The reading will be documented on the quality control form for each instrument and will be included in the instrumentation shipping kit.

(c) The operability check will be repeated at the survey site prior to starting the instrumentation survey, and periodically during the survey. The instrument readings will be recorded on the quality control form for each instrument.

3.2.2 Background radiation levels will be determined prior to entering the survey site.

3.2.3 An alpha instrumentation survey will be performed with an Eberline Model PAC-1SAG survey meter mated with an alpha scintillation detector (or equivalent). All alpha instrumentation readings will be taken at approximately 1 centimeter from the surface of the test media. All results will be recorded in disintegrations per minute (dpm).

3.2.4 A beta instrumentation survey will be performed with an Eberline Model E-520 survey meter (or equivalent), mated with a HP-210 hand held detector (or equivalent). All results will be recorded in millirad per hour (mrad/hr). All readings will be taken approximately 1 centimeter from the surface of the test media.

3.2.5 A beta-gamma instrumentation survey will be performed with an Eberline Smart Portable (ESP-2) survey meter (or equivalent) mated with a SPA-3 low energy gamma scintillation detector (or equivalent). All beta-gamma measurements will be taken at approximately 1 meter from the surface of the test media. The results will be recorded in microrads per hour and the distance at which the measurement was taken will be documented.

3.3 Surface Soil Sample Survey.

3.3.1 The Project Officer will evaluate the need to collect soil samples. Soil samples may be needed to assess projected airborne contamination during remedial clean-up or when vehicles and personnel transverse the contaminated site. The Project Officer will design a soil sampling plan to adequately assess potential health risks from low level contamination in soil. The grid developed for the instrumentation survey could be used to assist in determining the soil sample collection points.

3.3.2 Background soil samples should be collected from areas outside of the potentially contaminated area. Background sample data could be used to compare natural occurring radioisotopes in the natural surroundings versus what is present in the contaminated site.

3.3.3 Soil samples will be collected, labeiled and preserved as detailed in SOP 025 "Soil Sampling". Soil sample numbers will incorporate grid coordinates so that each can be readily identified and tracked back to the collection point.

3.4 Water Samples Surveys.

3.4.1 The Project Officer will evaluate the need to assess the potential contamination in the water bodies surrounding the contaminated survey site.

3.4.2 A water sampling plan will be designed to accomplish this task. Sampling will be accomplished according to protocols established in SOP 007 "Surface Water Sampling Procedures"

3.4.3 Background water samples should be collected from tap water sources in the near-by areas, and any other water bodies that could provide background data comparison to the potentially contaminated water site.

3.4.4 Water samples may be treated with Nitric Acid to prevent the plating of radiological materials to walls of the sample containers. Use of preservative is dictated specifically by the method and/or laboratory used for analysis (refer to work plan or QAPjP).

3.4.5 All sample containers should be labelled and packaged to assist in tracking management and to prevent leaking and spills.

3.5 Other Environmental Surveys.

3.5.1 The Project Officer will evaluate the need to assess the potential contamination in other environmental media such as air samples, vegetation samples, animal samples, etc.

3.5.2 A sampling plan and assessment methodologies will be developed for site specific environmental assessment.

3.6 Refer to SOP 3 and 16.

4.0 Maintenance

Refer to manufacturer's manuals for calibration and maintenance of instruments.

5.0 Precautions

NOTE: For purpose of this protocol, the soil surface is defined as the top 1-15 centimeter of soil.

6.0 References

Krey, Phillip W. (Acting Director) and Beck, Harold L. (Acting Deputy Director). 1990. EML Procedures Manual 27th Edition, Volume 1 (HASL-300), Chieco, Nancy A. *et al.* eds, Environmental Measurements Laboratory, U.S. Department of Energy

STANDARD OPERATING PROCEDURE 031
SAMPLE CONTAINER CLEANING

1.0 Scope and Application

The purpose of this standard operating procedure is to define laboratory protocols to be used in cleaning and preparing containers used to collect environmental samples.[30]

2.0 Materials

a. Polyethylene bottles
b. Amber glass bottles
c. 40 ml vials
d. Bottle caps
e. Polytetrafluoroethelyne (PTFE) liners
f. 5% NaOH
g. 5% Ultrex HNO_3
h. Deionized water
i. Alconox detergent
j. Hexane (Nanograde or equivalent)
k. Acetone
l. Methelyne Chloride

3.0 Procedures

3.1 Polyethylene bottles

3.1.1 Rinse bottles and lids sequentially with 5% NaOH, with deionized water, with 5% Ultrex nitric acid, and with deionized water.

3.1.2 Drain and allow to air dry.

3.2 Amber glass bottles and 40 ml vials

3.2.1 Wash bottles in detergent and rinse with copious amounts of distilled water.

3.2.2 Rinse with acetone

3.2.3 Rinse with methelyne chloride

3.2.4 Rinse with hexane

[30] This SOP is included for completeness only. It is anticipated that sample containers will either be provided by the laboratory, or that the sampling contractor will purchase new, certified clean sample containers.

3.2.5 Allow bottles to air dry.

3.2.6 Place bottles in a drying oven and heat to 200°C.

3.2.7 Allow bottles to cool prior to sealing with clean caps and PTFE liners.

3.3 Bottle Caps

3.3.1 If applicable, remove paper liners from caps.

3.3.2 Wash caps with detergent, followed by a distilled water rinse.

3.3.3 Dry caps in drying oven at 40°C.

3.4 PTFE liners

3.4.1 Always handle liners with forceps or tweezers, never use fingers.

3.4.2 Wash liners with detergent, followed by distilled water rinse.

3.4.3 Rinse the liners with acetone, followed by hexane (Nanograde or equivalent).

3.4.4 Allow liners to air dry prior to placing in clean caps, then heat liner and caps in drying oven at 40°C for 2 hours.

3.4.5 Allow caps and liners to cool prior to placing on clean bottles.

3.5 A statistically representative number of randomly selected clean sample containers shall be analyzed for TAL/TCL analytes (GWP Tables 8.2 - 8.5). Results of these analyses shall be provided to the contracting officer's representative (COR).

4.0 Maintenance

Not Applicable.

5.0 Precautions

None.

6.0 References

None

STANDARD OPERATING PROCEDURE 032
DRIVE-POINT PIEZOMETER INSTALLATION

SOP being drafted

July, 1993

STANDARD OPERATING PROCEDURE 033
SLUG TESTS

1.0 Scope and Application

A slug test is conducted to determine the characteristics of a confined aquifer in soil materials where the conductivity is too small to conduct a pumping test.

2.0 Materials

Test Conducted with Inert Cylinder

a. Transducer or other water level indicator
b. Logbook
c. Semilogarithmic paper-arithmetic vertical scale and logarithmic horizontal scale
d. Inert, negatively buoyant cylinder of known volume

Test Conducted with Input/Output of Water

a. Teflon bailer with teflon-coated stainless steel leader and rope or pump.
b. Logbook
c. Semilogarithmic paper
d. Transducer or other water level indicator

Note: All well intrusive equipment must be decontaminated prior to and after use, as is indicated in SOP 005.

3.0 Procedure

The slug test is conducted by measuring the response of a well to either a raising or a lowering of the water table. Two methods are commonly employed, insertion of an inert object or the addition/removal of water. The insertion of an object gives an instantaneous water level change, thereby providing a more accurate test than is obtained by adding or bailing water.

3.1 OPTION 1 - INERT OBJECT INSERTION

3.1.1 Select an appropriate transducer for the range of water level change anticipated in the slug test.

3.1.2 Submerge the transducer in the well to a suffcient depth to provide effective performance. The range of the transducer must be considered in the determination of the submersion depth. Well bottom sediment plugging of the transducer must be avoided as well as transducer interference by the inert object.

3.1.3 Measure the water level (background) for 24 hours.

3.1.4 Lower an inert object into the well to displace the water and thereby raise the water level. The inert object may be a retrievable sealed PVC cylinder filled with sand or similar material. All intrusive equipment must be decontaminated as is described in SOP 005.

3.1.5 Record the water level response during cylinder emplacement and record the water level response (falling) with the cylinder in place. This is called the falling head slug test.

3.1.6 Once the water level has stabilized, the cylinder is removed and the rising head slug test is conducted by measuring the response of the water level to the removal of the cylinder.

3.2 OPTION 2 - ADDING OR REMOVING WATER

3.2.1 Select an appropriate transducer for the range of water level change anticipated in *the slug test.*

3.2.2 Submerge the transducer in the well to a sufficient depth to provide effective performance. The range of the transducer must be considered in selection of the submersion depth. Well bottom sediment plugging of the transducer must be avoided.

3.2.3 Measure the water level background for 24 hours before initiating the water addition/extraction test.

3.2.4 Water levels and water volumes extracted/added are recorded during the entire test.

3.2.5 Water addition/extraction is continued until a condition of water table level equilibrium is reached. At equilibrium the rate of addition/extraction equals the well recharge rate and the recharge/drawdown remains constant.

3.2.6 Water addition/withdrawal is then stopped and the response of the water level is continuously monitored and readings recorded.

NOTE: If removing water from a well, the water must be containerized for testing and if necessary, properly disposed of. If adding water to the well, the water should be from a non-chlorinated approved water source.

4.0 Interpretation

4.1 The field data are used in a mathematical analysis to determine the hydraulic condition in the well. Hydraulic conductivity, transmissivity, and the storage coefficient of the well can be determined from either the falling or rising head test. The coefficient of storage is the volume of water released from storage, per unit of aquifer storage area per unit change in head. The slug test may also be used to determine specific capacity; yield per unit of drawdown, expressed as gallons of water per minute per foot of drawdown (metric: cubic meters per day per meter).

5.0 Field Data Records

5.1 Logbook

5.1.1 Only one site or installation per logbook, and only one slug test per data table (see below).

5.1.2 The first page must include the well number, location, date of test, persons conducting the test, and reference plane for drawdown measurements.

5.1.3 Next page(s) must be table format with the columns designating time/date, water volume withdrawn/added or displaced by inert cylinder, water levels, etc.

5.1.4 Test data must be entered in a table as data are acquired. Data must include sufficient information to indicate that the water level was stable before the test, during equilibrium and after the test(s).

5.1.5 Further information on the logbook can be obtained from SOP 003.

6.0 Well Parameters, Data Logging and Plotting Procedures

6.1 Figure 1 (H. H. Cooper, et al., 1967) gives the definition and relationships of a confined aquifer well in which a volume of water has been displaced or added. The parameters need to be known to determine all formational characteristics listed in section 3.1 (above).

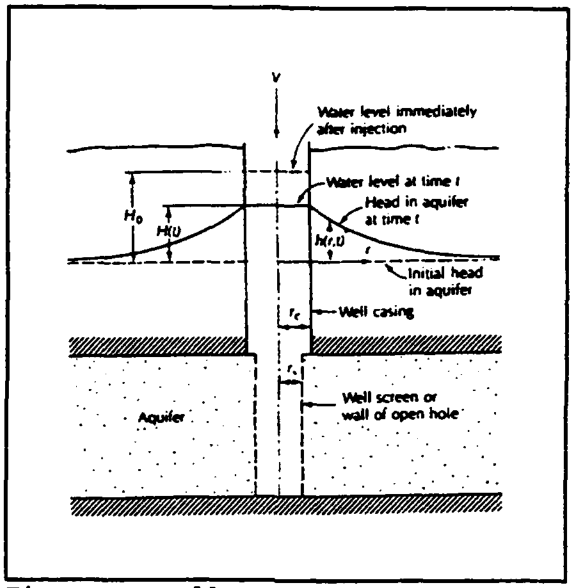

Figure 2 Well Parameters

6.2 Data logging and plotting procedures

6.2.1 Record the water level in the well immediately after the inert object emplacement/withdrawal (option 1) or at the equilibrium of the water table (option 2). This is the initial water level reading.

6.2.2 Following the initial water level reading, the water level in the well is continuously recorded along with the time of the level measurement.

6.2.3 The ratio of the initial water level to the change in head are plotted with respect to time.

6.2.4 The ratio is plotted on the arithmetic scale and time is plotted along the logarithmic scale.

6.2.5 The relationships of the initial water level to changes in the water level are a function of parameters shown in Figure 1 and the formation transmissivity. The values of the function relationship are plotted for a series of transmissivities and are depicted in Figure 2.

6.2.6 The resulting field data plot (curve) is compared to a series of type curves (Figure 2). The field-data curve is placed over the type curves with the arithmetic axis coincident. The field data curve is matched to the type curve that has the same curvature.

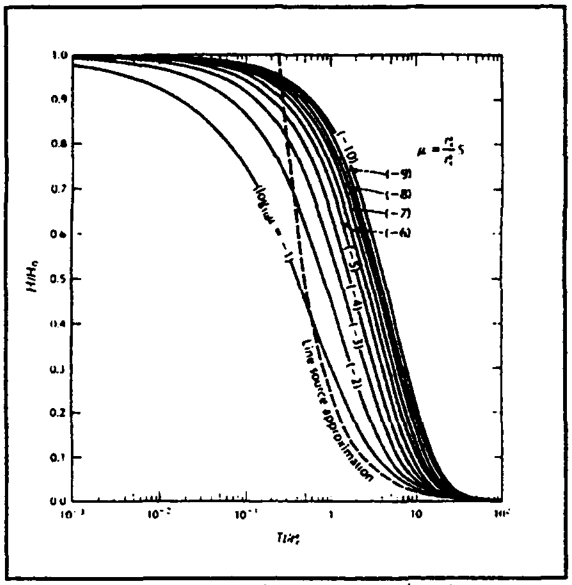

Figure 3 Transmissivity / Time Function Curves

6.2.7 The formation transmissivity is determined.

6.2.8 The value of storativity is calculated.

7.0 Maintenance

7.1 The transducers must be kept clean, operable, and thoroughly tested before emplacement in the well. A plugged or malfunctioning piezometer will give erroneous responses or fail to give any response.

8.0 Precautions

8.1 The well must be cased above the aquifer.

8.2 The well must penetrate the entire aquifer.

8.3 The well must be an open hole or be screened.

9.0 References

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite Diameter Well to an Instantaneous Charge of Water, Water Resources Research, 3, pages 263-269.

Driscoll, F. G., 1986. Groundwater and Wells, Johnson Division, St. Paul, Minnesota 55112.

Fetter, C. W. Jr. 1980. Applied Hydrogeology, C. E. Merrill Publishing Company, Columbus, OH 43216.

STANDARD OPERATING PROCEDURE 034
"ORPHAN OR UNCLAIMED" WELLS

1.0 Scope and Application

The purpose of this standard operating procedure is to provide a plan of action for protecting, evaluating, and redeveloping, or abandoning "orphan or unclaimed" wells discovered during RI field investigations.

2.0 Material

a. Field Notebook
b. Padlock
c. Duct tape

3.0 Procedure

Upon discovering an "unclaimed" or "orphaned" well, the following steps should be taken to preserve the integrity of the well, prevent contamination to the aquifer, and determine the history of the well.

3.1 Note any markings, or features of the "well" such as type of casing, amount of stickup, presence or absence of protective casing, presence or absence of cap, etc. in the field notebook (see also SOP 003).

3.2 Accurately locate the well on map, air photo, or in field notebook by direction and distance from landmarks. This will ensure that the well can be located again (see also SOP 003).

3.3 The well will be immediately secured from easy intrusion as follows:

3.3.1 If protective casing is in place, make sure it is locked.

3.3.2 If a lock is in place, no further immediate action is necessary.

3.3.3 If no lock is in place, and the hasp is in working order, procure a lock and secure the well as soon as possible.

3.3.4 If the hasp is missing or broken, or if the protective casing is missing, secure the well by taping it shut.

3.4 Notify within 24 hours orally or by facsimile:

a - Project manager
b - Appropriate APG project manager(s)

c - Maryland Department of the Environment - appropriate study area manager
d - EPA Remedial Project Manager

3.5 Begin to research all available documentation to attempt to determine the history of the well no later than the next working day.

3.6 No later than 1 week later. Return to the well with a water level indicator or weighted tape measure and appropriate decon materials (see SOPs 003, 005, 010, and 016) to determine the depth of the well, whether the well does or does not have water in it, and the water level.

3.7 If the well is appropriately located, (*e.g.* use of that well would contribute to attaining site data objectives either as a sampling well or as a piezometer) and its surface casings appear intact, initiate procedures to evaluate whether the well construction is adequate for environmental sampling. This evaluation should include a thorough records search to determine well construction and downhole geophysics to determine grout, screen, and casing integrity. This evaluation may also include a downhole video camera survey to verify screen and casing type and condition.

3.8 If it is desirable to use the well, **and** the well is appropriately constructed, **and** downhole geophysics indicate that the casing, screen, and grout are intact, then re-development proceedings pursuant to Section 6.12 of the GWP may be initiated. Otherwise initiate abandonment procedures (appendix A 1.12.2 of the GWP and SOP 028)

4.0 Maintenance

Not Applicable.

5.0 Precautions

Not Applicable.

6.0 References

COMAR 26.04.04.11 "Abandonment Standards"

STANDARD OPERATING PROCEDURE 035
AGENT SCREENING

*** SOP currently being drafted ***

July, 1993

STANDARD OPERATING PROCEDURE 036
TURBIDITY MEASUREMENTS (DRT 100)

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure is to delineate protocols for measuring the turbidity of all types of aqueous solutions, including drinking water, saline water, and industrial and domestic wastes. Turbidity is an indication of the optical properties that cause light to be scattered or absorbed through an aqueous sample. Turbidity is largely a function of the refractive index and the size and shape of the particles suspended or dissolved in the solution. Turbidity meters do not produce an "absolute" measurement, but one that is "relative" to the optical nature of the solids in solution.

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

2.0 MATERIAL

a. Turbidity meter (DRT 100 or equivalent)
b. Lint free laboratory wipes (Kimwipes or equivalent)
c. Formazin standards (from manufacturer)
d. Sample bottle
e. Cuvettes

3.0 PROCEDURE

3.1 Calibration of the turbidity meter will be checked on a daily basis as follows.

3.1.1 Set the range switch to 1000 range before turning the turbidity meter on and whenever the light shield is not in place over the sample well.

3.1.2 Allow the turbidity meter 15 to 60 minutes to warm-up.

3.1.3 Clean the reference standard with kimwipes.

3.1.4 Place the formazin suspension or reference standard in the turbidity meter sample well.

3.1.5 Place the light shield over the reference standard.

3.1.6 Rotate the front panel range switch counterclockwise to the appropriate NTU range.

3.1.7 Adjust the reference adjust knob counterclockwise to read the same value as the reference standard value. This value is stamped on top of the reference standard.

3.1.8 The turbidity meter is now standardized on all ranges to the factory formazin calibration and unknown samples may be read directly in NTU, FTU, or JTU.

3.1.9 Rotate the range switch clockwise to the 1000 range before removing the reference standard.

3.1.10 Record reading in Field Logbook. (Refer to SOPs 003, and 016.)

3.1.11 Do not leave the reference standard in the sample well for long periods.

3.2 Turbidity will be measured as follows.

3.2.1 Pour aqueous sample into a new cuvette assuring no air bubbles.

3.2.2 Place the cuvette into the sample well.

3.2.3 Place the light shield over the sample.

3.2.4 Rotate the range switch counterclockwise to the range which provides best readability and sensitivity for the sample being measured.

3.2.5 Allow the turbidity meter to stabilize before recording the NTU value.

3.2.6 Turn the range switch clockwise to the 1000 range and then remove the sample.

3.2.7 Do not leave the filled cuvette in the sample well for long periods.

3.2.8 Repeat steps 3.2.1 - 3.2.7 for additional samples.

3.3 Cuvette cleaning procedure is as follows.

3.3.1 Cuvette must be clean and free of rubs or scratches.

3.3.2 Wash the cuvette in a detergent solution.

3.3.3 Rinse thoroughly 8-10 times, preferably with distilled water to remove all streaks.

3.3.4 Polish with kimwipes.

3.3.5 Cuvettes must be stored in a clean dust-free environment.

4.0 MAINTENANCE

4.1 Source Lamp may be replaced as follows.

4.1.1 Remove the instrument case per manufacturer instruction.

4.1.2 Remove the bulb by loosening a screw and removing the electrical leads.

4.1.3 Insert the new bulb and reconnect the electrical leads.

4.1.4 Before tightening the screw, be sure to position the filament so that it will be parallel to the axis of the sample well.

4.1.5 Insert the lamp alignment tool in the sample well to focus the new bulb.

4.1.6 Move the lamp bracket assembly in or out until a focused image of the filament is within the rectangular box on the lamp alignment tool.

4.1.7 Once the filament image has been aligned and focused within the rectangular box on the lamp adjustment tool, tighten all screws snugly.

4.1.8 Replace the instrument case

5.0 PRECAUTION

5.1 Handle the reference standard or sample cuvettes by the top to prevent surface scratches or finger smudges which will cause analysis errors.

5.2 Check the mechanical meter zero when the instrument is in a vertical position and the power switch is off. Adjust to zero only if necessary by means of the black screw on the meter face.

5.3 The turbidity meter should be left on for the entire work shift to minimize warm-up and recalibration delays.

5.4 Do not leave the reference standard or filled cuvette in the sample well for long periods.

5.5 Leave the light shield in place on the instrument when it is not in use in order to protect the sample well for long periods.

5.6 Always set the range switch to 1000 range before turning the instrument on and whenever the light shield is not in place over the well.

6.0 REFERENCES

Manufacturer's Manual

STANDARD OPERATING PROCEDURE 037
DISSOLVED OXYGEN MEASUREMENTS (YSI Model 57)

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for measuring the dissolved oxygen (DO) of all types of aqueous solutions, including drinking water, saline water, and industrial and domestic wastes. DO is a measurement of the amount of soluble oxygen in an aqueous solution. It is a general indication of an aerobic/anaerobic condition of a water sample.

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

2.0 Material

a. DO meter (YSI model 57 or equivalent)
b. Self-stirring BOD bottle probe
c. Membrane standards
d. BOD bottle

3.0 Procedure

3.1 Setup

It is important that before the meter is prepared for use and calibrated, it should be placed in the intended operating position, i.e., vertical, tilted, or horizonal. The instrument may need readjustment if the operating position is altered. The setup procedures should be as follows:

3.1.1 With the switch set to **OFF**, adjust the meter pointer to zero with the screw in the center of the meter panel.

3.1.2 Switch to **RED LINE** and adjust the **RED LINE** knob until the meter needle aligns with the red mark if necessary.

3.1.3 Switch to **ZERO** and adjust to 0 mg/L scale with the **ZERO** control knob.

3.1.4 Attach the prepared probe to the **PROBE** connector of the instrument and adjust the retaining ring finger tight.

3.1.5 Before calibrating, allow 15 minutes for optimum probe stabilization. Repolarize whenever the instrument has been **OFF** or the probe has been disconnected.

3.2 Calibration

Calibration is accomplished by exposing the probe to a known oxygen concentration, such as water-saturated air (%), or water of a known oxygen content (mg/L), and then adjusting the calibration controls so the display shows a reading matching the oxygen concentration of the known sample. Calibration can be disturbed by physical shock, touching the membrane, and fouling of the membrane or drying out of the electrolyte. Calibration will be checked after each series of measurements. Calibration of the DO meter will be performed on a daily basis as follows.

3.2.1 Place the probe in moist air. BOD probes can be placed in partially filled (50 ml) BOD bottles. Wait 10 minutes for temperature stabilize ~2°C.

3.2.2 Switch to **TEMPERATURE** and read. Refer to Table 1 for solubility of oxygen in fresh water (calibration value).

3.2.3 Determine altitude or atmospheric correction factor from Table 2.

3.2.4 Multiply the calibration value from Table 1 by the correction factor from Table 2 to obtain the correct calibration value.

EXAMPLE: Assume a temperature of 20°C and an altitude of 1100 ft. From Table 1, the calibration value of 20°C is 9.09 mg/L. From Table 2, the *correction factor for* 1100 ft is 0.96. Therefore, the corrected calibration value is 9.09 mg/L x 0.96 = 8.73 mg/L.

3.2.5 Switch to the appropriate mg/L range, set the **SALINITY** knob to zero and adjust the **CALIBRATE** knob until the meter reads the calibration value from Step 4. Wait two minutes to verify calibration stability. Readjust if necessary.

3.3 DO Measurement

3.3.1 With the instrument prepared for use and the probe calibrated, place the probe in the sample.

3.3.2 Turn the **STIRRER** knob **ON**.

3.3.3 Adjust the **SALINITY** knob to the salinity of the sample if appropriate.

3.3.4 Allow sufficient time for the probe to equilibrate to the sample temperature and dissolved oxygen.

3.3.5 Read dissolved oxygen on appropriate scale.

3.3.6 Before measuring the DO of the next sample, rinse probe and sample bottle with distilled water and then with next water sample.

3.3.7 Follow steps 3.3.1 - 3.3.6 for the next sample(s).

3.3.8 The DO meter should normally be left on during the working day to avoid the delay of waiting for probe repolarization.

4.0 MAINTENANCE

The following steps will be taken to maintain the DO meter.

4.1 Replace the batteries when the **RED LINE** knob is at its extreme adjustment or at least annually.

4.2 In the **BATT CHECK** position on the **STIRRER** knob, the voltage of the stirrer batteries is displayed on the red **0-10** scale. Do not permit them to discharge below 6 volts.

4.3 Replace membrane every 2 to 4 weeks depending on application. Probes will be stored in a humid environment to prevent drying out.

5.0 PRECAUTION

The DO meter case is water resistant when properly closed. As a precaution against damaged gaskets or loose fittings, the instrument case will be opened and inspected for moisture whenever the instrument has been subjected to immersion or heavy spray. The case is opened by removing the screws on the rear cover an lifting the cover off.

6.0 REFERENCES

Manufacturer's handbook.

TABLE 1. SOLUBILITY OF OXYGEN IN WATER EXPOSED TO WATER SATURATED AIR AT 760 mm Hg PRESSURE

Temp. °C	Solubility mg/L	Temp. °C	Solubility mg/L	Temp. °C	Solubility mg/L
0	14.62	17	9.67	34	7.07
1	14.22	18	9.47	35	7.95
2	13.83	19	.9.28	36	7.84
3	13.46	20	9.09	37	6.73
4	13.11	21	8.92	38	6.62
5	12.77	22	8.74	39	6.52
6	12.45	23	8.58	40	6.41
7	12.14	24	8.42	41	6.31
8	11.84	25	8.26	42	6.21
9	11.56	26	8.11	43	6.12
10	11.29	27	7.97	44	6.02
11	11.03	28	7.83	45	5.95
12	10.78	29	7.69	46	5.84
13	10.54	30	7.56	47	5.74
14	10.31	31	7.43	48	5.65
15	10.08	32	7.31	49	5.56
16	9.87	33	7.18	50	5.47

Derived from 17th Edition, Standard Methods for the Examination of Water and Wastewater.

TABLE 2. CALIBRATION VALUES FOR VARIOUS ATMOSPHERIC PRESSURES AND ALTITUDES

Pressure			Altitude in		Calibration Value(%)
inches Hg	mm Hg	kPa	feet	meter	
30.23	768	102.3	-276	-84	101
29.92	760	101.3	0	0	100
29.61	752	100.3	278	85	99
29.33	745	99.3	558	170	98
29.02	737	98.3	841	256	97
28.74	730	97.3	1126	343	96
28.43	722	96.3	1413	431	95
28.11	714	95.3	1703	519	94
27.83	707	94.2	1995	608	93
27.52	699	93.2	2290	698	92
27.24	692	92.2	2587	789	91
26.93	684	91.2	2887	880	90
26.61	676	90.2	3190	972	89
26.34	669	89.2	3496	1066	88
26.02	661	88.2	3804	1160	87
25.75	654	87.1	4115	1254	86
25.43	646	86.1	4430	1350	85
25.12	638	85.1	4747	1447	84
24.84	631	84.1	5067	1544	83
24.53	623	83.1	5391	1643	82
24.25	616	82.1	5717	1743	81
23.94	608	81.1	6047	1843	80
23.62	600	80.0	6381	1945	79
23.35	593	79.0	6717	2047	78
23.03	585	78.0	7058	2151	77
22.76	578	77.0	7401	2256	76
22.44	570	76.0	7749	2362	75
22.13	562	75.0	8100	2469	74
21.85	555	74.0	8455	2577	73
21.54	547	73.0	8815	2687	72
21.26	540	71.9	9178	2797	71
20.94	532	70.9	9545	2909	70
20.63	524	69.9	9917	3023	69
20.35	517	68.9	10293	3137	68
20.04	509	67.9	10673	3253	67
19.76	502	66.9	11058	3371	66

Derived from 17th Edition, Standard Methods for the Examination of Water and Wastewater.

STANDARD OPERATING PROCEDURE 038
REDOX POTENTIAL MEASUREMENTS

1.0 Scope And Application

The purpose of this standard operating procedure is to delineate protocols for measuring the redox of flooded sediment and soil. Redox is an indication of the reduction of oxidation intensity of an anaerobic system. Redox will be expressed in mV. 'A complete anaerobic system redox potential is -150 Mv. A positive value indicates an aerobic system.

Redox measurement in a natural system is difficult to obtain due to the absence of true equilibria, heterogeneity of media, and pH effects deprived redox measurements in natural media of precise thermodynamic significance (Ponnamperuma 1972). Despite the difficulties involved in the redox measurements in natural media, it is widely accepted that redox readings in natural anaerobic systems can provide valuable environmental information. Whitfield found redox useful as a semiquantative indicator of the degree of stagnation of a particular aquatic environment as did Ponnamperuma for flooded soils and sediments. The redox measurements of natural waters are not representative of that median, since natural waters are in a highly dynamic state rather than in or near equilibrium, according to Stumm and Morgan. It is generally recognized that redox measurements in oxygenated natural waters are invalid.

2.0 Material

a. pH Meter
b. Combination pH electrode
c. Lint free laboratory wipes (Kimwipes, or equivalent)
d. Distilled water
e. Sample bottle
f. Standard solution (pH 4 and 7 buffers saturated with quinhydrone).
g. Wash bottle

3.0 Procedure

3.1 Calibration of the pH meter will be calibrated on a daily basis as follows.

3.1.1 Prepare beaker of standard solution with known voltage(s).

3.1.2 Connect electrodes to instrument.

3.1.3 Turn on and clear

3.1.4 Rinse electrode with distilled water blot excess with laboratory wipes.

3.1.5 Immerse probe in beaker of standard solution.

3.1.6 Press mV key.

3.1.7 After the reading stabilizes, the absolute mV of solution is displayed.

3.1.8 Rinse electrode and blot excess.

3.2 Redox will be measured after calibration as follows.

3.2.1 Prepare sample in a beaker.

3.2.2 Rinse electrode and blot excess water.

3.2.3 Immerse electrode in sample and stir briefly.

3.2.4 Press mV switch.

3.2.5 Record the reading after it stabilizes.

3.2.6 For next sample(s), follow step 3.2.1 - 3.2.5.

4.0 Maintenance

4.1 Check the batteries each time the meter is used.

4.2 Keep the probe stored in a 0.1 M KCL solution when not in use. Alternatively, the electrode may be rinsed with deionized water and trapping any residual water inside the protective cap.

5.0 Precaution

5.1 Remove coatings of oil material or particulate matter that can impair electrode response by gentle wiping or detergent washing, followed by distilled water rinsing.

6.0 References

Beckman Instruments, Inc., User Manual for . 10, 11, and 12 pH/ISE meter.

Ponnamperuma, F. N., "The Chemistry of Submerged Soils," Advances in Agronomy, Vol 24, 1972.

Stumm, W. and Morgan, J. J., Aquatic Chemistry, Wiley, New York, 1970.

Whitfield, M., "Eh as an Operational Parameter in Estuarine Studies," Limnol. Oceanogr., Vol 14, 1969.

STANDARD OPERATING PROCEDURE 039
SAMPLE PRESERVATION AND CONTAINER REQUIREMENTS

1.0 Purpose and Scope

The purpose of this standard operating procedure is to define the preservatives and techniques to be employed in preserving environmental samples between collection and analysis.

2.0 Material

a. Containers (see § 3.0 below for description)
b. HNO_3
c. H_2SO_4
d. NaOH
f. Ice chests
g. Ice

3.0 Definition of Container Types

Type A **Container**: 80 oz amber glass, ring handle bottle/jug, 38-mm neck finish.
Closure: White polypropylene or black phenolic, baked polyethylene cap, 38-430 size, 0.015-mm Polytetrafluoroethelyne (PTFE) liner.

Type B **Container**: 40-mL glass vial, 24 mm neck finish
Closure: White polypropylene or black phenolic, open top, screw cap, 15-mm opening, 24-400 size.
Septum: 24-mm disc of 0.005-in PTFE bonded to 0.120-in silicon for total thickness of 0.125-in.

Type C **Container**: 1-L high density polyethylene, cylinder-round bottle, 28-mm neck finish.
Closure: White polyethylene cap, white ribbed, 28-410 size; F217 polyethylene liner.

Type D **Container**: 120-mL wide mouth glass vial, 48-mm neck finish.
Closure: White polyethylene cap, 40-480 size; 0.015-mm PTFE liner.

Type E **Container**: 250-mL boston round glass bottle
Closure: White polypropylene or black phenolic, open top, screw cap.
Septum: Disc of 0.005-in PTFE bonded to 0.120-in silicon for total thickness of 0.125-in.

Type F **Container**: 8-oz short, wide mouth, straight -sided, flint glass jar, 70-mm neck finish.
Closure: White polypropylene or black phenolic, baked polyethylene cap, 48-400 size; 0.030-mm PTFE liner.

Type G **Container**: 4-oz tall, wide mouth, straight -sided, flint glass jar, 48-mm neck finish.
Closure: White polypropylene or black phenolic, baked polyethylene cap, 48-400 size; 0.015-mm PTFE liner.

Type H **Container**: 1-L amber, Boston round, glass bottle, 33-mm pour-out neck finish.
Closure: White polypropylene or black phenolic, baked polyethylene cap, 33-430 size; 0.015-mm PTFE liner.

Type K **Container**: 4-L amber glass ring handle bottle/jug, 38-mm neck finish.
Closure: White polypropylene or black phenolic, baked polyethylene cap, 38-430 size; 0.015-mm PTFE liner.

Type L **Container**: 500-mL high-density polyethylene, cylinder bottle, 28-mm neck finish.
Closure: White polypropylene, white ribbed, 28-410 size; F217 polyethylene liner.

4.0 Procedure

4.1 All containers must be certified clean, with copies of laboratory certification furnished to the contracting officer's representative (COR).

4.2 Water samples will be collected according to procedures detailed in SOPs 007, 013, and 014 into containers appropriate to the intended analyte as given in Table 039-1.

4.2.1 Samples taken for metals analysis will be acidified in the field to a pH < 2 by the addition of HNO_3. Filtered samples will be acidified after filtration. After acidifying the sample, the container should be lightly capped, then swirled to thoroughly mix the sample. The cap will then be loosened to release any excess pressure this operation may have generated.

4.2.2 Samples taken for total phosphorous content will be acidified in the field to a pH < 2 by the addition of H_2SO_4. After acidifying the sample, the container should be lightly capped swirled to thoroughly mix the sample. The cap will then be loosened to release any excess pressure this operation may have generated.

4.2.3 Samples taken for cyanide will be alkalized to a pH > 12 by the addition of NaOH.

4.2.4 No preservatives will be added to any other water samples. These samples will be immediately placed on ice and cooled to 4°C.

4.3 Soil, sediment, and sludge samples will be collected according to procedures detailed in SOPs 021, 025, and 041 into containers appropriate to the intended analyte as given in Table 039-2.

4.3.1 Samples taken for metals analysis will be tightly capped, placed on ice, and maintained at a temperature of 4°C.

4.3.2 Samples taken for total phosphorous content will be tightly capped, placed on ice, and maintained at a temperature of 4°C.

4.3.3 Samples taken for cyanide will be alkalized to a pH > 12 by the addition of NaOH.

4.3.4 No preservatives will be added to any other soil samples. These samples will be immediately placed on ice and cooled to 4°C.

4.3.5 Where field screening indicates the presence of mustard, methylene chloride or chloroform will be added to the sample container to cover and preserve the sample. ** awaiting confirmation of this procedure from CRDEC **

5.0 Maintenance

Not Applicable.

6.0 Precautions

HCl shall not be used to acidify samples. HCl will react with thiodiglycol to produce mustard agent by reverse hydrolysis.

Note that acidifying a sample containing cyanide may liberate HCN gas.

- Avoid breathing any fumes emanating from acidified samples.
- Acidify samples only in the open, rather than in closed spaces such as a vehicle.
- Hold suspected HCN - generating sample away from body and downwind while manipulating it.
- See the HASP for other safety measures

7.0 References

Test Methods for Evaluating Solid Waste, SW-845, (EPA 1986)
A Compendium of Superfund Field Operations Methods, EPA 540-P87-001
A Compendium of ERT Soil Sampling and Surface Geophysics Procedures, (EPA 1991)

Table 039-1
Preservation Requirements for Water Samples

Analyte	Bottle Requirement, Volume	Required Headspace	Preservative	Holding Time
Volatile Organic Compounds	(2)Type B, 80-mL total	0%	Cool to 4#C	7 days
Semivolatile Organic Compounds	Type A, K, or (2)H, 2-L total	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
Pesticides/ Arochlors	Type A, K, or (2)H, 2-L total	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
Total Metals	Type C, H, or (2)L, 1-L total	10%	HNO_3 to pH < 2 Cool to 4#C	6 months except Mercury (28 days)
Dissolved Metals	Type C, H, or (2)L, 1-L total	10%	HNO_3 to pH < 2 Cool to 4#C	6 months except Mercury (28 days)
Cyanide	Type C, H, or (2)L, 1-L total	10%	NAOH to pH > 12 Cool to 4#C	14 days
Total Phosphorous	(1) Type C, 1-L	10%	H_2SO_4 to pH < 2 Cool to 4#C	28 days
Explosives	(2) Type H, 1-L ea.	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
Thyodiglycol	(2) Type H, 1-L ea.	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
Dioxins/ Furans	(2) Type H, 1-L ea.	10%	Cool to 4#C	30 days to extraction (45 days to analysis)
Org-P and Org-s Compounds	(2) Type H, 1-L ea.	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
IMPA and MPA	(1) Type E, 250-mL	0%	Cool to 4#C	40 days
Herbicides	(2) Type H, 1-L ea.	10%	Cool to 4#C	7 days to extraction, 40 days after extraction

Table 039-2
Preservation Requirements for Soil and Sediment Samples

Analyte	Bottle Requirement, Volume	Required Headspace	Preservative	Holding Time
Volatile Organic Compounds	(2) Type D, 240-mL total	0%	Cool to 4#C	14 days
Semivolatile Organic Compounds	Type F or G, 3 oz.	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
Pesticides/ Arochlors	Type F or G, 3 oz.	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
Total Metals	Type F or G, 3 oz.	10%	Cool to 4#C	6 months except Mercury (28 days)
Cyanide	Type I, 1-L	10%	Cool to 4#C	14 days
Total Phosphorous	1 1-L Polyethylene bottle	10%	Cool to 4#C	28 days
Explosives	(2) 1-L amber glass bottles	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
Thyodiglycol	(2) 1-L amber glass bottles	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
Dioxins/ Furans	(2) 1-L amber glass bottles	10%	Cool to 4#C	30 days to extraction (45 days to analysis)
Org-P and Org-s Compounds	(2) 1-L amber glass bottles	10%	Cool to 4#C	7 days to extraction, 40 days after extraction
IMPA and MPA	1 250-mL glass bottle, septum top	0%	Cool to 4#C	40 days
Herbicides	(2) 1-L amber glass bottles	10%	Cool to 4#C	7 days to extraction, 40 days after extraction

STANDARD OPERATING PROCEDURE 040
CONFINED SPACE ENTRY

1.0 Purpose and Scope

The following standard operating procedure provides the instructions necessary for entering a confined space. Always consult with Safety Program Management prior to conducting a job that involves entering a confined space.

A "confined space" means any space having a limited means of access or egress or so enclosed that adequate dilution ventilation is not obtained by natural air movement, or mechanically induced movement; and is subject to the accumulation of toxic or combustible agents or an oxygen deficiency. Confined spaces include but are not limited to any of the following areas: a storage tank, tank car, process vessel, bin, tank trailer, or any other tank-like compartment usually having one or more manholes for entry; an open-topped space more than four feet deep, such as a bin, silo, pit, vat, vault, vessel, or floating roof storage tank; a ventilation or exhaust duct, manhole, sewer, tunnel, pipeline, and similar structure; and an oven, furnace, kiln, or similar structure.

Confined spaces are herein classified into three categories based on hazards and the potential for exposure to the identified hazards. The classes and definitions include:

> Class A = A class A confined space includes those spaces that are designed to contain, are known to contain, or have contained hazardous or toxic materials (e.g., underground storage tanks, tank cars, process vessels, pipelines, etc.).
>
> Class B = A class B confined space includes those spaces that are subject to the infiltration of toxic or hazardous vapors or materials or to the reduction of oxygen content through displacement or chemical reaction (e.g.,bins,silos, pits, vats, manholes, sewers, tunnels, etc.).
>
> Class C = A class C confined space includes those spaces that meet the definition of a confined space, but have a relatively low probability for the accumulation of hazardous or toxic materials or for oxygen deficiency (e.g., open-topped space, construction site trench, etc.).

Whenever personnel are to enter a confined space, due consideration must be given to the safety of the person entering the space. The Project Manager, Field Operations Manager, and worker shall consider all possible options to ensure worker safety. At a minimum, consideration shall be given to using lifelines, the buddy system, and standby safety personnel.

2.0 Responsibilities

2.1 Safety Program Management will:

a. Provide guidance and assistance to field personnel in the preparation of procedures and the identification and classification of confined spaces

b. Approve or disapprove entry procedures and SOPs for entry into confined spaces

c. Recommend engineering controls necessary to ensure a safe working environment

2.2 Project Manager/Field Operations Manager will:

a. Complete all necessary confined space permits

b. Ensure all field personnel have read and understand the confined space entry procedure

c. Ensure team composition is adequate to safely perform tasks

d. Ensure personnel entering confined spaces and the personnel serving as safety spotters are properly trained in rescue and cardiopulmonary resuscitation procedures

e. Provide for constant communication between employees inside the confined space and employees outside the confined space

2.3 Safety Spotter will:

a. Ensure proper rescue equipment is on site prior to confined space entry

b. Maintain continuous contact, either visual or verbal, with entrant

3.0 Required Equipment

a. Oxygen Analyzer
b. Explosimeter
c. Organic Vapor Monitor
d. Personal Protective Equipment

4.0 Prerequisites

4.1 All personnel working in confined spaces are properly trained in safe entry and rescue procedures.

4.2 A safety spotter is available to remain outside the confined space to give assistance as needed. The safety spotter shall be equipped with a self-contained breathing apparatus if conditions warrant.

5.0 Precautions and Limitations

5.1 If for any reason a hazardous or unsafe condition presents itself for which there is no clear procedure or guideline, work shall cease until Program Safety Management can be notified and the condition rectified.

5.2 No person shall enter a confined space without an emergency response spotter outside the confined space.

5.3 A ladder shall be provide for any trench which is deeper than 4 ft. or when appropriate in other confined spaces.

6.0 Performance Steps

6.1 Evaluate the work area against the definition of a confined space.

6.2 Notify the Project Manager or Program Safety Management of any work spaces not previously identified that are suspected of meeting the definition of a confined space.

6.3 Contact the APG designated confined space attendant prior to entry and verify APG requirements for entry.

6.4 Obtain positive identification of the materials that are (or have been) present in the space.

a. Evaluate the hazards presented by the materials and byproducts.

b. Determine if any atmospheric monitoring will be required.

6.5 Determine the necessary safety precautions and protective clothing required for the particular space, based on the classification of the confined space.

a. If the space meets the definition of a class A confined space, then proceed to step 6.6.

b. If the space meets the definition of a class B confined space, then proceed to step 6.7.

c. If the space meets the definition of a class C confined space, then proceed to step 6.8.

6.6 **Enter class A confined space.**

a. Prepare a confined space entry permit. Include the following as a minimum:

1) Identity of the space

2) Purpose of the entry
3) Date of authorized entry
4) Authorized entrants
5) Eligible attendants
6) Personnel eligible to be in charge of entry
7) Substances stored in the confined space
8) Potential hazards
9) Permitted work
10) PPE requirements
11) Safety equipment requirements
12) Signature and printed name of authorizing person

b. Ensure that any line, except for a fire suppressant or extinguishing system, that enters the space and carries a harmful agent is physically disconnected from the space or blocked by a device capable of ensuring complete closure.

c. Render inoperable by disconnection any fixed mechanical device or equipment which, if operated, might endanger personnel.

d. Except for lighting, padlock or tag out-of-service electrical service equipment.

e. Select a suitable entrance point that will be safe for the entrant to pass through. Open the entrance.

f. Survey the entrance to the confined space for oxygen levels, combustible vapors, and other hazards.

g. Verify, based on levels obtained from step f. above, that all precautions are sufficient to permit entry. Ensure entrant is properly suited in required personal protective equipment. Allow entrant to enter the confined space.

h. Conduct atmospheric monitoring inside the confined space to determine the presence of combustible, toxic gases, or an oxygen deficient atmosphere.

1) Determine oxygen levels prior to any other testing.

2) Draw test air from lowest to highest elevations of the confined space: 12-18 inches off of floor, mid-levels, and within 12-18 inches of the top (if possible).

3) For spaces greater than 500 cubic feet, draw test air from additional sample points in sufficient number to categorize the atmosphere in the confined space.

i. Once inside, verify any communication equipment used is properly working.

j Monitor for oxygen levels, combustible vapors, and any other identified hazards on a continuous basis while working in class A confined spaces. Continuous monitoring shall include all instruments on with the alarms functioning and set, or a second attendant whose only purpose is to monitor the work environment for the identified hazards.

k. Proceed to Step 6.9.

6.7 Enter class B confined space.

a. Ensure that any line, except for a fire suppressant or extinguishing system, that enters the space and carries a harmful agent is physically disconnected from the space or blocked by a device capable of ensuring complete closure.

b. Render inoperable by disconnection any fixed mechanical device or equipment which, if operated, might endanger personnel.

c. Except for lighting, padlock or tag out-of-service electrical service equipment.

d. Select a suitable entrance point that will be safe for the entrant to pass through. Open the entrance.

e. Survey the entrance to the confined space for oxygen levels, combustible vapors, and other hazards.

f. Verify, based on levels obtained from step e. above, that all precautions are sufficient to permit entry. Ensure entrant is properly suited in the required personal protective equipment. Allow entrant to enter the confined space.

g. Conduct atmospheric monitoring inside the confined space to determine the presence of combustible, toxic gases, or an oxygen deficient atmosphere.

1) Determine oxygen levels prior to any other testing.

2) Draw test air from lowest to highest elevations of the confined space: 12-18 inches off of floor, mid-levels, and within 12-18 inches of the top (if possible).

3) For spaces greater than 500 cubic feet, draw test air from additional sample points in sufficient number to categorize the atmosphere in the confined space.

h. Once inside, verify any communication equipment used is properly working.

i. Monitor for oxygen levels, combustible vapors, and any other identified hazards on a continuous basis while working in class B confined spaces. Continuous monitoring shall include all instruments on with the alarms functioning and set or a second attendant whose only purpose is to monitor the work environment for the identified hazards.

j. Proceed to Step 6.9.

6.8 Enter class C confined space.

a. Select a suitable entrance point that will be safe for the entrant to pass through. Open the entrance.

b. Survey the entrance to the confined space for oxygen levels, combustible vapors, and other hazards.

c. Verify based on levels obtained from step f. above that all precautions are sufficient to permit entry. Allow entrant to enter the confined space.

d. Conduct atmospheric monitoring inside the confined space to determine the presence of combustible, toxic gases, or an oxygen deficient atmosphere.

1) Determine oxygen levels prior to any other testing.

2) Draw test air from lowest to highest elevations of the confined space: 12-18 inches off of floor, mid-levels, and within 12-18 inches of the top (if possible).

3) For spaces greater than 500 cubic feet, draw test air from additional sample points in sufficient number to categorize the atmosphere in the confined space.

e. Monitor for oxygen levels, combustible vapors, and any other identified hazards on an intermittent basis while working in class C confined spaces. Intermittent monitoring shall include a complete set of readings for all initial parameters on a specified basis. The frequency of the monitoring shall be determined prior to entrance by Safety Program Management.

6.9 Exit confined space.

6.10 Close off confined space to prevent unauthorized access.

6.11 Cancel confined space permit (if appropriate).

7.0 Documentation

Document the entry and results of all atmospheric monitoring in the field logbook. Maintain a copy of the confined space entry permit (if appropriate) in the project files.

8.0 References

COMAR 09.12.35,MarylandOccupational Safety and Health Standards for Confined Spaces

STANDARD OPERATING PROCEDURE 041
SLUDGE SAMPLING PROCEDURES

1.0 Scope and Application

The purpose of this standard operating procedure is to delineate protocols for sampling sludges. Sludges include solid matter derived from waste materials that are suspended In or settled from a liquid. This procedure can be applied to the collection Of sludge samples from areas of deposition such as: tanks, sumps, landfills, ditches, ponds and lagoons. It Is Important to collect a representative sample of the waste material.

2.0 Material

a. Stainless steel or Teflon tray
b. Stainless steel hand core sludge sampler and extensions
c. Stainless steel dip sampler, spoons, trowels, spoons, and ladles
d. *Sample bottles*
e. Plastic sheeting
f. Utility knife
g. Polypropylene rope

3.0 Procedure

The liquid content of the sludge sample may vary from nearly all liquid to a dense, nearly liquid-free material. It may be necessary to use a variety of equipment to obtain the required samples, even at a single site.

3.1 General Procedure:

3.1.1 Upon arrival at the site, immediately set up and organize the equipment.

3.1.2 Establish background levels of airborne organic compounds using a photoionization detector (PID)or a flame ionization detector (FID).

3.1.3 Cut a section of 6 mi[plastic sheeting of approximately 6 ft x 6 ft. Place the sheeting on the upgradient side of the sample area.

3.1.4 Arrange the sample containers. sampler(s), and decontamination equipment on the plastic sheeting.

3.1.5 Don PPE in accordance with the site health and safety plan.

3.1.6 Collect the sample(s). The preferred method of collecting sludge samples will be by hand corer, refer to Section 3.2. If using a scoop, trowel, spoon, or ladle, refer to Section 3.3.

3.2 Hand Corer

3.2.1 Ensure that the corers and liners are properly decontaminated prior to use.

3.2.2 Force the corer Into the sludge with a smooth continuous motion to a depth of 9 to 12 inches.

3.2.3 Twist the corer to detach the sample; then withdraw the corer in a single smooth motion.

3.2.4 Remove the top of the corer and, if excess liquid Is present, decant the liquid Into a sample bottle. This liquid will be labelled and analyzed.

3.2.5 Remove the nosepiece of the corer and deposit the sample into a stainless steel or Teflon tray.

3.2.6 Transfer the sample Into sample bottles using a stainless steel laboratory spoon or equivalent object.

3.2.7 If possible, the top 6 Inches of the core will be sampled Into 3 separate sample bottles. 2 inches per bottle, to ensure that an accurate chronology of contamination can be determined.

3.2.8 Ensure that each sample bottle Is properly labeled, noted on the chain-of-custody form, and placed In the sample cooler with Ice packs.

3.2.9 Decontaminate sampling equipment according to SOP 005.

3.2.10 Dispose of all sampling wastes In properly labelled containers

3.3 Scoop, Trowel, Spoon, or Ladle

3.3.1 Ensure that the sampling equipment Is properly decontaminated prior to use.

3.3.2 Insert the sampling device Into the material at the selected point and slowly remove the sample. Care should be taken to retain as much of the solid component as possible.

3.3.3 Transfer the sample Into the appropriate sample bottles.

3.3.4 Ensure that each sample bottle Is property labeled, noted on the chain-of-custody form, and placed In the sample cooler with Ice packs.

3.3.5 Decontaminate sampling equipment according to SOP 005

3.3.6 Dispose of all sampling wastes in properly labelled containers.

3.4 Sampling Location

For all samples mark the sampling location on a site map. Photograph (optional, recommended) the sampling site. Describe each sampling location in the field logbook. Establish the sampling coordinates using the Global Positioning System and record the coordinates for each sample In the field logbook.

4.0 Maintenance

Not applicable.

5.0 Precautions

Sludges may contain high levels of contaminants.

It Is extremely Important to continually monitor the levels of contaminants, using the appropriate survey instruments (e.g., PID, indicator tubes) in the breathing zone of the sampler(s) and other field team members.

Refer to the HASP for appropriate PPE.

Field team members should consult with the Site Health and Safety Coordinator for all health and safety questions or concerns relating to sampling activities.

6.0 References

EPA/54/P-87/001, A Compendium of Superfund Field Operations Methods.

STANDARD OPERATING PROCEDURE 042
DISPOSAL OF ENVIRONMENTAL WELL DEVELOPMENT/PURGE WATER

SOP being drafted

STANDARD OPERATING PROCEDURE 043
HYDROLAB MULTIPARAMETER WATER QUALITY MONITORING INSTRUMENT

1.0 Purpose and Scope

Use of brand names in this SOP is in nowise intended as endorsement or mandate that a given brand be used. Alternate equivalent brands of detectors, sensors, meters, etc. are acceptable. If alternate equipment is to be used, the contractor shall provide applicable and comparable SOPs for the maintenance and calibration of same.

SOP being drafted

STANDARD OPERATING PROCEDURE 044
ASSESSMENT OF EXISTING WELLS USING DOWNHOLE GEOPHYSICS

SOP being drafted

STANDARD OPERATING PROCEDURE 045
ASSESSMENT OF TIDAL EFFECTS ON GROUND-WATER

SOP being drafted