Environmental Investigations Standard Operating Procedures and Quality Assurance Manual

NOVEMBER 2001

U.S. Environmental Protection Agency
Region 4
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SECTION 3
SAMPLE CONTROL, FIELD RECORDS, AND DOCUMENT CONTROL

SECTION OBJECTIVES:

- Present standard procedures for sample identification.
- Present standard procedures for sample control.
- Present standard procedures for chain-of-custody.
- Present standard procedures for maintenance of field records and document control.

3.1 Introduction

Sample identification, chain-of-custody records, receipt for sample forms, and field records (with the exception of surveying notes) should be recorded with waterproof, non-erasable ink. If errors are made in any of these documents, corrections should be made by crossing a single line through the error and entering the correct information. All corrections should be initialed and dated. If possible, all corrections should be made by the individual making the error.

If information is entered onto sample tags, logbooks, or sample containers using stick-on labels, the labels should not be capable of being removed without leaving obvious indications of the attempt. Labels should never be placed over previously recorded information. Corrections to information recorded on stick-on labels should be made as stated above.

Following are definitions of terms used in this section:

Project Leader:	The individual with overall responsibility for conducting a specific field investigation in accordance with this SOP
Field Sample Custodian:	Individual responsible for maintaining custody of the samples and completing the sample tags and Chain-of-Custody Record
Sample Team Leader:	An individual designated by the project leader to be present during and responsible for all activities related to the collection of samples by a specific sampling team.
Sampler:	The individual responsible for the actual collection of a sample.
Transferee:	Any individual who receives custody of samples subsequent to release by the field sample custodian.
Laboratory Sample Custodian:	Individual responsible for accepting custody of samples from the field sample custodian or a transferee.

One individual may fulfill more than one of the roles described above.

3.2 Sample and Evidence Identification

PERFORMANCE OBJECTIVE:
• To accurately identify samples and evidence collected.

3.2.1 Sample Identification

The method of sample identification used depends on the type of sample collected. In-situ field samples are those collected for specific field analysis or measurement where the data are recorded directly in bound field logbooks or on the Chain-of-Custody Record, with identifying information, while in the custody of the sampling team. Examples of such in-situ field measurements and analyses include pH, temperature, dissolved oxygen and conductivity. Samples other than those collected for in-situ analysis are identified by using a standard sample tag (Figure 3-3) which are attached to the sample container. In some cases, particularly with biological samples, the sample tag may have to be included with or wrapped around the sample. Sample tags are sequentially numbered and are accountable documents after they are completed and attached to a sample or other physical evidence. The following information shall be included on the sample tag using waterproof, non-erasable ink:

- project number;
- field identification or sample station number;
- date and time of sample collection;
- designation of the sample as a grab or composite;
- a very brief description of the sampling location;
- the signature of either the sampler(s) or the designated sampling team leader and the field sample custodian (if appropriate);
- whether the sample is preserved or unpreserved;
- the general types of analyses to be performed (checked on front of tag); and
- relevant comments (such as readily detectable or identifiable odor, color, or known toxic properties).

Samples or other physical evidence collected during criminal investigations are to be identified by using the "criminal sample tag." This tag is similar to the standard sample tag shown in Figure 3-3, except that it has a red border around the front and a red background on the back of the tag. If a criminal sample tag is not available, the white sample tag may be used and should be marked "Criminal" in bold letters on the tag.

If a sample is split with a facility, state regulatory agency, or other party representative, the recipient should be provided (if enough sample is available) with an equal weight or volume of sample (see Section 2.3.6).

3.2.2 Photograph, Digital Still Image and Video Identification

Photographs and Digital Still Images

When photographs or digital images are taken, a record of each exposure or image shall be kept in a bound field logbook. The following information shall be recorded in the logbook:

- an accurate description of what the photograph or image shows, including the name of the facility or site and the specific project name and project number;
- the date and time that the photograph or image was taken;
- the name of the individual who took the photograph or digital image.

When photographs are used in technical reports or placed in the official files, the film shall be developed with the negatives supplied uncut. The identifying information that was recorded in the field logbook shall be entered on the back of the prints. For criminal investigations, the negatives must be maintained with the bound field logbook in the project file and stored in a secured file cabinet.

When digital images are used in technical reports or placed in the official files, the disk with the original, unaltered file of the images or a printed copy of the unaltered images shall be placed in the official files as well. If printed copies of the images are used, each image shall be identified using the information that was recorded in the field logbook. For enforcement cases, it is imperative that the individual who took the image be identified in the field logbook in the event their testimony is required.

Video

When a video tape is made for use as evidence in an enforcement case, the following information should be recorded in a bound field logbook:

- the date and time that the video was recorded;.
- a brief description of the subject of the video tape;
- the person recording the video.

Video records shall include a visual notation (placard) at the beginning of the of the video with the appropriate information (i.e., location, date, time). An audio record may also be included in the video tape with the above logistical information as well as a narrated description of the video record.

A label shall be placed on the video tape with the appropriate identifying information (i.e., project name, project number, date, location etc.). In the event testimony regarding a video tape recording is required for an enforcement case, one individual should be responsible for recording the video for each case. The original, unaltered tape shall be placed in the official files.

3.2.3 Identification of Physical Evidence

Physical evidence, other than samples, shall be identified by using a sample tag or recording the necessary information on the evidence. When samples are collected from vessels or containers which can be moved (drums for example), the vessel or container should be marked with the field identification or sample station number for future identification, when necessary. The vessel or container may be labeled with an indelible marker (e.g., paint stick or spray paint). The vessel or container need not be marked if it already has a unique marking or serial number; however, these numbers shall be recorded in the bound field log-books. In addition, it is suggested that photographs of any physical evidence (markings, etc.) be taken and the necessary information recorded in the field logbook.

Occasionally, it is necessary to obtain recorder and/or instrument charts from facility owned analytical equipment, flow recorders, etc., during field investigations and inspections. Mark the charts and write the following information on these charts while they are still in the instrument or recorder :

- Starting and ending time(s) and date(s) for the chart.

- An instantaneous measurement of the media being measured by the recorder shall be taken and entered at the appropriate location on the chart along with the date and time of the measurement.

- A description of the location being monitored and other information required to interpret the data such as type of flow device, chart units, factors, etc.

After the chart has been removed, the field investigator shall indicate on the chart who the chart (or copy of the chart) was received from and enter the date and time, as well as the investigator's initials.

Documents such as technical reports, laboratory reports, etc., should be marked with the field investigator's signature, the date, the number of pages, and from whom they were received. Confidential documents should not be accepted, except in special circumstances such as process audits, hazardous waste site investigations, etc.

3.3 Chain-of-Custody Procedures

PERFORMANCE OBJECTIVE:

- To maintain and document the possession of samples or other evidence from the time of collection until they or the data derived from the samples are introduced as evidence.

3.3.1 Introduction

Chain-of-custody procedures are comprised of the following elements: 1) maintaining custody of samples or other evidence, and 2) documentation of the chain-of-custody for evidence. To document chain-of-custody, an accurate record must be maintained to trace the possession of each sample, or other evidence, from the moment of collection to its introduction into evidence.

3.3.2 Sample Custody

A sample or other physical evidence is in custody if:

- it is in the actual possession of an investigator;
- it is in the view of an investigator, after being in their physical possession;
- it was in the physical possession of an investigator and then they secured it to prevent tampering; and/or
- it is placed in a designated secure area.

3.3.3 Documentation of Chain-of-Custody

Sample Tag

A sample tag (Figure 3-3) should be completed for each sample using waterproof, non-erasable ink as specified in Section 3.2.

Sample Seals

Samples should be sealed as soon as possible following collection using the EPA custody seal shown in Figure 3-5. The sample custodian should write the date and their initials on the seal. Except for criminal investigations, the use of custody seals may be waived if field investigators keep the samples in their custody as defined in Section 3.3.2 from the time of collection until the samples are delivered to the laboratory analyzing the samples. Custody seals will always be used for criminal investigations.

Chain-of-Custody Record

The field Chain-Of-Custody Record (Figure 3-1) is used to record the custody of all samples or other physical evidence collected and maintained by investigators. All physical evidence or sample sets shall be accompanied by a Chain-Of-Custody Record. This Chain-Of-Custody Record documents transfer of custody of samples from the sample custodian to another person, to the laboratory, or other organizational elements. To simplify the Chain-of-Custody Record and eliminate potential litigation problems, as few people as possible should have custody of the samples or physical evidence during the investigation. This form shall not be used to document the collection of split samples where there is a legal requirement to provide a receipt for samples (see Section 3.4). The Chain-Of-Custody Record also serves as a sample logging mechanism for the laboratory sample custodian. A separate Chain-of-Custody Record should be used for each final destination or laboratory used during the investigation.

All information must be supplied in the indicated spaces (Figure 3-1) to complete the field Chain-Of-Custody Record. The reverse side of the Chain-of-Custody Record (Figure 3-2) describes the requirements for station ID, sample ID and media codes

- All samplers and sampling team leaders (if applicable) must sign in the designated signature block.
- One sample should be entered on each line and not be split among multiple lines.
- If multiple sampling teams are collecting samples, the sampling team leader's name should be indicated in the "Tag Number" column (or adjacent to this column) for the appropriate sample(s).

- If the individual serving as the field sample custodian is different from the individual serving as the project leader, the field sample custodian's name and the title of the sample custodian (e.g., Jane Doe, Sample Custodian) should be recorded in the "Remarks/Air bill" block at the top of the Chain-of-Custody Record. The "Remarks/Air bill" block may also be used to record Air bill numbers or registered or certified mail serial numbers.

- The total number of sample containers for each sample must be listed in the "Total Containers" column. The number of individual containers for each analysis must also be listed in the respective column. Required analyses should be circled or entered in the appropriate location as indicated on the Chain-of-Custody Record.

- The tag numbers for each sample and any needed remarks should be in the "Tag Numbers" column.

- The sample custodian and subsequent transferee(s) should document the transfer of the samples listed on the Chain-of-Custody Record. The person who originally relinquishes custody should be the sample custodian. Both the person relinquishing the samples and the person receiving them must sign the form. The date and time that this occurs should be documented in the proper space on the Chain-of-Custody Record.

- Usually, the last person receiving the samples or evidence should be the laboratory sample custodian or their designee(s).

The Chain-of-Custody Record is a serialized document. Once the Record is completed, it becomes an accountable document and must be maintained in the project file. The suitability of any other form for chain-of-custody should be evaluated based upon its inclusion of all of the above information in a legible format.

If chain-of-custody is required for documents received during investigations, the documents should be placed in large envelopes, and the contents should be noted on the envelope. The envelope shall be sealed and an EPA custody seal placed on the envelope such that it cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for the envelope. Any time the EPA seal is broken, that fact shall be noted on the Chain-Of-Custody Record and a new seal affixed. The information on the seal should include the sample custodian's initials and the date.

Physical evidence such as video tapes or other small items shall be placed in Zip-Loc® type bags or envelopes and an EPA custody seal should be affixed so that they cannot be opened without breaking the seal. A Chain-Of-Custody Record shall be maintained for these items. Any time the EPA seal is broken, that fact shall be noted on the Chain-of-Custody Record and a new seal affixed. The information on the seal should include the sample field custodian's initials and the date.

EPA custody seals can be used to maintain custody of other items when necessary by using similar procedures as those previously outlined in this section.

Samples should not be accepted from other sources unless the sample collection procedures used are known to be acceptable, can be documented, and the sample chain-of-custody can be established. If such samples are accepted, a standard sample tag containing all relevant information and the Chain-Of-Custody Record shall be completed for each set of samples.

3.3.4 Transfer of Custody with Shipment

- Samples shall be properly packaged for shipment in accordance with the procedures outlined in Appendix D.

- All samples shall be accompanied by the Chain-Of-Custody Record. The original and one copy of the Record will be placed in a plastic bag inside the secured shipping container if samples are shipped. When shipping samples via common carrier, the "Relinquished By" box should be filled in; however, the "Received By" box should be left blank. The laboratory sample custodian is responsible for receiving custody of the samples and will fill in the "Received By" section of the Chain-of-Custody Record. One copy of the Record will be retained by the project leader. The original Chain-of-Custody Record will be transmitted to the project leader after the samples are accepted by the laboratory. This copy will become a part of the project file.

- If sent by mail, the package shall be registered with return receipt requested. If sent by common carrier, an Air Bill should be used. Receipts from post offices and Air Bills shall be retained as part of the documentation of the chain-of-custody. The Air Bill number or registered mail serial number shall be recorded in the remarks section of the Chain-Of-Custody Record.

3.4 Receipt for Samples Form (CERCLA/RCRA/TSCA)

PERFORMANCE OBJECTIVE:

- To assure that staff comply with environmental laws which require providing a Receipt for Samples Form.

3.4.1 Introduction

Section 3007 of the Resource Conservation and Recovery Act (RCRA) of 1976 and Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) of 1980 require that a "receipt" for all facility samples collected during inspections and investigations be given to the owner/operator of each facility before the field investigator departs the premises. The Toxic Substances Control Act (TSCA) contains similar provisions. The laws do not require that homeowners or other off-site property owners be given this form.

3.4.2 Receipt for Samples Form

The Receipt for Samples form (Figure 3-4) is to be used to satisfy the receipt for samples provisions of RCRA, CERCLA, and TSCA. The form also documents that split samples were offered and either "Received" or "Declined" by the owner/operator of the facility or site being investigated. All information must be supplied in the indicated spaces to complete the Receipt for Samples form.

- The sampler(s) must sign the form in the indicated location. If multiple sample teams are collecting samples, the sample team leader's name should be indicated in the "EPA Sample Tag No./Remarks" column.

- Each sample collected from the facility or site must be documented in the sample record portion of the form. The sample station number, date and time of sample collection, composite or grab sample designation, whether or not split samples were collected (yes or no should be entered under the split sample column), the tag numbers of samples collected which will be removed from the site, a brief description of each sampling location, and the total number of sample containers for each sample must be entered.

- The bottom of the form is used to document the site operator's acceptance or rejection of split samples. The project leader must sign and complete the information in the "Split Samples Transferred By" section (date and time must be entered). If split samples were not collected, the project leader should initial and place a single line through "Split Samples Transferred By" in this section. The operator of the site must indicate whether split samples were received or declined and sign the form. The operator must give their title, telephone number, and the date and time they signed the form. If the operator refuses to sign the form, the sampler(s) should note this fact in the operator's signature block and initial this entry.

The Receipt for Samples form is serialized and becomes an accountable document after it is completed. A copy of the form is to be given to the facility or site owner/operator. The original form must be maintained in the project files.

3.5 Field Records

PERFORMANCE OBJECTIVE:

- To accurately and completely document all field activities.

Each project should have a dedicated logbook. The project leader's name, the sample team leader's name (if appropriate), the project name and location, and the project number should be entered on the inside of the front cover of the logbook. It is recommended that each page in the logbook be numbered and dated. The entries should be legible and contain accurate and inclusive documentation of an individual's project activities. At the end of all entries for each day, or at the end of a particular event, if appropriate, the investigator should draw a diagonal line and initial indicating the conclusion of the entry. Since field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these field logbooks become accountable documents and must be maintained as part of the official project files. All aspects of sample collection and handling, as well as visual observations, shall be documented in the field logbooks. The following is a list of information that should be included in the logbook:

- sample collection equipment (where appropriate);
- field analytical equipment, and equipment utilized to make physical measurements shall be identified;
- calculations, results, and calibration data for field sampling, field analytical, and field physical measurement equipment;
- property numbers of any sampling equipment used, if available;
- sampling station identification;
- time of sample collection;
- description of the sample location;
- description of the sample;

- who collected the sample;
- how the sample was collected;
- diagrams of processes;
- maps/sketches of sampling locations; and
- weather conditions that may affect the sample (e.g., rain, extreme heat or cold, wind, etc.)

3.6 Document Control

PERFORMANCE OBJECTIVE:

- To assure that project files are maintained in accordance with Divisional guidelines.

Document control refers to the maintenance of inspection and investigation project files. All information below shall be kept in project files. Investigators may keep copies of reports in their personal files, however, all official and original documents relating to inspections and investigations shall be placed in the official project files. The following documents shall be placed in the project file, if applicable:

- request memo from the program office;
- copy of the study plan;
- original Chain-Of-Custody Records and bound field logbooks;
- copy of the Receipt for Sample forms;
- records obtained during the investigation;
- complete copy of the analytical data and memorandums transmitting analytical data;
- official correspondence received by or issued by the Branch relating to the investigation including records of telephone calls;
- photographs and negatives associated with the project;
- one copy of the final report and transmittal memorandum(s); and
- relevant documents related to the original investigation/inspection or follow-up activities related to the investigation/inspection.

Inappropriate personal observations and irrelevant information should not be placed in the official project files. At the conclusion of the project, the project leader shall review the file to ensure that it is complete.

3.7 Disposal of Samples or Other Physical Evidence

PERFORMANCE OBJECTIVE:

- To ensure that proper disposal procedures are used for samples or other evidence.

Disposal of samples or other physical evidence obtained during investigations is conducted on a case-by-case basis. Before samples which have been analyzed are disposed of, the ASB sample custodian shall contact the project leader via E:mail, indicating that the samples will be disposed of by a certain date unless the project leader dictates otherwise. If the sample custodian does not receive a message from the project leader within the time specified in the E:mail, the samples will be disposed of. Personnel should check with the EPA Program Office requesting the inspection or investigation before granting permission to dispose of samples or other physical evidence. The following general guidance is offered for the disposal of samples or other physical evidence:

- No samples, physical evidence, or any other document associated with a criminal investigation shall be disposed of without written permission from EPA's Criminal Investigations Division.

- Samples associated with routine inspections may be disposed of following approval from the project leader. Sample tags will be discarded along with the samples.

3.8 Field Operations Records Management System (FORMS)

PERFORMANCE OBJECTIVE:

- To introduce the procedure for streamlining sample documentation

FORMS is a computer program designed to streamline the documentation required by SESD and/or the Contract Laboratory Program (CLP) for sample identification and chain-of-custody. Once the appropriate information is entered into the computer, FORMS will generate stick-on labels for the sample tags and sample containers (CLP), and will generate sample receipt forms and chain-of-custody records for the appropriate laboratory. The advantages to this system include faster processing of samples and increased accuracy. Accuracy is increased because the information is entered only once, and consequently, consistent for the tags, bottle labels, sample receipt forms and chain-of-custody records. Operating instructions are available for use with the FORMS program.

FIGURE 3-1
CHAIN-OF-CUSTODY FORM

EPA REGION 4
U.S. ENVIRONMENTAL PROTECTION AGENCY

CHAIN OF CUSTODY RECORD

SCIENCE AND ECOSYSTEMS SUPPORT DIVISION
980 COLLEGE STATION ROAD
ATHENS, GEORGIA 30605-2720

PROJECT NO.	PROJECT NAME / LOCATION	SAMPLERS (SIGN)
PROJECT LEADER	REMARKS / AIR BILL	

LAB USE ONLY	STATION ID (1)	SAMPLE ID (2)	MEDIA CODE (3)	20__ DATE	TIME	COMP OR GRAB	REMARKS	TOTAL CONTAINERS	COD, TOC, NUTRIENTS	BOD, SOLIDS	METALS	EXT ORG / PEST / PCBs	VOA	CYANIDE			TAG NUMBER

RELINQUISHED BY: (PRINT)	DATE:	RECEIVED BY: (PRINT)	RELINQUISHED BY: (PRINT)	DATE:	RECEIVED BY: (PRINT)
(SIGN)	TIME:	(SIGN)	(SIGN)	TIME:	(SIGN)

DISTRIBUTION: White and Pink copy to accompany sample shipment to laboratory. Pink copy retained by laboratory. White copy is returned to samplers. Yellow copy retained by samplers.

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FIGURE 3-2
MEDIA CODES

① **Station ID** - **Station ID is required *if* positional data is recorded for the sample.** Any combination of letters, numbers, or other characters. Maximum of 20 characters. Use this column to identify a sampling station where one or more samples or field measurements are taken. A few examples are well numbers, NPDES permit numbers, Air permit numbers, AOC numbers, Grid numbers, Site designations, etc., or combinations of these as appropriate.

② **Sample ID** - **Required.** Any combination of letters or numbers. Maximum of 8 characters. **NOTE: For QA/QC samples, the Sample ID must begin with the letters "QA for the sample to be properly identified.**

③ **Media Code** - **Required.** Choose the code that most closely describes the sample:

Environmental Samples

SF -Surface Soil (0"-12")
SB -Subsurface Soil (>12")
PW -Potable Water
MS -Municipal Water Supply
IW -Industrial Well
WA -Waste
SW -Surface Water
SD -Sediment
GW -Groundwater
PC -Precipitation
OT -Other (Unknown)
OB -Other Biota
MP -Municipal Proc. Wastewater
IP -Industrial Proc. Wastewater
WP -Wipe Sample
FI -Fish Sample
VG -Vegetation
MI -Macroinvertebrates
WW -Wastewater
SL -Sludge (non-RCRA)
UI -UIC Injection Wells
US -Underground Storage Tanks
PT -Petroleum Tanks
AA -Ambient Air
IA -Indoor Air
ME -Municipal Eff. Wastewater
IE -Industrial Eff. Wastewater
PE -Periphyton
TI -Tissue

Field QA/QC Samples

TS -Trip Blank-Soil
TW -Trip Blank-Water
TP -Trip Blank-Wipe
EB -Equipment Rinse Blank
GR -Grout Blank
MB -Drilling Mud Blank
DB -Potable Decon Blank
BB -Bentonite Blank
FA -Field Blank Air
FB -Filter Sand Blank
OW -Organic Free Water Blank
PB -Preservative Blank
GB -Glove Blank
BO -Bottle Blank
FL -Field Blank
IB -Dry Ice Blank
BK -Other Blank

BL -Blender Blank

FIGURE 3-3
SAMPLE TAG

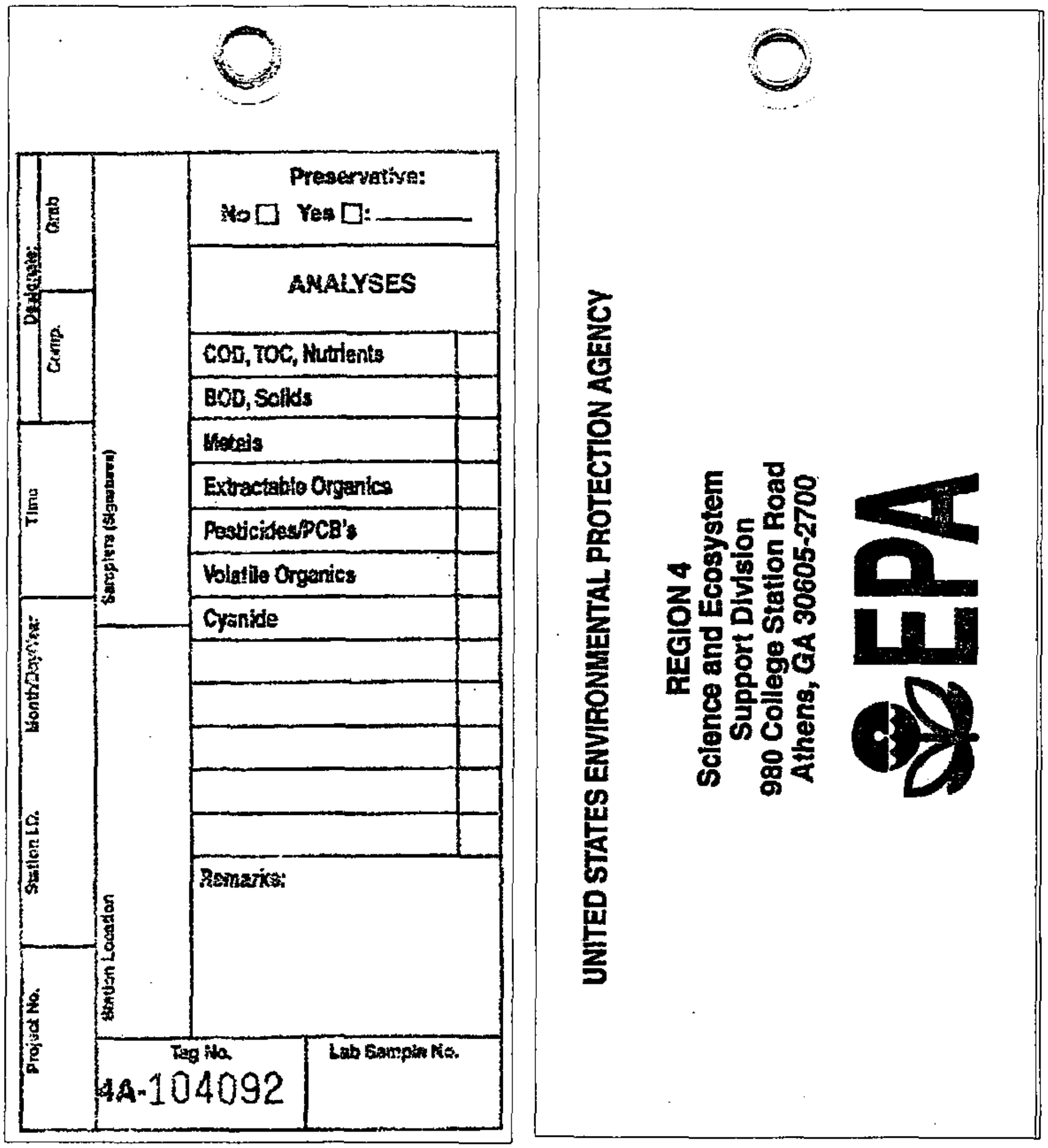

FIGURE 3-4
RECEIPT FOR SAMPLES FORM

US EPA REGION 4
960 COLLEGE STATION ROAD
ATHENS, GEORGIA 30605-2720

RECEIPT FOR SAMPLES

PROJECT NO.	PROJECT NAME	NAME & LOCATION OF FACILITY/SITE
SAMPLERS: (SIGNATURE)		

STATION NO.	19__ DATE	TIME	COMP	GRAB	STATION LOCATION/DESCRIPTION	NO. OF EPA CONTAINERS	SPLIT SAMPLES Y OR N	EPA SAMPLE TAG NO.S/REMARKS

SPLIT SAMPLES TRANSFERRED BY: (PRINT)	DATE	SPLIT SAMPLES RECEIVED BY ☐ OR DECLINED BY ☐ (PRINT)	DATE/TIME
(SIGN)	TIME	(SIGN)	TELEPHONE
		(TITLE)	

DISTRIBUTION: Original to Coordinator Field Files; Copy to Facility/Site Representative

*U.S. GOVERNMENT PRINTING OFFICE: 1990-531-617 (12/89)

No. 4 4609

FIGURE 3-5
EPA CUSTODY SEAL

United States Environmental Protection Agency Athens, Georgia REGION 4		Date ________ Initial ________ OFFICIAL SAMPLE SEAL

SECTION 6
DESIGN AND INSTALLATION OF MONITORING WELLS

PERFORMANCE OBJECTIVES:

- Ensure that the monitoring well will provide high quality samples.
- Ensure that the monitoring well is constructed properly and will last the duration of the project.
- Ensure that the monitoring well will not serve as a conduit for contaminants to migrate between aquifers.

6.1 Introduction

Methods and procedures for the design and installation of monitoring wells to be employed in Region 4 are contained in this section. They are to be used for all permanent and temporary monitoring wells installed for collecting ground water samples for analysis.

6.2 Permanent Monitoring Wells - Design Considerations

The design and installation of permanent monitoring wells involves drilling into various types of geologic formations that exhibit varying subsurface conditions. Designing and installing permanent monitoring wells in these geologic environments may require several different drilling methods and installation procedures. The selection of drilling methods and installation procedures should be based on field data collected during a hydrogeologic site investigation and/or a search of existing data. Each permanent monitoring well should be designed and installed to function properly throughout the duration of the monitoring program. When designing monitoring wells, the following should be considered:

- short-and long-term objectives;
- purpose(s) of the well(s);
- probable duration of the monitoring program;
- contaminants likely to be monitored;
- types of well construction materials to be used;
- surface and subsurface geologic conditions;
- properties of the aquifer(s) to be monitored;
- well screen placement;
- general site conditions; and
- potential site health and safety hazards.

Each of the above considerations can be expanded into many subtopics depending on the complexity of the project. In designing permanent monitoring wells, the most reliable, obtainable data should be utilized. Once the data have been assembled and the well design(s) completed, a drilling method(s) has to be selected. The preferred drilling procedures for installing permanent monitoring wells are those that temporarily case the borehole during drilling and the construction of the well, e.g. hollow-stem augers and sonic methods. However, site conditions may not always be amenable to using these methods When this occurs, alternate methods should be selected that will perform the job equally as well. The following discussion of methods and procedures for designing and installing monitoring wells will cover the different aspects of selecting materials, drilling boreholes, and installing monitoring devices.

6.3 Drilling Methods

The following drilling methods are listed in general order of preference; however, final selection should be based on actual site conditions. In all cases, the proper field QA/QC procedures should be initiated before and during drilling to minimize the potential for contamination. These QA/QC procedures include, but are not limited to, sampling and analyzing of all drilling materials such as drilling muds, filter sand, bentonite pellets, grouts, and any potable water introduced during drilling.

6.3.1 Hollow-Stem Auger

This type of auger consists of a hollow, steel stem or shaft with a continuous, spiraled steel flight, welded onto the exterior stem. A hollow auger bit, generally with carbide teeth, disturbs soil material when rotated, whereupon the spiral flights transport the cuttings to the surface. This method is best suited in soils that have a tendency to collapse when disturbed. A monitoring well can be installed inside of hollow-stem augers with little or no concern for the caving potential of the soils and/or water table. However, retracting augers in caving sand conditions while installing monitoring wells can be extremely difficult or impossible, especially since the augers have to be extracted without being rotated. If caving sands exist during monitoring well installations, a drilling rig must be used that has enough power to extract the augers from the borehole without having to rotate them. A bottom plug, trap door, or pilot bit assembly can be fastened onto the bottom of the augers to keep out most of the soils and/or water that have a tendency to clog the bottom of the augers during drilling. Potable water (analyzed for contaminants of concern) may be poured into the augers (where applicable) to equalize pressure so that the inflow of formation materials and water will be held to a minimum when the bottom plug is released. Water-tight center plugs are not acceptable because they create suction when extracted from the augers. This suction forces or pulls cuttings and formation materials into the augers, defeating the purpose of the center plug. Augering without a center plug or pilot bit assembly is permitted, provided that the soil plug, formed in the bottom of the augers, is removed before sampling or installing well casings. Removing the soil plug from the augers can be accomplished by washing out the plug using a side discharge rotary bit, or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger. The type of bottom plug, trap door, or pilot bit assembly proposed for the drilling activity should be approved by a senior field geologist prior to drilling operations. Boreholes can be augered to depths of 150 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

6.3.2 Solid-Stem Auger

This type of auger consists of a solid stem or shaft with a continuous spiraled steel flight, welded on the outer side of the stem, connected to an auger bit and when rotated transports cuttings to the surface. This auger method is used in cohesive and semi-cohesive soils that do not have a tendency to collapse when disturbed. Boreholes can be augered to depths of 200 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 150 feet.

Both of the previously discussed auger methods can be used in unconsolidated soils and semi-consolidated (weathered rock) soils, but not in competent rock. Each method can be employed without introducing foreign materials into the borehole such as water and drilling fluids, minimizing the potential for cross contamination. *Minimizing the risk of cross contamination is one of the most important factors to consider* when selecting the appropriate drilling method(s) for a project.

6.3.3 Sonic Methods.

These methods alternately advance concentric hollow drill stems using rotation in conjunction with axial vibration of the drill stem. After each stage of drill stem advancement, the inner string is removed with a core of drill cuttings while the outer string remains to hold the borehole open. The cuttings can be removed nearly intact from the inner casing for examination of stratigraphy prior to disposal. Because there are no auger flights to increase the drill stem diameter, the quantity of cuttings removed from the hole is minimized as compared to hollow stem augering. Smearing of the formation materials on the borehole walls is reduced as well. This drilling method is useful in a variety of materials, from flowing sands to heavily consolidated or indurated formations.

In flowing sands, the drill casings can be filled and/or pressurized with potable water to prevent excess entry of formation materials into the drill string. The same QA/QC requirements for sampling of material introduced to the borehole apply as in other drilling methods. Because the amount of water introduced into the borehole can be significant, an approximation of the water used in the drilling process should be logged for use in estimating appropriate well development withdrawal.

Sonic drilling allows a larger diameter temporary casing to be set into a confining layer while drilling proceeds into deeper aquifers. This temporary casing is then removed during the grouting operation. In many cases this will be acceptable technique. However, the level of contamination in the upper aquifer, the importance of the lower aquifers for drinking water uses, the permeability and continuity of the confining layer, and state regulations should be taken into account when specifying this practice as opposed to permanent outer casing placed into the confining unit. Note that when using the temporary casing practice, it is critical that grout be mixed and placed properly as specified elsewhere in this section.

Because the total borehole diameter in sonic drilling is only incrementally larger than the inner casing diameter, particular care should be taken that the well casing is placed in the center of the drill stem while placing the filter pack. Centralizers may be required to facilitate this in the case of deep wells with PVC casing.

6.3.4 Rotary Methods

These methods consists of a drill pipe or drill stem coupled to a drilling bit that rotates and cuts through the soils. The cuttings produced from the rotation of the drilling bit are transported to the surface by drilling fluids which generally consist of water, drilling mud, or air. The water, drilling mud, or air are forced down through the drill pipe, and out through the bottom of the drilling bit. The cuttings are then lifted to the surface between the borehole wall and the drill pipe, (or within a concentric drill stem in reverse rotary). The drilling fluids not only force the cuttings to the surface but also keeps the drilling bit cool. When considering this method, it is important to evaluate the potential for contamination when fluids and/or air are introduced into the borehole. If the rotary method is selected as one of the drilling methods, water rotary is the preferred method, followed by air rotary and mud rotary.

Due to the introduction of the various circulating fluids, the use of rotary methods requires that the potential for contamination by these fluids be evaluated. Water and mud rotary methods present the possibility of trace contamination of halogenated compounds when municipal water supplies are used as a potable water source. Air rotary drilling can introduce contamination through the use of lubricants or entrained material in the air stream. In any of the rotary (or sonic) methods, care must be exercised in the selection and use of compounds to prevent galling of drill stem threads.

Water Rotary

When using water rotary, potable water (that has been analyzed for contaminants of concern) should be used. If potable water (or a higher quality water) is not available on-site, then potable water will have to be transported to the site or an alternative drilling method will have to be selected. Water rotary is the preferred rotary method because potable water is the only fluid introduced into the borehole during drilling. Water does not clog the formation materials reducing well development time; however this potable water will flow out into the surrounding formation materials (if permeable) and mix with the natural formation water. This mixing of the drilling water and the natural formation water should be evaluated when determining the drilling method. Generally, a large majority of the drilling water will be recovered during well development.

Air Rotary

Air rotary drilling uses air as a drilling fluid to entrain cuttings and carry them to the surface. High air velocities, and consequently large air volumes and compressor horsepower are required. 'Down-the-hole' (DTH) percussion hammers driven by the air stream can be used with this method to rapidly penetrate bedrock materials. Where a casing through unconsolidated material is required to prevent borehole collapse, it can be driven in conjunction with advancement of the drill stem.

When using air rotary drilling in any zone of potential contamination, dual-tube reverse circulation with a cyclone velocity dissipater for cuttings containment and separation is the preferred method. Allowing cuttings to blow uncontrolled from the borehole (as with the conventional air rotary method) is not acceptable.

When using air rotary, the issue of contaminants being introduced into the borehole by the air stream must be addressed. Screw compressor systems should have a coalescing filter system in good working order to capture excess entrained compressor oils. The lubricant to be used with 'down-the-hole' hammers as well as thread lubricants to be used on drill stem should be evaluated for their potential impact on analytical samples.

Mud Rotary

Mud rotary is the least preferred rotary method because contamination can be introduced into the borehole from the constituents in the drilling mud, cross contamination can occur along the borehole column, and it is very difficult to remove the drilling mud from the borehole after drilling and during well development. The drilling mud can also carry contaminates from a contaminated zone to an uncontaminated zone thereby cross-contaminating the borehole. If mud rotary is selected, only potable water and pure (no additives) bentonite drilling muds should be used. All materials used should have adequate documentation as to manufacturer's recommendations and product constituents. QA/QC samples of drilling muds and potable water should be sampled at a point of discharge from the circulation system to assure that pumps and piping systems are not contributing cross-contamination from previous use.

6.3.5 Other Methods

Other methods such as the cable-tool method, jetting method, and boring (bucket auger) method are available. If these and/or other methods are selected for monitoring well installations, they should be approved by a senior field geologist before field work is initiated.

6.4 Borehole Construction

6.4.1 Annular Space

The borehole or hollow stem auger should be of sufficient diameter so that well construction can proceed without major difficulties. For open boreholes, the annular space should be approximately 2" to allow the uniform deposition of well materials around the screen and riser, and to allow the passage of tremie pipes and well materials without unduly disturbing the borehole wall. For example, a 2" nominal diameter (nom.) casing would require a 6" inside diameter (ID) borehole.

In hollow stem augers and sonic method drill casing, the ID should be of sufficient size to allow the passage of the tremie pipe to be used for well grout placement, as well as free passage of filter sands or bentonite pellets dropped through the auger or casing. In general, 4-1/4" ID should be the minimum size used for placement of 2"nom. casing and 8-1/4" ID for 4"nom. casing. Larger augers should be used where installation difficulties due to geologic conditions or greater depths are anticipated, e.g. larger augers might be required to place a bentonite pellet seal through a long water column.

6.4.2 Overdrilling the Borehole

Sometimes it is necessary to overdrill the borehole so that any soils that have not been removed or that have fallen into the borehole during augering or drill stem retrieval, will fall to the bottom of the borehole below the depth where the filter pack and well screen are to be placed. Normally, 3 to 5 feet is sufficient for overdrilling. The borehole can also be overdrilled to allow for an extra space or a "sump" area below the well screen. This "sump" area provides a space to attach a 5 or 10 foot section of well casing to the bottom of the well screen. The extra space or "sump" below the well screen serves as a catch basin or storage area for sediment that flows into the well and drops out of suspension. These "sumps" are added to the well screens when the wells are screened in aquifers that are naturally turbid and will not yield clear formation water (free of visible sediment) even after extensive development. The sediment can then be periodically pumped out of the "sump" preventing the well screen from clogging or "silting up". If the borehole is overdrilled deeper than desired, it can be backfilled to the designed depth with bentonite pellets, chips, or the filter sand that is to be used for the filter pack.

6.4.3 Filter Pack Placement

When placing the filter pack into the borehole, a minimum of 6-inches of the filter pack material should be placed under the bottom of the well screen to provide a firm footing and an unrestricted flow under the screened area. Also, the filter pack should extend a minimum of 2-feet above the top of the well screen to allow for settling and to isolate the screened interval from the grouting material. In open boreholes, the filter pack should be placed by the tremie or positive displacement method. Placing the filter pack by pouring the sand into an open drill stem is acceptable with the use hollow stem augers, and other methods where the borehole is temporarily cased down to the filter pack.

6.4.4 Filter Pack Seal-Bentonite Pellet Seal (Plug)

Bentonite pellets consist of ground, dried bentonite compacted into pellets available in several sizes. Bentonite pellets are compressed to a bulk density of 70-80 lbs/cu.ft. and hydrate to a 30% min. solids material.

Where neat cement grouts are to be used, the placement of a bentonite pellet seal above the filter pack is mandatory to prevent the possibility of grout infiltration into the screened interval prior to setting. Bentonite chips or other sealing products should not be substituted in this application. Where bentonite grouts are to be used, the placement of a bentonite pellet seal is optional, but desirable.

Since the pellets begin hydrating rapidly, they are very difficult to place by the tremie method. They may be placed by pouring slowly into either open boreholes or hollow stem augers. A tamper should be used to ensure that the material is being placed properly and to rapidly break up any pellet bridging that occurs.

Pellet seals should be designed for a two foot thickness of dry pellets above the filter pack. Hydration may extend the height of the seal. Where neat cement grouts are to be used the pellets should be hydrated for eight hours, or the manufacturer's recommended hydration time, whichever is greater. Where the water table is temporarily below the pellet seal, potable (or higher quality) water should be added repeatedly to hydrate the pellets prior to grouting.

6.4.5 Grouting the Annular Space

The annular space between the casing and the borehole wall should be filled with either a 30% solids bentonite grout, a neat cement grout, or a cement/bentonite grout. Each type of grout selected should be evaluated as to its intended use and integrity.

Bentonite grout shall be a 30% solids pure bentonite grout with a minimum density of 10 lb/gal. Drilling muds are not acceptable for grouting. The grout should be placed into the borehole, by the tremie method, from the top of the bentonite seal to within 2-feet of the ground surface or below the frost line, whichever is the greater depth. The bentonite pellet seal or filter pack should not be disturbed during grout placement, either by the use of a side discharge port on the tremie tube, or by maintaining clearance between the bottom of the tremie tube and the bentonite seal or filter pack. The grout should be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. The preferred method of achieving proper solids content is by measurement of ingredients per the manufacturer's specifications during mixing. Bentonite grouts should have a minimum density of 10 lbs/gal to ensure proper gelling and low permeability. The density of the first batch of grout should be measured while mixing to verify proper measurement of ingredients. In addition, the grouting operation should not cease until the bentonite grout flowing out of the borehole has a minimum density of 10 lbs/gal. A mud balance should be used to measure the specified grout density of the bentonite grout. Estimating the grout density is not acceptable.

Neat cement grouts are generally dictated where a high level of dissolved solids or a particular dissolved constituent would prevent proper gelling of a bentonite grout. Neat cement grouts should be mixed using 6.5 to 7 gallons of water per 94-lb bag of Type 1 Portland cement. The addition of bentonite (5 to 10 percent) to the cement grout is generally used to delay the "setting" time and may not be needed in all applications. The specific mixtures and other types of cement and/or grout proposed should be evaluated on a case by case basis by a senior field geologist.

6.4.6 Above Ground Riser Pipe and Outer Protective Casing

The well casing, when installed and grouted, should extend above the ground surface a minimum of 2.5 feet. A vent hole should be drilled into the top of the well casing cap to permit pressure equalization, if applicable. An outer protective casing should be installed into the borehole after the annular grout has cured for at least 24 hours. The outer protective casing should be of steel construction with a hinged, locking cap. Generally, outer protective casings used over 2-inch well casings are 4 inches square by 5 feet long. Similarly, protective casings used over 4-inch well casings are 6 inches square and 5 feet long. Round protective casings are also acceptable. All protective casings should have sufficient clearance around the inner well casings, so that the outer protective casings will not come into contact with the inner well casings after installation. The protective casings should have a minimum of two weep holes for drainage. These weep holes should be a minimum 1/4-inch in diameter and drilled into the protective casings just above the top of the concrete surface pads to prevent water from standing inside of the protective casings. Protective casings made of aluminum or other soft metals are normally not acceptable because they are not strong enough to resist tampering. Aluminum protective casing may be used in very corrosive environments such as coastal areas.

A protective casing is installed by pouring concrete into the borehole on top of the grout. The protective casing is then pushed into the wet concrete and borehole a minimum of 2 feet. Extra concrete may be needed to fill the inside of the protective casing so that the level of the concrete inside of the protective casing is at or above the level of the surface pad. In areas where frost heave of the surface pad is possible, the protective casing should first be pressed into the top surface of the grout seal and concrete poured around the protective casing. A granular material such as sand or gravel can then be used to fill the space between the riser and protective casing. The protective casing should extend approximately 3 feet above the ground surface or to a height so that the cap of the inner well casing is exposed when the protective casing is opened. At each site, all locks on the outer protective casings should be keyed alike.

6.4.7 Concrete Surface Pad

A concrete surface pad should be installed around each well at the same time as the outer protective casing is being installed. The surface pad should be formed around the well casing. Concrete should be placed into the pad forms and into the borehole (on top of the grout) in one operation making a contiguous unit. The size of the concrete surface pad is dependent on the well casing size. If the well casing is 2 inches in diameter, the pad should be 3 feet x 3 feet x 4 inches. If the well casing is 4 inches in diameter, the pad should be 4 feet x 4 feet x 6 inches. Round concrete surface pads are also acceptable. The finished pad should be slightly sloped so that drainage will flow away from the protective casing and off of the pad. A minimum of one inch of the finished pad should be below grade to prevent washing and undermining by soil erosion.

6.4.8 Surface Protection-Bumper Guards

If the monitoring wells are located in a high traffic area, a minimum of three bumper guards consisting of steel pipes 3 to 4 inches in diameter and a minimum 5-foot length should be installed. These bumper guards should be installed to a minimum depth of 2 feet below the ground surface in a concrete footing and extend a minimum of 3 feet above ground surface. Concrete should also be placed into the steel pipe to provide additional strength. Substantial steel rails and/or other steel materials can be used in place of steel pipe. Welding bars between the bumper posts can provide additional strength and protection in high traffic areas, but the protective bumpers should not be connected to the protective casing.

6.5 Construction Techniques

6.5.1 Well Installation

The borehole should be bored, drilled, or augered as close to vertical as possible, and checked with a plumb bob or level. Deviation from plumb should be within 1° per 50ft of depth. Slanted boreholes will not be acceptable unless specified in the design. The depth and volume of the borehole, including the overdrilling if applicable, should have been calculated and the appropriate materials procured prior to drilling activities. The well casings should be secured to the well screen by flush-jointed threads and placed into the borehole and plumbed by the use of centralizers and/or a plumb bob and level. Another method of placing the well screen and casings into the borehole and plumbing it at the same time is to suspend the string of well screen and casings in the borehole by means of the wireline on the drill rig. The string of well screen and casings can be placed into the borehole and plumbed in one easy operation. This wireline method is especially useful if the borehole is deep and a long string of well screen and casings have to be set and plumbed. No lubricating oils or grease should be used on casing threads. Teflon tape can be used to wrap the threads to insure a tight fit and minimize leakage. No glue of any type should be used to secure casing joints. Teflon "O" rings can also be used to insure a tight fit and minimize leakage; however, "O" rings made of other materials are not acceptable if the well is going to be sampled for organic compound analyses. Before the well screen and casings are placed on the bottom of the borehole, at least 6 inches of filter material should be placed at the bottom of the borehole to serve as a firm footing. The string of well screen and casings should then be placed into the borehole and plumbed. Centralizers can be used to plumb a well, but centralizers should be placed so that the placement of the filter pack, bentonite pellet seal, and annular grout will not be hindered. Centralizers placed in the wrong locations can cause bridging during material placement. Monitoring wells less than 50 feet deep generally do not need centralizers. If centralizers are used they should be placed below the well screen and above the bentonite pellet seal. The specific placement intervals should be decided based on site conditions. When installing the well screen and casings through hollow-stem augers, the augers should be slowly extracted as the filter pack, bentonite seal, and grout are tremied and/or poured into place. The gradual extraction of the augers will allow the materials being placed in the augers, to flow out of the bottom of the augers into the borehole. If the augers are not gradually extracted, the materials (sand, pellets, etc.) will accumulate at the bottom of the augers causing potential bridging problems. After the string of well screen and casing is plumb, the filter material should then be placed around the well screen (by the tremie method in open boreholes) up to the designated depth. After the filter pack has been installed, the bentonite pellet seal (if used) should be placed directly on top of the filter pack to an unhydrated thickness of two feet. When installing the seal for use with neat cement grouts, the bentonite pellet seal should be allowed to hydrate a minimum of eight hours or the manufacturer's recommended hydration time, whichever is longer. After the pellet seal has hydrated for the specified time, the grout should then be pumped by the tremie method into the annular space around the casings up to within 2 feet of the ground surface or below the frostline, whichever is the greater depth. The grout should be allowed to set for a minimum of 24 hours before the surface pad and protective casing are installed. After the surface pad and protective casing are installed, bumper guards should be installed (if needed). The bumper guards should be placed around the concrete surface pad in a configuration that provides maximum protection to the well. Each piece of steel pipe or approved material should be installed into an 8-to 10-inch diameter hole, to a minimum depth of 2 feet below ground surface, and filled with concrete. As previously stated, the bumper guard should extend above the ground surface a minimum of 3 feet. The total length of each bumper guard should be a minimum of 5 feet.

After the wells have been installed, the outer protective casing should be painted with a highly visible enamel paint. The wells should be permanently marked with the well number, date installed, site name, elevation, etc., either on the cover or an appropriate place that will not be easily damaged and/or vandalized.

If the monitoring wells are installed in a high traffic area such as a parking lot, in a residential yard, or along the side of a road it may be desirable to finish the wells to the ground surface and install water-tight flush mounted traffic and/or man-hole covers. Flush mounted traffic and man-hole covers are designed to extend from the ground surface down into the concrete plug around the well casing. Although flush mounted covers may vary in design, they should have seals that make the unit water-tight when closed and secured. The flush mounted covers should be installed as far above grade as practical to minimize standing water and promote runoff. Permanent identification markings should be placed on the covers or in the concrete plug around the cover. Expansive sealing plugs may be used in the well riser to prevent infiltration of any water that might enter the flush cover.

6.5.2 Double Cased Wells

Double cased wells should be constructed when there is reason to believe that interconnection of two aquifers by well construction may cause cross contamination, and/or when flowing sands make it impossible to install a monitoring well using conventional methods. A pilot borehole should be bored through the overburden and/or the contaminated zone into the clay confining layer or bedrock. An outer casing (sometimes called surface or pilot casings) should then be placed into the borehole and sealed with grout. The borehole and outer casing should extend into tight clay a minimum of two feet and into competent bedrock a minimum of 1 foot. The total depths into the clay or bedrock will vary, depending on the plasticity of the clay and the extent of weathering and\or fracturing of the bedrock. The final depths should be approved by a senior field geologist. The size of the outer casing should be of sufficient inside diameter (ID) to contain the inner casing, and the 2-inch minimum annular space. In addition, the borehole should be of sufficient size to contain the outer casing and the 2-inch minimum outer annular space, if applicable.

The outer casing should be grouted by the tremie method from the bottom to within 2 feet of the ground surface. The grout should be pumped into the annular space between the outer casing and the borehole wall. This can be accomplished by either placing the tremie tube in the annular space and pumping the grout from the bottom of the borehole to the surface, or placing a grout shoe or plug inside the casing at the bottom of the borehole and pumping the grout through the bottom grout plug and up the annular space on the outside of the casing. If the outer casing is set into very tight clay, both of the above methods might have to be used, because the clay usually forms a tight seal in the bottom and around the outside of the casing preventing grout from flowing freely during grout injection. On the other hand, outer casing set into bedrock normally will have space enough to allow grout to flow freely during injection. A minimum of 24 hours should be allowed for the grout plug (seal) to cure before attempting to drill through it. The grout mixture used to seal the outer annular space should be either a neat cement, cement/bentonite, cement/sand, or a 30% solids bentonite grout. However, the seal or plug at the bottom of the borehole and outer casing should consist of a Type I portland cement/bentonite or cement/sand mixture. The use of a pure bentonite grout for a bottom plug or seal is not acceptable, because the bentonite grout cures to a gel-like material, and is not rigid enough to withstand the stresses of drilling. When drilling through the seal, care should be taken to avoid cracking, shattering, and/or washing out the seal, which will be discussed in the next section. If caving conditions exist so that the outer casing cannot be sufficiently sealed by grouting, the outer casing should be driven into place and a grout seal placed in the bottom of the casing. Removal of outer casings, which are sometimes called temporary surface casings, after the well screens and casings have been installed and grouted is not acceptable. Trying to remove outer surface casings after the inner casings have been grouted could jeopardize the structural integrity of the well.

<u>Bedrock Wells</u>

The installation of monitoring wells into bedrock can be accomplished in two ways:

1. The first method is to drill or bore a pilot borehole through the soil overburden into the bedrock. An outer casing is then installed into the borehole by setting it into the bedrock, and grouting it into place as described in the previous section. After the grout has set, the borehole can then be advanced through the grout seal into the bedrock. The preferred method of advancing the borehole into the bedrock is rock coring. Rock coring makes a smooth, round hole through the seal and into the bedrock without cracking and/or shattering the seal. Roller cone bits are used in soft bedrock, but extreme caution should be taken when using a roller cone bit to advance through the grout seal in the bottom of the borehole because excessive water and "down" pressure can cause cracking, eroding (washing), and/or shattering of the seal. Low volume air hammers may be used to advance the borehole, but they have a tendency to shatter the seal because of the hammering action. If the structural integrity of the grout seal is in question, a pressure test can be utilized to check for leaks. A visual test can also be made by examining the cement/concrete core that is collected when the seal is cored with a diamond coring bit. If the seal leaks (detected by pressure testing) and/ or the core is cracked or shattered, or if no core is recovered because of washing, excessive down pressure, etc., the seal is not acceptable. The concern over the structural integrity of the grout seal applies to all double cased wells. Any proposed method of double casing and/or seal testing will be evaluated on its own merits, and will have to be approved by a senior field geologist before and during drilling activities, if applicable. When the drilling is complete, the finished well will consist of an open borehole from the ground surface to the bottom of the well. There is no inner casing, and the outer surface casing, installed down into bedrock, extends above the ground surface, and also serves as the outer protective casing. If the protective casing becomes cracked or is sheared off at the ground surface, the well is open to direct contamination from the ground surface and will have to be repaired immediately or abandoned. Another limitation to the open rock well is that the entire bedrock interval serves as the monitoring zone. In this situation, it is very difficult or even impossible to monitor a specific zone, because the contaminants being monitored could be diluted to the extent of being nondetectable. The installation of open bedrock wells is generally not acceptable in the Superfund and RCRA programs, because of the uncontrolled monitoring intervals. However, some site conditions might exist, especially in cavernous limestone areas (Karst topography) or in areas of highly fractured bedrock, where the installation of the filter pack and its structural integrity are questionable. Under these conditions the design of an open bedrock well may be warranted.

2. The second method of installing a monitoring well into bedrock is to install the outer surface casing and drill the borehole (by an approved method) into bedrock, and then install an inner casing and well screen with the filter pack, bentonite seal, and annular grout. The well is completed with a surface protective casing and concrete pad. This well installation method gives the flexibility of isolating the monitoring zone(s) and minimizing inter-aquifer flow. In addition, it gives structural integrity to the well, especially in unstable areas (steeply dipping shales, etc.) where the bedrock has a tendency to shift or move when disturbed. Omitting the filter pack around the well screen is a general practice in some open rock borehole installations, especially in drinking water and irrigation wells. However, without the filter pack to protect the screened interval, sediment particles from the well installation and/or from the monitoring zone could clog the well screen and/or fill the screened portion of the well rendering it inoperable. Also, the filter pack serves as a barrier between the bentonite seal and the screened interval. Rubber inflatable packers have been used to place the bentonite seal when the filter pack is omitted, but the packers have to remain in the well permanently and, over a period of time, will decompose and possibly contribute contaminants to the monitoring zone.

6.6 Well Construction Materials

6.6.1 Introduction

Well construction materials are chosen based on the goals and objectives of the proposed monitoring program and the geologic conditions at the site(s). In this section, the different types of available materials will be discussed.

6.6.2 Well Screen and Casing Materials

When selecting the materials for well construction, the prime concern should be to select materials that will not contribute foreign constituents, or remove contaminants of concern from the ground water. If the monitoring program is designed to analyze for organic compounds, stainless steel materials are the preferred choice. If the monitoring program calls for the analyses of only inorganic compounds or the contaminants or formation are highly corrosive, then rigid PVC materials meeting National Sanitary Foundation (NSF) Standard 14 type WC (Well Casing) are acceptable. PVC materials may be acceptable for monitoring identified organic compounds in a soluble aqueous phase where incompatibilities are known to not exist. EPA document EPA/540/S-95/503, Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation (http://www.epa.gov/ada/download/issue/napl.pdf) should be used for guidance in this area and in the use of PVC with Nonaqueous Phase Liquids (NAPLs). Another concern is to select materials that will be rugged enough to endure the entire monitoring period. Site conditions will generally dictate the kind of materials that can be used. A preliminary field investigation should be conducted to determine the geologic conditions, so that the most suitable materials can be selected. The best grade or highest quality material for that particular application should be selected. Each manufacturer can supply the qualitative data for each grade of material that is being considered. All materials selected for monitoring well installation should be evaluated and approved by a senior field geologist prior to field activities.

Well screen and casing materials generally used in monitoring well construction on RCRA and Superfund sites are listed in order of preference:

(1) Stainless Steel (304 or 316)
(2) Rigid PVC meeting NSF Standard 14 (type WC)
(3) Other (where applicable)

There are other materials used for well screens and casings such as black iron, carbon steel, galvanized steel, and fiberglass, but these materials are not recommended for use in long term monitoring programs at hazardous waste sites, because of their low resistance to chemical attack and potential constituent contribution to the ground water. In cases where a driven casing is used, or a high strength outer casing is needed, carbon steel may be acceptable in non-corrosive aquifers. This outer casing should have threaded connections. Welding casing is not an acceptable practice unless all relevant safety issues have been adequately addressed.

The minimum nominal casing size for most permanent monitoring wells will be 2". Where a complete program of installation, monitoring, and abandonment is being designed, smaller wells may be installed if suitable purging and sampling equipment for the smaller diameter wells can be specified and obtained. The length of well screens in permanent monitoring wells should be long enough to effectively monitor the interval or zone of interest. However, well screens designed for long term monitoring purposes should normally not be less than 5 feet in length. Well screens less that 5 feet long are acceptable in only temporary monitoring wells where ground water samples are collected for screening purposes.

6.6.3 Filter Pack Materials

The filter pack materials should consist of clean, rounded to well-rounded, hard, insoluble particles of siliceous composition. The required grain-size distribution or particle sizes of the filter pack materials should be selected based upon a sieve analysis conducted on the soil samples collected from the aquifer materials and/or the formation(s) to be monitored. Filter pack materials should not be acceptable unless proper documentation can be furnished as to the composition, grain-size distribution, cleaning procedure, and chemical analysis. If a data search reveals that there is enough existing data to adequately design the well screen and filter pack, then it may not be necessary to conduct a sieve analysis on the formation materials to be monitored. However, all data and design proposals will be evaluated and approved by a senior staff geologist before field activities begin.

6.6.4 Filter Pack and Well Screen Design

The majority of monitoring wells are installed in shallow ground water aquifers that consist of silts, clays, and sands in various combinations. These shallow aquifers are not generally characteristic of sand aquifers used for drinking water. Therefore, modifications to the procedures used for the design of water well filter packs may be required. In cases where insufficient experience exists with local or similar materials, the filter pack and well screen design should be based on the results of a sieve analysis conducted on soil samples collected from the aquifer or the formation(s) that will be monitored.

In formations consisting primarily of fines (silts and clays), the procedures for water well screen design may result in requirements for filter packs and screen slot sizes that are not available. In those cases the selection of 0.010" screen slots with a 20-40 sand filter pack, or 0.005" screen slots with 100 sand filter pack for very fine formations, will be acceptable practice. Table 6.6.1 provides size specifications for the selection of sand packs for fine formation materials. ASTM standard D5092, Design and Installation of Ground Water Monitoring Wells in Aquifers, may be consulted for further guidance on specifications for sand appropriate for these applications.

Table 6.6.1
Sand Pack Specifications

Screen Opening (in)	Sand Pack Mesh Name	1% Passing Size (d-1) (in)	10% Passing Size (d-10) (in)	30% Passing Size (d-30) (in)	Derived 60% Passing Size (d-60) (in)	Range for Uniformity Coefficient
0.005"-0.006"	100	3.5 - 4.7	5.5 - 6.7	6.7 - 8.3	8.5 - 13.4	1.3 - 2.0
0.010"	20-40	9.8 - 13.8	15.7 - 19.7	19.7 -23.6	20 - 31.5	1.1 - 1.6

The following procedure should be used in coarser grained formations.

The data from the sieve analysis are plotted on a grain-size distribution graph, and a grain-size distribution curve is generated. From this grain-size distribution curve, the uniformity coefficient (Cu) of the aquifer material is determined. The Cu is the ratio of the 60 percent finer material (d60) to the 10 percent finer material (d10)

$$Cu = (d60/d10)$$

The Cu ratio is a way of grading or rating the uniformity of grain size. For example, a Cu of unity means that the individual grain sizes of the material are nearly all the same, while a Cu with a large number means a large range of sizes. As a general rule, a Cu of 2.5 or less should be used in designing the filter pack and well screen.

Before designing the filter pack and well screen, the following factors should be considered:

1. Select the well screen slot openings that will retain 90 percent of the filter pack material.

2. The filter pack material should be of the size that minimizes head losses through the pack and also prevents excessive sediment (sand, silt, clay) movement into the well.

3. A filter material of varying grain sizes is not acceptable because the smaller particles fill the spaces between the larger particles thereby reducing the void spaces and increasing resistance to flow. Therefore, filter material of the same grain size and well rounded is preferred.

4. The filter pack design is based on the gradation of the finest aquifer materials being analyzed.

Steps to design a filter pack in aquifers:

1. Construct a grain-size distribution curve, on a grain-size distribution graph, from the sieve analysis of the aquifer materials. The filter pack design (as stated above) is based on the gradation of the finest aquifer materials.

2. Multiply the d30 size from the grain-size distribution graph by a factor of four to nine (Pack-Aquifer ratio). A factor of four is used if the formation is fine-grained and uniform (Cu is less than 3), six if it is coarse-grained and non-uniform, and up to nine if it is highly non-uniform and contains silt. Head losses through filter packs increase as the Pack-Aquifer(P-A) ratios decrease. In order to design a fairly stable filter pack with a minimum head loss, the d30 size should be multiplied by a factor of four.

3. Plot the point from step 2 on the d30 abscissa of a grain-size distribution graph and draw a smooth curve with a uniformity coefficient of approximately 2.5.

4. A curve for the permissible limits of the filter pack is drawn plus or minus 8 per cent of the desired curve with the Cu of 2.5.

5. Select the slot openings for the well screen that will retain 90 per cent or more of the filter pack material.

The specific steps and procedures for sieve analysis and filter pack design can be found in soil mechanics, ground water, and water well design books. The staff geologists and/or engineers should be responsible for the correct design of the monitoring wells and should be able to perform the design procedures.

6.7 Safety Procedures for Drilling Activities

A site health and safety plan should be developed and approved by the Branch Safety Officer or designee prior to any drilling activities, and should be followed during all drilling activities. The driller or designated safety person should be responsible for the safety of the drilling team performing the drilling activities. All personnel conducting drilling activities should be qualified in proper drilling and safety procedures. Before any drilling activity is initiated, the area should be surveyed with the necessary detection equipment to locate, flag, or mark, all under ground utilities such as electrical lines, natural gas lines, fuel tanks and lines, water lines, etc. Before operating the drill rig, a pilot hole should be dug (with hand equipment) to a depth of two to three feet to check for undetected utilities or buried objects. Proceed with caution until a safe depth is reached where utilities normally would not be buried. The following safety requirements should be adhered to while performing drilling activities:

1. All drilling personnel should wear safety hats, safety glasses, and steel toed boots. Ear plugs are required and will be provided by the safety officer or driller.

2. Work gloves (cotton, leather, etc.) should be worn when working around or while handling drilling equipment.

3. All personnel directly involved with the drilling rig(s) should know where the kill switch(s) is located in case of emergencies.

4. All personnel should stay clear of the drill rods or augers while in motion, and should not grab or attempt to attach a tool to the drill rods or augers until they have completely stopped rotating. Rod wipers, rather than gloves or bare hands should be used to remove mud, or other material, from drill stem as it is withdrawn from the borehole.

5. Do not hold drill rods or any part of the safety hammer assembly while taking standard penetration tests or while the hammer is being operated.

6. Do not lean against the drill rig or place hands on or near moving parts at the rear of the rig while it is operating.

7. Keep the drilling area clear of any excess debris, tools, or drilling equipment.

8. Do not climb on the drilling rig while it is being operated or attempt to repair the rig while it is being operated. The driller will direct all work on the rig.

9. Do not move or pick up any drilling equipment unless directed by the driller and/or the project leader.

10. Each drill rig will have a first-aid kit and a fire extinguisher located on the rig in a location quickly accessible for emergencies. All drilling personnel will be familiarized with their location.

11. Work clothes will be firm fitting, but comfortable and free of straps, loose ends, strings etc., that might catch on some moving part of the drill rig.

12. Rings or other jewelry will not be worn while working around the drill rig.

13. The drill rig should not be operated within a minimum distance of 20 feet of overhead electrical power lines and/or buried utilities that might cause a safety hazard. In addition, the drill rig should not be operated while there is lightening in the area of the drilling site. If an electrical storm moves in during drilling activities, vacate the area until it is safe to return.

6.8 Well Development

A newly completed monitoring well should not be developed for at least 24 hours after the surface pad and outer protective casing are installed. This will allow sufficient time for the well materials to cure before development procedures are initiated. The main purpose of developing new monitoring wells is to remove the residual materials remaining in the wells after installation has been completed, and to try to re-establish the natural hydraulic flow conditions of the formations which may have been disturbed by well construction, around the immediate vicinity of each well. A new monitoring well should be developed until the column of water in the well is free of visible sediment, and the pH, temperature, turbidity, and specific conductivity have stabilized. In most cases the above requirements can be satisfied; however, in some cases the pH, temperature, and specific conductivity may stabilize but the water remains turbid. In this case the well may still contain well construction materials, such as drilling mud in the form of a mud cake and/or formation soils, that have not been washed out of the borehole. Excessive or thick drilling muds can not be flushed out of a borehole with one or two well volumes of flushing. Continuous flushing over a period of several days may be necessary to complete the well development. If the well is pumped to dryness or near dryness, the water table should be allowed to sufficiently recover (to the static water level) before the next development period is initiated. Caution should be taken when using high rate pumps and/or large volume air compressors during well development because excessive high rate pumping and high air pressures can damage or destroy the well screen and filter pack. The onsite geologist should make the decision as to the development completion of each well. All field decisions should be documented in the field log book.

The following development procedures, listed in increasing order of the energy applied to the formation materials, are generally used to develop monitoring wells:

1. Bailing
2. Pumping/overpumping
3. Surging
4. Backwashing ("rawhiding")
5. Jetting
6. Compressed air (with appropriate filtering): airlift pumping and air surging

These developmental procedures can be used, individually or in combination, in order to achieve the most effective well development. In most cases, overpumping and surging will adequately develop the well without imparting undue forces on the formation or well materials. Except when compressed air is being used for well development, sampling can be initiated as soon as the ground water has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24 hours after development to sample a new monitoring well. Wells developed with stressful measures may require as long as a 7-day interval before sampling. In particular, air surge developed wells require 48 hours or longer after development so that the formation can dispel the compressed air and restabilize to pre-well construction conditions. Because of the danger of introducing contaminants with the airstream, the possibility of entraining air in the aquifer, and the violent forces imparted to the formation, air surging is the least desired method of development. The selected development method(s) should be approved by a senior field geologist before any well installation activities are initiated.

6.9 Well Abandonment

When a decision is made to abandon a monitoring well, the borehole should be sealed in such a manner that the well can not act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers. To properly abandon a well, the preferred method is to completely remove the well casing and screen from the borehole, clean out the borehole, and backfill with a cement or bentonite grout, neat cement, or concrete. In order to comply with state well abandonment requirements, the appropriate state agency should be notified (if applicable) of monitoring well abandonment. However, some state requirements are not explicit, so a technically sound well abandonment method should be designed based on the site geology, well casing materials, and general condition of the well(s).

6.9.1 Abandonment Procedures

As previously stated the preferred method should be to completely remove the well casing and screen from the borehole. This may be accomplished by augering with a hollow-stem auger over the well casing down to the bottom of the borehole, thereby removing the grout and filter pack materials from the hole. The well casing should then be removed from the hole with the drill rig. The clean borehole can then be backfilled with the appropriate grout material. The backfill material should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method). The top 2 feet of the borehole should be poured with concrete to insure a secure surface seal (plug). If the area has heavy traffic use, and/or the well locations need to be permanently marked, then a protective surface pad(s) and/or steel bumper guards should be installed. The concrete surface plug can also be recessed below ground surface if the potential for construction activities exists. This abandonment method can be accomplished on small diameter (1-inch to 4-inch) wells without too much difficulty. With wells having 6-inch or larger diameters, the use of hollow-stem augers for casing removal is very difficult or almost impossible. Instead of trying to ream the borehole with a hollow-stem auger, it is more practical to force a drill stem with a tapered wedge assembly or a solid-stem auger into the well casing and extract it out of the borehole. Wells with little or no grouted annular space and/or sound well casings can be removed in this manner. However, old wells with badly corroded casings and/or thickly grouted annular space have a tendency to twist and/or break-off in the borehole. When this occurs, the well will have to be grouted with the remaining casing left in the borehole. The preferred method in this case should be to pressure grout the borehole by placing the tremie tube to the bottom of the well casing, which will be the well screen or the bottom sump area below the well screen. The pressurized grout will be forced out through the well screen into the filter material and up the inside of the well casing sealing holes and breaks that are present. The tremie tube should be retracted slowly as the grout fills the casing. The well casing should be cut off even with the ground surface and filled with concrete to a depth of 2 feet below the surface. If the casing has been broken off below the surface, the grout should be tremied to within 2 feet of the surface and then finished to the ground surface with concrete. The surface pad or specified surface protection shall then be installed.

A PVC well casing may be more difficult to remove from the borehole than a metal casing, because of its brittleness. If the PVC well casing breaks during removal, the borehole should be cleaned out by using a drag bit or roller cone bit with the wet rotary method to grind the casing into small cuttings that will be flushed out of the borehole by water or drilling mud. Another method is to use a solid-stem auger with a carbide tooth bit to grind the PVC casing into small cuttings that will be brought to the surface on the rotating flights. After the casing materials have been removed from the borehole, the borehole should be cleaned out and pressure grouted with the approved grouting materials. As previously stated, the borehole should be finished with a concrete surface plug and adequate surface protection, unless directed otherwise.

6.10 Temporary Monitoring Well Installation

6.10.1 Introduction

Five types of temporary monitoring well installation techniques have been demonstrated as acceptable. The type selected for a particular site is dependent upon site conditions. The project leader and site geologist should be prepared to test temporary well installations on site and select the best solution. Temporary wells are cost effective, may be installed quickly, and provide a synoptic picture of ground water quality.

Temporary monitoring well locations are not permanently marked, nor are their elevations normally determined. Sand pack materials may or may not be used, but typically there is no bentonite seal, grout, surface completion, or extensive development (as it normally applies to permanent monitoring wells). Temporary wells are generally installed, purged, sampled, removed, and backfilled in a matter of hours.

Due to the nature of construction, turbidity levels may initially be high. However, these levels may be reduced by low flow purging and sampling techniques as described in Section 7.2.4.

Temporary wells may be left overnight, for sampling the following day, but the well must be secured. If the well is not sampled immediately after construction, the well should be purged prior to sampling as specified in Section 7.2.4.

6.10.2 Data Limitation

Temporary wells described in this section are best used for delineation of contaminant plumes, at a point in time, and for some site screening purposes. They are not intended to replace permanent monitoring wells. Perhaps the best use for temporary wells is in conjunction with a mobile laboratory, where quick analytical results can be used to delininate contaminant plumes.

6.10.3 Temporary Well Materials

Materials used in construction of temporary monitoring wells are the same standard materials used in the construction of permanent monitoring wells. Sand used for the filter pack (if any) should be as specified in Section 6.6.3. The well screen and casing should be stainless steel for ruggedness and suitability for steam cleaning and solvent rinsing. Other materials may be acceptable, on a case by case basis. Some commercially available temporary well materials, pre-packed riser, screen and filter pack assemblies are available commercially; however, these pre-assembled materials cannot be cleaned. Appropriate QA/QC must be performed to assure there will be no introduction of contamination.

6.10.4 Temporary Monitoring Well Borehole Construction

Borehole construction for temporary wells is as specified in Section 6.4, using a drill rig. Alternatively, boreholes may be constructed using hand augers or portable powered augers (generally limited to depths of ten feet or less). If a drill rig is used to advance the borehole, the augers must be pulled back the length of the well screen (or removed completely) prior to sampling. When hand augers are used, the borehole is advanced to the desired depth (or to the point where borehole collapse occurs). In situations where borehole collapse occurs, the auger bucket is typically left in the hole at the point of collapse while the temporary well is assembled. When the well is completely assembled, a final auger bucket of material is quickly removed and the well is immediately inserted into the borehole, pushing, as needed, to achieve maximum penetration into the saturated materials.

6.10.5 Temporary Monitoring Well Types

Five types of monitoring wells which have been shown to be acceptable are presented in the order of increasing difficulty to install and increasing cost:

No Filter Pack

This is the most common temporary well and is very effective in many situations. After the borehole is completed, the casing and screen are simply inserted. This is the most inexpensive and fastest well to install. This type well is extremely sensitive to turbidity fluctuations, because there is no filter pack. Care should be taken to not disturb the casing during purging and sampling.

Inner Filter Pack

This type differs from the "No Pack" only in that a filter pack is placed inside the screen to a level approximately 6 inches above the well screen. This ensures that all water within the casing has passed through the filter pack. For this type well to function properly, the static water level must be 6-12 inches above the filter pack.

Traditional Filter Pack

For this type, the screen and casing are inserted into the borehole, and the sand is poured into the annular space surrounding the screen and casing. Occasionally, it may be difficult to effectively place a filter pack around shallow open boreholes, due to collapse. This method requires more sand than the "inner filter pack" well, increasing material costs. As the filter pack is placed, it mixes with the muddy water in the borehole, which may increase the amount of time needed to purge the well to an acceptable level of turbidity.

Double Filter Pack

The borehole is advanced to the desired depth. As with the "inner filter pack" the well screen is filled with filter pack material and the well screen and casing inserted until the top of the filter pack is at least 6 inches below the water table. Filter pack material is poured into the annular space around the well screen. This type temporary well construction can be very effective in aquifers where fine silts or clays predominate. This construction technique takes longer to implement and uses more filter pack material than others previously discussed.

Well-in-a-Well

The borehole is advanced to the desired depth. At this point, a 1-inch well screen and sufficient riser is inserted into a 2-inch well screen with sufficient riser, and centered. Filter pack material is then placed into the annular space surrounding the 1-inch well screen, to approximately 6 inches above the screen. The well is then inserted into the borehole.

This system requires twice as much well screen and casing, with subsequent increase in material cost. The increased amount of well construction materials results in a corresponding increase in decontamination time and costs. If pre-packed wells are used, a higher degree of QA/QC will result in higher overall cost.

6.10.6 Backfilling

It is the generally accepted practice to backfill the borehole from the abandoned temporary well with the soil cuttings. Use of cuttings would not be an acceptable practice if waste materials were encountered or a confining layer was inadvertently breached. Likewise, where the borehole is adjacent to or, downslope of contaminated areas, the loose backfilled material could create a high permeability conduit for the contaminant migration. If for some reason the borehole cannot be backfilled with the soil cuttings, then the same protocols set forth in Section 6.9 should be applied. Section 5.15 should be referenced regarding disposal of IDW.

6.11 Temporary Monitoring Well Installation Using the Geoprobe® Screen Point 15 Groundwater Sampler

6.11.1 Introduction

The Geoprobe® Screen Point 15 Groundwater Sampler is a discrete interval ground water sampling device that can be pushed to pre-selected sampling depths in saturated, unconsolidated materials, opened and sampled as a temporary monitoring well. It is a sealed sample device, opened at the desired depth, yielding a representative, uncompromised sample from that depth. Using knock-out plugs, this method also allows for grouting of the push hole during sample tool retrieval after sample collection.

The Screen Point 15 sampler consist of four parts (drive point, screen, sampler sheath and drive head), with an assembled length of 52 inches (1321 mm) and a maximum OD of 1.5 inches (38 mm). When opened, it has an exposed screen length of 41 inches (1041 mm). It is typically pushed using 1.25-inch probe rod.

The following is a step-by-step description of the components and procedures used to install a Screen Point 15 Groundwater Sampler.

6.11.2 Assembly of Screen Point 15 Groundwater Sampler

1. Install O-ring on expendable point and firmly seat in the necked end of the sampler sheath.

2. Place a grout plug in the lower end of the screen section.

3. When using a stainless steel screen, place another O-ring in the groove on the upper end of the screen and slide it into the sampler sheath.

4. Place an O-ring on the bottom of the drive head and thread into the top of the sampler sheath.

5. The Screen Point 15 Groundwater Sampler is now assembled and ready to push for sample collection.

6.11.3 Installation of Screen Point 15 Groundwater Sampler

1. Attach drive cap to top of sampler and slowly drive it into the ground. Raise the hammer assembly, remove the drive cap and place an O-ring in the top groove of the drive head. Add a probe rod and continue push.

2. Continue to add probe rods until the desired sampling depth is reached.

3. When the desired sampling depth is reached, re-position the probe derrick and position either the casing puller assembly or the rod grip puller over the top of the top probe rod.

4. Thread a screen push adapter on an extension rod and attach sufficient additional extension rods to reach the top of the Screen Point 15 sampler. Add an extension handle to the top of the string of extension rods and run this into the probe rod, resting the screen push adapter on top of the sampler.

5. To expose the screened portion of the sampler, exert downward pressure on the sampler, using the extension rod and push adapter, while pulling the probe rod upward. To expose the entire open portion of the screen, pull the probe rod upward approximately 41 inches.

6. At this point, the Screen Point 15 Groundwater Sampler has been installed as a temporary well and may be sampled using appropriate ground water sampling methodology. EIB personnel typically use a peristaltic pump, utilizing low-flow methods, to collect ground water samples from these installations (see Section 7, Ground Water Sampling, for a detailed description of these techniques and methods).

6.11.4 Special Considerations for Screen Point 15 Installations

<u>Grouting</u>

In many applications, it may be appropriate to grout the abandoned probe hole where a Screen Point 15 sampler was installed. This is accomplished via pressure grouting through the probe rod during sampler retrieval. To accomplish this, the grout plug is knocked out of the bottom of the screen using a grout plug push adapter and a grout nozzle is fed through the probe rod, extending just below the bottom of the screen. As the probe rod and sampler are pulled, grout is injected in the open hole below the screen at a rate that just fills the open hole created by the pull. Teflon® grout plugs are used for all EIB investigations using this method of abandonment.

<u>Screen Material Selection</u>

Screen selection is also a consideration in sampling with the Screen Point 15 sampler. The screens are available in two materials, stainless steel and PVC. Because of stainless steel's durability, ability to be cleaned and re-used and overall inertness and compatibility with most contaminants, it is the choice of materials for all EIB investigations.

6.12 References

1. National Ground Water Association, Manual of Water Well Construction Practices, NGWA, Westerville, OH

2. US-EPA, Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells (EPA/600/4-89, March 1991)

3. ASTM, Standard Practice for Design and Installation of Ground water Monitoring Wells in Aquifers (D5092-90).

4. Driscoll, Fletcher, Ph.D., Groundwater and Wells, Johnson Division, St. Paul, MN, 1986

5. US-EPA, Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation, (EPA/540/S-95/503, July 1995), (http://www.epa.gov/ada/download/issue/napl.pdf)

SECTION 7
GROUND WATER SAMPLING

PERFORMANCE OBJECTIVES:

- To collect a sample representative of ground water residing in the formation of interest.
- To reduce the potential bias caused by the sampling equipment used to obtain the sample.

7.1 Introduction

Ground water sampling may be required for a variety of reasons, such as examining potable or industrial water supplies, checking for and/or tracking contaminant plume movement in the vicinity of a land disposal or spill site, Resource Conservation Recovery Act (RCRA) compliance monitoring, or examining a site where historical information is minimal or non-existent but where it is thought that ground water contamination may have occurred.

Ground water samples are usually obtained from either temporarily or permanently installed ground water monitoring wells. They can also be obtained, however, anywhere ground water is present, such as in a pit or a dug or drilled hole.

Occasionally, the ground water source may not be in the ideal location to meet a particular objective (e.g., to track a contaminant plume). In that case, either a temporary or permanent monitoring well should be installed. An experienced and knowledgeable person will need to locate the well and supervise its installation so that samples will be representative of the ground water.

Additional guidance is given in RCRA Ground-Water Monitoring: Technical Guidance (1) and Chapter 11 of SW-846 (2). The ground water sampling procedures described in this SOP will meet or exceed the requirements of these documents.

Ground water sampling procedures can be sub-divided into two areas, purging and sampling, each of which has different goals and objectives. Within the topic of purging, it is necessary, because of the inherently different characteristics of the two types of wells, to address permanent and temporary wells separately. The procedures and techniques which follow in this section reflect these differences.

7.2 Purging

7.2.1 Purging and Purge Adequacy

Purging is the process of removing stagnant water from a monitoring well, immediately prior to sampling, causing its replacement by ground water from the adjacent formation, which is representative of actual aquifer conditions. In order to determine when a well has been adequately purged, field investigators should: 1) monitor the pH, specific conductance, temperature, and turbidity of the ground water removed during purging; and 2) observe and record the volume of water removed.

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined. To do this, the diameter of the well should be determined and the water level and total depth of the well are measured and recorded. Specific methodology for obtaining these measurements is found in Section 15.5 of this SOP. Once this information is obtained, the volume of water to be purged can be determined using one of several methods. One is the equation:

$$V = 0.041\ d^2h$$

Where: h = depth of water in feet
d = diameter of well in inches
V = volume of water in gallons

Alternatively, the volume may be determined using a casing volume per foot factor for the appropriate diameter well, similar to that in Table 7.2.1. The water level is subtracted from the total depth, providing the length of the water column. This length is multiplied by the factor in the Table 7.2.1 which corresponds to the appropriate well diameter, providing the amount of water, in gallons, contained in the well. Other acceptable methods include the use of nomographs or other equations or formulae.

With respect to volume, an adequate purge is normally achieved when three to five times the volume of standing water in the well has been removed. The field notes should reflect the single well volume calculations or determinations, according to one of the above methods, and a reference to the appropriate multiplication of that volume, i.e., a minimum three well volumes, clearly identified as a purge volume goal.

With respect to the ground water chemistry, an adequate purge is achieved when the pH, specific conductance, and temperature of the ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs) (twice the Primary Drinking Water Standard of 5 NTUs). Although ten NTUs is normally considered the minimum goal for most ground water sampling objectives, 1 NTU has been shown to be easily achievable and reasonable attempts should be made to reach this level. Stabilization occurs when pH measurements remain constant within 0.1 Standard Unit (SU), specific conductance varies no more that 10 percent, and the temperature is constant for at least three consecutive readings. There are no criteria establishing how many sets of measurements are adequate for the determination of stability. If the calculated purge volume is small, the measurements should be taken frequently to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes may be sufficient.

If, after three well volumes have been removed, the chemical parameters have not stabilized according to the above criteria, additional well volumes (up to five well volumes), should be removed. If the parameters have not stabilized within five volumes, it is at the discretion of the project leader whether or not to collect a sample or to continue purging. If after five well volumes, pH and conductivity have been stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible. The conditions of sampling should be noted in the field log.

TABLE 7.2.1
WELL CASING DIAMETER vs. VOLUME

WELL CASING DIAMETER 9 (INCHES) vs. VOLUME (GALS.)/FEET of WATER	
CASING	GALLONS/FT
1	0.041
2	0.163
3	0.367
4	0.653
5	1.02
6	1.469
7	1.999
8	2.611
9	3.305
10	4.08
11	4.934
12	5.875

In some situations, even with slow purge rates, a well may be pumped or bailed dry (evacuated). In these situations, this generally constitutes an adequate purge and the well can be sampled following sufficient recovery (enough volume to allow filling of all sample containers). It is not necessary that the well be evacuated three times before it is sampled. The pH, specific conductance, temperature, and turbidity should be measured, during collection of the sample from the recovered volume, as the measurements of record for the sampling event.

Attempts should be made to avoid purging wells to dryness. This can be accomplished, for example, by slowing the purge rate. If a well is pumped dry, it may result in the sample being comprised partially of water contained in the sand pack, which may be reflective, at least in part, of initial, stagnant conditions. In addition, as water re-enters a well that is in an evacuated condition, it may cascade down the sand pack or the well screen, stripping volatile organic constituents that may be present and/or introducing soil fines into the water column.

It is particularly important that wells be sampled as soon as possible after purging. If adequate volume is available, the well must be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered.

Equipment Available

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or, by using portable pumps/equipment when dedicated systems are not present. The equipment may consist of a variety of pumps, including peristaltic, large and small diameter turbine (electric submersible), bladder, centrifugal, gear-driven positive displacement, or other appropriate pumps. The use of any of these pumps is usually a function of the depth of the well being sampled and the amount of water that is to be removed during purging. Whenever the head difference between the sampling location and the water level is less than the limit of suction and the volume to be removed is reasonably small, a peristaltic pump should be used for purging. Appendix E of this SOP contains the operating instructions for all pumps commonly used during Branch ground water investigations.

Bailers may also be used for purging in appropriate situations, however, their use is discouraged. Bailers tend to disturb any sediment that may be present in the well, creating or increasing sample turbidity. If a bailer is used, it should be a closed-top Teflon® bailer.

7.2.2 Purging Techniques (Wells Without Plumbing or In-Place Pumps)

For permanently installed wells, the depth of water and depth of the well should be determined (if possible) before purging. Electrical water level indicators/well sounders can be used for this purpose. It is standard practice to mark the top of casing, providing a point of reference from which these measurements will be consistently made. Field investigators should look for these markings when taking these measurements. Extreme caution should be exercised during this procedure to prevent cross-contamination of the wells. This is a critical concern when samples for trace organic compounds or metals analyses are collected. At a minimum, the well sounding device should be cleaned by washing in a laboratory detergent solution, followed by rinses with tap water and analyte-free water. After cleaning, it should be placed in a clean plastic bag or wrapped in foil.

Purging with Pumps

When peristaltic pumps or centrifugal pumps are used, only the intake line is placed into the water column. The line placed into the water should be either standard-cleaned (see Appendix B) Teflon® tubing, for peristaltic pumps, or standard-cleaned stainless steel pipe attached to a hose for centrifugal pumps.

When submersible pumps (bladder, turbine, displacement, etc.) are used, the pump itself is lowered into the water column. The pump must be cleaned as specified in Appendix B.

Purging with Bailers

Standard-cleaned (Appendix B) closed-top Teflon® bailers with Teflon® leaders and new nylon rope are lowered into top of the water column, allowed to fill, and removed. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. The use of bailers for purging and sampling is discouraged because the correct technique is highly operator dependent.

Field Care of Purging Equipment

Regardless of which method is used for purging, new plastic sheeting should be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they need to be placed on the ground during the purging or they accidentally come into contact with the ground surface. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool or contained in a plastic-lined tub, both during transporting and during field use, to further minimize contamination from the transporting vehicle or ground surface.

Purging Entire Water Column

The pump/hose assembly or bailer used in purging should be lowered into the top of the standing water column and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representative of the ground water.

It is recommended that no more than three to five feet of hose be lowered into the water column. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is within one foot of the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the draw down. After the pump is removed from the well, all wetted portions of the hose and the pump should be cleaned as outlined in Appendix B of this SOP.

Careful consideration shall be given to using pumps to purge wells which are excessively contaminated with oily compounds, because it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative purging methods, such as bailers, should be considered.

General Low Flow/Low Stress Method Preference

The device with the lowest pump or water removal rate and the least tendency to stress the well during purging should be selected for use. For example, if a bailer and a peristaltic pump both work in a given situation, the pump should be selected because it will greatly minimize turbidity, providing a higher quality sample (Section 7.2.4 contains a description of low flow purging and sampling with a peristaltic pump used in a temporary well). If a Fultz® pump or a Grundfos Redi-Flo2® could both be used, the Redi-Flo2® may be given preference because the speed can be controlled to provide a lower pump rate, thereby minimizing turbidity.

Low Flow/Low Volume Purging Techniques/Procedures

Alternatives to the low flow purging procedures exist and may be acceptable. The low flow/low volume purging is a procedure used to minimize purge water volumes. The pump intake is placed within the screened interval at the zone of sampling, preferably, the zone with the highest flow rate. Low flow rate purging is conducted after hydraulic conditions within the well have re-stabilized, usually within 24 to 48 hours. Flow rates should not exceed the recharge rate of the aquifer. This is monitored by measuring the top of the water column with a water level recorder or similar device while pumping. These techniques, however, are only acceptable under certain hydraulic conditions and are not considered standard procedures.

7.2.3 Purging Techniques - Wells with In-Place Plumbing

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, etc. Many permanent monitoring wells at active facilities are also equipped with dedicated, in-place pumps. The objective of purging wells with in-place pumps is the same as with monitoring wells without in-place pumps, i.e., to ultimately collect a sample representative of the ground water. Among the types of wells identified in this section, two different approaches are necessary. The permanent monitoring wells with in-place pumps should, in all respects, be treated like the monitoring well without pumps. They generally are sampled only occasionally and require purging as described for wells without in-place pumps, i.e., 3 to 5 well volumes and stable parameters.

In the case of the other types of wells, however, not enough is generally known about the construction aspects of the wells to apply the same criteria as used for monitoring wells, i.e., 3 to 5 well volumes. The volume to be purged in these situations, therefore, depends on several factors: whether the pumps are running continuously or intermittently and whether or not any storage/pressure tanks are located between the sampling point and the pump. The following considerations and procedures should be followed when purging wells with in-place plumbing under the conditions described.

Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot, valve or other sampling point should be located between the pump and the storage tank. If not, locate the valve closest to the tank. Measurements of pH, specific conductance, temperature, and turbidity are recorded at the time of sampling.

Intermittently Running Pumps

If the pump runs intermittently, it is necessary to determine, if possible, the volume to be purged, including storage/pressure tanks that are located prior to the sampling location. The pump should then be run continuously until the required volume has been purged. If construction characteristics are not known, best judgement should be used in establishing how long to run the pump prior to collecting the sample. Generally, under these conditions, 30 minutes will be adequate. Measurements of pH, specific conductance, temperature and turbidity should be made and recorded at intervals during the purge and the final measurements made at the time of sampling.

7.2.4 Purging Techniques - Temporary Monitoring Wells

Temporary ground water monitoring wells differ from permanent wells because temporary wells are installed in the ground water for immediate sample acquisition. Wells of this type may include standard well screen and riser placed in boreholes created by hand augering, power augering, or by drilling. They may also consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as the Direct Push Wellpoint®, the Geoprobe® and the Hydropunch®. As such, the efforts to remove several volumes of water to replace stagnant water do not necessarily apply in these situations, because generally, stagnant water is non-existent. It is important to note, however, that the longer a temporary well is in place and not sampled, the more appropriate it may be to apply, to the extent possible, standard permanent monitoring well purging criteria to it.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, resulting primarily in increased turbidity. Therefore, the goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity samples in these types of wells are typically and routinely achieved by the use of low-flow purging and sampling techniques.

The following low-flow purging technique using peristaltic pumps has been used routinely to achieve acceptably low NTU values in a variety of temporary monitoring well applications.

In purging situations where the elevation of the top of the water column is no greater than approximately 25 feet below the pump head elevation, a peristaltic pump may be used to purge temporary wells. Enough tubing is deployed to reach the bottom of the temporary well screen. At the onset of purging, the tubing is slowly lowered to the bottom of the screen and is used to remove any formation material which may have entered the well screen during installation. This is critical to ensuring rapid achievement of low turbidity conditions. After the formation material is removed from the bottom of the screen, the tubing is slowly raised through the water column to near the top of the column. The tubing can be held at this level to determine if the pump is lowering the water level in the well. If not, secure the tubing at the surface to maintain this pumping level.

If the water column is lowered, and the pump is not variable speed, continue to lower the tubing as the water column is lowered. If a variable speed peristaltic pump is being used and draw down is observed on initiation of pumping, reduce the pump speed and attempt to match the draw down of the well. Sustained pumping at these slow rates will usually result in a relatively clear, low turbidity sample. If the draw down stabilizes, maintain that level, however, if it continues to lower, "chase" the water column until the well is evacuated. In this case, the recovered water column may be relatively free of turbidity and can be sampled. It may take several episodes of recovery to provide enough volume for a complete sample.

With many of the direct push sampling techniques, purging is not practical or possible, therefore, no purging is conducted. The sampling device is simply pushed to the desired depth and opened and the sample is collected and retrieved.

7.2.5 Investigation Derived Waste

Purging generates quantities of purge water or investigation derived waste (IDW), the disposition of which must be considered. What is appropriate for the disposition of the water is, in part, dependent on the nature of the investigation. If the IDW is generated at a RCRA facility, it will generally be contained and disposed on site in an on-site treatment facility. IDW generated during Superfund or other investigations may, at the discretion of the field project leader or the program manager (remedial project manager), be discharged to the ground, away from the well, or be containerized for later disposal or other appropriate action.

7.3 Sampling

Sampling is the process of obtaining, containerizing, and preserving the ground water sample after the purging process is complete. Non-dedicated pumps for sample collection generally should not be used. Many pumps are made of materials, such as brass, plastic, rubber, or other elastomer products which may cause chemical interferences with the sample. Their principle of operation may also render them unacceptable as a sample collection device. The pump may be turbine driven, which may release volatile organic constituents. It is recognized that there are situations, such as industrial or municipal supply wells or private residential wells, where a well may be equipped with a dedicated pump from which a sample would not normally be collected. Discretion should always be used in obtaining a sample.

7.3.1 Equipment Available

Because of the problems with most pumps described in the preceding paragraph, only three devices should be used to collect ground water samples from most wells. These are the peristaltic pump/vacuum jug assembly, a stainless steel and Teflon® bladder pump, and a closed-top, Teflon® bailer.

Other monitoring equipment used during sampling includes water level indicators, pH meters, thermometers, conductivity bridges, and nephelometers (turbidity meters).

7.3.2 Sampling Techniques - Wells With In-Place Plumbing

Samples should be collected following purging from a valve or cold water tap as near to the well as possible, preferably prior to any storage/pressure tanks that might be present. Remove any hose that may be present before sample collection and reduce the flow to a low level to minimize sample disturbance, particularly with respect to volatile organic constituents. Samples should be collected directly into the appropriate containers (see Standard Sample Containers, Appendix A). It may be necessary to use a secondary container, such as a clean 8 oz. sample jar or a stainless steel scoop, to obtain and transfer samples from spigots with low ground clearance. Also, refer to the Potable Water Supply discussion in Section 2.2. All measurements for pH, specific conductance, temperature, and turbidity should be recorded at the time of measurement.

7.3.3 Sampling Techniques - Wells without Plumbing

Following purging, samples should be collected using a peristaltic pump/vacuum jug assembly, a Teflon®/stainless steel bladder pump, or a closed-top Teflon® bailer. These techniques are described below.

Peristaltic pump/vacuum jug

The peristaltic pump/vacuum jug can be used for sample collection because it allows for sample collection without the sample coming in contact with the pump tubing. This is accomplished by placing a Teflon® transfer cap assembly onto the neck of a standard cleaned 4-liter (1-gallon) glass container. Teflon® tubing (¼-inch O.D.) connects the container to both the pump and the sample source. The pump creates a vacuum in the container, thereby drawing the sample into the container without it coming into contact with the pump tubing.

Samples for volatile organic compound analysis should be collected using a bailer or by filling the Teflon® tube, by one of two methods, and allowing it to drain into the sample vials. The tubing can be momentarily attached to the pump to fill the tube with water. After the initial water is discharged through the pump head, the tubing is quickly removed from the pump and a gloved thumb placed on the tubing to stop the water from draining out. The tubing is then removed from the well and the water allowed to either gravity drain or be reversed, by the pump, into the sample vials. (Note: When reversing the pump, make sure the discharge tubing is not submerged in purge water. This will prevent introducing potentially cross-contaminated purge water into the sample.) Alternatively, the tubing can be lowered into the well the desired depth and a gloved thumb placed over the end of the tubing. This method will capture the water contained in the tubing. It can then be removed from the well and the water collected by draining the contents of the tubing into the sample vials. Under no circumstances should the sample for volatile organic compound analysis be collected from the content of any other previously filled container. All equipment should be cleaned using the procedures described in Appendix B. Also, refer to the Potable Water Supply discussion, Section 2.2, for additional information.

When sampling for metals only, it is also permissible to collect the sample directly from the pump discharge tubing after an adequate purge has been demonstrated. When collecting samples in this manner there are several considerations to be aware of. The pump head tubing (silastic, etc,) must be changed after each well and a rinsate blank must be collected of a representative piece of the pump head tubing (only one blank per investigation). Also, precautions must be taken to ensure that the end of the discharge tubing is not allowed to touch the ground or other surface to ensure the integrity of the sample collected in this manner.

Bladder Pumps

After purging has been accomplished with a bladder pump, the sample is obtained directly from the pump discharge. If the discharge rate of the pump, during purging, is too great, so as to make sample collection difficult, care should be taken to reduce the discharge rate at the onset of actual sample collection. This is necessary to minimize sample disturbance, particularly with respect to samples collected for volatile organic compounds analysis.

Bailers

When bailing, new plastic sheeting should be placed on the ground around each well to provide a clean working area. New nylon rope should be attached to the bailer via a Teflon® coated stainless steel wire. This coated wire is semi-permanently attached to the bailer and is decontaminated for reuse as the bailer is cleaned. The bailer should be gently immersed in the top of the water column until just filled. At this point, the bailer should be carefully removed and the contents emptied into the appropriate sample containers.

7.3.4 Sample Preservation

Immediately after collection, all samples requiring preservation must be preserved with the appropriate preservative. Consult Appendix A for the correct preservative for the particular analytes of interest. All samples preserved using a pH adjustment (except VOCs) must be checked, using pH strips, to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip. Do not place the strip in the sample.

7.3.5 Special Sample Collection Procedures

Trace Organic Compounds and Metals

Special sample handling procedures should be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which comes into contact with the water in the well must be cleaned in accordance with the cleaning procedures described in Appendix B. Pumps should not be used for sampling, unless the interior and exterior portions of the pump and the discharge hoses are thoroughly cleaned. Blank samples should be collected to determine the adequacy of cleaning prior to collection of any sample using a pump.

Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, an adequate purge, with respect to turbidity, is often difficult to achieve. Removal and insertion of equipment after the purge and prior to actual sampling may negate the low turbidities achieved during purging and elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to collect the aliquot for metals first.

Filtering

As a standard practice, ground water samples will not be filtered for routine analysis. Filtering will usually only be performed to determine the fraction of major ions and trace metals passing the filter and used for flow system analysis and for the purpose of geochemical speciation modeling. Filtration is not allowed to correct for improperly designed or constructed monitoring wells, inappropriate sampling methods, or poor sampling technique.

When samples are collected for routine analyses and are filtered, such as under conditions of excessive turbidity, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis should not be filtered. Prior to filtration of the ground water sample for any reason other than geochemical speciation modeling, the following criteria must be demonstrated to justify the use of filtered samples for inorganic analysis:

1. The monitoring wells, whether temporary or permanent, have been constructed and developed in accordance with Section 6.

2. The ground water samples were collected using sampling techniques in accordance with this section, and the ground water samples were analyzed in accordance with US-EPA approved methods.

3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of the following:

    - Redevelopment or re-installation of permanent ground water monitoring wells.

    - Implementation of low flow/low stress purging and sampling techniques.

4. Turbidity measurements should be taken during purging and sampling to demonstrate stabilization or lack thereof. These measurements should be documented in the field notes.

If the ground water sample appears to have either a chemically-induced elevated turbidity, such as would occur with precipitate formation, or a naturally elevated colloid or fine, particulate-related turbidity, filtration will not be allowed.

If filtration is necessary for purposes of geochemical modeling or other **pre-approved** cases, the following procedures are suggested:

1. Accomplish in-line filtration through the use of disposable, high capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 mm is suggested.

2. Use a 5 µm pore-size filter for the purpose of determining the colloidal constituent concentrations. A 0.1 µm pore-size filter should be used to remove most non-dissolved particles.

3. Rinse the cartridge or barrel-type filter with 500 milliliters of the solute (ground water to be sampled) prior to collection of sample. If a membrane filter is used, rinse with 100 milliliters of solute prior to sample collection.

Potential differences could result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter "dissolved" trace element concentrations; these include filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidally-associated trace elements, and concentration of organic matter. Therefore, consistency is critical in the comparison of short-term and long-term results. Further guidance on filtration may be obtained from the following: 1) Metals in Ground Water: Sampling Artifacts and Reproducibility (3); 2) Filtration of Ground Water Samples for Metals Analysis (4); and 3) Ground Water Sampling - A Workshop Summary (5).

Bacterial Sampling

Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in the following: 1) Sampling for Organic Chemicals and Microorganisms in the Subsurface (6); 2) Handbook for Evaluating Water Bacteriological Laboratories (7); and 3) Microbiological Methods for Monitoring the Environment, Water and Wastes (8).

7.3.6 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground water samples shall be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of field studies. Cleaning procedures utilized in the field (Appendix B), or field repairs shall be thoroughly documented in field records.

7.3.7 Auxiliary Data Collection

During ground water sample collection, it is important to record a variety of ground water related data. Included in the category of auxiliary data are water level measurements, well volume determinations, pumping rates during purging, and occasionally, drillers or boring logs. This information should be documented in the field records. Well volume determinations are described in Section 7.2.1.

Water Level Measurements

Water table measurements from the top of the well casings (referenced to National Geodetic Vertical Datum) in permanent wells, and ground surface elevations in temporary wells should be made to assist in determining the general direction of ground water flow and gradient. The methodology to be used to determine well water levels are given in Section 15.5. Tracer dyes and radioactive and thermal detection methods can be used to determine direction and velocities of flow (9). Also, a study of the general topography and drainage patterns will generally indicate direction of ground water flow.

The ground surface elevation and top of casing elevation at the wells should be determined by standard engineering survey practices as outlined in Section 15.

Well Pumping Rate - Bucket/Stop Watch Method

The pumping rate for a pump can be determined by collecting the discharge from the pump in a bucket of known volume and timing how long it takes to fill the bucket. The pumping rate should be in gallons per minute. This method shall be used primarily with pumps with a constant pump rate, such as gasoline-powered or electric submersible pumps. Care should be taken when using this method with some battery-powered pumps. As the batteries' charge decreases, the pump rate also decreases so that pumping rate calculations using initial, high pump rates may be erroneously high. If this method is used with battery-powered pumps, the rate should be re-checked frequently to ensure accuracy of the pumping rate calculations.

7.4 References

1. US EPA., RCRA Ground-Water Monitoring: Draft Technical Guidance, November 1992, Office of Solid Waste, EPA/530-R-93-001.

2. US EPA., Test Methods for Evaluating Solid Waste, Volume II: Field Manual, Physical/Chemical Methods, November 1986, Office of Solid Waste and Emergency Response, SW-846.

3. Puls, Robert W., Don A. Clark, and Bert Bledsoe. Metals in Ground Water: Sampling Artifacts and Reproducibility. *Hazardous Waste and Hazardous Materials* 9(2): 149-162 (1992).

4. Puls, Robert W., and Michael J. Barcelona. Filtration of Ground Water Samples for Metals Analysis. *Hazardous Waste and Hazardous Materials* 6(4): 385-393 (1989).

5. Ground Water Sampling - A Workshop Summary. Proceedings from the Dallas, Texas November 30 - December 2, 1993 Workshop. US EPA Office of Research and Development Robert S. Kerr Environmental Research Laboratory. EPA/600/R-94/205, January 1995.

6. Sampling for Organic Chemicals and Microorganisms in the Subsurface, US EPA, EPA-600/2-77/176 (1977).

7. Handbook for Evaluating Water Bacteriological Laboratories, US EPA, ORD, Municipal Environmental Research Laboratory, Cincinnati, Ohio, 1975.

8. Microbiological Methods for Monitoring the Environment, Water and Wastes, US EPA, ORD, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, 1978.

9. "Groundwater", Section 18, USDA-SCS National Engineering Handbook, United States Department of Agriculture, Soil Conservation Service, 1978.

SECTION 10
SURFACE WATER SAMPLING

PERFORMANCE OBJECTIVE:

- To collect a representative sample of the surface water of interest.

10.1 Introduction

Surface water sampling techniques and equipment are designed to minimize effects on the chemical and physical integrity of the sample. If the guidance provided in this section is followed, a representative sample of the surface water should be obtained.

The physical location of the investigator when collecting a sample may dictate the equipment to be used. If surface water samples are required, direct dipping of the sample container into the stream is desirable. This is possible, however, only from a small boat, a pier, etc., or by wading in the stream. Wading, however, may cause the re-suspension of bottom deposits and bias the sample. Wading is acceptable if the stream has a noticeable current (is not impounded), and the samples are collected while facing upstream. If the stream is too deep to wade, or if the sample must be collected from more than one water depth, or the sample must be collected from a bridge, etc., supplemental sampling equipment must be used.

10.2 Surface Water Sampling Equipment

10.2.1 Dipping Using Sample Container

A sample may be collected directly into the sample container when the surface water source is accessible by wading or other means. The sampler should face upstream and collect the sample without disturbing the sediment. The surface water sample should always be collected prior to the collection of a sediment sample at the same location. The sampler should be careful not to displace the preservative from a pre-preserved sample container such as the 40-ml VOC vial.

10.2.2 Scoops

Stainless steel scoops are useful for reaching out into a body of water to collect a surface water sample. The scoop may be used directly to collect and transfer a surface water sample to the sample container, or it may be attached to an extension in order to access the selected sampling location. The scoop is one of the most versatile sampling tools available to the field investigator.

10.2.3 Peristaltic Pumps

Another device that can be effectively used to sample a water column, such as a shallow pond, is the peristaltic pump/vacuum jug system. The use of a metal conduit to which the tubing is attached, allows for the collection of a vertical sample (to about a 25 foot depth) which is representative of the water column. Commercially available pumps vary in size and capability, with some being designed specifically for the simultaneous collection of multiple water samples.

10.2.4 Discrete Depth Samplers

When discrete samples are desired from a specific depth, and the parameters to be measured do not require a Teflon® coated sampler, a standard Kemmerer or Van Dorn sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends of the sampler open while being lowered in a vertical position, thus allowing free passage of water through the cylinder. The Van Dorn sampler is plastic and is lowered in a horizontal position. In each case, a messenger is sent down a rope when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill respective sample containers. With a rubber tube attached to the valve, dissolved oxygen sample bottles can be properly filled by allowing an overflow of the water being collected. With multiple depth samples, care should be taken not to stir up the bottom sediment and thus bias the sample.

When metals and organic compounds parameters are of concern, then a double check valve, stainless steel bailer or Kemmerer sampler should be used to collect the sample.

10.2.5 Bailers

Teflon® bailers may also be used for surface water sampling, if the study objectives do not necessitate a sample from a discrete interval of the water column. A closed top bailer with a bottom check-valve is sufficient for many studies. As the bailer is lowered through the water column, water is continually displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. This technique may not be successful where strong currents are found.

10.2.6 Buckets

A plastic bucket can be used to collect samples for in-situ analyses, e.g., pH, temperature and conductivity. However, the bucket should be rinsed twice with the sample water prior to collection of the sample.

SECTION 12
SOIL SAMPLING

PERFORMANCE OBJECTIVES:

To collect a soil sample that is representative of conditions as they exist at the site:

- By selecting the appropriate sampling device(s);
- By taking measures to avoid introducing contamination as a result of poor sampling and/or handling technique;
- By reducing the potential of cross contamination between samples.

12.1 Introduction

Prior to conducting a soil sampling investigation, a sampling strategy should be developed based on the objectives of the investigation (Section 5.5 of this SOP contains a discussion of soil sampling strategies). After developing a soil sampling strategy, the appropriate equipment and techniques must be used to conduct the investigation. This section discusses the various soil sample collection methods, sample handling, and available sampling equipment which has been shown to be technically appropriate.

12.2 Equipment

Selection of equipment is usually based on the depth of the samples to be collected, but it is also controlled to a certain extent by the characteristics of the soil. Manual techniques and equipment such as hand augers are usually used for collecting surface or shallow, subsurface soil samples. Power operated equipment is usually associated with deep sampling but can also be used for shallow sampling when the bore hole begins to collapse or when the soil is so tight that manual sampling is not practical.

12.2.1 Precautions for Trace Contaminant Soil Sampling

All soil sampling equipment used for sampling trace contaminants should be constructed of inert materials such as stainless steel where possible. Pans used for mixing should be made of Pyrex® (or equivalent) glass. In no case will chromium, cadmium, galvanized, or plated equipment be used for soil sampling when trace levels of inorganic contaminants are of concern. Similarly, no painted or plastic equipment may be used where trace levels of organic contaminants are of concern. Paint, scaly or heavy rust and grease must be removed before use, most often by sandblasting the equipment. Ancillary equipment such as auger flights may be constructed of other materials since this equipment does not come in direct contact with the samples. The procedures outlined in Section 5.13.7 should be followed.

The procedures outlined in Section 5.13.7 should be followed.

12.3 Sampling Methodology

This discussion of soil sampling methods reflects both the equipment used to collect the sample as well as how the sample is handled and processed after retrieval. Selection of equipment is usually based on the depth of sampling, but it is also controlled, to a certain extent, by the characteristics of the material. Simple, manual techniques and equipment, such as hand augers, are usually selected for surface or shallow, subsurface soil sampling. As the depth of the sampling interval increases, some type of powered sampling equipment is usually needed to overcome the friction induced by soil resistance and depth. The following is an overview of the various sample collection methods employed over three general depth classifications: surface, shallow subsurface, and deep subsurface. Any of the deep collection methods described may be used to collect samples from the shallower intervals.

12.3.1 Manual Collection Techniques and Equipment

These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual methods becomes impractical.

Surface Soils

Surface soils may be collected with a wide variety of equipment, if constructed of appropriate materials. Spoons or hand-augers are typically used to collect surface soil samples.

If a thick, matted root zone is encountered at or near the surface, it should be removed before the sample is collected. The collected soil is placed in a pan, thoroughly mixed, (Section 5.13.8), and placed in the appropriate sample container(s). Section 12.4 contains specific procedures for collecting and handling soil samples for volatile organic compounds analysis.

Shallow Subsurface Soils

Hand augers are the most common equipment used to collect shallow subsurface samples. Typically, 4-inch auger-buckets with cutting heads are pushed and twisted into the ground, then removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand-auger depends upon the soil properties. In sand, augering is usually easily performed, but the depth of collection is limited to the depth at which the sand begins to flow. At this depth, the bore hole will usually collapse and cannot be advanced. Deeper sampling must be accomplished using power equipment. Hand-augering may also be of limited use in tight clays or cemented sands. Regardless of the soil type, at depths approaching 20 feet sidewall friction may become so severe that power equipment must be used.

Power augers such as the Little Beaver® may be used to advance the borehole where hand augers are impractical. Power augers are a sampling aid, not a sampling device, and can be used to advance a borehole to approximately 20 feet, depending upon soil conditions.

If power augers are used to advance the borehole, care must be taken that exhaust fumes, gasoline, and\or oil do not contaminate the borehole. The soil sample may then be collected using a hand auger. After the sample has been collected, the borehole may again be advanced (if necessary), and additional samples collected. The auger bucket must be replaced between samples with a properly decontaminated auger bucket. When a new borehole is advanced, the entire hand auger assembly must be replaced with a properly decontaminated hand auger assembly.

If the borehole is advanced using a hand auger, upon reaching the desired sampling depth replace the bucket with a properly decontaminated bucket. The sample may then be collected. After the sample has been collected, the borehole may be advanced (if necessary) with the bucket that was used to collect the sample. Each sample must be collected using a properly decontaminated bucket.

Before the soil is placed in a pan, it is necessary to remove the top several inches of soil to minimize the possibility of cross-contamination of the sample from fall-in of material from the upper portions of the hole. Once the soil is placed in a pan, it is thoroughly mixed, (Section 5.13.8), and placed in the appropriate sample container(s). Section 12.4 contains specific procedures for collecting and handling soil samples for volatile organic compounds analysis.

12.3.2 Powered Equipment

Powered equipment may be used to acquire soil samples from any depth (surface, shallow subsurface, and deep subsurface). When power equipment is used to advance the borehole and collect the sample, care must be taken that exhaust fumes, gasoline, and\or oil do not contaminate the borehole and the sample. Among the common types of powered equipment used to collect subsurface soil samples are split-spoon samplers driven with a drill rig drive-weight assembly or pushed using drill rig hydraulics; continuous split-spoon samplers; direct-push rigs; and back-hoes. The use of each of these is described below.

Drill Rigs

Drill rigs offer the capability of collecting soil samples from greater depths. For all practical purposes, the depth of investigation achievable by this method is controlled only by the depth of soil overlying bedrock, which may be in excess of 100 feet.

Split-spoon samplers are usually driven either inside a hollow-stem auger or an open borehole after the auger(s) have been temporarily removed. The spoon is driven with a 140-pound hammer through a distance of up to 24 inches and removed.

Continuous split-spoon samplers may be used to obtain five-foot long, continuous samples approximately 3 to 5 inches in diameter. These devices are placed inside a five-foot section of hollow-stem auger and advanced with the auger during drilling. As the auger advances, the central core of soil moves into the sampler and is retained.

Before the soil is placed in a pan, it is necessary to remove the top several inches of soil to minimize the possibility of cross-contamination of the sample from fall-in of material from the upper portions of the hole. Once the soil is placed in a pan, it is thoroughly mixed, (Section 5.13.8), and placed in the appropriate sample container(s). Section 12.4 contains specific procedures for collecting and handling soil samples for volatile organic compounds analysis.

Direct Push Rigs

This method uses a standard split-spoon modified with a locking tip which keeps the spoon closed during the sampling push. Upon arrival at the desired depth, the tip is remotely released and the push continued. During the push, the released tip moves freely inside of the spoon as the soil core displaces it. This technique is particularly beneficial at highly contaminated sites, because no cuttings are produced. The push rods are generally retrieved with very little residue resulting in minimal exposure to sampling personnel and reduced IDW.

Before the soil is placed in a pan, it is necessary to remove the top several inches of soil to minimize the possibility of cross-contamination of the sample from fall-in of material from the upper portions of the hole. Once the soil is placed in a pan, it is thoroughly mixed, (Section 5.13.8), and placed in the appropriate sample container(s). Section 12.4 contains specific procedures for collecting and handling soil samples for volatile organic compounds analysis.

Geoprobe® Large Bore Soil Sampler

Geoprobe® offers several tools for soil sample collection. Among these are the Macro-Core® Soil Sampler and the large bore and dual tube soil sampling systems. The Environmental Investigations Branch utilizes the large bore soil sampling system for collection of surface and subsurface soil samples. The selection of this system does not preclude the use of the other systems at a future time.

The Large Bore sampler is a solid barrel, piston sealed, direct push device for collecting discrete interval samples of unconsolidated materials at depth. The sampler is approximately 30-inches (762 mm) long and has a 1.5-inch (38 mm) outside diameter. The Large Bore sampler is capable of recovering a discrete sample core 22 inches x 1.0 inches (559 mm x 25 mm) contained inside a removable liner. Sample volume measures up to 283 ml. The liner is a 24-inch long by 1.15-inch OD (610 mm x 29 mm) removable/replaceable thin-walled tube that fits inside the Large Bore sample tube. Liners facilitate retrieval of the sample and may be used for storage, when applicable. The Large Bore soil sampler is pushed with 1.25-inch diameter probe rod.

The following is a step-by-step description of the components and procedures used to collect a soil sample with the Large Bore sampler.

Assembly of Large Bore Sampler

1. Select a liner tube and push on to cutting shoe (one end of liner should be slightly flared, push this end on to shoe).

2. Insert end of tube opposite cutting shoe into sample tube and screw cutting shoe firmly into sample tube.

3. Thread piston tip onto piston rod then run piston assembly through the end of the sample tube opposite the cutting shoe, seating the piston tip in the cutting shoe. There should be a short section of exposed piston rod sticking out of sample tube.

4. Place drive head over exposed end of piston rod and thread into end of sample tube.

5. Install piston stop-pin in top of drive head. This retains the piston rod assembly during the push.

6. The Large Bore sampler is now fully assembled and ready for sample collection.

Sample Collection Using Large Bore Sampler

1. Attach assembled Large Bore sampler to end of probe rod.

2. Attach drive cap to probe rod and push rod into ground.

3. Add additional rods to push Large Bore sampler to target sampling depth.

4. At the desired target sampling depth, remove the drive cap to access inside of probe rod.

5. Couple extension rods and extension rod handle together and insert into probe rod. Using handle, turn the extension rods inside probe rod. This should engage the piston-stop pin and remove it from the drive head attached to the top of the sample tube. Retrieve extension rods and attached piston-stop pin.

6. Add addition probe rod, if required, reattach drive cap to top of probe rod and push probe rod and Large Bore sampler 24 inches to fill sampler.

7. Attach pull cap and retrieve tool string.

8. When retrieved, remove the piston rod, with piston tip, and the drive head.

9. Using the Large Bore wrench, unscrew the cutting shoe from the down-hole end of the sample tube.

10. Remove the cutting shoe and attached liner and sample from sample tube.

11. Sample has now been collected and is contained in the liner. At this time, it can be sub-sampled, per analytical requirements.

Special Considerations for Large Bore Soil Sampling

Liner Use and Material Selection

Due to the mode of operation, the Large Bore soil sampler must be used with a liner. Liners are available in the following materials: stainless steel, brass, cellulose acetate butyrate (CAB) and Teflon®. For the majority of environmental investigations conducted by EIB, either CAB or Teflon® liners are used. If samples are collected for organic compound analyses, Teflon® liners are required. CAB liners may be used if metals or other inorganic constituents are the object of the investigation.

Sample Orientation

When the liners and associated sample are removed from the sample tubes, it is important to maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely what depth an aliquot was collected from. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of liner and black caps on the bottom to maintain the proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.

Back-Hoes

Back-hoes may be utilized in the collection of shallow subsurface soil samples. Samples may be collected directly from the bucket, or the trench wall (subject to applicable safety procedures).

The bucket must be free of rust, grease, and paint. Only soil which has not been in contact with the bucket may be sampled, unless the bucket is cleaned according to the procedures described in Appendix B of this SOP.

Trenches offer the capability of collecting samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. The sample should be collected without entering the trench itself, if possible. To collect the sample without entering the trench, use a stainless steel scoop attached to rigid electrical conduit with a scoop bracket to "dress" (remove surface layer of soil smeared on the trench wall as the bucket passed) the wall of the trench. Replace the scoop with a decontaminated scoop. Collect the soil.

The collected soil is placed in a pan, thoroughly mixed, (Section 5.13.8), and placed in the appropriate sample container(s). Section 12.4 contains specific procedures for collecting and handling soil samples for volatile organic compounds analysis

12.4 Soil/Sediment Sampling (Method 5035)

The following sampling protocol is recommended for site investigators assessing the extent of volatile organic compounds (VOCs) in soils and sediments at a project site. Because of the large number of options available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

12.4.1 Equipment

Soil\sediment for VOC analyses may be retrieved using the equipment specified in Sections 11 and 12 of this SOP. Once the soil\sediment has been obtained, the EnCore™ VOC sampler, syringes, stainless steel spatula, standard 2 oz soil VOC container, or pre-prepared 40 mL vials may be used/required for sub-sampling collection. The specific sample containers and the sampling tools required will depend upon the data quality objectives established for the site or sampling investigation. The various methods are described below.

12.4.2 Sampling Methodology - Low Concentrations

When total VOC concentrations in the soil/sediment are expected to be less than 200 μg/kg, the samples may be collected directly with the EnCore™ sampler or syringe. If using the syringes, the sample must be placed in the sample container (40 ml pre-prepared vial) immediately to reduce volatilization losses. The 40 ml vials should contain 10 ml of organic free water for an un-preserved sample or approximately 10 ml of organic free water and a preservative. It is recommended that the 40 ml vials be prepared and weighed by the laboratory (commercial sources are available which supply preserved and tared vials). When sampling directly with the EnCore™ sampler, the vial must be immediately capped.

A soil/sediment sample for VOC analysis may also be collected with conventional sampling equipment (as described in Sections 11 and 12 of this SOP). A sample collected in this fashion must either be placed in the final sample container (EnCore™ or 40 ml pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2 oz. soil jar) is used, the sample must be transferred to the final sample container (EnCore™ or 40 ml pre-prepared vial) as soon as possible not to exceed 30 minutes.

NOTE: After collection of the sample into either the EnCore™ Sampler or other container, the sample must immediately be stored in an ice chest and cooled.

Soil\sediment samples may be prepared for shipping and analysis as follows:

EnCore™ Sampler - the sample may simply be capped, locked and secured in a plastic bag.

Syringe - Add about 3.7 cc (approximately 5 grams) of sample material to 40 ml pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seals on the container, place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

Stainless Steel Laboratory Spatulas - Add between 4.5 and 5.5 grams (approximate) of sample material to 40 ml containers. Secure the containers in a plastic bag. Do not use a custody seal on the container, place the custody seal on the plastic bag.

12.4.3 Sampling Methodology - High Concentrations

Based upon the data quality objectives and the detection level requirements, this high level method may also be used. Specifically, the sample may be packed into a single 2-oz. glass container with a screw cap and septum seal. The sample container must be filled quickly and completely to eliminate head space. Soils\sediments containing high total VOC concentrations may also be collected as described in Section 12.4.2, and preserved using 10 ml methanol.

12.4.4 Waste Samples

Collect an un-preserved sample into a single 2 – oz glass container. Handle waste samples in accordance with Section 14 of this SOP.

12.4.5 Special Techniques and Considerations

Effervescence

If low concentration samples effervesce from contact with the acid preservative, (see Sec. 12.4.2) then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved as needed, or all samples must be collected un-preserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence (rapid formation of bubbles) then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may placed into an appropriate hazardous waste container and the vials triple rinsed with organic free water. An appropriate amount of organic free water, equal to the amount of preservative solution, should be placed into the vial. The sample may then be collected as an un-preserved sample. Note that the amount of organic free water placed into the vials will have to be accurately measured.

Sample Size

While this method is an improvement over earlier ones, field investigators must be aware of an inherent limitation. Because of the extremely small sample size, sample representativeness for VOC's may be reduced compared to samples with larger volumes collected for other constituents . The sampling design and objectives of the investigation should take this into consideration.

Holding Times

Sample holding times are specified in Appendix A. Field investigators should note that the holding time for an un-preserved VOC soil/sediment sample is 48 hours. Arrangements should be made to ship the soil/sediment VOC samples to the laboratory by overnight delivery the day they are collected so the laboratory may preserve and\or analyze the sample within 48 hours of collection.

Percent Moisture

Samplers must ensure that the laboratory has sufficient material to determine percent moisture in the VOC soil/sediment sample to correct the analytical results to dry weight. If other analyses requiring percent moisture determination are being performed upon the sample, these results may be used. If not, a separate sample (minimum of 2 oz.) for percent moisture determination will be required.

Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

Shipping

Methanol and sodium bisulfate are considered dangerous goods, therefore shipment of samples preserved with these materials by common carrier is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulations must be followed when shipping methanol and sodium bisulfate. Consult the above documents or the carrier for additional information. Shipment of the quantities of methanol and sodium bisulfate used for sample preservation falls under the exemption for small quantities. A summary of the requirements for shipping samples follows. Refer to the code for a complete review of the requirements.

1. The maximum volume of methanol or sodium bisulfate in a sample container is limited to thirty30) mls.

2. The sample container must not be full of methanol.

3. The sample container must be stored upright and have the lid held securely in place. Note that the mechanism used to hold the cap in place must be able to be completely removed so weight is not added to the sample container, as specified in Method 5035.

4. Sample containers must be packed in a sorbent material capable of absorbing spills from leaks or breakage of the sample containers.

5. The maximum sample shuttle weight must not exceed 64 pounds.

6. The maximum volume of methanol or sodium bisulfate per shipping container is 500 mls.

7. The shipper must mark the sample shuttle in accordance with shipping dangerous goods in acceptable quantities.

8. The package must not be opened or altered until no longer in commerce.

12.4.6 Summary

The following summary table lists the options available for compliance with SW846 Method 5035. The advantages and disadvantages are noted for each option. SESD's goal is to minimize the use of hazardous material (methanol and sodium bisulfate) and minimize the generation of hazardous waste during sample collection.

OPTION	PROCEDURE	ADVANTAGES	DISADVANTAGES
1	Collect 2 - 40 mL vials with ~5 grams of sample and 1 - 2 oz., glass w/septum lid for screening and % moisture	Screening conducted by lab	Presently a 48 hour holding time for unpreserved samples
2	Collect 3 Encore™; and 1- 2 oz., glass w/septum lid for screening and % moisture	Lab conducts all preservation/preparation procedures	Presently a 48 hour holding time for preparation of samples
3	Collect 2 - 40 ml vials with 5 grams of sample and preserve w/methanol or sodium bisulfate and 1 - 2-oz., glass w/septum lid for screening and % moisture	High level VOC samples may be composited Longer holding time	Hazardous materials used in field
4	Collect 1 - 2-oz., glass w/septum lid for analysis and % moisture	Lab conducts all preservation/preparation procedures	May have significant VOC loss

APPENDIX B
STANDARD FIELD CLEANING PROCEDURES

PERFORMANCE OBJECTIVE:

- To remove contaminants of concern from sampling, drilling and other field equipment to concentrations that do not impact study objectives using a standard cleaning procedure.

B.1 Introduction

Cleaning procedures in this appendix are intended for use by field personnel for cleaning sampling and other equipment in the field. Emergency field sample container cleaning procedures are also included; however, they should not be used unless absolutely necessary. Cleaning procedures for use at the Field Equipment Center (FEC) are in Appendix C.

Sampling and field equipment cleaned in accordance with these procedures must meet the minimum requirements for Data Quality Objectives (DQO) definitive data collection. Deviations from these procedures should be documented in the approved study plan, field records, and investigative reports.

These are the materials, methods, and procedures to be used when cleaning sampling and other equipment in the field.

B.1.1 Specifications for Cleaning Materials

Specifications for standard cleaning materials referred to in this appendix are as follows:

- <u>Soap</u> shall be a standard brand of phosphate-free laboratory detergent such as Liquinox®. Use of other detergent must be justified and documented in the field logbooks and inspection or investigative reports.

- <u>Solvent</u> shall be pesticide-grade isopropanol. Use of a solvent other than pesticide-grade isopropanol for equipment cleaning purposes must be justified in the study plan. Otherwise its use must be documented in field logbooks and inspection or investigation reports.

- <u>Tap water</u> may be used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

- <u>Analyte free water (deionized water)</u> is tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. Analyte free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

- Organic/analyte free water is defined as tap water that has been treated with activated carbon and deionizing units. A portable system to produce organic/analyte free water under field conditions is available. At a minimum, the finished water must meet the analytical criteria of analyte free water and should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic/analyte free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

- Other solvents may be substituted for a particular purpose if required. For example, removal of concentrated waste materials may require the use of either pesticide-grade hexane or petroleum ether. After the waste material is removed, the equipment must be subjected to the standard cleaning procedure. Because these solvents are not miscible with water, the equipment must be completely dry prior to use.

Solvents, laboratory detergent, and rinse waters used to clean equipment shall not be reused during field decontamination.

B.1.2 Handling and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. Following are acceptable materials used for containing the specified cleaning solutions:

- Soap must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.

- Solvent must be stored in the unopened original containers until used. They may be applied using the low pressure nitrogen system fitted with a Teflon® nozzle, or using Teflon® squeeze bottles.

- Tap water may be kept in clean tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.

- Analyte free water must be stored in clean glass, stainless steel, or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.

- Organic/analyte free water must be stored in clean glass, Teflon®, or stainless steel containers prior to use. It may be applied using Teflon® squeeze bottles, or with the portable system.

Note: Hand pump sprayers generally are not acceptable storage or application containers for the above materials (with the exception of tap water). This also applies to stainless steel sprayers. All hand sprayers have internal oil coated gaskets and black rubber seals that may contaminate the solutions.

B.1.3 Disposal of Solvent Cleaning Solutions

Procedures for the safe handling and disposition of investigation derived waste (IDW), including used wash water, rinse water, and spent solvents are in Section 5.15.

B.1.4 Equipment Contaminated with Concentrated Wastes

Equipment used to collect samples of hazardous materials or toxic wastes or materials from hazardous waste sites, RCRA facilities, or in-process waste streams should be field cleaned before returning from the study. At a minimum, this should consist of washing with soap and rinsing with tap water. More stringent procedures may be required at the discretion of the field investigators.

B.1.5 Safety Procedures for Field Cleaning Operations

Some of the materials used to implement the cleaning procedures outlined in this appendix can be harmful if used improperly. Caution should be exercised by all field investigators and all applicable safety procedures should be followed. At a minimum, the following precautions should be taken in the field during these cleaning operations:

- Safety glasses with splash shields or goggles, and latex gloves will be worn during all cleaning operations.
- Solvent rinsing operations will be conducted in the open (never in a closed room).
- No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

B.1.6 Handling of Cleaned Equipment

After field cleaning, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the cleaning area to prevent recontamination. If the equipment is not to be immediately re-used it should be covered with plastic sheeting or wrapped in aluminum foil to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.

B.2 Field Equipment Cleaning Procedures

Sufficient clean equipment should be transported to the field so that an entire study can be conducted without the need for field cleaning. However, this is not possible for some specialized items such as portable power augers (Little Beaver®), well drilling rigs, soil coring rigs, and other large pieces of field equipment. In addition, particularly during large scale studies, it is not practical or possible to transport all of the precleaned field equipment required into the field. In these instances, sufficient pre-cleaned equipment should be transported to the field to perform at least one days work. The following procedures are to be utilized when equipment must be cleaned in the field.

B.2.1 Specifications for Decontamination Pads

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.
- The pad should not leak excessively.
- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.
- Water should be removed from the decontamination pad frequently.

- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.

At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. No solvent rinsates will be placed in the pit. Solvent rinsates should be collected in separate containers for proper disposal. See Section 5.15 of this SOP for proper handling and disposal of these materials. If the decontamination pad has leaked excessively, soil sampling may be required.

B.2.2 "Classic Parameter" Sampling Equipment

"Classic Parameters" are analyses such as oxygen demand, nutrients, certain inorganics, sulfide, flow measurements, etc. For routine operations involving classic parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample or analyte-free water between sampling locations. A brush may be used to remove deposits of material or sediment, if necessary. If analyte-free water is unavailable the samplers should be flushed at the next sampling location with the substance (water) to be sampled, before the sample is collected.

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gaging equipment may be cleaned with tap water between measuring locations, if necessary.

The previously described procedures are not to be used for cleaning field equipment to be used for the collection of samples undergoing trace organic or inorganic constituent analyses.

B.2.3 Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds

The following procedures are to be used for all sampling equipment used to collect routine samples undergoing trace organic or inorganic constituent analyses:

1. Clean with tap water and soap using a brush if necessary to remove particulate matter and surface films. Equipment may be steam cleaned (soap and high pressure hot water) as an alternative to brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.

2. Rinse thoroughly with tap water.

3. Rinse thoroughly with analyte free water.

4. Rinse thoroughly with solvent. Do not solvent rinse PVC or plastic items.

5. Rinse thoroughly with organic/analyte free water. If organic/analyte free water is not available, equipment should be allowed to completely dry. Do not apply a final rinse with analyte water. Organic/analyte free water can be generated on-site utilizing the portable system.

6. Remove the equipment from the decontamination area and cover with plastic. Equipment stored overnight should be wrapped in aluminum foil and covered with clean, unused plastic.

B.2.4 Well Sounders or Tapes

1. Wash with soap and tap water.

2. Rinse with tap water.

3. Rinse with analyte free water.

B.2.5 Goulds® Pump Cleaning Procedure

CAUTION - During cleaning always disconnect the pump from the generator.

The Goulds© pump should be cleaned prior to use and between each monitoring well. The following procedure is required:

1. Using a brush, scrub the exterior of the contaminated hose and pump with soap and tap water.

2. Rinse the soap from the outside of the pump and hose with tap water.

3. Rinse the tap water residue from the outside of pump and hose with analyte-free water.

4. Place the pump and hose in a clean plastic bag.

B.2.6 Redi-Flo2® Pump

The Redi-Flo2® pump should be cleaned prior to use and between each monitoring well. The following procedure is required:

CAUTION - Make sure the pump is not plugged in.

1. Using a brush, scrub the exterior of the pump, electrical cord and garden hose with soap and tap water. Do not wet the electrical plug.

2. Rinse with tap water.

3. Rinse with analyte free water.

4. Place the equipment in a clean plastic bag.

To clean the Redi-Flo2® ball check valve:

1. Completely dismantle ball check valve. Check for wear and/or corrosion, and replace as needed.

2. Using a brush, scrub all components with soap and tap water.

3. Rinse with analyte free water.

4. Reassemble and re-attach the ball check valve to the Redi-Flo2® pump head.

B.2.7 Automatic Sampler Tubing

The Silastic® and Tygon® tubing previously used in the automatic samplers may be field cleaned as follows:

1. Flush tubing with tap water and soap.

2. Rinse tubing thoroughly with tap water.

3. Rinse tubing with analyte free water.

B.3 Downhole Drilling Equipment

These procedures are to be used for drilling activities involving the collection of soil samples for trace organic and inorganic constituent analyses, and for the construction of monitoring wells to be used for the collection of groundwater samples for trace organic and inorganic constituent analyses.

B.3.1 Introduction

Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. The decontamination pad should meet the specifications of Section B.2.1.

Tap water (potable) brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank.

A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam (200°F plus), with a soap compartment, should be obtained.

B.3.2 Preliminary Cleaning and Inspection

The drill rig should be clean of any contaminants that may have been transported from another hazardous waste site, to minimize the potential for cross-contamination. Further, the drill rig itself should not serve as a source of contaminants. In addition, associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

- All downhole augering, drilling, and sampling equipment should be sandblasted before use if painted, and/or there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam cleaning (soap and high pressure hot water), or wire brushing. Sandblasting should be performed prior to arrival on site, or well away from the decontamination pad and areas to be sampled.

- Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (soap and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other hazardous waste sites before being brought on site.

- Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sand paper can be used to remove the printing and/or writing. Most well material suppliers can supply materials without the printing and/or writing if specified when ordered.

- The drill rig and other equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

- PVC or plastic materials such as tremie tubes should be inspected. Items that cannot be cleaned are not acceptable and should be discarded.

B.3.3 Drill Rig Field Cleaning Procedure

Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (soap and high pressure hot water) between boreholes.

B.3.4 Field Cleaning Procedure for Drilling Equipment

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment. This procedure does <u>not</u> apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses, which should be cleaned as outlined in Section B.2.3.

1. Clean with tap water and soap, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with soap) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing.

2. Rinse thoroughly with tap water.

3. Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to ensure that it stays in place.

When there is concern for low level contaminants it may be necessary to clean this equipment between borehole drilling and/or monitoring well installation using the procedure outlined in Section B.2.3.

B.4 Emergency Disposable Sample Container Cleaning

New one-pint or one-quart mason jars may be used to collect samples for analyses of organic compounds and metals in waste and soil samples during an emergency. These containers would also be acceptable on an emergency basis for the collection of water samples for extractable organic compounds, pesticides, and metals analyses. These jars cannot be used for the collection of water samples for volatile organic compound analyses.

The rubber sealing ring should not be in contact with the jar and aluminum foil should be used, if possible, between the jar and the sealing ring. If possible, the jar and aluminum foil should be rinsed with pesticide-grade isopropanol and allowed to air dry before use. Several empty bottles and lids should be submitted to the laboratory as blanks for quality control purposes.

APPENDIX C
FIELD EQUIPMENT CENTER STANDARD CLEANING PROCEDURES

PERFORMANCE OBJECTIVE:

- To remove contaminants of concern from sampling, drilling and other field equipment to concentrations that do not impact study objectives using a standard cleaning procedure.

C.1 Introduction

Cleaning procedures outlined in this appendix are intended for use at the Field Equipment Center (FEC) for cleaning sampling and other field equipment prior to field use. These procedures are not intended to be used in the field. Cleaning procedures for use in the field are in Appendix B.

Sampling and other field equipment cleaned in accordance with these procedures will meet the minimum requirements for Data Quality Objective (DQO) Definitive Data Collection. Deviations from these procedures should be documented in the approved study plan, field records, and investigative reports.

C.1.1 Specifications For Cleaning Materials

The specifications for standard cleaning materials referred to in this appendix are as follows:

- Soap shall be a standard brand of phosphate-free laboratory detergent such as Liquinox®.
- Disinfectant soap shall be a standard brand of disinfectant cleaner.
- Solvent shall be pesticide grade isopropanol.
- Tap water may be obtained from any spigot at the FEC.
- Nitric acid solution (10%) shall be made from reagent-grade nitric acid and deionized water.
- Analyte free water (deionized water) is tap water that has been treated by passing it through a standard deionizing resin column. At a minimum, it should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard Inductively Coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan.
- Organic/analyte free water is defined as tap water that has been treated with activated carbon and deionizing units. At a minimum, it must meet the analytical criteria of analyte free water and should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels determined by the Region 4 laboratory for a given set of analyses. Organic/analyte free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

- Other solvents may be substituted for a particular investigation if needed. Pesticide-grade acetone or methanol are acceptable. However, it should be noted that if pesticide-grade acetone is used, the detection of acetone in samples collected with acetone rinsed equipment is considered suspect. Pesticide-grade methanol is much more hazardous to use than either pesticide-grade acetone or isopropanol, therefore its use is discouraged.

Solvents, nitric acid solution, laboratory detergent, and rinse waters used to clean equipment cannot be reused.

C.1.2 Handling and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated. Containers should be constructed of the proper materials to ensure their integrity. Following are the materials to be used for storing the specified cleaning materials:

- Soap should be kept in clean containers until use. It should be poured directly from the container.

- Disinfectant soap should be kept in clean containers until use. It should be poured directly from the container.

- Solvents should be stored in the unopened original containers until used. Solvents may be applied using the low pressure nitrogen system fitted with a Teflon® nozzle, or by using Teflon® squeeze bottles.

- Tap water may be kept in clean tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.

- Analyte free water should be stored in cleaned containers that can be closed when not being used. It may be applied from squeeze bottles.

- Organic/analyte free water should be stored in cleaned glass, Teflon®, or stainless steel containers prior to use. It may be applied using Teflon® squeeze bottles, or directly from the system.

- Nitric acid should be kept in the glass container it is received in, and placed in squeeze bottles prior to application.

C.1.3 *Disposal of Spent Cleaning Solutions*

Procedures for safe handling and disposition of spent cleaning solutions, including washwater, rinse water, spent acid solutions, and spent solvents are as follows:

Washwater

Since equipment is decontaminated before its return to the FEC, the washwater may be disposed in the sanitary drain in the washroom. When large equipment (vehicles, augers, etc.) is washed outside, it may wash onto the ground without recovery of the washwater.

Rinsewater

Since equipment is decontaminated before its return to the FEC, the rinsewater may be disposed in the sanitary drain in the washroom. When large equipment (vehicles, augers, etc.) is rinsed outside, it may go onto the ground without recovery.

Nitric Acid

Nitric acid cleaning solutions are to be diluted to a pH greater than 2.0, and flushed down the sanitary drain in the washroom. If used outdoors, this material should be captured and diluted to a pH greater than 2.0, and flushed down the sanitary drain in the washroom.

Solvent

All solvents used should be captured, properly labeled, and stored on the premises of the FEC until arrangements for proper disposal are made. Used solvents can be classified as either "solvent for recovery" or "solvent for disposal". Solvent for recovery is that which was used in the standard field cleaning or FEC cleaning of equipment. Solvent used for cleaning badly contaminated equipment (e.g., tar removal, etc.) should be designated for disposal. The two groups should be labeled "For Recovery" or "For Disposal" and stored separately at the FEC.

C.1.4 Safety Procedures for Cleaning Operations

Some materials used to implement the cleaning procedures outlined in this Appendix are harmful if used improperly. Caution should be exercised and all applicable safety procedures shall be followed. At a minimum, the following precautions shall be taken in the washroom during these cleaning operations:

- Safety glasses with splash shields or goggles, a neoprene apron, and neoprene gloves will be worn during all cleaning operations. When cleaning heavy items such as hollow-stem augers or other drill rig equipment, safety boots will be worn.
- All solvent rinsing operations will be conducted under a fume hood or in the open (never in a closed room).
- No eating, smoking, drinking, chewing, or any hand to mouth contact shall be permitted during cleaning operations.

C.1.5 Handling and Labeling of Cleaned Equipment

After cleaning, equipment should be handled only by personnel wearing clean latex gloves to prevent re-contamination.

After the cleaned equipment is wrapped in aluminum foil and sealed in plastic, the date that the equipment was cleaned should be written on the plastic. If the equipment was not cleaned according to the procedures outlined in this appendix, this should also be noted on the plastic.

C.1.6 Initial Processing of Returned Equipment

Field or sampling equipment that needs to be repaired will be identified with a "repair" tag. Any problems encountered with the equipment and specific required repairs shall be noted on this tag, as well as the date and the initials of the investigator. Field equipment or reusable sample containers needing cleaning or repairs will not be stored with clean equipment, sample tubing, or sample containers.

All coolers, plastic wrapped equipment, containers, and tubing not used in the field may be placed back into stock after the following precautions are taken:

- Soap and hot water rinse plastic containers. Allow to air dry.
- If plastic wrapping leaks after soap/water rinse, remove the equipment and place it into the standard cleaning process.

C.2 Trace Organic and Inorganic Constituent Sampling Equipment

Sampling equipment used to collect samples undergoing trace organic and/or inorganic constituent analyses should be thoroughly cleaned. The following procedures are to be used.

C.2.1 Teflon® and Glass

1. Wash equipment thoroughly with soap and hot tap water using a brush or scrub pad to remove any particulate matter or surface film.
2. Rinse equipment thoroughly with hot tap water.
3. Rinse equipment with 10 percent nitric acid solution. Small and awkward equipment such as vacuum bottle inserts and well bailer ends may be soaked in the nitric acid solution instead of being rinsed with it. Fresh nitric acid solution should be prepared for each cleaning session.
4. Rinse equipment thoroughly with analyte free water.
5. Rinse equipment thoroughly with solvent and allow to air dry for at least 24 hours.
6. Wrap equipment in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal. Seal the foil wrapped equipment in plastic and label.

When this sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone, hexane, or petroleum ether to remove the materials before proceeding with the first step. In extreme cases, it may be necessary to steam clean the field equipment before proceeding with Step 1. If the equipment cannot be cleaned utilizing these procedures, it should be discarded.

C.2.2 Stainless Steel or Steel

1. Wash equipment thoroughly with soap and hot tap water using a brush or scrub pad to remove any particulate matter or surface film.

2. Rinse equipment thoroughly with hot tap water.

3. Rinse equipment thoroughly with analyte free water.

4. Rinse equipment thoroughly with solvent and allow to air dry for at least 24 hours.

5. Wrap equipment in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal. Seal the foil wrapped equipment in plastic and label.

When this sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone, hexane, or petroleum ether to remove the materials before proceeding with the first step. In extreme cases, it may be necessary to steam clean the field equipment before proceeding with Step 1. If the equipment cannot be cleaned utilizing these procedures, it should be discarded.

C.2.3 Reusable Composite Sample and Organic/Analyte Free Water Containers *

These containers will be rinsed with organic/analyte free water and the rinse water will be submitted to the Region 4 laboratory. This activity may be conducted in the event of a special, civil or criminal investigation.

C.3 Automatic Wastewater Sampling Equipment

C.3.1 ISCO© and Other Automatic Samplers

- The exterior and accessible interior (excluding the waterproof timing mechanism) portions of the automatic samplers will be washed with soap and tap water then rinsed with tap water.

- Desiccant in the flow meters should be checked and replaced, if necessary, each time the equipment is cleaned.

- The face of the timing case mechanism will be cleaned with a clean damp cloth.

- Tubing (sample intake and pump tubing) will be discarded after each use.

- New pre-cleaned, Silastic pump tubing (see Appendix C.4.1) will be installed.

C.3.2 ISCO© 1680, 2700, and 3700 Rotary Funnel, Distributor, and Metal Tube

1. Clean with hot tap water, soap, and a brush.

2. Rinse thoroughly with analyte free water.

3. Replace in sampler.

C.3.3 All Automatic Sampler Headers

1. Disassemble header and using a bottle brush, wash with hot tap water and soap.

2. Rinse thoroughly with analyte free water.

3. Dry thoroughly, then reassemble header and wrap with aluminum foil.

4. Seal in Plastic

C.3.4 Reusable Glass Composite Sample Containers

1. Wash containers thoroughly with hot tap water and laboratory detergent, using a bottle brush to remove particulate matter and surface film.

2. Rinse containers thoroughly with hot tap water.

3. Rinse containers with at least 10 percent nitric acid.

4. Rinse containers thoroughly with tap water.

5. Rinse containers thoroughly with analyte free water.

6. Rinse twice with solvent and allow to air dry for at least 24 hours.

7. Cap with aluminum foil or Teflon® film.

When these containers are used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the containers several times with pesticide-grade acetone, hexane, or petroleum ether to remove the materials before proceeding with Step 1. Any bottles that have a visible film, scale, or discoloration remaining after this cleaning procedure shall also be discarded.

C.3.5 Plastic Reusable Composite Sample Containers (2700 - 5 gal., 3700 - 4 gal.)

1. Wash containers thoroughly with hot tap water and laboratory detergent, using a bottle brush to remove particulate matter and surface film.

2. Rinse containers thoroughly with hot tap water.

3. Rinse containers with at least 10 percent nitric acid.

4. Rinse containers thoroughly with tap water.

5. Rinse containers thoroughly with analyte free water.

6. Cap with aluminum foil or Teflon® film.

Any plastic composite sample containers that have a visible film, scale, or other discoloration remaining after this cleaning procedure will be discarded.

C.3.6 ISCO© 1680, 2700, and 3700 Glass Sequential Bottles for GC/MS Analyses

1. Rinse with 10 percent nitric acid.

2. Rinse thoroughly with tap water.

3. Wash in dishwasher at wash cycle, using laboratory detergent cycle, followed by tap and analyte free water rinse cycles.

4. Rinse twice with solvent and allow to air dry for at least 24 hours.

5. Replace in covered, automatic sampler base; cover with aluminum foil for storage and mark the base as follows: "Cleaned for organic analyses."

C.3.7 Bottle Siphons for Composite Containers

Tubing should be rinsed with solvent and dried in the drying oven overnight before use. The ends of the siphon should be capped with aluminum foil and/or Teflon® film for storage. The tubing will be sealed in plastic and labeled. The siphon should be flushed with sample thoroughly before use.

C.3.8 Reusable Teflon® Composite Mixer Rods

1. Wash equipment thoroughly with soap and hot tap water using a brush or scrub pad to remove any particulate matter or surface film.

2. Rinse equipment thoroughly with hot tap water.

3. Rinse equipment with at least a 10 percent nitric acid solution.

4. Rinse equipment thoroughly with tap water.

5. Rinse equipment thoroughly with analyte free water.

6. Rinse equipment thoroughly with solvent and allow to air dry for at least 24 hours.

7. Wrap equipment in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal. Seal the foil wrapped equipment in plastic and label.

When this sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone, hexane, or petroleum ether to remove the materials before proceeding with Step 1. In extreme cases, it may be necessary to steam clean the field equipment before proceeding with Step 1. If the equipment cannot be cleaned utilizing these procedures, it should be discarded.

C.4 Cleaning Procedures for Tubing

C.4.1 Silastic® Pump Tubing

The Silastic® pump tubing in the automatic samplers and peristaltic pumps should be replaced after each study. After installation, the exposed ends should be capped with clean, unused aluminum foil.

C.4.2 Teflon® Sample Tubing

Use only new Teflon® tubing which has been pre-cleaned as follows for the collection of samples for trace organic compound or ICP analyses:

1. Teflon® tubing shall be precut in 10, 15 or 25-foot lengths before cleaning.

2. Rinse outside of tubing with solvent.

3. Flush interior of tubing with solvent.

4. After flushing with solvent, pressurize the tubing to a safe level (one end only) to flush out solvent.

5. Dry overnight in the drying oven.

6. Coil. Cap ends with aluminum foil. Wrap tubing in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal. Seal the foil wrapped tubing in plastic and label.

C.4.3 Stainless Steel Tubing

1. Wash with soap and hot tap water using a long, narrow, bottle brush.

2. Rinse equipment thoroughly with hot tap water.

3. Rinse equipment thoroughly with analyte free water.

4. Rinse equipment thoroughly with solvent and allow to air dry for at least 24 hours.

5. Cap ends with aluminum foil. Wrap tubing in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal. Seal the foil wrapped tubing in plastic and date.

When this sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone, hexane, or petroleum ether to remove the materials before proceeding with Step 1. If the equipment cannot be cleaned utilizing these procedures, it should be discarded.

C.4.4 Glass Tubing

New glass tubing should be cleaned as follows:

1. Rinse thoroughly with solvent.

2. Air dry for at least 24 hours.

3. Wrap tubing completely with aluminum foil and seal in plastic (one tube/pack) to prevent contamination during storage.

C.5 Cleaning Procedures for Miscellaneous Equipment

C.5.1 Well Sounders and Tapes

1. Wash with soap and tap water.

2. Rinse with hot tap water.

3. Rinse with analyte free water.

4. Allow to air dry overnight.

C.5.2 Goulds® Pump

CAUTION - Never plug the pump in while cleaning.

Cleaning:

1. Remove garden hose (if attached), and clean separately.

2. Using a brush or scrub pad, scrub the exterior of the hose, electrical cord and pump with soap and tap water. Do not wet the electrical plug.

3. Rinse with analyte free water.

4. Air dry.

5. Place pump and hose in clean plastic bag and label.

C.5.3 Redi-Flo2® Pump

CAUTION - Make sure that the controller is not plugged in.
CAUTION - Do not wet the controller.

Controller Box Cleaning:

1. Wipe the controller box with a damp cloth. Immediately remove any excess water.

2. Let the controller box dry completely.

Pump Cleaning:

CAUTION - Make sure that the pump is not plugged in.

1. Remove garden hose (if attached) and ball check valve. Clean these items separately.

2. Using a brush or scrub pad, scrub the exterior of the electrical cord and pump with soap and tap water. Do not wet the electrical plug.

3. Place pump in clean water and have it discharge into a bucket or or another area to clean the inside of the pump, using a soap and water mixture first. Then run tap water or DI water through the pump and flush out the soap.

4. Completely air dry.

5. Place equipment in clean plastic bag.

To clean the Redi-Flo2® ball check valve:

1. Completely dismantle ball check valve. Check for wear and/or corrosion, and replace as needed.

2. Using a brush, scrub all components with soap and hot tap water.

3. Rinse with analyte-free water.

4. Completely air dry.

5. Reassemble the ball check valve and re-attach to Redi-Flo2® pump head.

Note: The analyte-free water within the Redi-Flo2® pump head should be changed at the FEC upon return from the field according to the manufacturer's instructions.

C.5.4 Little Beaver®

The engine and power head should be cleaned with a power washer, steam jenny, or hand washed with a brush using soap to remove oil, grease, and hydraulic fluid from the exterior of the unit. Do not use degreasers. Rinse thoroughly with tap water.

Auger flights and bits should be cleaned as follows:

1. Inspect thoroughly. If severe rust, corrosion, paint, or hardened grout is present, the equipment will require sandblasting prior to cleaning.

2. Clean with tap water and soap, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with soap) may be necessary to remove matter that is difficult to remove with the brush. Augers that are steam cleaned should be placed on racks or saw horses at least two feet aboveground.

3. Rinse thoroughly with tap water.

4. Completely air dry. Remove and wrap with clean, unused plastic. Return to storage.

At the direction of the project leader or the Quality Assurance Officer, this equipment may be cleaned as specified in Section C.2.2 prior to use.

C.5.5 Drill Rig, Grout Mixer, and Associated Equipment

- A thorough interior and exterior cleaning of the drill rig is required at the end of each study. The exterior (including undercarriage) should be washed with soap and tap water and then rinsed with tap water. The steam jenny may be used.

- The pump and tank on the drill rig should be flushed with tap water until clear, and then drained.

- The pump on the grout mixer should be flushed with tap water until clear, then drained.

- The grout mixer should be washed with soap and tap water. The steam jenny may be used.

Drilling equipment (tools, rods, augers, etc.) should be cleaned as follows:

1. Inspect thoroughly. If severe rust, corrosion, paint, or hardened grout is present the equipment may require sandblasting prior to cleaning.

2. Clean with tap water and soap, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with soap) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that has been steam cleaned should be placed on racks or saw horses at least two feet above ground. Hollow-stem augers, drill rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside and outside.

3. Rinse thoroughly with tap water.

4. Let completely air dry. Remove and cover with clean, unused plastic and label.

At the direction of the project leader, Quality Assurance Officer, or drill rig operator, this equipment may be cleaned as specified in Section C.2.2 prior to use.

C.5.6 Miscellaneous Sampling and Flow Measuring Equipment

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gaging equipment, and other miscellaneous sampling equipment shall be washed with soap and hot tap water, rinsed with hot tap water, rinsed thoroughly with analyte free water, and completely air dried before being stored. This procedure is not to be used for equipment utilized for the collection of samples for trace organic or inorganic constituent analyses.

C.5.7 Field Analytical Equipment

Field instruments for in-situ water analysis should be wiped with a clean, damp cloth. The probes on these instruments (pH, conductivity, DO, etc.), should be rinsed with analyte-free water and air dried.

Any desiccant in these instruments should be checked and replaced, if necessary, each time the equipment is cleaned.

C.5.8 Ice Chests and Shipping Containers

Ice chests and reusable containers shall be washed with soap (interior and exterior) and rinsed with tap water and air dried before storage. If in the opinion of the field investigators the container is severely contaminated with concentrated waste or other toxic material, it shall be cleaned as thoroughly as possible, rendered unusable, and properly disposed.

C.5.9 Pressure Field Filtration Apparatus

1. Wash equipment thoroughly with soap and hot tap water using a brush to remove any particulate matter or surface film.

2. Rinse equipment thoroughly with hot tap water.

3. Rinse equipment with 10 percent nitric acid solution.

4. Rinse equipment thoroughly with analyte free water.

5. Rinse equipment thoroughly with solvent and allow to air dry for at least 24 hours.

6. Assemble the apparatus and cap both the pressure inlet and sample discharge lines with aluminum foil to prevent contamination during storage.

7. Wrap equipment in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal. Seal the foil wrapped equipment in plastic and date.

During steps 1 through 5 as outlined above and immediately after assembling, pressure should be applied to the apparatus after each rinse step (water and acid) to drive the rinse material through the porous glass filter holder in the bottom of the apparatus.

When this sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone, hexane, or petroleum ether to remove the materials before proceeding with the first step. In extreme cases, it may be necessary to steam clean the field equipment before proceeding with Step 1. If the equipment cannot be cleaned utilizing these procedures, it should be discarded.

C.5.10 Organic/Analyte Free Water Storage Containers

NOTE: These containers will be used only for transporting organic/analyte free water.

1. Wash containers thoroughly (interior and exterior) with hot tap water and laboratory detergent, using a bottle brush to remove particulate matter and surface film.

2. Rinse containers thoroughly with hot tap water.

3. Rinse containers with at least 10 percent nitric acid.

4. Rinse containers thoroughly with tap water.

5. Rinse containers thoroughly with analyte free water.

6. Rinse containers thoroughly with solvent and allow to air dry for at least 24 hours.

7. Cap with aluminum foil or Teflon® film.

8. Store in plastic bags.

When transporting organic/analyte free water to the field, use only containers cleaned as specified above. Thoroughly rinse the interior of the container with organic/analyte free water prior to filling. Cap with one layer of Teflon® film, one layer of aluminum foil, and label the container as "organic/analyte free water" and include the date it was prepared. Do not store the organic/analyte free water at the FEC for more than three days.

C.5.11 Portable Solvent Rinse System

1. Replace Teflon® tubing if necessary. Wash nozzle and tubing fittings with hot, soapy water.
2. Rinse with analyte-free water.
3. Wrap nozzle and tubing ends with aluminum foil.

C.5.12 Splash Suits

CAUTION: Splash suits should be inspected for wear or damage. If, after consultation with the Branch Safety Officer, the suit cannot be repaired, it should be discarded.

1. Wash and brush suit thoroughly inside and out with a brush in hot tap water and soap.
2. Rinse suit thoroughly inside and out with tap water.
3. Hang suit up until completely dry.
4. Fold suit and place in clean, clear plastic bag and tap shut. Mark the suit's size on the bag.

C.5.13 SCBA Face-masks

CAUTION: Face-masks should be inspected for wear or damage. If, after consultation with the Safety Officer, the face-mask cannot be repaired, it should be discarded.

1. Wash face-mask thoroughly inside and out with hot tap water and disinfectant soap. Use only soft brushes. Do not use scouring pads of any type.
2. Rinse face-mask thoroughly inside and out with tap water.
3. Hang face-mask up until completely dry.
4. Place face-mask in plastic bag and return to SCBA case.

APRs are completely dismantled prior to cleaning. Then Steps 1 - 3 for SCBA face-masks are used. When Completely dry, the APR is reassembled and placed in a plastic bag.

C.5.14 Garden Hose

1. Brush exterior with soap and tap water
2. Rinse with tap water.
3. Flush interior with tap water until clear (minimum of one gallon).
4. Let completely air dry.
5. Coil and place in clean plastic bag.

C.5.15 Portable Tanks for Tap Water

1. Scrub interior and exterior with soap and tap water.

2. Rinse with tap water.

3. Let completely air dry.

4. Close.

C.5.16 Vehicles

Vehicles utilized by field investigators should be washed (if possible) at the conclusion of each field trip. This should minimize contamination of equipment or samples due to contamination of vehicles.

When vehicles are used in conjunction with hazardous waste site inspections, or on studies where pesticides, herbicides, organic compounds, or other toxic materials are known or suspected to be present, a thorough interior and exterior cleaning (using soapy tap water) is mandatory at the conclusion of such investigations. It shall be the responsibility of the field investigators to see that this procedure is followed. Personnel involved will use appropriate safety measures.

Vehicles shall be equipped with trash bags and/or trash containers to facilitate vehicle cleaning. Field investigators are responsible for keeping field vehicles clean by removing trash and other debris. Contaminated trash and equipment should be kept separate from ordinary trash and should be properly disposed on-site or upon return (Section 5.15).

C.6 Preparation of Disposable Sample Containers

C.6.1 Introduction

No disposable sample container (with the exception of the glass and plastic compositing containers) may be reused. All disposable sample containers will be stored in their original packing containers. When packages of uncapped sample containers are opened, they will be placed in new plastic garbage bags and sealed to prevent contamination during storage.

Specific pre-cleaning instructions for disposable sample containers are given in the following sections.

C.6.2 Plastic Containers used for "Classical" Parameters

Plastic containers used for oxygen demand, nutrients, classical inorganics, and sulfides have no pre-cleaning requirement. However, only new containers may be used.

C.6.3 Glass Bottles for Semi-Volatile GC/MS Analytes

These procedures are to be used only if the supply of pre-cleaned, certified sample bottles is disrupted. The Quality Assurance Officer will instruct personnel in the proper implementation of these procedures.

If desired, pesticide-grade methylene chloride may be substituted for pesticide-grade isopropanol. In addition, 1:1 nitric acid may be substituted for the 10% nitric acid solution.

When these sample containers are cleaned and prepared, they should be cleaned in standard sized lots of 100 to facilitate the quality control procedures outlined in Section 5.14.

1. Wash bottles and jars, Teflon® liners, and caps in hot tap water and soap.

2. Rinse three times with tap water.

3. Rinse with 10% nitric acid solution.

4. Rinse three times with analyte free water.

5. Rinse bottles, jars, and liners (not caps) with solvent.

6. Oven dry bottles, jars, and liners at 125°C. Allow to cool.

7. Place liners in caps and close containers.

8. Store in contaminant-free area.

C.6.4 Glass Bottles for Volatile GC/MS and TOX Analyses

These procedures are to be used only if the supply of pre-cleaned, certified sample bottles is disrupted. The Quality Assurance Officer will instruct personnel in the proper implementation of these procedures.

When these sample containers are cleaned and prepared, they should be cleaned in standard sized lots of 100 to facilitate the quality control procedures outlined in Section 5.14.

1. Wash vials, bottles and jars, Teflon" liners and septa, and caps in hot tap water and laboratory detergent.

2. Rinse all items with analyte free water.

3. Oven dry at 125°C and allow to cool.

4. Seal vials, bottles, and jars with liners or septa as appropriate and cap.

5. Store in a contaminant free area.

C.6.5 Plastic Bottles for ICP Analytes

These procedures are to be used only if the supply of pre-cleaned, certified sample bottles is disrupted. The Quality Assurance Officer will instruct personnel in the proper implementation of these procedures.

When these sample containers are cleaned and prepared, they should be cleaned in standard sized lots of 100 to facilitate the quality control procedures outlined in Section 5.14.

1. Wash bottles and caps in hot tap water with soap.

2. Rinse both with 10% nitric acid solution.

3. Rinse three times with analyte-free water.

4. Invert bottles and dry in contaminant free environment.

5. Cap bottles.

6. Store in contaminant free area.

APPENDIX D
SAMPLE SHIPPING PROCEDURES

D.1 Introduction

Samples collected during field investigations or in response to a hazardous materials incident must be classified prior to shipment, as either environmental or hazardous materials samples. In general, environmental samples include drinking water, most groundwater and ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, biological specimens, or any samples not expected to be contaminated with high levels of hazardous materials.

Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods. Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by the International Air Transport Authority (IATA), which is equivalent to United Nations International Civil Aviation Organization (UN/ICAO) (1). Transportation of hazardous materials (dangerous goods) by EPA personnel is covered by EPA Order 1000. 18 (2)

D.2 Shipment of Dangerous Goods

The project leader is responsible for determining if samples collected during a specific field investigation meet the definitions for dangerous goods. If a sample is collected of a material that is listed in the Dangerous Goods List, Section 4.2, IATA, then that sample must be identified, packaged, marked, labeled, and shipped according to the instructions given for that material. If the composition of the collected sample(s) is unknown, and the project leader knows or suspects that it is a regulated material (dangerous goods), the sample may not be offered for air transport. If the composition and properties of the waste sample or highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport.

In addition, the shipment of pre-preserved sample containers or bottles of preservatives (e.g., NaOH pellets, HCL, etc.) which are designated as dangerous goods by IATA is regulated. Shipment of nitric acid is forbidden on all aircraft. Dangerous goods must not be offered for air transport without contacting the Division dangerous goods shipment designee.

D.3 Shipment of Environmental Laboratory Samples

Guidance for the shipment of environmental laboratory samples by personnel is provided in a memorandum dated March 6, 1981, subject "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Laboratory Samples" (3). By this memorandum, the shipment of the following <u>unpreserved</u> samples is not regulated:

- Drinking water
- Treated effluent
- Biological specimens
- Sediment
- Water treatment plant sludge
- POTW sludge

In addition, the shipment of the following preserved samples is not regulated, provided the amount of preservative used does not exceed the amounts found in 40 CFR 136.3 (4) (see Appendix A). It is the shippers' (individual signing the airway bill) responsibility to ensure that proper amounts of preservative are used:

- Drinking water
- Ambient water
- Treated effluent
- Biological specimens
- Sediment
- Wastewater treatment plant sludge
- Water treatment plant sludge

Samples determined by the project leader to be in these categories are to be shipped using the following protocol, developed jointly between US-EPA, OSHA, and DOT. This procedure is documented in the "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples" (3).

Untreated wastewater and sludge from POTW's are considered to be "diagnostic specimens" (not environmental laboratory samples). However, because they are not considered to be etiologic agents (infectious) they are not restricted and may be shipped using the procedures outlined below.

Environmental samples should be packed prior to shipment by air using the following procedures:

1. Allow sufficient headspace (ullage) in all bottles (except VOC containers with a septum seal) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).

2. Be sure the lids on all bottles are tight (will not leak).

3. Place bottles in separate and appropriately sized polyethylene bags and seal the bags with tape (preferably plastic electrical tape). Up to three VOC bottles may be packed in one Whirl-Pak container.

4. Optionally, place three to six VOC vials in a quart metal can and then fill the can with vermiculite.

5. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber or duct tape. Line the cooler with a large heavy duty plastic bag.

6. Place two to four inches of vermiculite in the bottom of the cooler and then place the bottles and cans in the cooler with sufficient space to allow for the addition of vermiculite between the bottles and cans.

7. Put "blue ice" (or ice that has been "double bagged" in heavy duty polyethylene bags and properly sealed) on top of and/or between the samples. Fill all remaining space between the bottles or cans with vermiculite.

8. Securely fasten the top of the large garbage bag with tape (preferably plastic electrical tape).

9. Place the Chain-of-Custody Record and the CLP Traffic Report Form (if applicable) into a plastic bag, and tape the bag to the inner side of the cooler lid.

10. Close the cooler and securely tape (preferably with fiber tape) the top of the cooler shut. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

11. Shipping containers must be marked "THIS END UP", and arrow labels which indicate the proper upward position of the container should be affixed to the container. A label containing the name and address of the shipper should be placed on the outside of the container. Labels used in the shipment of hazardous materials (e.g., Cargo Only Air Craft, Flammable Solids, etc.) are not permitted to be on the outside of containers used to transport environmental samples.

D.4 References

1. Dangerous Goods Regulations, International Air Transport Authority (IATA). Current Edition. which changes annually.

2. EPA Order 1000.18, February 16, 1979.

3. "Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples," Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273), US-EPA, April 13, 1981.

4. 40 CFR 136.3. July 1, 2001. See Table 11, Footnote 3.

APPENDIX E
PUMP OPERATING PROCEDURES

E.1 Peristaltic Pump

E.1.1 Introduction

When relatively small volumes of water are required for purging and sampling, and the water level is within the limit of suction (generally around 25 feet vertical separation between the pump and water surface) peristaltic pumps can be used. These pumps are generally small, light-weight, and portable and are powered by 12-volt batteries.

The application of these pumps differs with respect to purging and sampling. The following sections detail the use of peristaltic pumps for both purposes.

E.1.2 Purging with a Peristaltic Pump

1. Place a coil of standard-cleaned (Appendix B) Teflon® tubing, equal to the well depth plus an additional five to ten feet, in a standard cleaned bucket or box which has been lined with clean plastic sheeting or a garbage bag. Enough tubing is needed to run from the ground surface up to the top of the well casing and back down to the bottom of the well. This will allow for operation of the pump at all possible water level conditions in the well.

2. Place one end of the tubing into the vacuum side of the peristaltic pump head. Proper sizing of the Teflon® and Silastic® or Tygon® tubing should allow for a snug fit of the Teflon® tubing inside the flexible tubing mounted in the pump head.

3. Run a short section of tubing (does not have to be Teflon®) from the discharge side of the pump head to a graduated bucket.

4. Place the free end of the coil of Teflon® tubing into the well until the end of the tubing is just below the top of the water column.

5. Secure the Teflon® tubing to the well casing or other secure object using electrician's tape or other suitable means. This will prevent the tubing from being lost in the well should all of the tubing be deployed and come loose from the pump head.

6. Turn on the pump to produce a vacuum on the well side of the pump head and begin the purge. Observe pump direction to ensure that a vacuum is being applied to the purge line. If the purge line is being pressurized, either switch the tubing at the pump head or reverse the polarity of the cables on the pump or on the battery.

7. Purge the well according to the criteria described in Section 7.2 of this manual. If the pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well several feet at a time, as needed, until the drawdown stabilizes or the well is evacuated to dryness. If the pump is a variable speed peristaltic pump, and the water level in the well is being drawn down, reduce the speed of the pump in an attempt to stabilize the drawdown. If the well can be purged without evacuating the well to dryness, a sample with greater integrity can be obtained.

8. For wells which are not evacuated to dryness, particularly those with recovery rates equal to or very nearly equal to the purge rate, there may not be a complete exchange and removal of stagnant water in that portion of the water column above the tubing intake. For this reason, it is important that the tubing intake be placed in the very uppermost portion of the water column while purging. Standard field measurements should frequently be taken during this process to verify adequacy of the purge (See Section 7.2 for specific details regarding purge adequacy measurements).

E.1.3 Sampling with a Peristaltic Pump

Flexible tubing used in peristaltic pump heads is not acceptable for collecting samples for organic compounds analyses and cannot easily be field cleaned between sampling locations prior to collecting samples for other parameters. For these reasons, it is necessary to use a vacuum container, placed between the pump and the well for sample collection with a peristaltic pump. However, if the flexible pump tubing is decontaminated according to Appendix C of this SOP, samples for analyses of some inorganic constituents may be collected through the tubing if blanks are collected. This method is detailed in the following steps.

NOTE: Samples for volatile organic compound analyses cannot be collected using this method. If samples for VOC analyses are required, they must be collected with a Teflon® or stainless steel bailer or by other approved methods, such as the straw method. The straw method involves allowing the tubing to fill, by either lowering it into the water column or filling it via suction applied by the pump head. Upon filling, the tubing is removed from the well and allowed to drain into the sample vial. This is repeated, as necessary, until all vials are filled.

1. Disconnect the purge tubing from the pump. Make sure the tubing is securely attached to the protective casing or other secure object.

2. Insert the tubing into one of the ferrule nut fittings of a Teflon® vacuum container transfer cap assembly.

3. Place a suitable length of Teflon® tubing between the remaining transfer cap assembly ferrule nut fitting and the vacuum side of the flexible tubing in the peristaltic pump head. Securely hand tighten both fittings.

4. Turn the pump on. Water should begin to collect in the transfer container (typically a 4-liter or 1-gallon sample container) within a few minutes. If water does not begin to flow into the container within five minutes, check the transfer cap fittings and make sure the assembly is tightly attached to the container. It may be necessary to tighten the ferrule nuts with a wrench or pliers to achieve a vacuum in the system, particularly when approaching the maximum head difference between the pump and water table.

5. When the transfer container is nearly full, turn off the pump, remove the transfer cap assembly, and pour the sample into the appropriate containers. Samples to be analyzed for extractable organic compounds, metals, and cyanide can be collected using this system. Because the one-gallon (4-liter) containers used by the Branch are rinsed with nitric acid during cleaning, they cannot be used for collecting samples to be analyzed for nitrogen sensitive parameters.

6. If additional sample volume is needed, replace the transfer cap assembly, turn the pump on, and collect additional volume. The use of Teflon® valves or ball check devices to retain the water column in the sample delivery tubing during the transfer phase, when large volumes of sample are required, is acceptable. These devices, however, must be constructed so that they may be completely disassembled and cleaned according to the procedures in Appendix C.2.1

7. When sampling is completed, all Teflon® tubing should be discarded.

E.2 Large Diameter Electric Submersible Pumps

E.2.1 Introduction

Pumps included within this category are any of the typical, large diameter (3-inch to 4-inch) electric submersibles, such as Goulds®, Grunfos®, or Jacuzzi®. These pumps are necessary when large amounts of water must be removed from wells such as deep, 4-inch monitoring wells and drilled or bored potable wells.

These pumps are generally powered by 120-volt generators and require a minimum of two persons for operation. As such, utmost care should be observed to ensure the safe operation of this equipment, particularly from an electrical hazard standpoint. The following sections detail the safety and operation of these pumps.

E.2.2 Safety

1. Place the generator on dry ground or plastic sheeting as far as practical from the well, in the down-wind direction, and ground it. Several grounding kits consisting of a roll of copper wire and a grounding rod are available. Wet the ground thoroughly with tap water at the grounding location, if dry, and drive the grounding rod several feet into the ground.

2. Inspect the electrical cord for frays, breaks, exposed wiring, etc.

3. Check the head space of the well for the presence of an explosive atmosphere with a combustible gas meter.

4. With the current tripod and spool set-up, a minimum of two people are required to place, retrieve, and operate these pumps safely. If they are used without the aid of the tripod, i.e., all electrical and suspension lines are spooled separately, at least three people are needed to successfully lower and raise the pumps.

5. Wear rubber safety boots to insulate against shock hazards.

6. If purge water is not collected, direct the discharge away from the well and generator, preferably downgradient of area.

7. Make sure that the generator is set to proper voltage.

8. Do not add gasoline or oil to the generator while it is running.

9. Carry the generator, gasoline, and oil in a trailer dedicated to this type of equipment. Do not haul this equipment in the back of any passenger vehicle or with any sampling equipment or containers.

E.2.3 Pre-loadout Checkout Procedure

1. Check the oil and gasoline in generator, filling up as needed. Take generator outside and start it. Place a load on the generator, if possible.

2. Inspect the pump, and all hose, rope and electrical cord and connections.

E.2.4 Operation

1. Erect tripod over well head and load hose spool. Connect pump to steel winch cable. Using winch crank, lower pump, hose and electrical cord into the well. If no tripod is available, lower the pump into the well by hand. This will require at least three people, one to lower pump with the rope, one to feed the hose and cord into the well, maintaining proper tension, and one to feed rope, hose and electrical cord from cart.

NOTE: Keep all hose, electrical cord and cable off of the ground at all times. Do not allow the rope, cord, or the hose to scrape or rub on the well casing.

2. Place pump five feet below the top of the water column.

3. Start generator, then connect power cord from pump.

4. After starting pump, closely observe operation to determine if drawdown is occurring in well. If the water level is not pulled down significantly, keep pump at initial level and continue to purge. If the water level drops, lower the pump to keep up with the drawdown. Do not allow the pump to run dry, as this will damage it.

E.2.5 Maintenance and Precautions

1. Do not put up wet.

2. Empty hose of contaminated water before leaving sampling location. Do not bring back hose with water in it.

3. Do not pump dry.

4. Do not run generator without checking oil.

5. Do not put pump in trailer with generator.

E.2.6 Trouble Shooting

No Power to Pump	1. Loose connections at pump.	1. Check wiring at pump. Repair as needed. (Generator Off!!)
	2. Cord unplugged at generator.	2. Plug pump back in.
Generator Running, No Pump Output	1. Pump out of water.	1. Lower pump into water.
	2. Hose collapsed or kinked.	2. Unkink hose.
	3. Generator output failing.	3. Put load on generator and check output or check voltage output meter.
Sluggish Discharge	1. Sediment or other material clogging screen.	1. Remove material from screen.
	2. Kinked hose.	2. Unkink hose.

E.3 QED® Bladder and Purge Pumps

E.3.1 Introduction

Several QED® bladder pumps and purge pumps (no bladder) which can be used for purging monitoring wells are available. Bladder pumps have a very low efficiency when used near the top of the water column and will generally not purge more than 0.5 gallon per minute. The purge pump, however, can achieve pump rates of several gallons per minute in these situations. The efficiency of the bladder pumps is restricted by the rigid Teflon® bladder, which requires significant hydrostatic head for rapid and complete filling. The purge pump, having no bladder, fills much faster under the same conditions.

Both pumps operate by cycling a pressurized gas on and off in a discharge and refill cycle. The gas, usually atmospheric air, is pressurized and regulated by a compressor/regulator combination (controller), which can consist of either a small, battery powered unit, capable of providing pressure to operate the bladder pump at a depth of approximately 75 feet, or a larger, gasoline powered unit that will allow operation at depths of over 150 feet.

E.3.2 Operation - Bladder Pump

1. Connect air supply hose to "pump supply" connection on controller and to brass air connection on hose reel cart.

2. Lower pump into well and place top of pump several feet below the top of the water column

3. Turn on the compressor. If the gasoline powered compressor is used, place as far from the well as possible, in the down wind direction.

4. Adjust the timing of the discharge and refill cycles until maximum flow is achieved.

5. Lower pump, as necessary, if water level is reduced in well.

E.3.3 Operation - Purge Pump

1. Connect air supply hose to "pump supply" connection on controller and connection on top of pump. Observe flow direction arrow on purge pump exhaust adapter. The arrow must point in the direction of air flow from the controller to the pump.

2. Attach adequate length of standard garden hose to hose fitting at top of pump.

3. Lower pump, air hose and garden hose into water column until top of pump is several feet below top of water column.

4. Follow Steps 3 through 5 above.

E.3.4 Trouble Shooting

Compressor running, no pressure on discharge cycle	1.	Air supply fittings loose.	1.	Check all fittings and tighten.
	2.	Bladder is perforated.	2.	Replace bladder.
	3.	Exhaust adapter installed in wrong direction.	3.	Remove adapter and replace in correct orientation.
Compressor running, pressure low, no water discharged	1.	Obstruction in ball check assembly allowing water to be pushed out of pump at check.	4.	Remove obstruction.
	2.	Air supply fittings loose.	5.	Check all fittings.

E.4 Small Diameter Electric Submersible Pumps

E.4.1 Introduction

Included within this category is the Grundfos Redi-Flo2 small diameter electric submersible pump. With a diameter of approximately 1.75 inches, it is designed to be used in 2-inch diameter and larger wells. (Note: If used in any well larger than 4-inch diameter, this pump must be equipped with a cooling shroud to prevent the pump from overheating. If this condition occurs, internal sensors will send a shut-off signal to the controller and the pump will not be operable until it cools to a temperature within the operating range). The Redi-Flo2 is a variable speed pump capable of providing pump rates from less than 100 ml/minute to in excess of 8 gallons per minute.

The pump, depending on the controller being used, operates with either 115v or 220v power. The pump rate is controlled by adjusting the frequency of the current going to the pump motor. It is a light-weight pump and can be easily handled by one person when lowering, but two people are generally needed when removing the pump, one to pull and another to reel in the hose and power lead.

E.4.2 Safety

1. Place the generator on dry ground or plastic sheeting as far as practical from the well, in the down-wind direction, and ground it. Several grounding kits consisting of a roll of copper wire and a grounding rod are available. Wet the ground thoroughly with tap water at the grounding location, if dry, and drive the grounding rod several feet into the ground.

2. Inspect the electrical extension cord, as well as the lead to the pump, for frays, breaks, exposed wiring, etc.

3. Check the head space of the well for the presence of an explosive atmosphere with a combustible gas meter.

4. Wear rubber boots to insulate against shock hazards.

5. If purge water is not collected, direct the discharge away from the well and generator, preferably downgradient of the area.

6. Make sure that the generator is set to the proper voltage.

7. Do not add gasoline or oil to the generator while it is running.

8. Carry the generator, gasoline, and oil in a trailer dedicated to this type of equipment. Do not haul this equipment in the back of any passenger vehicle or with any sampling equipment or containers.

E.4.3 Pre-loadout Checkout Procedures

1. Check the oil and gasoline in the generator, making sure that there is enough gasoline to test the generator prior to loading onto the trailer. Take the generator outside and start. Place a load on the generator, if possible.

2. Inspect the pump and all hoses, rope, and electrical cord and connections. In particular, open the water reservoir on the bottom of the pump and check to make sure that it is full of water. If not, using the syringe in the controller case, top the reservoir off with organic/analyte-free water. Return the pump to its operating vertical position and shake. Re-open the reservoir and add additional water, if needed, to top it off a second time.

E.4.4 Operation

1. Place the pump, the controller, and enough hose for the measured well depth on plastic sheeting next to the well. Set the generator in a dry, safe location downwind of the well, but do not plug the cord from the controller into the generator.

2. After checking the head space of the well for safety, lower the pump, power lead, and hose into the well, placing the pump approximately five feet into the water column.

3. Start the generator, <u>then</u> connect the power cord from the pump. Make sure the proper voltage has been selected.

4. After starting the pump, closely observe operation to determine if drawdown is occurring in the well. If the water level is not pulled down, raise the pump in the water column one to two feet from the top of the water column and continue to purge. If the water level drops, however, lower the pump to keep up with the drawdown. Do not allow the pump to run dry. This condition will create a thermal overload and shut the pump down. While this may not necessarily damage the pump, it will create delays in sampling.

E.4.6 Maintenance and Precautions

1. Empty the hose of contaminated water before leaving the sampling location. Do not bring the hose back to the FEC if it contains purge water from a site.

2. Field clean the pump before leaving the sampling location (see Appendix B).

3. Do not run the generator without first checking the oil.

4. Do not put the pump in the trailer with the generator.

5. If the pump is equipped with a check valve or back flow preventer, periodically check this device to make sure that it is operating. This is a common place for debris or other material to accumulate and interfere with the proper operation of the device.

E.4.7 Trouble Shooting

<u>Generator Running, No Pump Output</u>	1. Loose connection at pump.	1. Check wiring at pump. Repair as needed. (Generator off!!)
	2. Cord unplugged at generator.	2. Plug pump back in.
	3. Over voltage on controller display.	3. Adjust generator output/idle speed; allow generator more warm-up time.
	4. Pump out of water.	4. Lower pump into water.
	5. Hose collapsed or kinked.	5. Unkink hose.
	6. Pump will not run or shuts down with thermal overload signal.	6. Open cooling water reservoir and check cooling water. Add additional organic/analyte-free water to cooling water reservoir.