

Environmental Investigations
Standard Operating Procedures
and
Quality Assurance Manual
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SECTION 1

SECTION 1 PREFACE

1.1 Introduction

This document, the Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, contains the standard operating and field quality assurance procedures used by Region 4 field investigators. The manual originated in 1980 with the title Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual and was revised in 1986 with the same title and revised again in 1991 with the title, Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual. The specific procedures outlined in the manual are based on the experiences of Region 4 field investigators or are specifically referenced at the end of each section.

This manual will be provided to each Region 4 employee responsible for conducting field investigations for activities contained in these Standard Operating Procedures (SOP). Each employee is expected to read and be familiar with each section of the SOP. This is intended to be a dynamic document and will be revised periodically as needed. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.2 Performance Objectives

Performance objectives have been included at the beginning of sections and sub-sections where applicable. The performance objective lists the minimum requirements necessary for meeting the intent of the procedures that follow in the section. The purpose of the performance objective is to allow flexibility within field procedures where appropriate, however any deviations from the procedures in the SOP should be approved by the appropriate authority and thoroughly documented.

1.3 Section Objectives

Section objectives are included at the beginning of sections where performance objectives are not applicable. Section objectives provide a brief summary of the intention and content of the section.

SECTION 2

SECTION 2

INVESTIGATIONS, INSPECTIONS, AND OVERVIEW ACTIVITIES

SECTION OBJECTIVES:

- Define the standard types of investigations, inspections, and field studies conducted.
- Outline the general requirements for study plans, and reports for standard types of investigations, inspections and field studies.
- List available agency guidance and special requirements for the standard types of investigations, inspections, and field studies.

2.1 Introduction

The investigations, inspections, and overview activities conducted can be broadly categorized as either enforcement or non-enforcement related activities

The enforcement related activities include Resource Conservation and Recovery Act (RCRA) case development inspections, RCRA comprehensive ground water monitoring evaluations, water enforcement case preparation studies, National Pollutant Discharge Elimination System (NPDES) compliance monitoring, diagnostic evaluations of municipal wastewater treatment plants, investigations of Superfund hazardous waste sites, contractor overviews, investigations and monitoring of oil spills and Superfund spills, and investigations of toxic episodes and spills.

Non-enforcement activities include investigations of potential Superfund hazardous waste sites for National Priority Listing (NPL) purposes, technical assistance studies at municipal wastewater treatment plants, studies involving water quality and permitting issues, studies and inspections of abandoned hazardous waste sites, air quality studies, and a broad range of studies for national programs, as well as technical assistance studies for state and local agencies. However, the studies and data derived from non-enforcement type investigations could be used for enforcement purposes. Field investigations include all environmental media, i.e . surface and ground water, air, soils, sediments, and wastes.

2.2 Potable Water Supply Investigations

Special procedures apply when a sample is collected from a private or public potable water supply. Investigators should always obtain the following information from the residents and/or owners in the event contaminants are detected in the sample:

- resident's and/or owner's name,
- resident's and/or owner's mailing address; and
- resident's and/or owner's home and work telephone numbers.

Immediately upon receipt, the project leader should carefully examine the resulting data. Any exceedences of the primary or secondary drinking water standards, or the detection of any priority pollutants, RCRA 40 CFR 261 Appendix VIII compounds, or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 40 CFR 302 list of hazardous substances shall result in the project leader immediately providing the appropriate officials in the Water Management Division with the following information:

- the analytical data;
- the name, address (including zip code) and telephone numbers of the residents and/or owners,
- the site name and location, and
- the EPA site identification number (if applicable).

Investigators should not release potable water supply data to anyone before providing it to the Water Management Division.

2.3 Civil Enforcement Investigations and Studies

2 3.1 Introduction

This SOP covers the field and operational aspects of conducting field investigations, however, it is beyond the scope of this manual to cover all aspects of enforcement activities. Each enforcement investigation must be tailored to meet the needs of the anticipated enforcement action. The lead attorney and compliance specialists should be consulted on a continuing basis during the planning, conduct, and report writing phases of enforcement investigations.

Civil investigations are conducted for the Water and Waste Management Divisions and the Air, Pesticides, and Toxics Management Division to determine if a facility, site, or project is meeting the terms of a Consent Decree, order, water permit, etc. These investigations are conducted under a number of environmental laws which include

- The Clean Water Act (CWA, PL 92-500)
- The Resource Conservation and Recovery Act (RCRA, PL 94-580)
- The Hazardous and Solid Waste Amendments (HSWA) of 1984
- The Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
- The Superfund Amendments and Reauthorization Act (SARA) of 1986
- The Clean Air Act (CAA 42 U. S.C. 1857 - 1857L, as amended)
- The Toxic Substances Control Act (TSCA, PL 94-469)

2 3 2 Facility Entry

Authority -- Various federal environmental statutes grant EPA enforcement personnel authority to enter and inspect facilities. The authority granted in each statute is similar to that stated below in Section 308 of the Clean Water Act.

- "(a)(B) the Administrator or his authorized representative, upon presentation of his credentials (i) shall have a right of entry to, upon, or through any premises in which an effluent source is located or in which any records required to be maintained. .are located, and
- (ii) may at reasonable times have access to and copy any records, inspect any monitoring equipment or method required . . , and sample any effluents which the owner or operator of such source is required to sample. . ."

For the specific requirements for conducting inspections and collecting data pursuant to a particular Act, see Section 308 of the Clean Water Act, Section 9 of the Federal Insecticide, Fungicide, and Rodenticide Act, Section 3007 of the Resource Conservation and Recovery Act; Section 8 of the Toxic Substances Control Act, Section 1445 of the Safe Drinking Water Act; Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund); and Titles I, III, and IV of the Clean Air Act.

2.3 4 Unreasonable Search and Seizure

EPA authority under the various Acts is subject to the "unreasonable search and seizure" provisions of the Fourth Amendment to the Constitution. The prohibition is not against all searches and seizures, but only those which are unreasonable or which valid consent, if required, has not been given. Consent, in this context, means the intentional foregoing of right to privacy which is not the result of either fear, ignorance, or trickery.

To comply with the Acts and avoid any "unreasonable search" or procedural problems, a facility should be entered in the following manner:

1. The facility premises should be entered through the main gate or through the entrance designated by the source if in response to an inspection notification letter (a 308 letter for example)
2. The employee shall introduce herself/himself in a dignified, courteous manner to a responsible plant official. A responsible plant official may be the owner, operator, officer, or agent in charge of the facility, including the plant environmental engineer. Identification credentials shall always be presented
3. If only a guard is present at the entrance, employees shall present their credentials and suggest that the guard call their superior on the telephone. If the field investigators know the name of the responsible official they are to see, field investigators shall request the guard to call this individual directly
4. If the company provides a general sign-in sheet, it is acceptable to sign it. Field investigators shall not sign a release of liability (waiver) when entering a facility under the authority of Federal law
5. If entry is refused, field investigators shall not contest the issue with the facility representative, but will immediately do the following:
 - Obtain the name and position of the individual denying entry to the facility, and record the date and time
 - Cite the appropriate EPA authority to conduct the inspection, ask if the individual denying entry heard and understood the reason for your presence and record the answer and any reasons given for denial of entry.
 - Leave the premises immediately

After leaving the facility, the field investigators shall, at the earliest possible time, inform their immediate supervisor and the Office of Regional Counsel, by telephone of the events which took place and seek guidance on how to proceed

2.3 5 Requesting Information

The various laws and statutes under which EPA operates address the protection of trade secrets and confidential information. As a general policy, field investigators should not accept confidential information unless it is necessary for carrying out Agency functions under a particular Act. As a matter of practice, requests for confidential information can only be signed by an Agency employee who has had the appropriate Confidential Business Information (CBI) training and certification

In compliance with EPA regulations, an EPA request for company information, pursuant to statutory authority, will contain a statement allowing the facility to designate all or part of the information requested by the Agency as confidential by marking it according to: Code of Federal Regulations, Title 40, Part 2, Section 203.41; or Federal Register, 41 FR 36902. In addition to citing the appropriate regulations, the request for confidential information will state that:

- 1 The company may, if it desires, assert a business confidentiality claim covering part or all of the information in the manner described by [the applicable regulation], and that information covered by such a claim will be disclosed by EPA only to the extent, and by means of the procedures, set forth in [the applicable regulations]; and that
- 2 If no such claim accompanies the information when it is received by EPA, it may be made available to the public by EPA without further notice to the company.

If the collection of confidential information is required to carry out the responsibility of the Branch, personnel should consult carefully with the appropriate operating Division staff and the Office of Regional Counsel attorneys. In general, when such information is needed by Branch personnel, the request should state that this information will be transmitted directly to the Office of Regional Counsel

In general, Branch personnel shall not accept confidential information when conducting a plant evaluation, inspection, or reconnaissance. When Branch personnel must collect or observe confidential information, a separate logbook shall be maintained. When confidential information is entered into an inspector's logbook, the entire logbook and each page containing confidential information shall be marked "CONFIDENTIALITY CLAIM ". Upon returning to the EPA Region 4, facility, all such information shall be maintained in a locked filing cabinet and the Office of Regional Counsel shall be notified for ultimate disposition of the material.

All field investigators conducting investigations or inspections should be familiar with the inspection provisions of these acts, i.e., CWA (Section 308), RCRA (Section 3007), CERCLA (Section 104), and TSCA (Section 11).

2 3 5 Photographs

At no time should field investigators be denied the opportunity to take photographs during an investigation. If photographs are denied and no other means can be arranged to get the photographs, this is considered a denial of access on the part of the facility. At some facilities the process operations and/or equipment may be claimed as being proprietary. In these cases, the facility may make a CBI request to the Office of Regional Council (ORC). Generally, providing the facility with a duplicate copy of uncut prints for their review is acceptable to both parties. If this is unacceptable to the facility, the investigator may allow the facility to take the photographs, review them, and provide copies to EPA.

2.3.6 Split Samples

The inspection provisions of RCRA (Section 3007) and CERCLA (Section 104) require that, "If the officer or employee obtains any samples, prior to leaving the premises, he shall give to the owner, operator, or agent in charge a receipt describing the samples obtained and if requested a portion of each such sample equal in volume or weight to the portion retained." As a matter of policy, an offer will be made to the owner, operator, or agent in charge to split all samples collected on facility property.

2.4 Criminal Investigations and Studies

At the request of the Criminal Investigations Division (CID) and with the concurrence of the Regional Administrator/Deputy Regional Administrator, technical support for criminal investigations is provided. Only experienced personnel with adequate training (such as on-site supervision by senior investigators or the Criminal Investigations Course offered by the Federal Law Enforcement Training Center) should be project leaders during such investigations. Technical support shall be provided at the request of the CID Special Agent-in-Charge of the investigation in accordance with Appendix F of this SOP.

2.5 Clean Water Act Compliance Monitoring Inspections

2.5.1 Introduction

The term "compliance monitoring" covers all activities undertaken to ascertain a permittee's or discharger's compliance status. This includes, but is not limited to, Clean Water Act (CWA) compliance monitoring inspections and compliance review, e.g., the review of Discharge Monitoring Reports (DMR) or compliance schedule reports. The main functions of CWA compliance monitoring inspections are to verify the integrity of the self-monitoring information and to develop the basis for possible follow-up compliance or enforcement actions. All compliance monitoring inspections shall be conducted as though an enforcement action would result. General guidance for conducting compliance monitoring inspections is found in the US EPA, NPDES Compliance Inspection Manual (1).

A number of different types of compliance monitoring inspections have been defined including compliance evaluation inspections (CEI), compliance sampling inspections (CSI), toxic compliance sampling inspections (XSI), compliance biomonitoring inspections (CBI), performance audit inspections (PAI), diagnostic evaluations (DE), reconnaissance inspections (RI), pretreatment compliance inspections (PCI), sludge inspections (SI), legal support inspections (LSI), and Municipal Wastewater Treatment Plant technical assistance (TA) studies.

Activities associated with a visit to any facility for a compliance inspection shall not be double counted. Thus, a single visit cannot be counted as both a CSI and a CEI; it must be reported as one or the other. However, a single visit that encompasses separate activities (e.g., a PAI or legal support investigation) will be reported and counted as two separate activities. A compliance monitoring inspection (all types) is not considered complete until the appropriate portions of the Compliance Inspection Report Form (EPA Form 3560-3) have been completed and the information from the coding section entered into the permit compliance system (PCS).

Inspection Notification

Generally, CSIs and CEIs are conducted unannounced unless there is some reason to conduct the inspection on an announced basis. Routine PAI's and DE's are typically announced inspections due to the complexity of the logistics involved in these types of investigations.

The various types of compliance monitoring inspections are defined in the next section; references are given to available specific agency guidance for each type of inspection.

2.5.2 CWA Inspection Types

Compliance Evaluation Inspection (CEI)

The CEI is a nonsampling inspection designed to verify permittee compliance with applicable permit self-monitoring requirements, effluent limits, and compliance schedules. This inspection involves records reviews, visual observations, and evaluations of the treatment facilities, laboratories, effluents, receiving water, etc. The CEI examines both chemical and biological self-monitoring and forms the basis for all other inspection types except the Reconnaissance Inspection. Guidance for conducting CEIs is given in the NPDES Compliance Evaluation Inspection Manual (2).

Compliance Sampling Inspections (CSI)

CSI's are conducted where representative sample(s) of a permittee's influent and/or effluent are collected and analyzed 1) to verify the accuracy of the permittee's discharge monitoring reports, 2) to determine the quantity and quality of the effluent, 3) to develop permits, and/or 4) where appropriate, as evidence for enforcement proceedings. This activity also includes the same objectives listed for CEI's, and where appropriate, may serve to gather detailed information for the possible institution of legal action against the permittee. Guidance for conducting CSI's is given in the NPDES Compliance Sampling Inspection Manual (3).

Toxic Sampling Inspections (XSI)

The XSI has the same objectives as a conventional CSI. However, it places increased emphasis on toxic substances regulated by the NPDES permit. The XSI covers priority pollutants other than heavy metals, phenols, and cyanide, which are typically included in a CSI (if regulated by the NPDES permit). An XSI uses more resources than a CSI because highly sophisticated techniques are required to sample and analyze toxic pollutants. An XSI may also evaluate raw materials, process operations, and treatment facilities to identify toxic substances requiring controls.

Compliance Biomonitoring Inspection (CBI)

A CBI is an inspection utilizing a static or flow-through bioassay, in lieu of, or in addition to, the collection of samples. The objectives of this inspection are to:

- Identify those permittees which may be meeting the minimum technology based requirements of the CWA, but whose level of treatment is not sufficient to ensure the biological integrity of the receiving waters,
- Identify those permittees which may have potential toxicants in their discharge(s) that have not been identified or included in their NPDES permit, and
- Evaluate compliance with acute or chronic toxicity permit limit requirements.

In those instances where biomonitoring reveals the presence of toxic substances not addressed in the issued permit, the permittee may be required through the 308 process to chemically and/or physically characterize the composition of the discharge to identify and quantify the toxic substance or substances (CWA Section 308). Guidance for conducting these inspections is given in the Compliance Bio-Monitoring Inspection Manual (4).

Performance Audit Inspection (PAI)

The PAI is used to evaluate the permittee's self-monitoring program. As with a CEI, the PAI is used to verify the permittee's reported data and compliance through a records check. However, the PAI provides a more resource-intensive review of the permittee's self-monitoring program and evaluates the permittee's procedures for sample collection, flow measurement, chain-of-custody, laboratory analyses, data compilation, reporting, and other areas related to the self-monitoring program. During a CEI, the inspector makes a cursory visual observation of the treatment facility, laboratory, effluents, and receiving waters. During a PAI, the inspector actually observes the permittee performing the self-monitoring process from sample collection and flow measurement through laboratory analyses, data workup, and reporting. The PAI does not include the collection of samples by the inspector. However, the inspector may require the permittee to analyze performance samples for laboratory evaluation purposes.

Diagnostic Evaluations (DE)

The DE is a detailed performance evaluation that focuses primarily on municipal Publicly Owned Treatment Works (POTWs) which are not in compliance with permit requirements. The DE is designed to evaluate the POTW's design, operations, and influent/effluent wastewater characteristics and to provide a comprehensive evaluation of the reasons why the facility is not meeting permit limits. The final product consists of a formal report with data, data interpretation, and recommendations suitable for use in technical assistance, negotiations, and enforcement actions.

Reconnaissance Inspection (RI)

The RI is used to obtain a preliminary overview of a permittee's compliance program. The inspector performs a brief visual inspection of the permittee's treatment facility, effluent, and receiving waters. The RI is intended to obtain a broad coverage of permittees of unknown status with a minimum amount of resources.

Pretreatment Compliance Inspection (PCI)

The PCI evaluates the POTWs implementation of its approved pretreatment program. It includes a review of the POTWs records on monitoring, inspections, and enforcement activities for its industrial users. The PCI is usually conducted concurrently with another NPDES inspection of the POTW.

Sludge Inspection (SI)

The SI is primarily conducted at POTWs. Waste sludge generation and disposal practices are evaluated under the 40 CFR 503 regulations. The SI includes a review of the sludge monitoring records, sludge handling facilities, and sludge disposal practices.

Legal Support Inspection (LSI)

The LSI is an inspection conducted to satisfy a specific enforcement related problem. An example of this type of inspection may be an enforcement request to inspect a permittee to see if it is appropriate to terminate a specific enforcement order or a request to gather data to support a planned action.

Municipal Wastewater Treatment Plant Technical Assistance (TA) Studies

The TA program is designed to assist federal, state, and local agencies, and industries with technical issues associated with wastewater treatment problems. The TA includes analysis of the various technical problems, training in direct support of the program, and advice on the solutions to the problems.

2.5.3 Study Plans

Routine NPDES inspections (e.g., PAIs, CSIs, etc.) do not require a written study plan. Detailed investigations, such as diagnostic evaluations, water quality studies, and other large scaled technical evaluations will require a written study plan which should include the following minimal information:

- Introduction -- The name and location of the project, study dates, requestor, reason for request (e.g., NPDES compliance problems), project leader, and a list of EPA and other appropriate study contacts and telephone numbers
- Study Objectives -- A detailed description of the primary objectives of the project
- Sampling Schedule -- A detailed table showing all projected sampling stations, sampling parameters, and the total number of samples to be analyzed

The study plan may include more detailed information depending on the nature and complexity of the project. Copies of the study plan should be given to the appropriate personnel.

2.5.4 NPDES Compliance Inspection Reports

The results of all compliance inspections shall be reported utilizing the NPDES Compliance Inspection Report Form (EPA Form 3560-3). The completed form, formal narrative report, and transmittal memorandum constitute a compliance inspection report for all routine compliance inspections conducted by Branch personnel.

The completed inspection reports are forwarded to all appropriate parties as previously agreed for action and follow-up. The state and regional program office are kept fully informed via copies of all correspondence. In cases where EPA is involved in litigation with a permittee, no reports will be sent to the permittee without special permission from legal counsel.

Completion of NPDES Compliance Inspection Report Form (EPA Form 3560-3)

General instructions for completing EPA Form 3560-3 are printed on the back of the form.

The forms shall be signed by the investigator and dated on the day that the form is completed (not the inspection date). The name of the state inspector should be included for joint inspections. All routine compliance inspections forms shall be reviewed by the supervisor, who will sign and date the 3560-3 form in the "Reviewed By" section.

2.6 Superfund Investigations, Technical Assistance, and Overview Activities

2.6.1 Introduction

Superfund field activities include remedial investigations and feasibility studies (RI/FS), field investigations of potentially or known contaminated areas (FI), technical assistance (TA), and on-site overviews (OV) of Superfund contractor, potentially responsible party (PRP) contractor, and state personnel.

2.6.2 Superfund Investigation Types

Remedial Investigations/Feasibility Studies (RI/FS)

Remedial investigations are conducted to determine the nature and extent of contamination at specific Superfund sites. Investigations may include installation of temporary or permanent monitoring wells, geophysical exploration, surface and subsurface soil sampling, off-site environmental sampling, etc. Feasibility studies may be conducted concurrently with an RI to develop and evaluate potential remedial action alternatives. The Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (5) is useful for planning RI/FS investigations.

Field Investigations (FI)

These include all field investigations, other than RIs, of potentially or known contaminated areas, and they support all phases of the Superfund program. These investigations may include sampling of ground water, surface and subsurface soils, rivers, lakes, etc., and/or may entail geophysical studies, global positioning system (GPS) activities, etc.

Overviews (OV)

Activities include on-site overview of the field work of EPA Superfund field contractors, PRP contractors, and State Superfund contractors. Overviews are conducted to evaluate the contractors' capabilities and to correct deficiencies in performing Superfund field investigations. The Region 4, Hazardous Waste Field Overview Checklist (Exhibit 2.1) is completed during the overview, and a written report presenting the overview findings is completed and transmitted to the appropriate official in the Waste Management Division.

Technical Assistance (TA)

Activities range from directing field investigations with non-Agency field support to responding to telephone questions concerning all aspects of Superfund field investigations. In addition, field personnel provide a variety of training and technical assistance activities for Regional, State, and other Federal agency personnel in methods of conducting field operations at hazardous waste sites.

2.6.3 Planning for Field Investigative Support

Periodic meetings are typically held between a representative(s) of the Superfund Team and the Waste Management Division staff to discuss proposed initiatives and specific investigation needs. These meetings are usually conducted in October for yearly planning, and more frequently for quarterly planning.

Based on the priorities agreed upon by the Superfund Team, the Superfund Coach, and the Waste Management Division, field investigation schedules are prepared by the Superfund Team and updated as needed

2.6.4 Requests for Superfund Studies

Superfund investigations are prioritized by the Waste Management Division based on the need for field investigative support. Specific investigations are usually requested by project managers of the various Superfund programs, however, they may be requested by state agencies, congressional officials, etc. Routine requests for field investigative support are coordinated with the Superfund Team leader and Superfund Coach. Requests are then brought to the Superfund Team for scheduling and project leader/staff assignment. Although the initial contact may be by telephone or electronic mail, a formal request memorandum with a request form is required prior to commencement of the investigation.

2.6.5 Investigation Study Plans

Study plans are prepared for all Superfund investigations except overviews and some emergency investigations. Study plans for typical Superfund field investigations must be issued at least one week prior to the investigation. The timing and nature of some emergency requests may preclude the issuance of a study plan.

A copy of the study plan in draft form will be provided to the requestor to insure that the plan will meet their objectives. As a general rule, the Data Quality Objective (DQO) process should be consulted during the study plan preparation phase. The study plan should include, as appropriate:

- Introduction -- The project leader and support staff, requestor from the appropriate Superfund Branch, and the objective(s) of the investigation
- Background -- Facility compliance history, manufacturing processes, types of wastes produced, waste treatment methods, etc.
- Scope -- The study design should be discussed in this section including the number and location of the samples to be collected, information which will be obtained, and records to be reviewed
- Logistics -- The travel and study dates.
- Methodology -- Analyses to be conducted and who will conduct analyses, field and laboratory SOP references, and when samples will be received by the laboratory.

If the study is an RI, the following additional information, where appropriate, should be included.

- Site background and physical setting
- Initial Evaluation
- Sampling DQO
- Site Management Plan
- Quality Assurance Project Plan
- Field Sampling and Analyses Plan
- Field Health & Safety Plan.

2 6 6 Investigation Reports

Reports will be completed after each investigation and will contain the following, as appropriate

- Introduction -- When the investigation was conducted; EPA, state, or other regulatory agency participation; facility representatives and what their participation included; who requested the investigation; and the objectives
- Background -- Study area descriptions, manufacturing process and waste handling priorities, results of previous investigations, etc. A site map depicting major structures and facilities, as well as sampling locations will be included.
- Summary -- A brief summary of the key results and conclusions of the study.
- Discussion -- All aspects pertinent to the investigation, such as analytical results; deficiencies, site hydrology, an evaluation of the monitoring well system; a site map showing monitoring well locations, topography, and ground water flow direction; well depths, and ground water elevations.
- Methodology -- A statement indicating that this SOP was followed and/or reasons why not and whether or not samples were split and with whom.
- Conclusions -- At the discretion of the author, a conclusions section for complex investigations
- Reference and Appendices -- Laboratory data sheets, checklists, etc.

If the study is an RI, the following additional information should also be included where appropriate.

- Site information, including site description, site history, previous investigation results, regulatory actions, demography, and surrounding land use.
- Sampling strategy
- Nature and extent of contamination
- Contaminant fate and transport

In emergencies, samples are usually collected quickly and analyzed on a fast turn-around basis. In these cases, Team personnel may provide printed copies of sample data to the requestor as soon as practical. Where appropriate, a letter report detailing the field activities associated with the emergency field investigation will be prepared and transmitted to the requestor.

Internal Peer Review and Report Recipients

All Superfund reports will be reviewed internally. Final copies of the report will be sent to the requestor. If facility or state personnel request a copy of the report, this will be indicated in the report transmittal memo. The Regional Superfund program is responsible for distribution of data and reports to site owners or operators and to the public. All requests for such information should be referred to the proper program official for action.

2.7 RCRA Inspections, Investigations, and Overview Activities

2.7.1 Introduction

RCRA field activities include comprehensive ground water monitoring evaluations (CME), RCRA facility assessments (RFAs), case development inspection/evaluations (CDIE) for both the RCRA program and the Criminal Investigations Division (CID), and on-site field overviews (OV) of state, RCRA contractor, and federal facility personnel

2.7.2 RCRA Investigation Types

Comprehensive Ground Water Monitoring Evaluation (CME)

The CME is an overall review of a facility's compliance with all applicable RCRA requirements to determine adequacy of the ground water monitoring system. It includes an on-site examination of records and other documents and an evaluation of the facility's compliance with applicable RCRA requirements. Also evaluated is the effectiveness of the ground water monitoring system and the facility's hydrogeological conditions. Sampling and analysis of the ground water are usually conducted. Guidance for conducting CMEs is included in the RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (OSWER 9950.1) (6).

RCRA Facility Assessment (RFA)

The RFA is an agency lead activity which is the first step in a corrective action program. The purpose of the RFA is to identify known and/or probable releases of hazardous wastes or other constituents at solid waste management units (SWMUs) and at previously unaddressed regulated units. It includes a "desk-top" review of information submitted by the owner/operator to EPA and State Agencies. The RFA also consists of an on-site visit, and potentially a subsequent sampling investigation to determine whether or not releases of hazardous wastes or constituents have occurred. Guidance for conducting the RFA is in the Draft RCRA Preliminary Assessment/Site Investigation Guidance (7).

Case Development Investigation/Evaluation (CDIE)

These include all RCRA field investigations other than CME's and RFA's, including field sampling investigations, closure/post closure investigations, environmental investigations, trial burns, etc. The type of investigation dictates the specific field methodology. The CDIE is conducted to gather information on the composition/characteristics of wastes and/or an area impacted by the operation of a RCRA facility. The CDIE may also include verification of a sampling and analysis plan, collection of information on facility design and operation, verification of manifest descriptions, or other unanticipated needs or requests necessary for case development.

Overviews (OV)

Overviews of state RCRA compliance inspections or RCRA contractor inspections are conducted to evaluate their capability to conduct RCRA field investigations. The Region 4, Hazardous Waste Field Overview Checklist (Exhibit 2.1) is completed during the overview, and a written report presenting the overview findings is completed and transmitted to the appropriate EPA regional RCRA official.

2 7.3 Planning for Field Investigative Support

Periodic meetings are typically held between a representative(s) of the RCRA Team and the RCRA Branch staff to discuss proposed initiatives and specific investigation needs. These meetings are usually conducted in October for yearly planning, and more frequently for quarterly planning.

Based on the priorities agreed upon by the RCRA Team, the RCRA Coach, and the RCRA Branch, a tentative field investigations schedule is prepared by the RCRA Team and updated as needed. An updated schedule is provided to the RCRA Branch each month through the RCRA Team leader.

2 7.4 Requests for RCRA Studies

RCRA investigations are prioritized by the Region 4, RCRA program based on their need for field investigative support. Requests for field investigative support are coordinated with the RCRA Team Coach or their designee(s). A memorandum with a request form is required prior to commencement of the investigation.

2 7.5 Investigation Study Plans

Study plans are prepared for all RCRA investigations and issued at least one week prior to the investigation. A copy of the draft study plan should be provided to the RCRA program requestor to insure that the investigation will meet their enforcement or permitting objectives. As a general rule, the Data Quality Objective (DQO) process should be consulted during the study plan preparation phase. The study plan should include, as appropriate

- Introduction -- The project leader and support staff, requestor from the RCRA program, and the objective(s) of the investigation
- Background -- Facility compliance history, manufacturing processes, types of wastes produced, waste treatment methods, etc.
- Scope -- A discussion of the study design including the number and locations of the samples to be collected. Information which will be obtained and records to be reviewed.
- Logistics -- The travel and study dates
- Methodology -- Analyses to be conducted and who will conduct analyses, field and laboratory SOP references, and when samples will be received by the laboratory.

2 7 6 Investigation Reports

Reports will be completed after each investigation and will contain the following, as appropriate

- Introduction -- When the investigation was conducted; EPA, state, or other regulatory agency participation, facility representatives and what their participation included; who requested the investigation; and the objectives.
- Background -- Study area descriptions, manufacturing process and waste handling priorities, results of previous investigations, etc. A site map depicting major structures and facilities, as well as sampling locations will be included for all CMEs and CDIEs.
- Summary -- A brief summary of the key results and conclusions of the study.
- Discussion -- All aspects pertinent to the investigation e.g., analytical results, RCRA deficiencies, etc
- Methodology -- What information was obtained and from whom, what samples were collected, whether or not photographs were taken, etc. A statement indicating that this SOP was followed and/or reasons for deviations and whether or not samples were split and with whom
- Conclusions -- At the discretion of the investigator, a conclusions section for complex investigations.
- Reference and Appendices -- Raw data, checklists, etc

If the study was a CME, the following information should be included where appropriate

- A discussion of site hydrology
- An evaluation of the monitoring well system
- An evaluation of the assessment plan
- A site map showing monitoring well locations, SWMU's, topography, ground water flow direction, etc
- Well depth, ground water elevations
- CME checklist

Internal Peer Review and Report Recipients

All RCRA reports will be reviewed internally. Final copies of the report will be sent to the requestor. If facility or state personnel request a copy of the report, this will be indicated in the report transmittal memorandum.

2.8 Underground Storage Tank (UST) Investigations

2 8 1 Introduction

Laws protecting private and public water supplies from contamination by petroleum products due to leaking underground storage tanks were finalized on September 23, 1988 (40 CFR, Parts 280-281). Field investigations of potentially contaminated sites are requested by the Water Management Division and involve comprehensive ground water sampling and site inspections.

UST inspection objectives are as follows:

- Conduct sampling for metals and volatile and extractable organic compounds analyses at potable and groundwater monitoring wells located in the investigation area
- Determine whether the potable wells are contaminated with petroleum products.
- Determine the direction of the contamination plume and the source of the contamination

2 8 2 Investigation Reports

An investigation report containing the following information will be completed:

- Introduction -- When and where the investigation was conducted; investigation team members and telephone numbers, potable well owners addresses and telephone numbers; and requesting office.
- Background -- Site history, description, and results of previous studies
- Summary -- Summary of analytical results, whether petroleum pollutants are present, direction of plume movement if determined, and possible sources of contamination.
- Sketches/maps -- Showing potable well locations.

Internal Peer Review and Report Recipients

All UST reports will be reviewed internally. Final copies of the report will be sent to the appropriate Water Management Division official. If private or public potable water supplies are sampled, see Section 2.2 for reporting requirements.

2.9 Underground Injection Control (UIC) Investigations

2 9 1 Introduction

Laws protecting the ground water from contamination by the injection of wastes allow for the sampling of injection wells as well as other nearby wells. Field investigations of potentially contaminated sites are requested primarily by the Region 4, Underground Injection Control Unit and involve comprehensive ground water sampling and site inspections.

UIC inspection objectives are as follows.

- Conduct sampling for specified parameters, metals, and volatile and extractable organic compound analyses at injection, potable, and ground water monitoring wells located in the vicinity of the investigation area
- Determine whether the potable water wells in the vicinity are being contaminated with waste products from the injection wells
- If requested, determine the direction of the contamination plume and the source of the contamination

2 9 2 Investigation Reports

An investigation report containing the following information will be completed.

- Introduction -- When and where the investigation was conducted; investigation team members and telephone numbers; potable water well owners addresses and telephone numbers; and requesting office.
- Background -- Site history, description, and results of previous studies.
- Summary -- Summary of analytical results, whether pollutants are present, direction of plume movement, and possible sources of the contamination.
- Sketches/maps -- Showing potable well locations

Internal Peer Review and Report Recipients

All UIC reports will be reviewed internally. Final copies of the report will be sent to the appropriate Water Management Division official. If private or public potable water supplies are sampled, see Section 2 2 for reporting requirements

2.10 Ambient Air Monitoring Evaluations And Audits

2 10.1 Introduction

In 1979, the US EPA established a plan for obtaining reliable ambient air quality data. The plan includes a network of State and Local Air Monitoring Stations (SLAMS). The regulations governing the network (40 CFR 58) cover the data collection and reporting requirements for state and local air pollution control agencies. The purpose of this section is to provide procedures for the inspection and evaluation of the SLAMS network. Each SLAMS site must meet criteria for network design, instrument exposure, sample inlet, etc.

2 10.2 NAMS/SLAMS Site Evaluations

State and Local Air Monitoring Stations (SLAMS)

A SLAMS network should be designed to meet a minimum of four basic monitoring objectives. Each SLAM site within a network must meet at least one of the following objectives:

- To determine the highest concentrations expected to occur in the area covered by the network
- To determine representative concentrations in areas of high population density
- To determine the impact of ambient pollution levels of significant sources or source categories.
- To determine the general background concentration levels.

National Air Monitoring Stations (NAMS)

NAMS are a selected subset of the SLAMS sites, covering urban and multi-source areas. The emphasis is on areas of maximum concentrations and high population density. NAMS, like SLAMS, must conform to EPA siting criteria and operate according to quality assurance procedures that meet or exceed EPA's minimum specifications. The NAMS differ from the SLAMS in that NAMS must use continuous automated instruments for gaseous pollutants.

The NAMS fall into two categories

- Category (a) - stations in areas of expected maximum concentrations (usually middle scale)
- Category (b) - stations in areas with both poor air quality and high population density. These areas are not necessarily those with expected maximum concentrations. They will usually be densely populated neighborhoods, but may be areas where sensitive individuals are likely to live or work, if such areas are common to the neighborhood.

Urban areas where NAMS are required will usually have both types of stations. It is possible that only one monitoring station will be needed for PM_{10} or SO_2 , in which case it must be a Category (a) station.

Network Design

Site selection is based on population and expected pollutant concentration. Tables 2.10.1 and 2.10.2 show the population levels for which NAMS monitoring is required. The required spatial scales for NAMS are shown in Table 2.10.3. Although SLAMS do not have specific scale requirements, the scales that are appropriate to each pollutant are also shown in Table 2.10.3. Selection of urban areas and actual number of stations per area is jointly determined by EPA and the state agency.

TABLE 2.10.1

**GUIDELINES for PM₁₀ and SO₂ NAMS NETWORK SIZE
(APPROXIMATE NUMBER of STATIONS PER AREA)**

Population Area	Population Concentration		
	High ^a	Medium ^b	Low ^c
> 1,000,000	6-10	4-8	2-4
500,000-1,000,000	4-8	2-4	1-2
250,000-500,000	3-4	1-2	0-1
100,000-250,000	1-2	0-1	0
<p>(a) PM₁₀: High concentration areas are those for which ambient PM₁₀ data show ambient concentrations exceeding PM₁₀ National Ambient Air Quality Standards (NAAQS) by 20% or more</p> <p>SO₂: Defined as high when the ambient concentration exceeds the level of the primary NAAQS.</p> <p>(b) PM₁₀: Ambient concentrations exceed 80% of the NAAQS.</p> <p>SO₂: Ambient concentrations exceed 60% of the primary or 100% of the secondary NAAQS.</p> <p>(c) PM₁₀: Ambient concentrations are less than 80% of the NAAQS</p> <p>SO₂: Ambient concentrations are less than 60% of the primary or 100% of the secondary NAAQS</p>			

TABLE 2.10.2

POPULATION LEVELS for which NAMS MONITORING of POLLUTANTS other than PM_{10} and SO_2 is REQUIRED

POLLUTANT	POPULATION
Lead	500,000 ^a
CO	500,000
Ozone	200,000
NO_2	1,000,000
(a) The minimum is also a SLAMS requirement. NAMS monitoring is also required whenever the NAAQS has been exceeded in any of the last eight quarters.	

TABLE 2.10.3

SUMMARY of SPATIAL SCALES USUALLY NEEDED for SLAMS and NAMS

Spatial Scale	Scale Appropriate for SLAMS					
	SO_2	CO	O_3	NO_2	Pb	PM_{10}
Micro		X			X	X
Middle		X	X	X	X	X
Neighborhood	X	X	X	X	X	X
Urban	X		X	X	X	X
Regional	X		X		X	X
Spatial Scale	Scale Appropriate for NAMS					
	SO_2	CO	O_3	NO_2	Pb	PM_{10}
Micro		X			X	X
Middle					X	X
Neighborhood	X	X	X	X	X	X
Urban			X	X		
Regional						

Monitoring Methodology

The monitoring methods that must be used in NAMS/SLAMS are specified in 40 CFR 58, Appendix C (hereafter referred to as Appendix C). Reference methods (or their equivalent) must be used for all regulatory purposes.

An analyzer with a nonconforming range greater than twice the upper limit may be used if it has more than one range. At least one of these ranges must be designated a reference or equivalent method and it must be the one in which the pollutant concentration is likely to occur. Further, the EPA Administrator must determine that the resolution of the range is adequate. See Section 2.6, Appendix C, for further details.

Requests for approval of a sampling method must be submitted to the Director, National Exposure Research Laboratory (NERL), United States Environmental Protection Agency, Environmental Research Center, Research Triangle Park, North Carolina 27711.

Probe Siting

Tables 2.10.4 and 2.10.5 display the requirements for probe siting. For clarification or justification, refer to Appendix D of 40 CFR 58.

Only borosilicate glass and Teflon® or their equivalent are acceptable materials for intake sampling lines. The residence time in sampling probes for reactive gases must be less than 20 seconds.

2.10.3 State and Local QA Plan Reviews

Introduction

40 CFR, Part 58, Appendix A specifies the minimum quality assurance (QA) requirements applicable to SLAMS air monitoring data submitted to EPA. The QA Plan for an air monitoring network contains two distinct functions: control of the measurement process and assessment of the quality of monitoring data. The QA Plan must be approved by the Regional Administrator or his designee. In Region 4, the Region's QA Officer has been delegated the authority to approve QA Plans. The Air Monitoring Team (AMT) reviews QA Plans for SLAMS in Region 4.

Review/Approval Process

The AMT reviews state and local QA Plans submitted to the Regional Administrator for approval. At a minimum, each QA Plan must include operational procedures for the 14 elements listed in Section 2.0 of 40 CFR Part 58, Appendix A. Based on the review results and comments received from the reviewers, the AMT recommends approval/disapproval action to the Region 4 QA Officer. If the AMT Leader recommends disapproval of a state or local QA Plan, he/she will hold the review process in abeyance until he/she has requested and received additional information necessary to approve the QA Plan from the state or local agency which submitted the QA Plan.

TABLE 2.10.4
SUMMARY of PROBE SITING CRITERIA

Pollutant	Scale	Height Above Ground(m)	Other Spacing Criteria
CO	Micro Middle and Neighborhood	3 ± 1/2 3 - 15	6, 7, 3, 5
SO ₂	All	3 - 15	3, 8, 5
Ozone	All	3 - 15	1, 2, 3, 4, 5
NO ₂	All	3 - 15	1, 2, 3, 5, 8
Lead	Micro All Others	2 - 7 2 - 15	1, 2, 4, 9, 10, 11 1, 2, 4, 8, 9, 10
PM ₁₀	Micro All Others	2 - 7 2 - 15	1, 2, 4, 9, 10, 12 1, 2, 4, 9, 10, 12

1 Should be greater than 20 meters from tree driplines and must be 10 meters from the dripline when trees act as an obstruction.

2 Distance from inlet probe to obstacle, such as buildings, must be at least twice the height the obstacle protrudes above the inlet pole. Sites not meeting this criterion would be classified as middle scale.

3 Must have unrestricted airflow 270 degrees around the inlet probe, or 180 degrees if the probe is on the side of a building

4 No furnace or incinerator flues should be nearby. Distance is dependent on height of furnace or incineration flues, type of fuel or waste burned, and quality of fuel (sulfur, ash, or lead content) This is to avoid undue influences from minor pollutant sources.

5 The horizontal and vertical distance from supporting structures must be greater than 1 meter (When the probe is located on a rooftop, this distance is in reference to walls, parapets, or penthouses located on the roof)

6 Must be greater than 10 meters from a street intersection and should be located mid-block.

7 Must be 2-10 meters from the edge of the nearest traffic lane.

8 Spacing from roads varies with traffic (Table 2.8.5).

9 The horizontal distance from supporting structures must be greater than 2 meters

10 Must have unrestricted airflow 270 degrees around the sampler.

10, Must have unrestricted airflow 270 degrees around the sampler, except for street canyon sites

11 Must be 5-15 meters from major roadways.

12 Spacing from roads varies with traffic except for CO street canyon sites, which must be 2-10 meters from the edge of the nearest traffic lane.

TABLE 2.10.5

**MINIMUM DISTANCE BETWEEN SAMPLING PROBE and ROADWAYS
(EDGE of NEAREST TRAFFIC LANE)**

Roadway Average Daily Traffic (ADT) (vehicles per day)	Minimum Distance Between Roadways and Stations* (meters)		
Neighborhood - Scale CO Stations			
< 10,000	10		
15,000	25		
20,000	45		
30,000	80		
40,000	115		
50,000	135		
> 60,000	> 150		
Neighborhood and Urban-Scale Ozone and NO ₂ Stations			
< 10,000	10		
15,000	20		
20,000	30		
40,000	50		
70,000	100		
> 110,000	> 250		
Lead Stations			
	Micro Scale	Middle Neighborhood, Urban Scale	Regional Scale
10,000	5 - 15	> 15 - 50	> 50
20,000	5 - 15	> 15 - 75	> 75
40,000	5 - 15	> 15 - 100	> 100
* Distances should be interpolated based on traffic flow			

2 10 4 Performance Audits

Introduction

Performance audits are conducted by the appropriate AMT staff to assess local and state agencies' quality assurance program. The audits allow for an overall estimate of a given agencies' data quality. However, the result of an audit is not a definitive indicator of the overall quality of an agency's data base.

When scheduling audits with a state or local agency, the state Quality Assurance Coordinator must be notified in advance to allow for state agency representation during the audit. Upon arrival at the audit location, all principles involved must be briefed to explain the audit, its meaning, and the use of its results. Following the initial conference, the audits will be performed. The auditor will ask the station operator to verify that no unscheduled zero or span adjustments have been made prior to the audit. During the audit, the auditor will request the station operator to read the instrument responses from the agency monitor. All data will be recorded on the appropriate audit form. The form shall be signed by the auditor and an agency representative.

Following the completion of the audit, an exit conference will be conducted where results of the audit will be discussed. The auditor should not give copies of the audit form to the agency personnel until after returning to the office and after the audit data have been verified. Having verified an auditor's results, copies of the audit form will be sent to the affected agency and state Quality Assurance Coordinator.

Multi-Component Blends And Audit Gases

A multi-component blend of CO, SO₂, and NO₂ (or any combination of these three gases) may be used. However, the blend shall be composed of gases, each of which is either a Standard Reference Material (SRM) or an EPA Protocol Gas.

All audit gases shall be traceable to National Institute of Standards and Technology Standard Reference Materials (SRMs) or the gases used in the audit may be SRMs or EPA Protocol Gases.

Carbon Monoxide

Carbon monoxide audit concentrations shall be introduced into the monitor prior to any filters, dryers, or mixing chambers. Audit concentration points will be in the following ranges.

Audit Point	Concentration (ppm CO)
1	3 - 8
2	15 - 20
3	35 - 45
4	80 - 90

Note. Audit point #4 will be run only on monitors operated in the 0 to 100 ppm range.

Ozone

Ozone audit concentrations shall be introduced into the monitor at the same point where ambient air enters the sampling system. The audit concentration should be introduced through the probe, if possible. Audit concentration points will be in the following ranges.

Audit Point	Concentration (ppm O ₃)
1	0.03 - 0.08
2	0.15 - 0.20
3	0.35 - 0.45
4	0.80 - 0.90

Note: Audit point #4 will be run on monitors operating in the 0 to 1.0 ppm range.

Sulfur Dioxide

Sulfur dioxide audit concentrations shall be introduced into the monitor through the particulate filter. The audit concentration should be introduced through the probe, if possible. Audit concentration points will be in the following ranges.

Audit Point	Concentration (ppm SO ₂)
1	0.03 - 0.08
2	0.15 - 0.20
3	0.35 - 0.45
4	0.80 - 0.90

Note: Audit point #4 will only be run on monitors operating in the 0 to 1.0 ppm range.

Nitrogen Dioxide

Nitrogen dioxide audit concentrations shall be introduced into the monitor through the particulate filter. The audit concentration should be introduced through the probe, if possible. Audit concentration points will be in the following range.

Audit Point	Concentration (ppm NO ₂)
1	0.03 - 0.08
2	0.15 - 0.20
3	0.35 - 0.45
4	0.80 - 0.90

Note: Audit point #4 will only be run on monitors operating in the 0 to 1.0 ppm range. If the audit is being conducted with a gas phase titrator (gpt), it will be necessary to run a zero and span point on the monitor's NO_x and NO channels. If NO and/or NO_x data collected by a state/local agency are submitted

to the AIRS system, the NO and/or NO_x channel must be audited using either cylinder dilution or gpt

2 10.5 National Air Monitoring Audit System

Introduction

A systems audit is an on-site review and inspection of a state or local agency's ambient air monitoring program to assess its compliance with established regulations governing the collection, analysis, validation, and reporting of ambient air quality data. To promote uniformity in the evaluation of state and local agencies' monitoring programs and performance, the air monitoring staff will use the "short form" questionnaire and the reporting format described in detail in Section 2.0.11 of "The QA Handbook for Air Pollution Measurement System," Volume II, Ambient Air Specific Methods, US EPA, Office of Research and Development (ORD), NERL, Research Triangle Park, NC. (This Handbook is commonly referred to and will be called the "Red Book ") The use of the "long form" questionnaire is left to the discretion of the Regional QA Officer. The scope of the systems audit includes an appraisal of network management, field operations, laboratory operations, data management, quality assurance, and reporting. The systems audit results should present a clear, complete, and accurate picture of the agency's collection and reporting of ambient air monitoring data.

Frequency of Systems Audits

The EPA Regional Office retains regulatory responsibility to evaluate agency performance annually. For well-established agencies, an extensive systems audit and rigorous inspections may not be necessary every year. Agencies are presently scheduled on a three-year rotation, unless problems occur. The determination of the extent of the systems audit is left to the Regional Office's discretion.

Selection of Monitoring Sites for Inspection

It is suggested that approximately five percent of a state agency's sites be inspected during a systems audit. For smaller agencies, at least two sites should be inspected. One half of the sites to be inspected should be selected by the agency being audited, while the other half should be selected by the RO audit team.

Data Audits

A complete systems audit must include a review of the data processing and reporting procedures starting at the acquisition stage and terminating at the point of data entry into the AIRS computer system. The guidance for conducting a data audit is given in Section 11.3.3 of the Red Book.

Guidelines for Conducting Systems Audits of State and Local Agencies

A systems audit should consist of three separate phases:

- pre-audit activities;
- on-site activities, and
- post-audit activities.

Each of these activities is discussed in detail in Sections 2.0.11.4.1; 2.0.11.4.2; and 2.0.11.3 of the Red Book. Because of the length of these sections of the Red Book, they are incorporated by reference.

Audit Reporting

The systems audit report format discussed in section 2.0.11.4.4 in the Red Book has been prepared to be consistent with guidance offered by the State and Territorial Air Pollution Program Administrators (STAPPA)/Association of Local Air Pollution Control Officials (ALAPCO) Ad Hoc Air Monitoring Audit Committee. The Office of Air Quality Planning and Standards considers the format acceptable for annual systems audit reports. At a minimum, the systems audit report shall include:

- Executive Summary
- Introduction
- Audit Results
- Network Design
- Resources and Facilities
- Data and Data Management
- Quality Assurance/Quality Control
- Discussion
- Conclusions and Recommendations
- Appendix of Supporting Documentation

The Discussion section of the report should include a narrative of the process used to interpret audit results, identify the derivation of results affecting data quality, and outline the basis for corrective action recommendations.

The report's Conclusion and Recommendations should center around the overall performance of the agency's monitoring program. This section should include the major problems, corrective action agreements, the homogeneity of the reporting organization, and the appropriateness of pooling the precision and accuracy (PA) data.

The report's Appendix of Supporting Documentation contains copies of the completed short-form questionnaire, Corrective Action Implementation Request (CAIR) form, and documentation contributing significantly to the audit results.

2.10.6 National Performance Audit Program

Introduction

Appendix A, Part 2.4 of 40 CFR Part 58 requires agencies operating SLAMS networks to participate in EPA's National Performance Audit Program (NPAP). In addition, agencies receiving Section 105 grants in Region 4 are required to participate in NPAP. The purposes of NPAP are to provide agencies with a means of self-appraisal for the specific operation audit and to provide EPA with an index of the data quality reported to the AIRS data bank.

Air Monitoring Team

The Air Monitoring Team's role is to coordinate the NPAP between state and local agencies and EPA's Office of Air Quality Planning and Standards (OAQPS).

Audit Survey

The audit survey is conducted annually on high volume samplers (TSP and PM₁₀) and semi-

annually on continuous sampler (SO₂, O₃, NO₂, and CO) and lead (Pb).

2.11 References

- 1 US-EPA, NPDES Compliance Inspection Manual, September 1994.
- 2 US-EPA, NPDES Compliance Evaluation Inspection Manual, MCD-75, United States Environmental Protection Agency, Washington, D.C.m 1981.
- 3 US-EPA, NPDES Compliance Sampling Inspection Manual, MCD-51, United States Environmental Protection Agency, Washington, D.C., 1979.
- 4 Compliance Biomonitoring Inspections Manual, MCD-62, United States Environmental Protection Agency, Washington, D.C., 1981.
- 5 Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA -- Interim Final; EPA/540/G-89/004
6. RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (OSWER 9950 1) September 1986.
- 7 Draft RCRA Preliminary Assessment/Site Investigation Guidance -- US-EPA, Permits and State Programs Division, Office of Solid Waste, August 1985.

**EXHIBIT 2.1
REGION 4
HAZARDOUS WASTE FIELD OVERVIEW CHECKLIST**

Facility/Site Name															
Address															
Project No			EPA ID No.												
Facility Contact			Phone No.												
Overview Personnel			Date												
State/Contractor Project Leader															
Affiliation			Phone No.												
Address															
Sampling Personnel															
Other Personnel & Affiliation															
Type of study?															
Study plan issued?			Date issued?												
Study plan reviewed by the Division?			Acceptable?												
<u>Comments</u>															
Was study plan followed?															
<u>Comments</u>															
Was a safety plan prepared for the study?															
<u>Comments</u>															
Was the safety plan adequate?															
<u>Comments</u>															
Was the safety plan followed?															
<u>Comments</u>															
Additional comments or information															
Checklist sections completed for this overview	1	2	3.	4.	5.	6.									
<table style="width: 100%; border: none;"> <tr> <td style="width: 10%; vertical-align: top;">Key</td> <td style="width: 45%;">1. General Procedures</td> <td style="width: 45%;">4. Surface Water Sampling</td> </tr> <tr> <td></td> <td>2. Ground Water Sampling</td> <td>5. Waste Sampling</td> </tr> <tr> <td></td> <td>3. Soil, Sediment, Sludge Sampling</td> <td>6. Monitoring Well Installation</td> </tr> </table>							Key	1. General Procedures	4. Surface Water Sampling		2. Ground Water Sampling	5. Waste Sampling		3. Soil, Sediment, Sludge Sampling	6. Monitoring Well Installation
Key	1. General Procedures	4. Surface Water Sampling													
	2. Ground Water Sampling	5. Waste Sampling													
	3. Soil, Sediment, Sludge Sampling	6. Monitoring Well Installation													

SECTION 1 - GENERAL PROCEDURES - SAFETY, RECORDS, QA/QC, CUSTODY, ETC

1	Type samples collected? <u>Comments:</u>
2	Were sampling locations properly selected? <u>Comments:</u>
3	Were sampling locations adequately documented in a bound field log book using indelible ink? <u>Comments:</u>
4	Were photos taken and a photolog maintained? <u>Comments:</u>
5	What field instruments were used during this study? <u>Comments:</u>
6	Were field instruments properly calibrated and calibrations recorded in a bound field log book? <u>Comments:</u>
7	Was sampling equipment properly wrapped and protected from possible contamination prior to sample collection? <u>Comments:</u>
8	Was sampling equipment constructed of Teflon®, glass, or stainless steel? <u>Comments:</u>
9	Were samples collected in proper order? (least suspected contamination to most contaminated?) <u>Comments:</u>
10	Were clean disposable latex or vinyl gloves worn during sampling? <u>Comments:</u>
11.	Were gloves changed for each sample station? <u>Comments:</u>
12	Was any equipment field cleaned? <u>Comments:</u>
13	Type of equipment cleaned <u>Comments:</u>
14	Were proper field cleaning procedures used? <u>Comments:</u>
15	Were equipment rinse blanks collected after field cleaning? <u>Comments:</u>
16	Were proper sample containers used for samples? <u>Comments:</u>

17	Were split samples offered to the facility owner or his representative? <u>Comments:</u>
18	Was a Receipt for Samples form given to facility representative? <u>Comments:</u>
19	Were any duplicate samples collected? <u>Comments:</u>
20	Were samples properly field preserved? <u>Comments:</u>
21.	Were preservative blanks utilized? <u>Comments:</u>
22	Were field and/or trip blanks utilized? <u>Comments:</u>
23	Were samples adequately identified with labels or tags? <u>Comments:</u>
24	Were samples sealed with custody seals after collection? <u>Comments:</u>
25.	What security measures were taken to insure custody of the samples after collection? <u>Comments:</u>
26	Were chain-of-custody and receipt for samples forms properly completed? <u>Comments:</u>
27	Were any samples shipped to a laboratory? <u>Comments:</u>
28	If yes to No 27, were samples properly packed? <u>Comments</u>
29	If shipped to a CLP lab, were Traffic Report Forms properly completed? <u>Comments</u>
30.	What safety monitoring equipment, protection, and procedures were used prior to and during sampling? <u>Comments</u>
31	Was safety monitoring equipment properly calibrated and calibrations recorded in a bound field log book? <u>Comments</u>

SECTION 2 - SAMPLING - GROUND WATER

1	Type of wells sampled? (monitoring, potable, industrial, etc.) <u>Comments:</u>
2	Were wells locked and protected? <u>Comments:</u>
3	Were identification marks and measurement points affixed to the wells? <u>Comments:</u>
4	What were the sizes and construction materials of the well casings? <u>Comments:</u>
5	Were the boreholes sealed with a concrete pad to prevent surface infiltration? <u>Comments:</u>
6	Was there a dedicated pump in the well? <u>Comments:</u>
7	Was clean plastic sheeting placed around the wells to prevent contamination of sampling equipment and containers? <u>Comments:</u>
8	Were total depths and depths to water determined before purging? <u>Comments:</u>
9	What device was used to determine depths? <u>Comments:</u>
10	Were measurements made to the nearest 0.01 ft? <u>Comments:</u>
11	Was the measuring device properly cleaned between wells? <u>Comments:</u>
12	Was the standing water volume in each well determined? <u>Comments:</u>
13	How was the volume determined? <u>Comments:</u>
14	Was a sufficient volume purged prior to sampling? <u>Comments:</u>
15	How many volumes? <u>Comments:</u>
16	How was the purged volume measured? <u>Comments:</u>
17	What was the method of purging? <u>Comments:</u>

18	Were pH, conductivity, temperature, and turbidity measurements taken and recorded at least once during each well volume purged? <u>Comments</u>			
19	Were pH, conductivity, temperature, and turbidity readings stable prior to sampling? <u>Comments</u>			
20	How many wells were sampled? <u>Comments</u>	Upgradient?	Downgradient?	
21.	How were the samples collected? <u>Comments</u> :	Bailer	Pump	Other
22	If a pump was used, what type? <u>Comments</u>			
23	If a pump was used, was it properly cleaned before and/or between wells? <u>Comments</u>			
24	What were the cleaning procedures? <u>Comments</u> :			
25	Did bailers have Teflon® coated wire leaders to prevent rope from coming into contact with water? <u>Comments</u>			
26	Were bailers open or closed top? <u>Comments</u>			
27	Was a clean bailer and new rope used at each well? <u>Comments</u>			
28	Were samples properly transferred from the sampling device to the sample containers? (i.e., volatile sample first - not aerated, etc.) <u>Comments</u>			
29	Was pH of preserved samples checked to insure proper preservation? <u>Comments</u>			
30	Were samples iced immediately after collection? <u>Comments</u>			
31.	For what analyses were the samples collected? <u>Comments</u>			
32	If samples were split, what were the sample/station numbers for these? <u>Comments</u>			
33	Are the ground water samples being filtered? <u>Comments</u> :			
34	If the ground water are being filtered, what procedure is being used? <u>Comments</u>			

35	Is low flow/low volume sampling being conducted (e.g., is the intake of the pump at the middle of the screen)? <u>Comments.</u>
36	If low flow/low volume sampling is being conducted, is the water level being measured constantly to insure minimal drawdown of the less than 3 to 4 inches? <u>Comments.</u>
33	Other comments or observations

SECTION 3 - SAMPLING - SOIL, SEDIMENT, SLUDGE, ETC. (Non-containerized)

1	Type of samples collected? <u>Comments:</u>
2	General description of samples? <u>Comments:</u>
3	How many samples were collected? <u>Comments:</u>
4	Were background and/or control samples collected? <u>Comments:</u>
5	Were representative samples collected? <u>Comments:</u>
6	Were grab or composite samples collected? <u>Comments:</u>
7	Were composite samples areal or vertical? <u>Comments:</u>
8	How many aliquots were taken for the composite sample? <u>Comments:</u>
9.	What procedures and equipment were used to collect samples? <u>Comments:</u>
10	Were samples thoroughly mixed prior to putting them into the sample containers? <u>Comments:</u>
11	Were samples properly placed into sample containers? <u>Comments:</u>
12	Were samples iced immediately after collection? <u>Comments:</u>
13	For what analyses were the samples collected? <u>Comments:</u>
14	If samples were split, what were the sample/station numbers for these? <u>Comments:</u>
15	Was a drilling rig, back hoe, etc. used to collect soil samples? <u>Comments:</u>
16	Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the SOP, Appendix B, prior to arriving on site? <u>Comments:</u>
17	What was the condition of the drilling and sampling equipment when it arrived on site? <u>Comments:</u>

18	Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment? <u>Comments:</u>
19	Was clean equipment properly wrapped and stored in a clean area? <u>Comments:</u>
20	Was the drilling rig(s) properly cleaned between well borings? <u>Comments:</u>
21	Were the cleaning and decontamination procedures conducted in accordance with the SOP? <u>Comments:</u>
22	Other comments or observations

SECTION 4 - SAMPLING - SURFACE WATER (Pond, Stream, River, Leachate, Etc)

1	Type of samples collected? <u>Comments:</u>
2	General description of samples? <u>Comments</u>
3	How many samples were collected? <u>Comments:</u>
4	Were background and/or control samples collected? <u>Comments:</u>
5	Were grab or composite samples collected? <u>Comments.</u>
6	How many aliquots were taken for the composite sample? <u>Comments:</u>
7	What procedures and equipment were used to collect the samples? <u>Comments</u>
8	Were samples collected directly into sample containers? <u>Comments.</u>
9	Did the sampler wade in the stream to collect the samples? <u>Comments.</u>
10	Were the samples collected upstream from the sampler? <u>Comments</u>
11	Did the sampler insure that roiled sediments were not collected along with the water samples? <u>Comments:</u>
12	Were representative samples collected? <u>Comments</u>
13	Was the pH of preserved samples checked to insure proper preservation? <u>Comments.</u>
14	Were samples iced immediately after collection? <u>Comments:</u>
15	For what analyses were the samples collected? <u>Comments</u>
16	If samples were split, what were the sample/station numbers for these? <u>Comments:</u>
17	Other comments or observations:

SECTION 5 - WASTE SAMPLING - DRUMS, TANKS, BARRELS, ETC (Containerized)

1	What was the objective of the sampling investigation? <u>Comments</u>
2	Description of units or sources sampled (closed/open, etc.)? <u>Comments</u>
3	General description of samples (Oil, sludge, waste) <u>Comments:</u>
4	How many samples were collected? <u>Comments:</u>
5	Were grab or composite samples collected? <u>Comments</u>
6.	How many aliquots were taken for the composite sample? <u>Comments:</u>
7	What type of equipment was used to collect the samples? <u>Comments:</u>
8.	What procedures were used to collect the samples? <u>Comments</u>
9	Were solid/semi-solid waste samples thoroughly mixed prior to putting them into the sample containers? <u>Comments:</u>
10	Were samples properly placed into sample containers? <u>Comments</u>
11	For what analyses were the samples collected? <u>Comments:</u>
12	Was equipment field cleaned? <u>Comments</u>
13	Was clean equipment properly wrapped and stored in a clean area? <u>Comments</u>
14	Were the cleaning and decontamination procedures conducted in accordance with the Appendix B of the EISOPQAM? <u>Comments:</u>
15	Were the study's objectives accomplished? <u>Comments</u>
16	If samples were split, what were the sample/ station numbers for these? <u>Comments:</u>
17.	Were any special safety measures taken during collection of the samples? <u>Comments:</u>

18	What level of safety protection was required for collection of the samples? <u>Comments</u>
19	Other comments or observations

SECTION 6 - MONITORING WELL INSTALLATION

GENERAL	
1	Were the wells installed in the proper locations in accordance with the study plan and/or project operations plan (POP)? <u>Comments</u>
2	Were the wells installed starting in the least contaminated area and proceeding to the most contaminated area? <u>Comments:</u>
3	Were proper safety protocols employed during the well installations? <u>Comments:</u>
4	Were samples of the drilling mud, water, bentonite pellets, filter pack materials, etc., collected for quality control analyses? <u>Comments:</u>
EQUIPMENT DECONTAMINATION	
5.	Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the SOP, Appendix B, prior to arriving on site? <u>Comments</u>
6	What was the condition of the drilling and sampling equipment when it arrived on site? <u>Comments</u>
7.	Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment? <u>Comments:</u>
8	Was clean equipment properly wrapped and stored in a clean area? <u>Comments:</u>
9	Was the drilling rig(s) properly cleaned between well borings? <u>Comments:</u>
10	Were the cleaning and decontamination procedures conducted in accordance with the SOP? <u>Comments:</u>
11	What type of drilling method(s) was used to install the wells? <u>Comments</u>
12	Was this drilling method(s) the same as proposed in the study plan and/or POP? <u>Comments</u>
13.	Were soil samples collected for logging and analyses as the wells were installed? <u>Comments:</u>
14	If yes to 13, at what intervals and by what method? <u>Comments:</u>

15.	If air rotary was used, was an in-line organic air filter employed? Was a cyclone velocity dissipator used? <u>Comments:</u>
16	What diameter borehole(s) were installed? <u>Comments:</u>
17	Were surface outer casings used? <u>Comments:</u>
18	If yes to 17, what size and to what depth? <u>Comments:</u>
19	Were the wells double cased? <u>Comments:</u>
20	If yes to 19, explain procedure <u>Comments:</u>
PERMANENT WELL INSTALLATION	
21	What type of well casing(s) and screen(s) were used? <u>Comments:</u>
22.	What diameter were the well casing(s) Screen(s)? <u>Comments:</u>
23	Was there a minimum two inch annulus around the casing between casing and borehole was or inside augers)? <u>Comments</u>
24	What was the length of the well screen(s)? <u>Comments</u>
25	What was the slot size of the well screen(s)? <u>Comments:</u>
26	Was the well screen(s) commercially manufactured? If so, by whom? <u>Comments</u>
27	Was the bottom of the well screen(s) plugged or capped? <u>Comments</u>
28	Were sand and/or gravel (filter) packs installed? <u>Comments:</u>
29	Specify type of materials in 28 [(play sand, Ottawa sand, etc.) and grain size (20/30, 20/40, etc)], if known. <u>Comments:</u>
30	Was a sieve analysis conducted to determine well screen slot size and filter pack grain size? <u>Comments</u>
31	Were the wells installed to the proper depths? <u>Comments:</u>

32	Were well screens placed at the proper intervals? <u>Comments</u>
33	Were the filter packs placed a minimum of two feet above the well screens? <u>Comments</u>
34	Was the tremie tube method used to place the filter packs? <u>Comments</u>
35	Were seals placed above the filter packs? <u>Comments</u> :
36	If yes to 35, what material was used for the seals? <u>Comments</u> :
37	Was the vertical thickness of the seals a minimum of two feet? <u>Comments</u>
38	If bentonite pellets were used for the seals above the filter packs, were they allowed to hydrate a minimum of 8 hours? <u>Comments</u> :
39.	Did contractor/driller have documentation from manufacturer stating recommended hydration time? <u>Comments</u>
40	Was the tremie tube method used to place the bentonite pellets? <u>Comments</u>
41	Was the annulus grouted from the seal to within two feet of the ground surface, or below the frost line? <u>Comments</u>
42	Was the tremie tube method used to place the grout in the annulus? <u>Comments</u>
43	If no to 42, what method was used? <u>Comments</u>
44.	What type of grout was used to seal the annulus (neat cement, cement/bentonite, cement/sand, etc.)? <u>Comments</u>
45	What grout mix ratio was used? (should be stated in the POP) <u>Comments</u> .
46	What was the density of the grout? (lb/gal, etc.) <u>Comments</u>
47	If bentonite grout was used, was the density at least 9 4 lb/gal? <u>Comments</u>
48	Was the density determined using a mud balance? <u>Comments</u>

49	Was the grout allowed to set a minimum of 24 hours before the surface pad was installed? <u>Comments:</u>
50	Was a concrete surface pad installed with an outer protective casing and locking cap? <u>Comments:</u>
51	How far below the ground surface did the concrete pad extend? <u>Comments:</u>
52	What were the dimensions of the concrete pads? <u>Comments:</u>
53	Did the well casings extend to a minimum of 2.5 feet above the ground surface? <u>Comments:</u>
54	How far above the ground surface did the outer protective casings extend? <u>Comments:</u>
55	Did the outer protective casings have weep holes? <u>Comments:</u>
56	Were the wells properly developed? <u>Comments:</u>
57	Describe method of development. <u>Comments:</u>
58	Give a general evaluation of the activities observed during the installation of the wells <u>Comments:</u>
TEMPORARY WELL INSTALLATION	
59	Describe methods and procedures <u>Comments:</u>

EXHIBIT 2.2
REGION 4
STATE/CONTRACTOR OVERVIEW CHECKLIST

***** NOTE ***** This checklist is for overseeing State personnel overseeing a facility or contractor or for overseeing a contractor overseeing contractors.

PART 1

State/Contractor Name	
Address	
Facility/Site Name	
Address	
Facility Contact	Phone No.
Facility Activities/Operations	
Project No.	EPA ID No.
Audit Personnel	Date
State/Contractor Project Leader	
Title	Phone No.
Sampling Personnel	
Other Personnel & Affiliation	
Type of study?	
Study/Work plan issued?	Date issued?
Study/Work plan reviewed by the Division?	Acceptable?
Was the Study/Work plan reviewed by the State/Contractor? <u>Comments</u>	
Was the study plan followed? <u>Comments.</u>	
Was a safety plan prepared for the study?	
Did the State/Contractor review the safety plan?	
Was the safety plan adequate? <u>Comments</u>	
Was the safety plan followed? <u>Comments</u>	
Did the State/Contractor have their own safety plan?	
Did the State/Contractor have a copy of the SOP or have a copy of their own SOP? <u>Comments</u>	
Was the State/Contractor familiar with the SOP?	
Additional Comments or Information	

PART 2

1	Was a field overview checklist completed? <u>Comments:</u>
2	Was the State/Contractor familiar with the facility and its operations? <u>Comments</u>
3	Was the State/Contractor trained in equipment handling and proper sampling techniques? <u>Comments:</u>
4	Did the State/Contractor observe calibration of safety monitoring and/or field measurement equipment? <u>Comments:</u>
5	Did the State/Contractor observe all phases of the field investigation such as sampling, field measurements, record keeping, packing and shipping samples, etc.? <u>Comments:</u>
6	Did the State/Contractor advise sampling personnel regarding improper procedures or practices whenever they were observed? <u>Comments</u>
7.	Did the State/Contractor assist with the sampling, equipment decontamination or any other phase of the investigation? <u>Comments:</u>
8	Were there improper procedures or practices used which the State/Contractor failed to recognize? <u>Comments</u>
9	Was sampling conducted in accordance with the SOP or other EPA standard operating procedures? <u>Comments</u>
10	Was equipment decontamination conducted in accordance with standard operating procedures specified by EPA? <u>Comments:</u>
11	List any problem areas observed relative to questions #8, #9 or #10: <u>Comments</u>
12	What are the qualifications of the investigative/sampling personnel (training and experience) by name? <u>Comments</u>
13	Had those personnel received training in sampling techniques and equipment handling? <u>Comments</u>
14	When was the latest training received and by whom was it provided? <u>Comments:</u>
15.	What equipment was available and/or used during the investigation? <u>Comments</u>

16	Did equipment appear to have been properly cleaned and protected from possible contamination prior to bringing it to the field? <u>Comments:</u>
17	What type of samples were collected? <u>Comments:</u>
18	For what analyses were the samples collected? <u>Comments:</u>
19	Was sampling conducted in accordance with standard operating procedures specified by the State or EPA? <u>Comments:</u>
20	Did investigative/sampling personnel conduct a comprehensive investigation/evaluation or only collect samples? <u>Comments:</u>
21	If investigative/sampling personnel only collected samples, how were their sampling efforts coordinated with the rest of the investigation? <u>Comments:</u>
22	If facility personnel collected samples, did the State/Contractor accept split samples? <u>Comments:</u>
23	Were adequate field records kept in a bound log book? <u>Comments:</u>
24	Were photographs taken and a photo log maintained? <u>Comments:</u>
25	Were QA/QC procedures adequate for the type of study being conducted and type/number of samples being collected? <u>Comments:</u>
26	Had investigative/sampling personnel received appropriate safety training? <u>Comments:</u>
27	Do investigative/sampling personnel undergo periodic refresher safety training? <u>Comments:</u>
28	Did investigative/sampling personnel have appropriate safety equipment for the investigation? <u>Comments:</u>
29	Are investigative/sampling personnel classified as to the type of investigations they can conduct? <u>Comments:</u>
30	Have investigative/sampling personnel had comprehensive physicals? <u>Comments:</u>
31	Do investigative/sampling personnel participate in a medical monitoring program? <u>Comments:</u>

32	Give a general evaluation of the activities observed during the overview and note any other comments or observations <u>Comments</u>
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**EXHIBIT 2.3
STATE PROGRAM EVALUATION
HAZARDOUS WASTE FIELD ACTIVITIES**

State	
Agency	
Specific Activity	RCRA or CERCLA
Location	
Telephone	
Activity Managers	
Evaluator	
Date	

PART 1 -- FIELD ACTIVITY STAFFING				
<u>Description of Field Activity</u>				
<u>Field Activity Personnel Staffing</u>				
NAME(s)	TITLE	TRAINING	EXPERIENCE	
<u>Field Safety Program and Training</u>	Personnel categorized as to activity?			
	Does a formal safety training program exist?			
	Does a formal safety training tracking system exist?			
	Does a formal medical monitoring program exist?			
	Safety Training Received?	In-House	Outside	EPA
	Safety Program Needs			
<u>Field Activity Adequately Staffed to meet Existing RCRA or CERCLA Inspection and Investigation Needs</u> <div style="display: flex; justify-content: space-between; width: 100%;"> Adequate Inadequate </div>				
<u>Projected Staffing Needs</u>				

PART 2 -- FIELD OPERATING PROCEDURES		
1	Does a standard operating procedures manual exist or is one being prepared? <u>Comments</u>	
2	Are inspection schedules and study plans prepared? <u>Comments</u>	
3.	Are these inspections and studies coordinated with the lab? <u>Comments</u> :	
4	Addressed in the SOP? <u>Comments</u> .	
5	Are formal inspection and investigation reports prepared? <u>Comments</u>	
6.	Are the field activities adequately addressed in the SOP Manual? <u>Comments</u>	
7	Does the SOP address (Sample Collection)	YES NO
	- Ground Water	
	- Surface Water	
	- Surface Soil	
	- Subsurface Soil	
	- Waste - Pits, Ponds, Lagoons	
	- Waste - Closed Container	
	- Tissue (Fish, etc)	
	- Air	
	- QC	
	<u>Comments</u>	
8	Does the SOP address (Sample Handling Techniques)	YES NO
	- Standard Sampling Containers	
	- Field Equipment & Sample Container Cleaning Procedures	
	- Sample Identification	
	- Sample Preservation & Holding Times	
	- Sample Chain-of-Custody	
	- Sample Packaging Techniques	
	- Identification of Hazardous Samples to Lab	
	- QC	

<u>Comments.</u>			
9	Does the SOP address: (Field Documentation and Records)	YES	NO
	Field Documentation or Bound Record Books <u>Comments:</u>		
	Photographs <u>Comments:</u>		
	Site Mapping (Sketching of sites) <u>Comments</u>		

PART 3 -- FIELD CONTRACTORS	
1.	Are field contract personnel used to conduct field investigations? <u>Comments:</u>
2	What activities do field contractors perform? <u>Comments</u>
3	If yes, does a quality control program exist to monitor contractor activities? <u>Comments:</u>

PART 4 - FACILITIES	
1	Is adequate space provided for the storage of field equipment? <u>Comments</u>
2	Are facilities and/or space provided for the cleaning, repair, and preparation of field equipment? <u>Comments.</u>
3	Specific Facility Needs.

PART 5 - FIELD EQUIPMENT AVAILABLE	
1	Sampling and Investigative Equipment Available:
	- Field Vehicles
	- Field Analytical Instrumentation
	- Surveying Equipment
	- Photographic Gear
	- Pumps and Automatic Samplers
	- Ground Water Sampling Equipment
	- Surface Water Equipment
	- Sediment Sampling Equipment
	- Soil Coring Equipment
	- Waste Sampling Equipment
	- Geophysical Equipment
	- Temporary Well Installation Equipment
2	Specific Sampling and Investigation Equipment Needs: <u>Comments</u>
3	Safety Equipment Available
	- Monitoring Equipment
	- Protective Clothing
	- Respiratory Protection
4	Are Safety Procedures available in written form or in a manual? <u>Comments</u>
5	Specific Safety Equipment Needs <u>Comments</u>
6	Does a specific field or safety equipment needs list exist? <u>Comments</u>
7	Is there an allowance for an equipment budget? <u>Comments</u>

SECTION 3

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

All sample identification, chain-of-custody records, receipt for sample forms, and field records 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:

<u>Project Leader</u>	The individual with overall responsibility for conducting a specific field investigation in accordance with this SOP
<u>Field Sample Custodian</u>	Individual responsible for maintaining custody of the samples and completing the sample tags, Chain-of-Custody Record, and Receipt for Sample form
<u>Sample Team Leader</u>	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.
<u>Sampler</u>	The individual responsible for the actual collection of a sample
<u>Transferee</u>	Any individual who receives custody of samples subsequent to release by the field sample custodian.
<u>Laboratory Sample Custodian</u>	Individual or their designee(s) 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 while in the field.

3.2 Sample and Evidence Identification

PERFORMANCE OBJECTIVES:

- To accurately identify samples and evidence collected.
- To adequately insure that chain-of-custody was maintained.

3.2 1 Sample Identification

The method of sample identification used depends on the type of sample collected. Samples collected for specific field analyses or measurement data are recorded directly in bound field logbooks or recorded directly on the Chain-of-Custody Record, with identifying information, while in the custody of the samplers. Examples include pH, temperature, and conductivity. Samples collected for laboratory analyses are identified by using standard sample tags (Figure 3-1) which are attached to the sample containers. In some cases, particularly with biological samples, the sample tags may have to be included with or wrapped around the samples. The 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,
- type of sample (water, wastewater, leachate, soil, sediment, etc.) and 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
- any 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 3-1, 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). The split sample should be clearly marked or identified with a stick-on label.

Tags for blank or duplicate samples will be marked "blank" or "duplicate," respectively. This requirement does not apply to blind-spiked or blank samples which are to be submitted for laboratory quality control purposes. Blind-spiked or blank samples shall not be identified as such. This identifying information shall also be recorded in the bound field logbooks and on the Chain-Of-Custody Record as outlined in Sections 3.3 and 3.5.

3.2.2 Photograph Identification

Photographs used in investigative reports or placed in the official files shall be identified on the back of the print with the following information:

- A brief, but accurate description of what the photograph shows, including the name of the facility or site and the location.
- The date and time that the photograph was taken.
- The name of the photographer.

When photographs are taken, a record of each frame exposed shall be kept in the bound field logbook along with the information required for each photograph. The film shall be developed with the negatives supplied uncut. The field investigator shall then enter the required information on the prints, using the photographic record from the bound field logbook, to identify each photograph. For criminal investigations, the negatives must be maintained with the bound field logbook in the project file and stored in a secured file cabinet.

3.2.3 Identification of Physical Evidence

Physical evidence, other than samples, shall be identified by utilizing 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), mark the vessel or container 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 logbooks. 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.
- Take an instantaneous measurement of the media being measured by the recorder. The instantaneous measurement shall be 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 any other information required to interpret

the data such as type of flow device, chart units, factors, etc

All of the above information should be initialed by the field investigator. 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 sample custody and 2) documentation of samples for evidence. To document chain-of-custody, an accurate record must be maintained to trace the possession of each sample 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 3-1) 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 utilizing the EPA custody seal (EPA Form 7500-2(R7-75)) shown in Figure 3-2. A similar seal is used for samples collected during criminal investigations, however, the seal is red. Though not required, red custody seal is preferred for sealing samples collected during criminal investigations. The sample custodian should write the date and their signature or initials on the seal. 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

Chain-of-Custody Record

The field Chain-Of-Custody Record (Figure 3-3) 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 Chain-of-Custody Record will be completed for all samples or physical evidence collected. A separate Chain-of-Custody Record should be used for each final destination or laboratory utilized during the investigation.

The following information must be supplied in the indicated spaces (Figure 3-3) to complete the field Chain-Of-Custody Record.

- The project number.
- The project name
- All samplers and sampling team leaders (if applicable) must sign in the designated signature block
- The sampling station number, date, and time of sample collection, grab or composite sample designation, and a brief description of the type of sample and/or the sampling location must be included on each line. One sample should be entered on each line and a sample should 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 No /Remarks" column.
- 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" section in the top right corner of the Chain-of-Custody Record. The Remarks section may also be used to record airbill numbers, registered or certified mail serial numbers, or other pertinent information

- The total number of sample containers must be listed in the "Total Containers" column for each sample. The number of individual containers for each analysis must also be listed. There should not be more than one sample type per sample. 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 are to be supplied in the "Tag No /Remarks" 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 occurred 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 signature or initials, as well as 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 signature or initials, as well as 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, a Government Bill of Lading (GBL) or Air Bill should be used. Receipts from post offices, copies of GBL's, and Air Bills shall be retained as part of the documentation of the chain-of-custody. The Air Bill number, GBL number, or registered mail serial number shall be recorded in the remarks section of the Chain-Of-Custody Record or in another designated area if using a form other than that shown in Figure 3-2.

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

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.

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. The following information must be supplied and entered on the Receipt for Samples form:

- The project number, project name, name of facility or site, and location of the facility or site must be entered at the top of the form in the indicated locations.
- 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.'s/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 copy of the 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

The term document control refers to the maintenance of inspection and investigation project files. All project files shall be maintained in accordance with Divisional guidelines. All documents as outlined 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.

Under no circumstances are any inappropriate personal observations or irrelevant information to

be filed in the official project files. The project leader shall review the file at the conclusion of the project to insure that it is complete.

3.7 Disposal of Samples or Other Physical 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, laboratory personnel shall contact the project leader or his/her supervisor in writing, requesting permission to dispose of the samples. The samples will not be disposed of until the project leader or his/her supervisor completes the appropriate portions of the memorandum, signs, and returns the memorandum to the laboratory, specifically giving them permission to dispose of the samples. 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 without written permission from EPA's Criminal Investigations Division
- Internal quality assurance samples are routinely disposed after the analytical results are reported. The laboratory does not advise the Quality Assurance Officer of the disposal of these samples
- Samples associated with routine inspections may be disposed following approval from the project leader

After samples are disposed, the laboratory shall send the sample tags to the Field Equipment Center (FEC) coordinator. These sample tags are accountable and must be placed and maintained in official files at the FEC.

3.8 Field Operations Records Management System (FORMS)

FORMS is a computer program designed to streamline the documentation required by ESD 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, sample containers (CLP), and field logbooks, and will generate the sample receipt and chain-of-custody reports 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 from the log book to the tags, bottle labels, and chain-of-custody forms. Operating instructions are available for use with the FORMS program.

FIGURE 3-1
SAMPLE TAG

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 4

960 COLLEGE STATION RD.

ATHENS, GA 30605-2720



Project No	Station ID	Month/Day/Year	Time	Designate		Preservative No <input type="checkbox"/> Yes <input type="checkbox"/> _____
				Comp	Grab	
Station Location				ANALYSES		
Remarks:				COD, TOC, Nutrients		
				BOD, Solids		
				Metals		
				Extractable Organics		
				Pesticides/PCB's		
				Volatile Organics		
				Cyanide		
Tag No 4A-		Lab Sample No				

FIGURE 3-2
EPA CUSTODY SEAL

 <p>UNITED STATES ENVIRONMENTAL PROTECTION AGENCY OFFICIAL SAMPLE SEAL</p>	SAMPLE No		DATE	SEAL BROKEN BY	DATE	
	SIGNATURE					
	PRINT NAME AND TITLE (INSPECTOR ANALYST or TECHNICIAN)					

EPA FORM 1500 (1/77 75)



CHAIN OF CUSTODY RECORD

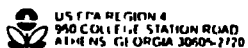
[illegible]

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

*U S GPO 1989-732 0 186

4-17906^(10/89)

FIGURE 3-3
CHAIN-OF-CUSTODY FORM



RECEIPT FOR SAMPLES

[illegible]

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 3-4
RECEIPT FOR SAMPLES FORM

SECTION 4 BRANCH SAFETY PROTOCOLS

SECTION OBJECTIVE:

- Present safety protocols to ensure that all operations are conducted in a manner which protects worker safety and meets compliance with all OSHA regulations and EPA safety policies

4.1 Introduction

The following parts of this section define safety protocols that are to be used by Branch investigators while conducting field operations. This section also covers the necessary training, equipment, and experience that is needed to conduct safe environmental investigations at hazardous waste sites.

The Division safety program is jointly coordinated by the Occupational Health and Safety Designee (OHSD), a Division Safety, Health and Environmental Manager (SHEM) coordinator; and a Branch safety officer. The OHSD appoints the SHEM to perform the following duties: 1) classify employees into safety categories based upon the type of work they are engaged in; 2) make requests for hazardous duty status; 3) provides and tracks safety related training; 4) notifies management of safety deficiencies; and 5) reviews project specific safety plans. The employees immediate supervisor is responsible for ensuring that their employees meet training and medical monitoring requirements. Specific projects will include a Site Safety Officer (SSO) whose responsibility is to ensure that the site safety plan is adhered to during the course of work. Other SSO responsibilities and duties are listed in Section 4.3.1. Responsibility for the safe conduct of site operations is ultimately the responsibility of each individual worker.

Field investigators will not be required to participate in any operation which violates OSHA and EPA regulations/guidance. The safety protocols in this section are written in accordance with those defined by the following regulations, guidance documents, and manuals;

29 CFR Part 1910.120, Hazardous Waste Operations and Emergency Response. These OSHA regulations govern workers at hazardous waste sites and include requirements for training, equipment, and practices involved in handling of hazardous materials

29 CFR Part 1910.1200, Hazard Communication. These OSHA regulations govern workers handling hazardous materials and include requirements for training, labeling, and documentation involved in handling hazardous materials.

Occupational Safety and Health Guidance Manual for Hazard Waste Activities: This NIOSH, OSHA, USCG, and EPA guidance manual is for those who are responsible for occupational safety and health programs at hazardous waste sites. It assumes a basic knowledge of science and experience in occupational safety and health. It is the product of four Agencies (NIOSH, OSHA, USCG, and EPA) mandated by CERCLA section 301 (f) to study the problem of protecting the safety and health of workers at hazardous waste sites.

Safety and Health Manual United States Environmental Protection Agency (USEPA), Region IV, Environmental Research Laboratory (ERL), Athens, Georgia, 1990: This manual covers safety practices and rules governing activities at EPA facilities in Athens, Georgia. Included in its contents are accident reporting procedures, procedures for natural and manmade emergencies, safety guidelines for offices and laboratories, and special rules for storage of equipment and wastes.

Field Health and Safety Manual USEPA, Region IV, 1990: This manual covers safety involved in all field activities performed in Region 4. It includes regional policy regarding training requirements, medical monitoring, and personal protection

The remaining parts of this section cover hazard communication, safety protocols, training, and equipment that are to be used when conducting hazardous waste investigations.

4.2 Hazard Communication Procedure

4.2 1 Introduction

The purpose of this hazard communication procedure is to ensure that the hazards of all chemicals used by the Branch are evaluated, and that information concerning their hazards are transmitted to Branch personnel. The transmittal of information is to be accomplished by means of a comprehensive hazard communication program which includes container labeling and other forms of warning, material safety data sheets (MSDS), and employee training.

4.2 2 Scope

This hazard communication procedure covers activities involving the use and storage of hazardous chemicals

4 2.3 Labels and Other Forms of Warnings

Personnel responsible for receiving and storage of hazardous chemicals from manufacturers and suppliers will ensure that the containers are marked with the following information:

- Identity of the hazardous chemical(s),
- Appropriate hazard warnings, and
- Name and address of the chemical manufacturer, importer, or other responsible party

Containers of hazardous chemicals generated during field investigations will be labeled with the following information

- Identity of the hazardous chemical(s) contained therein; and
- Appropriate hazard warnings.

Exempt from labeling requirements are any containers into which hazardous chemicals are transferred from labeled containers, and which are intended only for use by the person who performs the

transfer during the same work day which the transfer is made. Labels on containers or hazardous chemicals will not be removed or in any way defaced. Labels for containers of hazardous chemicals will be provided by the SHEM or a designee. Information on the labels will be in English. Information in other languages may be added as long as the information presented in English is in no way obscured.

4.2.4 Material Safety Data Sheets (MSDSs)

Personnel responsible for receiving hazardous chemicals from manufacturers or suppliers will ensure that MSDSs are obtained for each shipment received. Receipt of hazardous chemicals will be contingent upon both the provision of MSDSs and compliance of the MSDS with requirements set forth in OSHA's Hazardous Communication Final Rules, part (g).

The Branch Safety Officer or a designee will ensure that copies of MSDSs are posted in the following areas:

- The Field Equipment Center,
- The Air Laboratory,
- Battery Charging Shed; and
- All field vehicles used to transport hazardous chemicals or used as mobile laboratories where such hazardous chemicals are utilized.

4.2.5 The Hazardous Chemical Inventory

The Branch Safety Officer or a designee will compile a list of hazardous chemicals used or stored within the Branch. The list will include the following:

- Name used in-house for the chemical or mixture of chemicals;
- Correct chemical name for the chemical or each component of a mixture of chemicals;
- Location(s) of the chemical, and
- Location(s) of the posting of MSDSs related to the chemical or mixture of chemicals.

Employee Information and Training

The Branch safety officer or a designee will insure that personnel are provided with information and training on hazardous chemicals in their work area at the time of their initial assignment, and whenever a new hazard is introduced into their work area.

Information provided to personnel will consist of the following:

- Requirements of this Hazard Communication Procedure;
- Operations in their work area where hazardous chemicals are present; and
- Location and availability of this Hazard Communication Procedure in this SOP, the Hazardous

Chemical Inventory List in the Branch safety officer's office, and the locations of MSDSs as stated in Section 4.2.4

Training provided to personnel will consist of:

- Methods and observations that may be used to detect the presence or release of a hazardous chemical in the work area (e.g., monitoring conducted by the Branch Safety Officer or a designee, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.),
- The physical and health hazards of the chemicals in the work area;
- Measures such as appropriate work practices, emergency procedures, and personal protective equipment to be used by personnel to protect themselves from these hazards, and specific procedures to be implemented to protect them from exposure to hazardous chemicals, and
- The details of this Hazard Communication Procedure, including an explanation of the labeling system and the MSDSs, and how personnel can obtain and use the appropriate hazard information.

4.3 Safety Protocols

4.3.1 Site Safety Officer Duties

The following is a list of duties that are required for an individual designated to be a Site safety officer (SSO). Branch safety protocols are to be administered by the Division's Occupational Health and Safety Designee (OHSD) and the appointed Division Safety, Health, and Environmental Manager (SHEM). Safety protocols are to be followed by the SSO as well as each individual that is a part of the investigation. Safety during hazardous waste site investigations begins with the individual. However, it is the responsibility of the SSO to plan and coordinate the following during an investigation.

1. Ensure that each member of the investigative team is up to date on their site safety training (i.e. Annual Safety Refresher, CPR and First Aid) or has received an over-ride by the OHSD.
2. Meet with the project leader to gain knowledge of site operations and sampling strategies.
3. Prepare and enforce the site safety plan.
4. Make sure that necessary project specific safety equipment is available and operational. This includes checking out air monitoring instruments to ensure that they are fully operational, charged, and calibrated, for Level B operations - checking cool vest batteries and pumps, filling and checking self contained breathing apparatus (SCBA) air tanks and/or the airline system.
5. The SSO is also responsible for oversight of safety during the investigation. This oversight can include the following duties - safety sweep with air monitoring instruments at the commencement of the site investigation, directing the set-up of the command post and work zones (decontamination, exclusion, and contaminant reduction zones), and calibrating (or verifying such) and operating air monitoring instruments during the investigation, and conduct

medical monitoring for heat stress throughout the operation.

4.3 2 Safety Equipment

Investigators will be provided with the following safety equipment as appropriate:

- rain suit
- snow suit and ski mask
- work gloves
- safety glasses (prescription if necessary)
- goggles
- hearing protection
- hard hat
- steel toe/shank safety boots (leather and rubber)
- air purifying respirator (APR)
- first aid supplies

Field investigators will be responsible for properly operating and maintaining the safety equipment in the field. Should the safety equipment malfunction or be broken, field investigators are responsible for reporting the condition to appropriate personnel at the Field Equipment Center (FEC) upon its return. The report will include as accurate a description or account of the problem as possible.

Field investigators will not operate any equipment for which they have not received training or have insufficient familiarity to conduct safe operations.

Activities which will require a familiarization exercise for personnel prior to the actual execution of the work include:

- Confined space entry (requires a permit, see below);
- Level A, B, or C operations,
- Drilling or power augering,
- Drum openings,
- Brush cutting with power equipment,
- Boat operations,
- Generator operations, and
- Steam cleaning.

4 3 3 OSHA Confined Space Entry

According to 29 CFR Part 1910.146 an individual must have a permit to enter a space that meets the following definition for a confined space. Confined space means a space that is 1) large enough and so configured that an investigator can bodily enter and perform assigned work; 2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, or pits are spaces that may have limited means of entry); and 3) is not designed for continuous occupancy. Field investigators shall not enter a space if it meets this definition.

4 3 4 Entry into Enclosed Areas

When conducting hazardous waste site investigations in areas that do not meet the definition in OSHA 29 CFR Part 1910.146 or that are enclosed (areas that could potentially trap explosive vapors and/or have depleted oxygen), field investigators should monitor the atmosphere of the area to identify immediately dangerous to life and health (IDLH) and other dangerous conditions. Examples of dangerous conditions that may be encountered when working around enclosed areas (other than those listed in 29 CFR Part 1910.146) include areas that may support flammable or explosive atmospheres, oxygen-deficient environments, and highly toxic levels of airborne contaminants. Some examples of enclosed areas that field investigators may enter after conducting appropriate air monitoring include, building interiors (if possible the field investigator(s) should attempt to ventilate the enclosed area by opening doors and windows), trenches (less than 3 feet deep), low lying areas in tank farms, tractor trailers, sumps, and behind barriers such as tall buildings or tanks. At a minimum, field investigators should use direct reading instruments such as the combustible gas indicator (CGI), oxygen meter, and an organic vapor analyzer (OVA) to monitor the atmosphere in areas that may unexpectedly trap harmful vapors or have a depleted oxygen supply

4 3.5 Training Status Tracking System

A computer system is used for tracking the status of required safety training for all personnel involved in hazardous waste field operations within the Division. The system tracks the following safety training:

- Medical monitoring physical (annual renewal);
- 40-hour hazardous waste training (no required renewal),
- 8-hour refresher training (annual renewal);
- Cardio-pulmonary resuscitation (CPR) certification (annual renewal),
- First aid certification (tri-annual renewal);
- Fit testing (annual renewal);
- Fire extinguisher operation (annual renewal);
- International Air Transport Association (bi-annual renewal); and
- Hazard Communication (no required renewal).

It is the responsibility of the Branch safety officer or their designee to notify field investigators or their supervisor when renewals of required training are due. Notification will be at least 60 days prior to the actual renewal date. Scheduling training will be the responsibility of each individual unless otherwise stipulated in the notification. Upon scheduling of the training, the individual will notify the Branch safety officer of the date. Upon successful completion of training, a copy of the certificate received will be sent by the individual to the Branch safety officer for inclusion in the safety training file.

In the event that a field investigator's OSHA required training has lapsed by more than 90 days, the individual will not be allowed to enter onto a hazardous waste site. When lapses in training required by EPA policy occur, the individual will be allowed to enter hazardous waste sites at the discretion of the Occupational Health and Safety Designee (OHSD). The individual and their supervisor will be notified of the change in status. Upon successful completion of the required training, the individual and their supervisor will be notified of their return to prior status.

4 3 6 Site Operations

Upon initial entry at a hazardous waste site, a site survey will be conducted. In a facility that has active working employees, the site survey may be conducted in Level D accompanied by air monitoring. At sites that do not have active working employees, the SSO must use discretion when choosing the level of protection that will be used while conducting an initial site survey. All initial site surveys should be conducted using appropriate air monitoring instruments that detect explosive vapors (CGI), oxygen content, and organic vapors (OVA). The purpose of an initial site survey is to accomplish one or both of the following objectives:

- Determine the hazards that may exist which could affect site personnel
- Verify existing information or obtain new information about the site

To accomplish the first objective, an assessment of real or potential dangers from fire, explosion, airborne contaminants, radiation, and oxygen deficient atmospheres must be made. This assessment will be made as follows:

- Combustible Gases -- The atmosphere in any location capable of containing or generating a combustible concentration of gases will be monitored with a combustible gas meter. Response of the meter in excess of 25% of the lower explosive limit (LEL) will cause an immediate evacuation of the site.
- Oxygen Deficiency -- A location capable of containing or generating an oxygen deficiency either by depletion or displacement will be monitored with an oxygen meter. Any reading less than 19.5% oxygen will result in the use of self contained breathing apparatus (SCBA).
- Organic Vapors and Gases -- The atmosphere will be monitored with both a photoionization detector (PID) and a flame ionization detector (FID). When appropriate, cyanide gas and halogenated vapors will also be monitored. Any response above background concentrations will cause an upgrade to Level C respiratory protection. Any response above 5 ppm when contaminants are not known, will cause an upgrade to Level B respiratory protection. A response above 200 ppm when contaminants are not known will cause an upgrade to Level A protection.
- Inorganic Vapors and Gases -- There are only a few direct reading instruments with the capability to detect and quantify non-specific inorganic vapors and gases. PIDs have a very limited capability in this area. If specific inorganics are known or suspected of being present, an attempt should be made to provide appropriate monitoring if possible. In the absence of a monitoring capability always assume a worse case scenario and upgrade the level of protection (see below) to a level that gives respiratory and skin protection that is appropriate to a worse case assumption.
- Radiation -- A radiation survey will be conducted of the site. The primary survey instrument will be a Geiger-Mueller detector for beta/gamma radiation (see Appendix G for a discussion of limitations). Any response above background will result in evacuation of the area.

Following the initial survey, monitoring will be repeated when new areas of the site are entered, or when operations likely to cause a release are being conducted.

Levels of Personal Protection

Personal protective equipment is divided into four categories based on the degree of protection afforded. The following table compares the relative protection for each level.

	Level A	Level B	LEVEL C	LEVEL D
Respiratory	Maximum	Maximum	Moderate	Minimum
Skin	Maximum	High	Moderate	Minimum
Eye	Maximum	High	Moderate	Minimum

The relationship between air monitoring results and levels of protection (LOP) is shown in the following table

Instrument	Response	LOP
PID/FID	Background	D
PID/FID	Less than 5 PPM above background	C
PID/FID	5 PPM to 200 PPM	B
PID/FID	Greater than 200 PPM	A
Oxygen	Less than 19.5%	B
CN	Greater than 0 PPM and less than 10 PPM	B
CN	10 PPM or greater	A

NOTE Measurements from direct-reading air monitors are only one consideration for LOP decisions. If contaminants are known, protection can be achieved at a lesser LOP.

The four levels of protection (ranked from least protective Level D to most protective Level A) and a description of the situations for which each is appropriate is as follows.

LEVEL D	
REQUIRED	Long sleeved shirt, long pants or coveralls
	Boots with steel toes and shank
OPTIONAL	Gloves
	Rubber boots with steel toe and shank
	Boot covers (disposable)
	Safety glasses, goggles, or face shield (not for chemical splash protection)
	Hard hat
	Emergency Life Support Apparatus (ELSA)
	Thermal/weather protection (coat, overalls, sweater, hat, rain gear, cool vests, and heat stress monitors)
LEVEL D is used when.	The atmosphere contains no known or anticipated hazard.
	Work conditions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals

LEVEL C	
REQUIRED	LEVEL D (modified to require chemical resistant boots with steel toe & shank)
	Full-face Air Purifying Respirator (APR) (NIOSH approved)
	Disposable chemical-resistant overalls
	Chemical resistant gloves (inner and outer)
	Emergency Life Support Apparatus (ELSA) (for confined space initial entry)
OPTIONAL	Boot covers (disposable)
	Hard hat
	Face shield
	ELSA (for other than initial operations)
	Thermal/weather protection (coat, overalls, sweater, hat, rain gear, cool vests and heat stress monitors)
LEVEL C is used when.	The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through any exposed skin
	The types of air contaminants have been identified, concentrations measured, and an air-purifying respirator is available that can remove the contaminants
	All criteria for the use of air-purifying respirators are met

NOTE Level C operations require decontamination of personnel and equipment. Also, zones of protection are required.

Level C is not considered hazardous duty because adequate safety precautions have been taken to reduce the degree of risk.

MODIFIED LEVEL C	
REQUIRED	LEVEL C (modified to include chemically resistant splash suit and triple glove system)
	Cool vests and heat stress monitors (if ambient temperature exceeds 80°F) - see below
	Splash shield
	ELSA (for confined space initial entry)
OPTIONAL	Boot covers (disposable)
	Hard hat
	ELSA (for other than initial operations)
	Cool vests and heat stress monitors are optional if ambient temperature is 80°F or less)
Modified Level C is used when:	All requirements for atmospheric contaminants and APR use related to normal Level C have been met.
	Materials being handled require a high degree of splash or contact protection

NOTE 1 Modified Level C operations require decontamination of personnel and equipment. Also, zones of protection are required.

Modified Level C is not normally considered hazardous because adequate safety precautions have been taken to reduce the degree of risk to a negligible level. Modified Level C could be considered hazardous in a situation where atmospheric contamination was not the determining factor.

NOTE 2 When wearing a chemically resistant splash suit (Level B):

- Cool vests are required when wearing an chemically resistant suit for more than 30 minutes and the temperature is 80°F to 90°F
- Cool vests are required when wearing an chemically resistant suit for more than 15 minutes and the temperature is above 90°F.
- At the discretion of the SSO, a lack of shade may result in the need for cool vests regardless of the temperature
- Heat stress monitors are optional unless mandated by SSO.

LEVEL B	
REQUIRED	MODIFIED LEVEL C (without the requirement for splash shield, ELSA, and APR)
	Positive pressure, full-face piece self-contained breathing apparatus (SCBA)/airline system
OPTIONAL	Boot covers (disposable)
	Hard hat
	ELSA
	Cool vests and heat stress monitors (if ambient temperature is 80°F or less)
	Splash shield
Level B is used when	The type and concentration of atmospheric contaminants have been identified and require the maximum level of respiratory protection, but only a high level of skin protection.
	The atmosphere contains less than 19.5 percent oxygen.
	The presence of incompletely identified vapors or gases is indicated by direct-reading detecting equipment, but the concentrations of contaminants are not suspected of posing a hazard through skin contact.
	The work involves opening containers suspected of containing concentrated wastes where a likelihood of an air release is possible. In this situation, Level B is the initial protection and can be upgraded or downgraded as more information on the nature of the wastes is gathered

NOTE 1 Level B operations require decontamination of personnel and equipment. Also, zones of protection are required

Level B operations normally qualify as hazardous duty because the exact nature of atmospheric/skin contact risk is not known

NOTE 2 When wearing a chemically resistant suit (Level B)

- Cool vests are required when wearing an chemically resistant suit for more than 30 minutes and the temperature is 80°F to 90°F.
- Cool vests are required when wearing an chemically resistant suit for more than 15 minutes and the temperature is above 90°F.
- At the discretion of the SSO, a lack of shade may result in the need for cool vests regardless of the temperature
- Heat stress monitors are optional unless mandated by SSO.

LEVEL A	
REQUIRED	LEVEL D (with chemical resistant rubber boots with steel toe and shank)
	Totally-encapsulating chemical-protective suit
	Positive pressure, full face-piece self-contained breathing apparatus (SCBA)/airline system
OPTIONAL	Boot covers (disposable)
	Hard hat
	Cool vests and heat stress monitors (if ambient temperature is 80°F or less)
LEVEL A is used when	The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system.
	Measurements by direct-reading detecting equipment show concentrations high enough to pose a hazard through skin contact
	Operations are being conducted in confined, poorly ventilated areas not normally intended for human occupation, and conditions requiring a lower level of protection have not been determined (i.e., Levels B, C, or D)

NOTE 1: Level A operations require decontamination of personnel and equipment. Also, zones of protection are required.

Confined space operations require special training and compliance with OSHA permit-required confined space entry procedures.

Level A operations are hazardous duty due to the nature of the equipment worn, and the inability to reduce the risks to a negligible level.

NOTE 2: When wearing a totally-encapsulated, chemical-protective suit (Level A):

- Cool vests are required when wearing a totally-encapsulated, chemical-protective suit for more than 30 minutes and the temperature is 80°F to 90°F.
- Cool vests are required when wearing a totally-encapsulated, chemical-protective suit for more than 15 minutes and the temperature is above 90°F.
- At the discretion of the SSO, a lack of shade may result in the need for cool vests regardless of the temperature.
- Heat stress monitors are optional unless mandated by SSO.

Stress

Field personnel on hazardous waste sites are exposed to both psychological and physiological stress. Psychological stress is countered with adequate training and job proficiency. Physiological stress is primarily due to exposure of the worker to extremes of heat and cold.

Heat Stress

Heat stress can be the result of working during hot weather or wearing protective clothing that inhibits natural ventilation. It can occur even under moderate temperature conditions. Whenever possible, work should be scheduled during cooler parts of the day or night. The following protocols are to be used to counter heat stress:

- Allow workers to replace lost body fluids, water will be available at the site. Liquids for electrolyte replenishment will be available at the discretion of the SSO.
- Cool vests will be made available. Their use will be designated during modified Level C or higher protective level operations when ambient temperatures exceed 80°F or at the discretion of the SSO (see preceding policy)
- At the discretion of the SSO, workers' vital signs will be monitored (i.e., body temperature, blood pressure and heart rate). If deemed necessary by the site safety officer, workers will be fitted with heat stress monitors. Monitoring of vital signs will be mandatory during modified Level C or higher level operations when ambient temperatures exceed 80°F.
- Adequate shade will be provided to shelter workers from direct exposure to the sun during rest periods.
- Work teams will be rotated so that an individual's time on stressful jobs is minimized.
- Field personnel are encouraged to maintain their physical fitness.
- Intake of diuretics (coffee or alcohol) should be minimized prior to field work.

Cold Stress

Exposure to extreme cold can result in hypothermia. Field work during periods of low temperatures and high winds should be conducted to minimize the possibility of hypothermia. The following protocols are to be followed:

- Workers will dress as warmly as possible using the principle of layering their clothing to maximize protection.
- Gloves should be worn when handling metal equipment.
- At the discretion of the SSO, work tours will be limited to minimize exposure to the cold.
- Warm shelter will be made available for workers during breaks. Use of vehicles for warm shelter is discouraged due to the possibility of carbon monoxide exposure.

The SSO will carefully observe workers for signs of hypothermia/frostbite.

Site Control

Site control serves to minimize exposure to contaminants and is accomplished by. 1) providing site security to exclude unnecessary personnel; 2) limiting the number of workers and equipment on-site to the minimum required for effective operations; 3) conducting operations to reduce personal exposure and minimize the potential for airborne dispersion; and 4) implementing decontamination procedures

Work Zones

To control access of personnel and equipment to possible contaminants, the site will be divided into work zones. Three categories of zones and one command post are utilized. For all operations except Level D, work zones will be designated as follows.

- 1 Support Zone -- Along with the command post, this is the outermost boundary of the site. Contamination of personnel and equipment in this area is unlikely.
- 2 Contamination Reduction Zone -- This area serves as a corridor between the exclusion zone and the support zone. All personnel and equipment passing through this corridor from the exclusion zone to the support zone must undergo appropriate decontamination.
- 3 Exclusion Zone -- This is an area within the support zone, where actual operations are being conducted. Access to this area is limited to personnel and equipment being utilized at that particular time. The risk of contamination in this area is high.

Decontamination

Prior to exiting a hazardous waste site, all personnel and equipment (as needed) must undergo a thorough decontamination. The purpose of this decontamination is twofold. First, it minimizes the transportation of hazardous wastes from a site. Second, it protects workers from exposure which may occur while they are removing their protective equipment.

Decontamination must be conducted in an organized, stepwise manner. If certain pieces of the protective equipment are removed prior to the elimination of potential problems by decontamination, the worker may suffer damage due to inhalation or skin contact with contaminants. It is therefore important that persons doing the decontamination work know the proper procedures and the order in which to perform them to insure that such potential personal injuries do not occur. It is also important that site workers avoid contaminating themselves until after they have been cleared to exit the contamination reduction zone.

Decontamination procedures will generate a quantity of hazardous waste (e.g., contaminated solvents, disposable equipment, etc.) called investigation derived waste - IDW. This material must be handled and disposed of in accordance with Section 5.15.

Level A Decontamination Procedures

Level A operations pose a possibility of hazardous exposure to decontamination workers. Due to the nature of Level A work, personnel in the exclusion zone are likely to have contacted high concentrations of hazardous materials which remain on their protective equipment. Therefore, decontamination workers are required to perform their duties in Level B protection. Following are the Level A decontamination procedures.

- 1 Immediately upon leaving the exclusion zone, site workers will place all sampling equipment at a designated area provided at the first station. The area will be covered with disposable plastic. Site workers will then proceed to the first decontamination wash tub where their suit, boots, and outer gloves will be thoroughly scrubbed with the appropriate cleaning solution (usually alkaline soap and water). Long handle brushes will be provided for use by the decontamination workers. Decontamination workers should avoid touching the site workers until after they have cleared the rinse station.
- 2 Site workers' boots and outer gloves will usually be the most contaminated items. Therefore, this step of the decontamination procedure will be accomplished by using soap and water from the washtub/bucket and a brush which is stored in the tub/bucket. In this step, only the boots and gloves of the site worker will be scrubbed. The site workers' suits will be scrubbed using a cleaning solution from a pump sprayer and a brush which is not allowed to contact the more contaminated contents of the washtub/bucket.
- 3 After clearance from the decontamination personnel, the site worker will proceed to the rinse water washtub/bucket. At this location, the decontamination personnel will scrub the site workers' boots and outer gloves with water from the washtub/bucket using a long handle brush. The site workers' suits will be rinsed with water from a pump sprayer, scrubbed with a brush which has not been allowed to contact the contaminated water in the washtub/bucket, and finally rinsed a second time with water from a pump sprayer.
- 4 Once cleared by the decontamination personnel, the site worker will exit the rinse tub/bucket area and proceed to a location where the outer gloves and boot covers (if used) will be removed and discarded. Having been decontaminated, the site worker will exit the contamination reduction corridor and enter the support zone. The support zone will be located a distance of at least 25 feet upwind of the last station in the contamination reduction corridor.
- 5 Once in the support zone, the site workers may receive a fresh cylinder of air, new outer gloves, and new boot covers and return through the contamination reduction corridor to the exclusion zone. If there is to be no immediate return to the exclusion zone, site workers will proceed to the last station. At this location, site workers will remove their boots first, and then remove the suit. Following this, SCBAs and cool vests (if used) will be removed. Each site worker will then clean their SCBA masks with a soap and water rinse, followed by cleaning the inside of the mask with an alcohol wipe. Finally, the site workers will remove their inner glove systems which will be discarded.
- 6 Decontamination personnel for Level A operations will themselves require decontamination prior to entering the support zone. Decontamination personnel will perform decontamination on each other. A decontamination line separate from the Level A decontamination line will be set up for this purpose. Procedures used on this decontamination line will be those given for Level B decontamination. Under no circumstances will decontamination personnel attempt to perform personal decontamination in the Level A decontamination line.

Level B Decontamination Procedures

Level B operations pose a limited risk of exposure to decontamination personnel. Level B site workers often exit the exclusion zone with moderate levels of contamination on their outer gloves and boots. To a lesser extent, contamination may be present on their splash suits. To protect against exposure to this contamination, decontamination workers will perform their functions in Level C protection.

- 1 Upon exiting the exclusion zone, site workers will place all equipment in a designated area provided at the first station. The area will be covered with disposable plastic. Following the equipment drop, site workers will proceed to the first decontamination washtub/bucket area where their boots and outer gloves will be thoroughly scrubbed with the appropriate cleaning solution (usually alkaline soap and water). Long handle brushes will be provided for use by the decontamination workers. While at the first decontamination washtub/bucket area, decontamination workers will not attempt to scrub the site workers' suits above chest height. This procedure is to prevent the cleaning solution carrying contaminants from splashing into the open facial area of the impermeable suit. When scrubbing the impermeable suit and SCBA equipment below chest level, decontamination workers will apply water from a pump sprayer and use long handle brushes which have not come into contact with the water in the washtub/bucket. Following this step, decontamination workers will clean areas of the impermeable suit and SCBA above chest level as necessary with paper towels wetted with the cleaning solution from the pump sprayers. Immediately following this step, the decontamination workers will discard their outer gloves and don clean ones. Areas above chest level of the site workers will then be rinsed with clean water from a pump sprayer.
- 2 Once cleared from the first decontamination washtub/bucket area, site workers will then step into the rinse water washtub/bucket. At this location, decontamination workers will thoroughly scrub the site workers' boots and gloves with water from the washtub/bucket using a long handle brush. The site worker will then be rinsed with water from a pump sprayer. Following this, the decontamination workers will thoroughly scrub site workers (below chest level only) with a long handle brush which is not allowed to contact the contaminated water in the washtub/bucket. Site workers will be rinsed a second time with water from a pump sprayer.
- 3 Once cleared by decontamination personnel, site workers will exit the rinse tub/bucket and proceed to a location where the outer gloves and boot covers (if used) will be removed and discarded. Having been decontaminated, site workers will exit the contamination reduction corridor and enter the support zone. The support zone will be located a distance of at least 25 feet upwind of the last station in the contamination reduction corridor.
- 4 Once in the support zone, site workers may receive a fresh cylinder of air, new outer gloves and boot covers then return through the contamination reduction corridor to the exclusion zone. If there is to be no immediate return to the exclusion zone, the site workers will proceed to the last station. At this location, site workers will remove their boots first, then remove their SCBA. Following this, the impermeable suit and cool vest (if worn) will be removed. Each site worker will then clean their SCBA mask with a soap solution and water rinse, followed by cleaning the inside of the mask with an alcohol wipe. Finally, the site workers will remove their inner gloves and discard them.

- 5 Decontamination personnel for Level B operations will require a minimal amount of decontamination before exiting the contamination reduction zone. This decontamination will consist of a boot rinse in the rinse water washtub/bucket (not the decontamination cleaning solution washtub/bucket), followed by removing the outer gloves and discarding them. If boot covers are worn by decontamination personnel, the boot rinse can be eliminated and the covers can simply be removed and discarded. Decontamination workers can then enter the support zone where new respirator cartridges, outer gloves, and boot covers can be obtained for return to the contamination reduction corridor. If no immediate return to the corridor is anticipated, decontamination workers can remove their respirators and clean them in a soap wash and water rinse, followed by cleaning the inside of the mask with an alcohol wipe. Their inner gloves will then be removed and discarded.

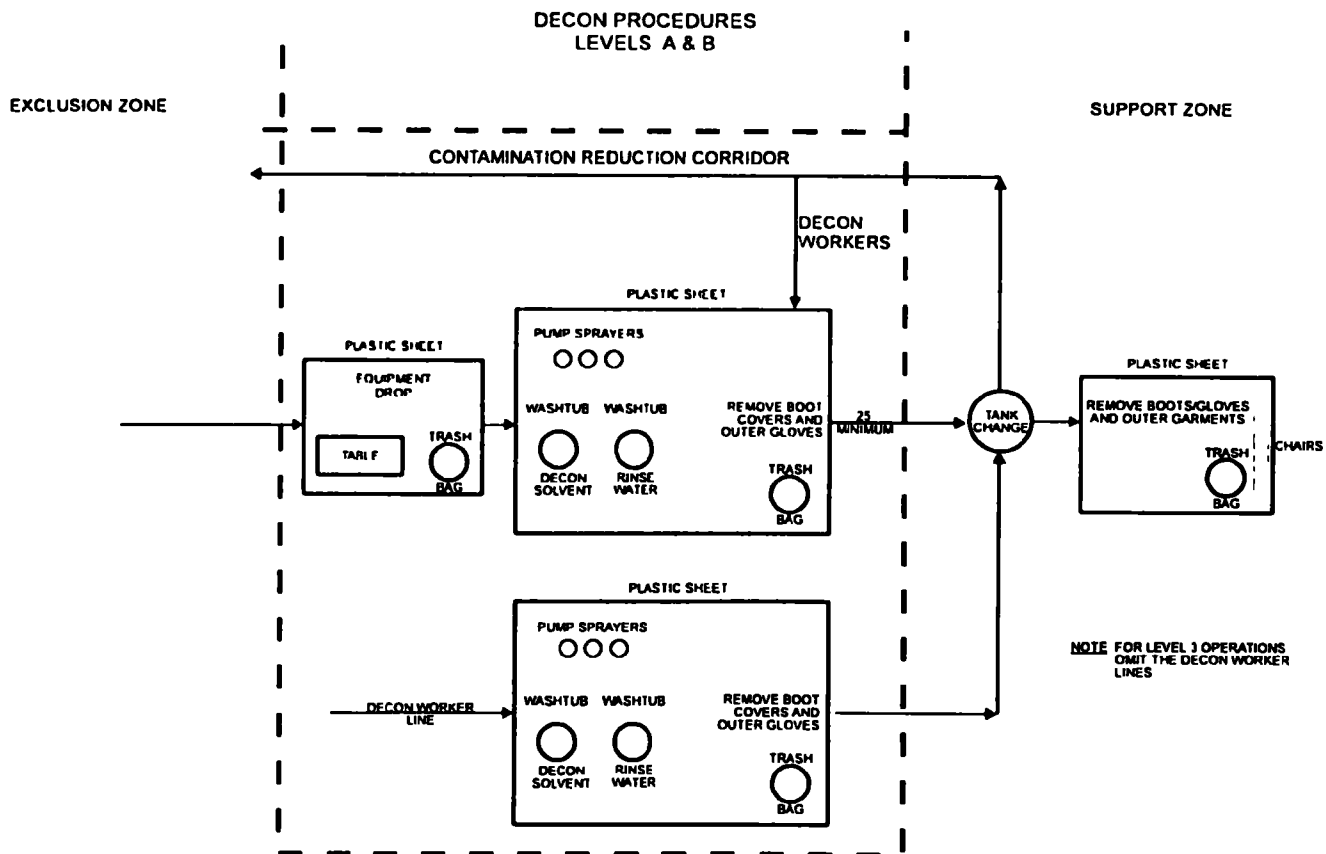
Level C Decontamination Procedures

Level C operations do not pose a significant risk of exposure to decontamination workers. Therefore, Level D protection is all that is required to be worn when performing decontamination functions.

- 1 Upon exiting the exclusion zone, site workers will place their equipment in a designated area provided at the first decontamination station. The area will be covered with disposable plastic. Following this, they will proceed to a decontamination cleaning solution washtub/bucket area where decontamination personnel will scrub their boots with a long handle brush. Once cleared from the cleaning solution washtub/bucket area, the site worker will step into a water rinse washtub/bucket. Upon leaving the water rinse tub/bucket, site workers will remove their outer gloves and boot covers (if used) and discard them.
- 2 Site workers are then clear to enter the support zone where they may obtain new respirator cartridges, outer gloves, and boot covers for return to the exclusion zone. If an immediate return is not anticipated, site workers may remove their respirators. Respirators will be washed in soap solution and rinsed in water. Following this, the inside of the respirators will be cleaned with an alcohol wipe. Finally, site workers will remove and discard their inner gloves.
- 3 Decontamination personnel may exit the contamination reduction corridor without having to conduct any decontamination upon themselves other than to remove and discard their gloves.

FIGURE 4-1
DECONTAMINATION ZONE FOR LEVELS A AND B

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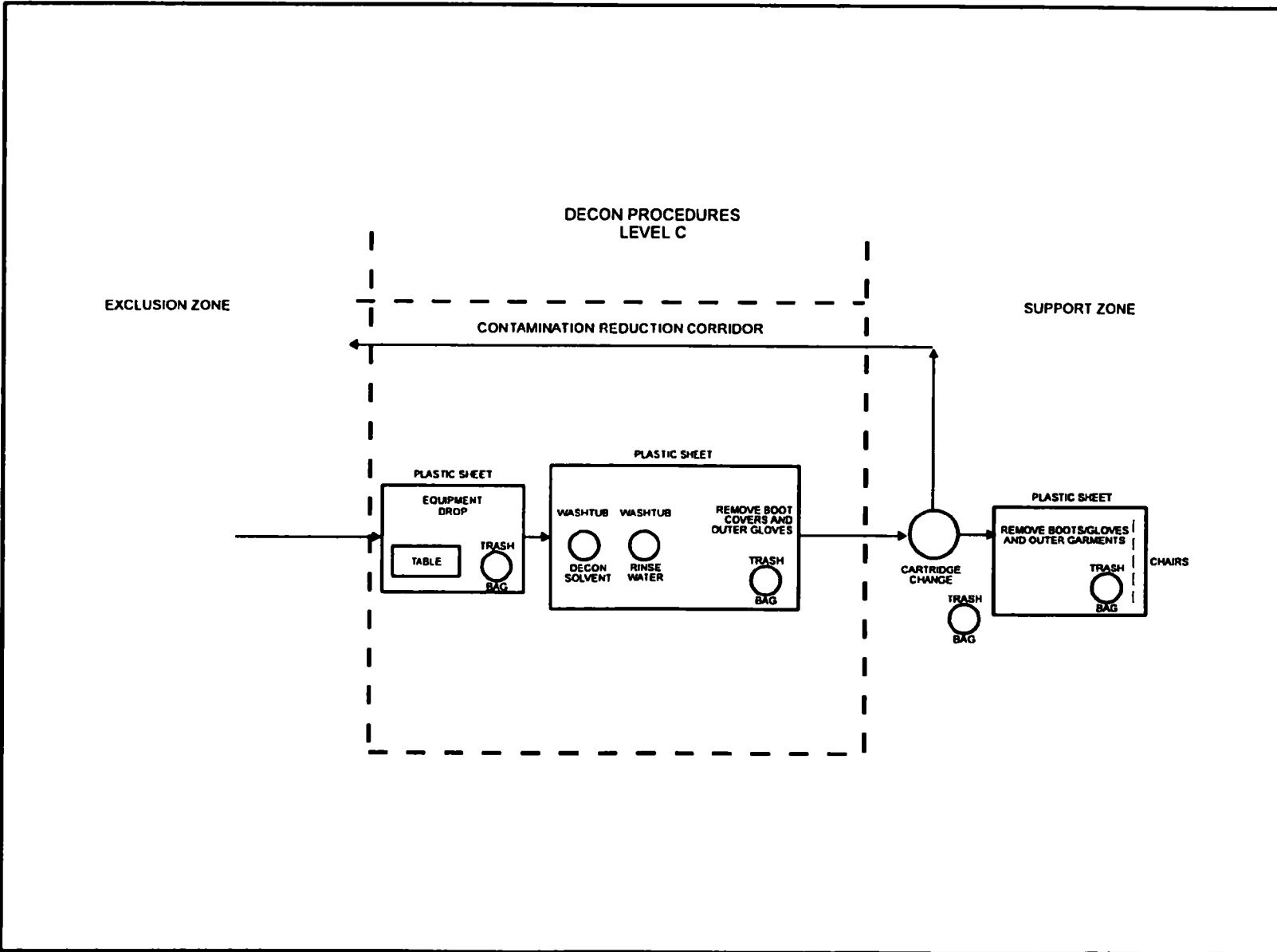


FIGURE 4-2
DECONTAMINATION ZONE FOR LEVEL C

Site Safety Plans

Site safety plans will be developed for every hazardous waste site project conducted. The plan will use the form included in this section. MSDSs will be attached for contaminants anticipated at the site. The plan will be submitted to the Branch safety officer and the OHSD for approval.

Prior to commencing site activities, investigators will be briefed on the contents of the safety plan. The plan's emergency instructions and directions to the closest hospital will be posted in a conspicuous location at the site command post and in each field vehicle. When there is more than one organization involved at the site, the development of the safety plan should be coordinated among the various groups.

SECTION 5 SAMPLING DESIGN AND QUALITY ASSURANCE PROCEDURES

SECTION OBJECTIVES:

- Define planning and quality assurance elements that must be incorporated in all sampling operations.
- Define sampling site selections and collection procedures for individual media
- Define sampling quality assurance procedures

5.1 Introduction

This section discusses the standard practices and procedures used by Branch personnel during field operations to ensure the collection of representative samples. Sampling activities conducted by field investigators are conducted with the expectation that information obtained may be used for enforcement purposes, unless specifically stated to the contrary in advance of the field investigation. Therefore, correct use of proper sampling procedures is essential. Collection of representative samples depends upon

- Ensuring that the sample is representative of the material being sampled.
- The use of proper sampling, sample handling, preservation, and quality control techniques

5.2 Definitions

Sample -- part of a larger lot, usually an area, a volume, or a period of time

Representative Sample -- a sample that reflects one or more characteristics of a population

Sample Representativeness -- the degree to which a set of samples defines the characteristics of a population, where each sample has an equal probability of yielding the same result.

Variability -- the range or "distribution" of results around the mean value obtained from samples within a population. There are three types of variability which must be measured or otherwise accounted for in field sampling

1 Temporal Variability

Temporal variability is the range of results due to changes in contaminant concentrations over time. An example would be the range of concentrations obtained for a given parameter in wastewater samples collected at different times from an outfall where contaminant concentrations vary over time.

2 Spacial Variability

Spacial variability is the range of results due to changes in contaminant concentrations as a function of their location. An example would be the range of concentrations obtained for a given parameter in surface soil from a site where discrete "hot spots" are present due to localized releases of contaminants on otherwise uncontaminated soil.

3 Sample Handling Variability

Sample handling variability is the range of results due to the sample collection and handling by the sampler. This variability manifests itself as a positive bias due to errors such as unclean sampling equipment, cross contamination, etc., or a negative bias due to improper containers or sample preservation.

Accuracy -- a measure of agreement between the true value and the measured value of a parameter

Precision -- measure of the agreement among individual measurements of identical samples

Bias -- consistent under or over-estimation of the true value due to sampling errors, sample handling errors, or analytical errors.

Grab Sample -- an individual sample collected from a single location at a specific time or period of time. Grab samples are generally authoritative in nature.

Composite Samples -- a sample collected over a temporal or spacial range that typically consists of a series of discrete, equal samples (or "aliquots") which are combined or "composited". Four types of composite samples are listed below:

- 1 Time Composite (TC) - a sample comprised of a varying number of discrete samples (aliquots) collected at equal time intervals during the compositing period. The TC sample is typically used to sample wastewater or streams.
- 2 Flow Proportioned Composite (FPC) - a sample collected proportional to the flow during the compositing period by either a time-varying/constant volume (TVCV) or time-constant/varying volume (TCVV) method. The TVCV method is typically used with automatic samplers that are paced by a flow meter. The TCVV method is a manual method that individually proportions a series of discretely collected aliquots. The FPC is typically used when sampling wastewater.
- 3 Areal Composite - sample composited from individual, equal aliquots collected on an areal or horizontal cross-sectional basis. Each aliquot is collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from within grids.
- 4 Vertical Composite - a sample composited from individual, equal aliquots collected from a vertical cross section. Each aliquot is collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes, and estuaries.

Quality Control Samples

Quality control samples are collected during field studies for various purposes which include the isolation of site effects (control samples), define background conditions (background sample), evaluate field/laboratory variability (spikes and blanks, trip blanks, duplicate, split samples).

The definitions for specific quality control samples are listed below:

Control Sample -- typically a discrete grab sample collected to isolate a source of contamination. Isolation of a source could require the collection of both an upstream sample at a location where the medium being studied is unaffected by the site being studied, as well as a downstream control which could be affected by contaminants contributed from the site under study.

Background Sample -- a sample (usually a grab sample) collected from an area, water body, or site similar to the one being studied, but located in an area known or thought to be free from pollutants of concern.

Split Sample -- a sample which has been portioned into two or more containers from a single sample container or sample mixing container. The primary purpose of a split sample is to measure sample handling variability.

Duplicate Sample -- two or more samples collected from a common source. The purpose of a duplicate sample is to estimate the variability of a given characteristic or contaminant associated with a population.

Trip Blanks -- a sample which is prepared prior to the sampling event in the actual container and is stored with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and submitted for analysis. At no time after their preparation are trip blanks to be opened before they reach the laboratory. Trip blanks are used to determine if samples were contaminated during storage and/or transportation back to the laboratory (a measure of sample handling variability resulting in positive bias in contaminant concentration). If samples are to be shipped, trip blanks are to be provided with each shipment but not for each cooler.

Spikes -- a sample with known concentrations of contaminants. Spike samples are often packaged for shipment with other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they reach the laboratory. Spiked samples are normally sent with each shipment to contract laboratories only. Spiked samples are used to measure negative bias due to sample handling or analytical procedures, or to assess the performance of a laboratory.

Equipment Field Blanks -- a sample collected using organic-free water which has been run over/through sample collection equipment. These samples are used to determine if contaminants have been introduced by contact of the sample medium with sampling equipment. Equipment field blanks are often associated with collecting rinse blanks of equipment that has been field cleaned.

Pre- and Post-Preservative Blanks -- a sample that is prepared in the field and used to determine if the preservative used during field operations was contaminated, thereby causing a positive bias in the contaminant concentration. On small studies, usually only a post-preservative blank is prepared at the end of all sampling activities. On studies extending beyond one week, a pre-preservative blank should also be prepared prior to beginning sampling activities. At the discretion of the project leader, additional preservative blanks can be prepared at intervals throughout the field investigation. These blanks are prepared by putting organic/analyte-free water in the container and then preserving the sample with the appropriate preservative.

Field Blanks -- a sample that is prepared in the field to evaluate the potential for contamination of a sample by site contaminants from a source not associated with the sample collected (for example air-borne dust or organic vapors which could contaminate a soil sample). Organic-free water is taken to the field in sealed containers or generated on-site. The water is poured into the appropriate sample containers at pre-designated locations at the site. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.

Material Blanks -- samples of sampling materials (e.g., material used to collect wipe samples, etc.), construction materials (e.g., well construction materials), or reagents (e.g., organic/analyte free water generated in the field, water from local water supplies used to mix well grout, etc.) collected to measure any positive bias from sample handling variability. Commonly collected material blanks are listed below:

Wipe Sample Blanks -- a sample of the material used for collecting wipe samples. The material is handled, packaged, and transported in the same manner as all other wipe samples with the exception that it is not exposed to actual contact with the sample medium.

Grout Blanks -- a sample of the material used to make seals around the annular space in monitoring wells.

Filter Pack Blanks -- a sample of the material used to create an interface around the screened interval of a monitoring well.

Construction Water Blanks -- a sample of the water used to mix or hydrate construction materials such as monitoring well grout.

Organic/Analyte Free Water Blanks -- a sample collected from a field organic/analyte free water generating system. The sample is normally collected at the end of sampling activities since the organic/analyte free water system is recharged prior to use on a study. On large studies, samples can be collected at intervals at the discretion of the project leader. The purpose of the organic/analyte free water blank is to measure positive bias from sample handling variability due to possible localized contamination of the organic/analyte free water generating system or contamination introduced to the sample containers during storage at the site. Organic/analyte free water blanks differ from field blanks in that the sample should be collected in as clean an area as possible (a usual location for the organic/analyte free water system) so that only the water generating system/containers are measured.

5.3 Sampling Design

5.3.1 Introduction

Development of a sampling design may follow the seven steps outlined in the EPA publication, "Guidance for the Data Quality Objectives Process" (1). The Data Quality Objectives (DQOs) process is a logical step-by-step method of identifying the study objective, defining the appropriate type of data to collect, clarifying the decisions that will be based on the data collected, and considering the potential limitations with alternate sampling designs. Investigations may be executed without completing the DQO process step-by-step; however, the basic elements of the DQO process should be considered by the project leader for each investigation.

Sampling designs are typically either non-probabilistic (directed sampling designs) or probabilistic (random sampling designs) in nature. The sampling design ultimately must meet specific study objectives. The location and frequency of sampling (number of samples) should be clearly outlined in the sampling design, as well as provisions for access to all areas of the site, the use of special sampling equipment, etc. Development of the sampling design in the context of DQOs and sampling optimization are discussed in the ASTM documents "Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives" (2), and "Standard Guide for the Generation of Environmental Data Related to Waste Management Activities" (3).

5.3.2 Representative Sampling

A "representative sample" is often defined as a sample that reflects one or more characteristics of the population being sampled. For example, the characteristic which is desired to be reflected by the sample may be the average, minimum, or maximum concentration of a constituent of concern. Ultimately a representative sample is defined by the study objectives. For instance, the objective of the study may be to determine the maximum concentration of lead in the sludge from a surface impoundment. One sample collected near the inlet to the impoundment may provide that information. The collection of a representative sample may be influenced by factors such as equipment design, sampling techniques, and sample handling.

5.3.3 Stratification and Heterogeneous Wastes

Environmental media, as well as waste matrices, may be stratified, i.e., different portions of the population, which may be separated temporally or spatially, may have similar characteristics or properties which are different from adjacent portions of the population. An example would be a landfill that contains a trench which received an industrial waste contaminated with chromium. The trench would be considered a strata within the landfill if chromium was the contaminant of concern. A special case, "stratification by component", is often observed with waste matrices when the constituent of interest is associated with one component of the matrix. An example would be slag contaminated with lead that is mixed with otherwise uncontaminated fire brick. Thus the lead is stratified by component, that being the slag. Stratified sampling designs are discussed later which incorporate independent sampling of each strata, thereby reducing the number of samples required.

Some environmental and waste matrices may be, for purposes of the field investigation, homogeneous (for instance the surface water in a limited segment of a small stream). If the composition of the matrix and the distribution of contaminants are known, or can be estimated, less sampling may be necessary to define the properties of interest. An estimate of the variability in contaminant distribution may be based on knowledge, or determined by preliminary sampling. The more heterogeneous the matrix, the greater the planning and sampling requirements.

A population could also have very localized strata or areas of contamination that are referred to as "hot spots". Specific procedures for hot spot identification and characterization are available in Statistical Methods for Environmental Pollution Monitoring (4).

5.3.4 Specific Sampling Designs

Sampling strategies used by the Branch typically fall into two general groups: **directed** or **probabilistic**. Directed or "authoritative" approaches typically rely on the judgement and experience of the investigators, as well as available information on the matrix of concern. Probabilistic, or "statistical" approaches may be appropriate when estimates on uncertainty and specific confidence levels in the results are required. The probabilistic approaches include: simple random sampling, stratified random sampling, and systematic grid sampling. The main feature of a probabilistic approach is that each location at the site has an equal probability of being sampled, therefore statistical bias is minimized.

5.3.5 Determining the Number of Samples to Collect

The number of samples to collect as part of a sampling design will typically be based on several factors, e.g., the study objectives, properties of the matrix, degree of confidence required, access to sampling points, and resource constraints. Practical guidance for determining the number of samples is included in several documents including the ASTM document Standard Guide for General Planning of Waste Sampling (5), the US-EPA document Characterization of Hazardous Waste Sites - A Methods Manual, Volume I - Site Investigations (6), and Statistical Methods for Environmental Pollution Monitoring by Richard O. Gilbert (4).

5.3.6 Authoritative or Directed Sampling

Directed sampling is based on the judgement of the investigator, and does not necessarily result in a sample that reflects the average characteristics of the entire matrix. Directed sampling is also called authoritative or judgmental sampling, and is considered non-probabilistic. The experience of the investigator is often the basis for sample collection, and bias (depending on the study objectives) should be recognized as a potential problem. However, preliminary or screening investigations, and certain regulatory investigations, may correctly employ directed sampling. Directed sampling may focus on "worst case" conditions in a matrix, for example, the most visually contaminated area or the most recently generated waste. In the presence of high temporal or spatial variability, directed samples have a very limited degree of representativeness.

5.3.7 Simple Random Sampling

Simple random sampling insures that each element in the population has an equal chance of being included in the sample. This is often the method of choice when, for purposes of the investigation, the matrix is considered homogeneous or when the population is randomly heterogeneous. If the population contains trends or patterns of contamination, a stratified random sampling or systematic grid sampling strategy would be more appropriate.

5.3.8 Systematic Sampling over Time or Space

Systematic sampling over time at the point of generation is useful if the material was sampled from a wastewater sewer, a materials conveyor belt, or being delivered via truck or pipeline. The sampling interval would be determined on a time basis, for example every hour from a conveyor belt or pipeline discharge, or from every third truck load. Systematic sampling over space might involve the collection of

samples at defined intervals from a ditch, stream, or other matrix that is spatially unique

5.3.9 Stratified Random Sampling

Stratified random sampling may be useful when distinct strata or "homogeneous sub-groups" are identified within the population. The strata could be located in different areas of the population, or the strata may be comprised of different layers. This approach is useful when the individual strata may be considered internally homogeneous, or at least have less internal variation, in what would otherwise be considered a heterogeneous population. Information on the site is usually required to establish the location of individual strata. A grid may be utilized for sampling several horizontal layers if the strata are horizontally oriented. A simple random sampling approach is typically utilized for sample collection within each strata. The use of a stratified random sampling strategy may result in the collection of fewer samples.

5.3.10 Systematic Grid Sampling

Systematic grid sampling involves the collection of samples at fixed intervals when the contamination is assumed to be randomly distributed. This method is commonly used with populations when estimating trends or patterns of contamination. This approach may not be acceptable if the entire population is not accessible, or if the systematic plan becomes "phased" with variations in the distribution of contaminants within the matrix. This approach may also be useful for identifying the presence of strata within the population. The grid and starting points should be randomly laid out over the site, yet the method allows for rather easy location of exact sample locations within each grid. Also, the grid size would typically be adjusted according to the number of samples that are required.

5.4 General Considerations for Sampling Designs

Prior to commencing work on any project, the objective of the study in terms of the purpose the data generated is to serve should be known. Some examples of uses for which data are generated include

- RCRA waste identification investigations;
- RCRA or Superfund screening investigations (presence or absence of contaminants).
- Superfund Remedial Investigations, Removal Actions, or Feasibility Studies;
- Surface water and sediment studies.
- Wastewater treatment plant evaluations,
- Monitoring investigations,
- UST/UIC investigations; and
- Special environmental characterization investigations.

The purpose of data collection is to meet the objectives of the investigation. The process of designing an investigation typically follows a logical series of steps. Proper evaluation of these steps will greatly enhance the project leader's ability to choose a design which adequately serves the purpose of the study. The DQO approach may not be strictly followed, but the elements of the approach are always considered during study planning. These elements include:

- Identification of objectives, and investigation boundaries,
- Collection of information concerning historical data, site survey, and site history.
- Sampling design selection and design optimization,
- Sample types and number,
- Analytical requirements and limitations, and
- Data interpretation and assessment

5.5 Soil Sampling Designs

The objectives of a soil sampling investigation must be clearly defined in terms of the purpose of the data generated. A discussion of study planning elements that include considerations specific to soil investigations follows.

5.5.1 Historical Sampling Data, Site Survey, and Site History

Investigations that are used for initial site screening purposes are one of the few cases where historical sampling data is usually not available. In this case, the purpose of the sampling effort is to determine the presence/absence of contaminants and if present, to determine their nature. Such a purpose can be served with a minimum of samples whose locations can be determined from a site survey and a review of the site history. When designing a soil sampling study for purposes other than site screening, a record of previous sampling efforts is usually available from which a relatively sound foundation of historical sampling data can be derived.

The site survey is invaluable for soil sample design. Information which should be obtained during a site survey includes:

- General site layout,
- Site access;
- Soil types and depths,
- Surface water drainage pathways,
- Existing site conditions,
- Visible staining of surface soil,
- Vegetation stress; and
- Possible offsite or non-site related sources

The site history should include factors such as previous land use both on and nearby the site, types of industrial operations conducted both on the site and on adjoining property, types of contaminants to which the site has been exposed, and locations of possible dumping/burial areas. The site history can be derived from property plats, tax records, aerial photos, and interviews with people familiar with the site.

5.5.2 Data Quality Objectives (DQOs)

Consideration of the purpose which the data generated from the soil sampling effort is to serve drives the selection of DQOs. DQO selection will then be the main factor which determines the types of samples to be collected, the types of equipment to be used, and the analytical requirements for the samples. See Section 5.12 for a discussion of DQOs.

5.5.3 Authoritative Designs for Soil Investigations

When the purpose of the investigation is to determine the presence of contaminants, a simple strategy can be used. Such a purpose is normally encountered during screening inspections, criminal investigations, and any other project where the scope is limited to gathering evidence of contamination. These cases are normally characterized by a lack of previous sampling data, thereby requiring that sample types and locations be determined by site history and a site survey. In these instances, an authoritative design is normally used.

Authoritative sampling usually involves a limited number of locations (10 to 15) from which grab samples are collected. Locations are selected where there is a good probability of finding high levels of contamination. Examples may include areas where significant releases or spillage occurred according to the site history or areas of visible staining, stressed vegetation, or surface drainage are noted in the site survey. An authoritative design usually involves the selection of two or three control sampling locations to measure possible contaminants migrating onto the site from adjacent sources not involved in the study. The selection of control locations is similar to the selection of other sampling locations, except that upstream or upgradient control samples are expected to be unaffected by site contaminants.

Because of the biased nature of an authoritative design, the degree of representativeness is difficult to estimate. Authoritative samples are not intended to reflect the average characteristics of the site. Since determining representativeness is not an issue with this type of design, duplicate samples designed to estimate variability are not normally collected. However, split samples should be collected to measure sample handling variability.

An interactive approach may be used in an authoritative design to determine the extent of contamination on a site when the source can be identified. Samples are typically collected using a pattern that radiates outward from the source. The direction of contaminant migration may not be known which will result in the collection of more samples, and in this case field screening would be desirable to help in determining appropriate sampling locations.

5.5.4 Systematic Grid Sampling Designs for Soil Investigations

In cases where both the presence of contaminants and the extent of contamination needs to be determined, an authoritative design is inappropriate as site variability cannot be estimated without collecting an inordinate number of samples. A systematic design is normally used during investigations when determining the extent of contamination, such as remedial investigations and removal actions.

Once a site has reached the stage where the extent of contamination becomes an issue, access to data from previous sampling efforts (screening investigations) which used an authoritative design is normally available. The preliminary data can be used to estimate the variability of contaminant concentrations as a function of area and/or depth for purposes of planning the more extensive systematic design. In the absence of previous sampling data a variability study should be conducted. An alternative would be to estimate the variability, with confirmation of the estimate being made during the more extensive systematic study. If a variability study is to be conducted, it will be limited in scope and will use certain default values or assumptions to determine the number of samples to collect for determining site variability. The methods used for variability studies are included in the following discussion of systematic sampling strategies.

Determination of the Number of Samples to Collect

When designing a systematic grid sampling investigation, the number of samples to be collected must be determined first. This can be calculated based on variability information derived from previous sampling data. Upon review of the historical data, a contaminant or contaminants of concern (COCs) can be selected. COCs are parameters which are closest to or in excess of an action level. Their presence is normally the driving force behind the need to determine the extent of contamination.

The following steps are to be followed to determine the number of samples to collect (6)

- 1 Select a margin of error (p) acceptable for the subsequent use of the data. For soil studies, a margin of error of 0.20 is not unusual. The margin of error may be obtained by dividing the precision wanted (in units of concentration; e.g. ± 10 ppm, etc.) by the known or anticipated mean concentration of the COCs. Note that changes in the precision or mean concentration for the COC relative to those anticipated during the planning process may require a re-evaluation of the assumed margin of error.
- 2 A coefficient of variation (CV), which is defined as the standard deviation of a COC divided by the mean of the COC, is either obtained using previous sampling data, or estimated based on anticipated variability. If a CV above 0.65 is obtained, a large number of samples will usually result.

The number of samples required may be minimized by using a stratified design if areas with known high variability can be identified and addressed separately from areas of lower variability. Areas of high variability will require more samples while areas of low variability will require fewer using the approach outlined in this section. The overall effect will normally be a substantially lower number of samples for the entire site.

- 3 A confidence level (t_a) needs to be established. For work involving hazardous wastes, a confidence level of 95% should be used. For a 95% confidence level, a factor of 1.96 (from standard statistical tables) is used to calculate the number of samples required.
- 4 The required number of samples is calculated using the following formula

$$n = \frac{t_a^2 (CV)^2}{p^2}$$

Where,

n = number of samples to collect
 t_a = statistical factor for a 95% confidence level
CV = coefficient of variation
p = margin or error

In a case where no previous sampling data is available, the default values given in the previous discussion can be used

$$n = \frac{(1.96)^2 (0.65)^2}{(0.20)^2}$$

$$n = 40 \text{ samples}$$

Upon completion of the soil sampling effort, the data obtained for the COCs is reviewed. It can then be determined if an adequate number of samples were collected with respect to the margin of error and confidence selected during the planning process. This determination is completed by calculating the CV using the data obtained during the study. The standard deviation of the concentration for a COC is divided by the mean concentration and the CV is calculated. This CV may be higher or lower than the CV selected during the planning process. Using this CV value, the same equation is used to determine the required number of samples based on the actual CV for the study. If this second value for "n" is less than or equal to the number of samples collected during the study, then the site has been characterized for the extent of

COCs within the limits of confidence and error stated. If the second value for "n" is significantly greater then additional sampling is necessary, or an adjustment to the margin of error or confidence level should be considered. If the collection of additional samples is deemed necessary by the investigation team, the data that has been generated may be used to plan for a more efficient and cost-effective re-sampling of the site. Areas of the site where higher than anticipated variabilities were obtained may be segregated from areas of lower variability (stratified design). A recalculation of the number of samples required to characterize each strata should then be completed and resampling may proceed.

The following table illustrates the number of samples required at a 95% confidence level with varying margins of error (p) and coefficients of variation (CV):

	Coefficient of Variation (CV)				
	0.1	0.5	0.65	1.0	2.0
Margin of Error (p)					
0.1	4	96	162	384	1537
0.2	1	24	40	96	384
0.3	-	10	18	42	170
0.5	-	4	6	15	61
1.0	-	1	2	4	15
2.0	-	-	-	1	4
	Number of Samples (n)				

Note that as the CV increases at a set margin of error, the number of samples required increases. When the variability is low (as measured by the standard deviation or the square root of the variance) relative to the mean of the data, then the CV is low. However, as the variability in the population begins to increase relative to the mean of the data, then the CV increases and the number of samples required increases if characterization of the site at a 95% confidence level and a set margin of error is desired.

A similar relationship is observed for the margin of error. When the precision required (say ± 10 ppm lead) is high relative to the mean of the data (say 100 ppm lead), then the margin of error is low (in this case 0.1). In this case 162 samples would be required with a CV of 0.65. If the investigators could accept a higher margin of error (e.g., $\pm 20\%$), and the mean concentration of the data is still 100 ppm lead, then the resulting margin of error (0.2) would result in a lower number of required samples. Note that 40 samples would be required at the same CV of 0.65.

If the investigators change the confidence level, then the numbers in the table provided would change accordingly. If the confidence level is decreased to 80%, then the required number of samples reflected in this table would be lower for each margin of error and CV combination.

Establishment of the Grid

Having determined the number of samples to collect, the project leader should then determine how to disperse the samples within the site. Commonly, a grid system is used. The number of grids is equal to the number of samples required for a systematic grid design. Grids may also be used to determine sampling locations when using a random design, however, with this type of design every grid is not sampled.

The size of the grids is calculated by dividing the area of the site by the number of samples required. The product of this calculation is the area of each grid. By taking the square root of the grid area, the length of a grid side is determined.

$$G = (a/n)^{1/2}$$

Where:

G	= length per side of each individual grid
a	= area
n	= number of samples required

The length of a grid size should be "rounded" down to some number convenient for the method used in laying out the grid (e.g., plane survey, geographical positioning system (GPS), etc.). Rounding down the grid size will increase the number of samples slightly. It is important to remember that the number of samples calculated is the minimum, and that site conditions may not allow for collection of all samples. Therefore, additional samples would be appropriate.

Grab vs Composite Samples

When designing a systematic grid sampling investigation, a determination of whether to collect grab or composite samples must be made. Grab samples may not adequately describe variability, even within individual grid cells, and therefore, limit the representativeness of the data set. If the study involves a small area with grid cells of 25 feet or less in length, then grab samples could be collected in each grid cell without significantly affecting the representativeness of the data. However, most studies have much larger grids (100 to 500 feet per side). In these cases, composite samples collected within each grid cell result in more representative data. It should be remembered that a composite sample under the best of conditions will yield an average value of contaminants within the grid. Composite samples are most appropriate where a reasonable degree of variability is anticipated, and where soil types are amenable to adequate mixing. This is normally the case when contaminants have been distributed by airborne deposition (relatively homogeneous distribution across the site). Where localized "hot spots" are present due to releases from process units, indiscriminate dumping, or the burying of wastes, a more specialized approach that takes these types of distribution into account is required. Situations where the distribution of contaminants is strongly non-random (heterogeneous distributions) are the most difficult to plan for and characterize.

Composite samples should consist of five to nine aliquots per sample located on compass points within the grid cell. Greater than nine aliquots per sample can result in dilution of fairly high concentrations down to a value below the analytical detection limits. Less than 5 aliquots may limit the representativeness of the sample with no added value over a single grab sample within the grid cell. A certain number of samples are collected (10 percent of the grid cells is often selected) during the investigation for variability determinations based on rotating the aliquot distribution pattern on the points of the compass within the grid cell.

Surface vs Sub-Surface Samples

The two main considerations for sub-surface soil samples are contaminant mobility and type of deposition. A contaminant that is relatively immobile in soil will naturally be found in the same area in which it was deposited. Mobile contaminants require specialized consideration of the likely extent of their migration in order to determine sub-surface soil sampling locations and depths. Airborne deposition of mobile contaminants normally require a considerable amount of sub-surface soil sampling to determine their extent in a systematic design.

5.6 Ground Water Sampling Designs

Sampling design, as it pertains to ground water, often involves the use of some form of temporary well point or direct push technology (DPT) for rapid in-field screening and plume delineation. These techniques are discussed in Section 6. Samples obtained using these techniques are usually analyzed immediately, using an on-site field laboratory, or are sent to an off-site laboratory for quick turnaround analyses. In this manner, delineations of both a horizontal (areal) and vertical nature can be rapidly achieved in the field. These delineations can then be used as the basis for locating and installing permanent ground water monitoring wells.

The degree of complexity for these delineations varies, depending on a number of factors which include

- The known or anticipated size of the suspected source area.
- Site stratigraphy
- The amount of information regarding hydrogeological conditions (thickness of aquifers or water-bearing units, depth to confining units, ground water flow direction, etc.)
- The type of contamination (aqueous phase, light non-aqueous phase liquid (LNAPL), or dense non-aqueous phase liquid (DNAPL))

In addition to the design considerations imposed by the preceding factors, screening program designs may be either simple iterative or grid-based. Grid-based may even transform, at some point, to a more or less iterative program.

5.6.1 Single Source Iterative Programs

The simplest case is one in which there is a small source area of an aqueous phase contaminant or component, such as benzene, toluene, ethyl benzene, and xylene (BTEX) contamination without associated product, and there is a high degree of confidence with respect to ground water flow direction. In this situation, a sample location would be placed in the middle of the source area, for source area characterization, and several locations would be established downgradient. It is not possible to specify the numbers and locations for these sampling points. Three points would typically be the minimum number, one located immediately downgradient of the source area and two located to either side of the center line. If contaminants were detected in any of the downgradient locations, additional locations would need to be established downgradient and/or side-gradient of those locations to complete boundary delineation. This process would continue until both the downgradient and lateral extent of the contamination were established.

As indicated, the numbers and locations of these sampling locations are subject to site scale and other factors and can only be determined in the field using best judgement. At this point, some attention should be given to vertical characterization of the contaminants. Additional samples should be collected at locations below the depths at which the contaminants were identified until the vertical extent is determined. If this is not accomplished during screening activities, it must be done during subsequent investigations with permanent monitoring wells.

Single-source light non-aqueous phase liquids (LNAPL) problems are generally no more complicated than the non-aqueous phase delineation problems. If there are no serious vertical profiling problems, however, the sampling device should be capable of identifying the presence of and determining the thicknesses of the floating LNAPL layers.

A more complex situation would be a single source area in which there is a dense non-aqueous phase liquid (DNAPL) product layer with associated aqueous phase contamination. The initial part of the investigation would be conducted in a manner similar to the simplest case. After delineation of the aqueous phase plume, additional characterization would be required for the DNAPL component. If a confining layer is present and the depth to the surface of this layer is known, samples should be collected from the boundary between the water-bearing formation and the confining unit to determine if DNAPL products are present. Wherever DNAPLs are found, additional samples must be collected. The rationale for sample location selection depends on both sub-surface structure and ground water flow direction. DNAPL constituents may flow down-dip on the surface of confining units, in directions that are totally contrary to ground water flow directions. No attempt at DNAPL characterization should be made until the site geology (stratigraphy, structure and ground water flow patterns) are known.

5.6.2 Multiple-Source Area Gridded Programs

Some ground water screening investigations involve identifying multiple source areas and determining the size and shape (delineation) of the associated plumes over relatively large areas. In these cases, it may be appropriate to pre-determine and establish a grid pattern to direct the collection of ground water samples. As the apparent contaminant pattern begins to develop, it may be appropriate to disregard established but unsampled sampling locations and concentrate on other areas within the grid pattern. It may even be appropriate to expand the area of investigation by establishing additional sampling locations. These locations may be determined by using a grid or may be located using best judgement, in an iterative manner.

Considerations regarding non-aqueous phases must be observed here as well. If aqueous phase sample analysis indicates that DNAPL constituents may be present, sampling should be conducted at the surface of the confining unit to determine if product layers are present.

5.6.3 Typical Ground Water Screening Devices

Listed below are numerous tools, devices and techniques available to field investigators that can be used to effectively collect ground water samples for rapid field screening and plume delineation.

- Temporary wells -- Well casing can be installed temporarily either inside hollow-stem augers or in an open hole after removal of hollow- or solid-stem augers. Because of the potential for cross-communication between vertical intervals, this technique is appropriate only for screening the upper portion of the saturated zone. Samples are pumped or bailed directly from the well casing. Because turbidity is likely to be a problem using this technique, care should be taken when using the samples for metals screening. Depth of the investigation is limited only by the capability of the drill rig and cross-contamination considerations. See section 6.10 for temporary well installation procedures.
- Geoprobe® -- Slotted steel pipe is hydraulically pushed or hammer driven to the desired sampling depth. Samples are usually acquired with a peristaltic pump. The device is subject to cross-communication at threaded rod joints. It requires some knowledge of the saturated interval. The Geoprobe® is most useful at depths less than 30 to 40 feet below ground surface.

- **Hydropunch®** -- A larger, more versatile device, similar to the Geoprobe®, which is pushed to sampling depths with a drill rig. It requires some knowledge of saturated intervals to use successfully. Depths of investigation with this technology are roughly correlated to the capability of the drill rig used to push the sampling device.
- **Hydrocone®** -- This is a pressure-sealed sampling device that is hydraulically pushed to the desired sampling depth. It is capable of collecting a discrete sample from any depth at which it can be pushed. A limited volume of about 700 ml is collected and is generally turbid. This technique is mainly applicable for the screening for volatile organic compounds. A temporary well point can be driven by the same drill rig to collect samples with greater volume requirements. Samples from depths exceeding 100 feet have been obtained with this device. Routine depths obtained without special anchoring are generally within the 50-foot range, but are dependent on the geological materials being encountered.

5.7 Surface Water and Sediment Sampling Designs

5.7.1 Sampling Site Selection

The following factors should be considered in the selection of surface water and sediment sampling locations:

- Study objectives,
- Water use,
- Point source discharges,
- Nonpoint source discharges,
- Tributary locations,
- Changes in stream characteristics;
- Type of stream bed,
- Depth of stream,
- Turbulence;
- Presence of structures (weirs, dams, etc.);
- Accessibility; and
- Tidal effect (estuarine)

If the study objective is to investigate a specific water use such as a source of water supply, recreation, or other discrete use, then considerations such as accessibility, flow, velocity, physical characteristics, etc., are not critical from a water quality investigation standpoint

If the objective of a water quality study is to determine patterns of pollution, provide data for mathematical modeling purposes, conduct assimilative capacity studies, etc., where more than a small area or short stream reach is to be investigated, then several factors become interrelated and need to be considered in sampling location selection. An excellent guide to conducting surface water stream studies is F. W. Kittrells, "A Practical Guide to Water Quality Studies" (7).

Before any sampling is conducted, an initial reconnaissance should be made to locate suitable sampling locations. Bridges and piers are normally good choices as sites since they provide ready access and permit water sampling at any point across the width of the water body. However, these structures may alter the nature of water flow and thus influence sediment deposition or scouring. Additionally, bridges and piers are not always located in desirable locations with reference to waste sources, tributaries, etc. Wading for water samples in lakes, ponds, and slow-moving rivers and streams must be done with caution since bottom deposits are easily disturbed, thereby resulting in increased sediments in the overlying water column. On the other hand, wadeable areas may be best for sediment sampling. In slow-moving or deep water, a boat is usually required for sampling. Sampling station locations can be chosen without regard to other means of access if the stream is navigable by boat, especially in estuarine systems where boats frequently provide the only access to critical sampling locations.

Fresh water environments are commonly separated into two types:

- Flowing water, including rivers, creeks, and small to intermittent streams; and
- Water that is contained, with restricted flow including lakes, ponds, and manmade impoundments

Since these waterways differ considerably in general characteristics, site selection must be adapted to each. Estuarine environments are a special case and are discussed separately.

In the selection of a surface water sampling site in rivers, streams, or creeks, areas that exhibit the greatest degree of cross-sectional homogeneity should be located. When available, previously collected data may indicate if potential sampling locations are well mixed or vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately downstream of a riffle area will insure good vertical mixing. These locations are also likely areas for deposition of sediments since the greatest deposition occurs where stream velocities decrease provided that the distance is far enough downstream from the riffle area for the water to become quiescent. Horizontal (cross-channel) mixing occurs in constrictions in the channel, but because of velocity increases, the stream bottom may be scoured, and therefore, a constriction is a poor location to collect sediment.

Typical sediment depositional areas are located:

- Inside of river bends,
- Downstream of islands;
- Downstream of obstructions, and
- Areas of flow reversals

Sites that are located immediately upstream or downstream from the confluence of two streams or rivers should generally be avoided since flows from two tributaries may not immediately mix, and at times due to possible backflow can upset the depositional flow patterns.

When several locations along a stream reach are to be sampled, they should be strategically located

- At intervals based on time-of-water-travel, not distance, e.g., sampling stations may be located about one-half day time-of-water-travel for the first three days downstream of a waste source (the first six stations) and then approximately one day through the remaining distance
- At the same locations if possible, when the data collected is to be compared to a previous study
- Whenever a marked physical change occurs in the stream channel. Example: A stream reach between two adjacent stations should not include both a long rapids section of swift shallow water with a rocky bottom, and a long section of deep, slow-moving water with a muddy bottom. Stations at each end of the combined reach would yield data on certain rates of change, such as reaeration, that would be an unrealistic average of two widely different rates. The actual natural characteristics of the stream would be better defined by inserting a third sampling station within the reach, between the rapids and the quiet water sections
- To isolate major discharges as well as major tributaries. Dams and weirs cause changes in the physical characteristics of a stream. They usually create quiet, deep pools in river reaches that previously were swift and shallow. Such impoundments should be bracketed with sampling stations. When time-of-water-travel through the pools are long, stations should be established within the impoundments

Some structures, such as dams, permit overflow and cause swirls in streams that accomplishes significant reaeration of oxygen deficient water. In such cases, stations should be located short distances upstream and downstream from the structures to measure the rapid, artificial increase in dissolved oxygen, which is not representative of natural reaeration.

When major changes occur in a stream reach, an upstream station, a downstream station, and an intermediate station should be selected. Major changes may consist of:

- A wastewater discharge,
- A tributary inflow,
- Non-point source discharge (farms or industrial sites); and
- A significant difference in channel characteristics.

The use of three stations is especially important when rates of change of unstable constituents are being determined. If results from one of only two stations in a subreach are in error for some unforeseen reason, it may not be possible to judge which of the two sets of results indicate the actual rate of change. Results from at least two of three stations, on the other hand, may support each other and indicate the true pattern of water quality in the subreach.

To determine the effects of certain discharges or tributary streams on ambient water quality, stations should be located both upstream and downstream from the discharges. In addition to the upstream and downstream stations bracketing a tributary, a station should be established on the tributary at a location upstream and out of the influence of the receiving stream.

Unless a stream is extremely turbulent, it is nearly impossible to measure the effect of a waste discharge or tributary immediately downstream from the source. Inflow frequently "hugs" the stream bank due to differences in density, temperature, and specific gravity, and consequently lateral (cross-channel) mixing does not occur for some distance.

Tributaries should be sampled as near the mouth as feasible. Frequently, the mouths of tributaries are accessible by boat. Care should be exercised to avoid collecting water samples from stratified locations which are due to differences in density resulting from temperature, dissolved solids, or turbidity.

Actual sampling locations will vary with the size of the water body and the mixing characteristics of the stream or river. Generally, for small streams less than 20 feet wide, a sampling site should be selected where the water is well mixed. In such cases, a single grab sample taken at mid-depth at the center of the channel is adequate to represent the entire cross-section. A sediment sample could also be collected in the same vicinity if available.

For slightly larger streams, at least one vertical composite should be collected from mid-stream. Samples should be collected just below the surface, at mid-depth, and just above the bottom. For larger streams and rivers, at least quarter point (1/4, 1/2, and 3/4 width) composite samples should be collected. Dissolved oxygen, pH, temperature, and conductivity should be measured from each aliquot of the vertical composite.

For large rivers, several locations across the channel width should be sampled. Vertical composites across the channel width should be located in a manner that is roughly proportional to flow, i.e. they should be closer together toward mid-channel, where most of the flow is, than toward the banks, where the proportion of total flow is less. The number of vertical composites required and the number of depths sampled for each are usually determined in the field by the investigators. This determination is based on a reasonable balance between the following two considerations:

- The larger the number of subsamples, the more closely the composite sample will represent the water body, and
- Subsample collection is time-consuming and expensive, and increases the chance of cross-contamination.

In most circumstances, a number of sediment samples should be collected along a cross-section of a river or stream in order to adequately characterize the bed material. A common procedure is to sample at quarter points along the cross-section. When the sampling technique or equipment requires that the samples be extruded or transferred on site, they may be combined into a single composite sample. However, samples of dissimilar composition should not be combined but should be stored for separate analysis in the laboratory. To insure representative samples, the preferred method is diver deployed coring tubes.

5.7.3 Lakes, Ponds, and Impoundments

Lakes, ponds, and impoundments have a much greater tendency to stratify than rivers and streams. The relative lack of mixing generally requires that more samples be obtained. Occasionally, an extreme turbidity difference may occur where a highly turbid river enters a lake. For these situations, each layer of the vertically stratified water column needs to be considered. Since the stratification is caused by water temperature differences, the cooler, more dense river water is beneath the warmer lake water. A temperature profile of the water column as well as visual observation of lake samples can often detect the different layers which can be sampled separately.

The number of water sampling stations on a lake, pond, or impoundment will vary with the objective of the investigation as well as the size and shape of the basin. In ponds and small impoundments, a single vertical composite at the deepest point may be sufficient. Dissolved oxygen, pH, and temperature are generally measured for each vertical composite aliquot. In naturally-formed ponds, the deepest point is usually near the center; in impoundments, the deepest point is usually near the dam.

In lakes and larger impoundments, several vertical subsamples should be composited to form a single sample. These vertical sampling locations are often collected along a transect or grid. The number of vertical subsamples and the depths at which subsamples are taken are usually at the discretion of the field investigators. In some cases, it may be of interest to collect separate composites of epilimnetic and hypolimnetic zones (above and below the thermocline or depth of greatest temperature change).

In lakes with irregular shapes and with several bays and coves that are protected from the wind, additional separate composite samples may be needed to adequately determine water quality. Similarly, additional samples should be collected where discharges, tributaries, land use characteristics, etc., are suspected of influencing water quality.

When collecting sediment samples in lakes, ponds, and reservoirs, the sampling site should be approximately at the center of the water mass. This is particularly true for reservoirs that are formed by the impoundment of rivers or streams. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir, and the bed sediments near the center of the water mass will be composed of fine-grained materials. The shape, inflow pattern, bathymetry, and circulation must be considered when selecting sediment sampling sites in lakes or reservoirs.

5.7.4 Estuarine Waters

Estuarine areas are zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types, dependent upon freshwater inflow and mixing properties.

- Mixed estuary -- Characterized by an absence of vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is found in major freshwater sheetflow areas, featuring shallow depths.
- Salt wedge estuary -- Characterized by a sharp vertical increase in salinity and channelized freshwater inflow into a deep estuary. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase.
- Oceanic estuary -- Characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh and saline water mixing occurring near, or at, the shore line.

A reconnaissance investigation should be conducted for each estuarine study unless prior knowledge of the estuarine type is available. The reconnaissance should focus upon the freshwater and oceanic water dynamics with respect to the study objective. National Oceanic Atmospheric Administration (NOAA) tide tables and United States Geological Survey (USGS) freshwater surface water flow records provide valuable insights into the estuary hydrodynamics. The basic in-situ measurement tools for reconnaissance are:

- Boat.
- Recording fathometer.
- Salinometer,
- Dissolved oxygen meter, and
- Global Positioning System (GPS) equipment and charts.

These instruments coupled with the study objective or pollution source location, whether it is a point or nonpoint source problem, provide the focus for selecting sampling locations. More often than not, preplanned sampling locations in estuarine areas are changed during the actual study period. Because of the dynamics of estuaries, the initial sampling results often reveal that the study objective could be better served by relocating, adding, or deleting sampling locations.

Water sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides. All estuarine sampling should include vertical salinity measurements at one to five-foot increments coupled with vertical dissolved oxygen and temperature profiles. A variety of water sampling devices are used, but in general, the Van Dorn (or similar type) horizontal sampler or peristaltic pump are suitable.

Samples are normally collected at mid-depth in areas where the depths are less than 10 feet, unless the salinity profile indicates the presence of a halocline (salinity stratification). In that case, samples are collected from each stratum. Depending upon the study objective, when depths are greater than 10 feet, water samples may be collected at the one-foot depth from the surface, mid-depth, and one-foot from the bottom

Generally, estuarine investigations are two phased, with study investigations conducted during wet and dry periods. Depending upon the freshwater inflow sources, estuarine water quality dynamics cannot normally be determined by a single season study

5.7.5 Control Stations

In order to have a basis of comparison of water quality, the collection of samples from control stations is always necessary. A control station upstream from the waste source is as important as are stations downgradient, and should be chosen with equal care to ensure representative results. In some situations it is desirable to have background stations located in similar, nearby estuaries which are not impacted by the phenomena or pollutants being investigated. At times it may be desirable to locate two or three stations downstream from the waste inflow to establish the rate at which the unstable material is changing. The time-of-water-travel between the stations should be sufficient to permit accurate measurement of the change in the constituent under consideration

5.8 Waste Sampling Designs

5.8.1 Introduction

Waste sampling involves the collection of materials that are typically generated from industrial processes, and therefore may contain elevated concentrations of hazardous constituents. Waste sampling in its broadest term is conventionally considered to be sampling of processed wastes or man-made waste materials. Because of the regulatory, safety, and analytical considerations, wastewater sampling should be separate from waste sampling. Environmental sampling is also different from waste sampling as it involves the collection of samples from natural matrices such as soil, sediment, groundwater, surface water and air.

It is convenient to distinguish waste management units into two types due to RCRA safety protocols. The first, "open units", are units where wastes are generated, stored, or disposed, and would be open to the environment and environmental influences. Examples of open waste units are surface impoundments and waste piles. "Closed units" are waste containers/drums, tanks, or sumps where the potential for the accumulation of toxic vapors or explosive/ignitable gases exists. While both open and closed waste units are considered dangerous because of the potential exposure to concentrated wastes, closed units are regarded as high hazards due to their potential to accumulate gases and vapors.

5.8.2 Waste Investigation Objectives

The first step in an investigation is the identification of study objectives. Thorough planning and researching of the waste generation/management practices is then required for the samples and associated data to reflect the waste population characteristic(s) of interest. Prior to sampling wastes, it is extremely important to obtain and assess all of the available information, e.g., waste generation process(es), waste handling and storage practices, previous field screening results, existing sampling and analytical data, any pertinent regulations, and permitting or compliance issues.

Common objectives in waste sampling investigations include:

- Determine if a material is a hazardous waste;
- Characterize a wastestream,
- Determine if a waste material has been released into the environment; or
- Characterize environmental media contaminated with hazardous waste

The most frequently used objective during RCRA Case Development/Investigation Evaluations and Criminal Investigations involve hazardous waste determinations. For studies that are designed to determine if a release has occurred, it is recommended that samples be collected from the source as well as both the affected and the unaffected media.

Waste matrices are frequently heterogeneous in nature due to the physical characteristics of the material (particle size, viscosity, etc.), the distribution of hazardous constituents within the matrix, or the manner in which the material has been managed or disposed. When waste is comprised of strata that can be separated by the sampling equipment (e.g., liquid-liquid or liquid-solid phases), it is not necessary to collect a sample that is representative of the entire unit to make a waste determination. An acceptable objective would be to make a waste determination on a specific strata. For example, in drums containing an oil and water mixture, a glass thief or a composite liquid waste sampler (COLIWASA) could be used to sample only the oil or only the water phase to determine if the phase of interest contains hazardous constituents or characteristics.

5.8.3 Considerations for Waste Sampling Designs

Waste sampling designs should consider the variability of the sample population in terms of the characteristic of concern, the physical size and state of items present in the population, and the ability to access all portions of the population for purposes of sampling. Elements of the sampling design may include the determination of the actual sampling locations and the number of samples to be collected, decisions on the type of samples (grab or composite) to collect, and selection of the appropriate sampling equipment. While sampling locations are usually restricted to accessible portions of a sample population, the number of samples is usually determined by preliminary information, the size of the sample population, field screening results, and the variability of the waste. Composite samples are used to obtain average concentrations of waste units while grab samples are utilized to delineate hot spots or to acquire data for sample variability.

A small wastestream that has a hazardous constituent or characteristic randomly distributed (relatively homogeneous matrix) requires fewer samples than a large wastestream that has a constituent or characteristic of concern which is non-randomly distributed (heterogeneous matrix). For a waste that is randomly distributed, a directed or systematic grid sampling design would be appropriate depending on the objectives, whereas a stratified sampling or very specialized design should be employed for wastes that are non-randomly distributed.

Reviewing the available preliminary information should improve the effectiveness of any sampling investigation. If waste variability cannot be estimated after review of available information, then a preliminary sampling and analytical effort may be necessary. A preliminary sampling investigation would be important when the study's objective is to fully characterize a waste stream using a probabilistic or "statistical" design.

Probabilistic sampling designs similar to the ones used to characterize a site with soil contamination can be used to characterize large units such as waste piles or surface impoundments with random contaminant distributions. Note that an authoritative design is often appropriate to demonstrate the maximum degree of contamination in certain waste management units. Examples include the collection of a sludge sample for inorganic analyses at the inlet to a surface impoundment, or a sample for volatile organic compound analysis from the most recently generated material placed in a waste pile.

A comprehensive probabilistic design may be required to fully characterize unusually complex wastestreams that have a high degree of heterogeneity. For some highly complex, heterogeneous wastes where an average concentration would not be reflected by a design of reasonable scope, an authoritative sampling design based on the sampler's experience may be the only feasible approach.

No background or control samples are required when collecting highly concentrated waste samples.

5.8.4 Waste Sampling Equipment

An extremely important factor in the sampling strategy will be determined by the physical characteristics of the waste material. Selecting appropriate sampling equipment can be one of the most challenging tasks in developing a sampling design. By selecting sampling equipment that will not discriminate against certain physical characteristics (e.g., phase, particle size, etc.), sampling bias can be minimized during waste sampling. Because wastes often stratify due to different densities of phases, settling of solids, or varying waste constituents generated at different times, it also may be important to obtain a vertical cross section of the entire unit.

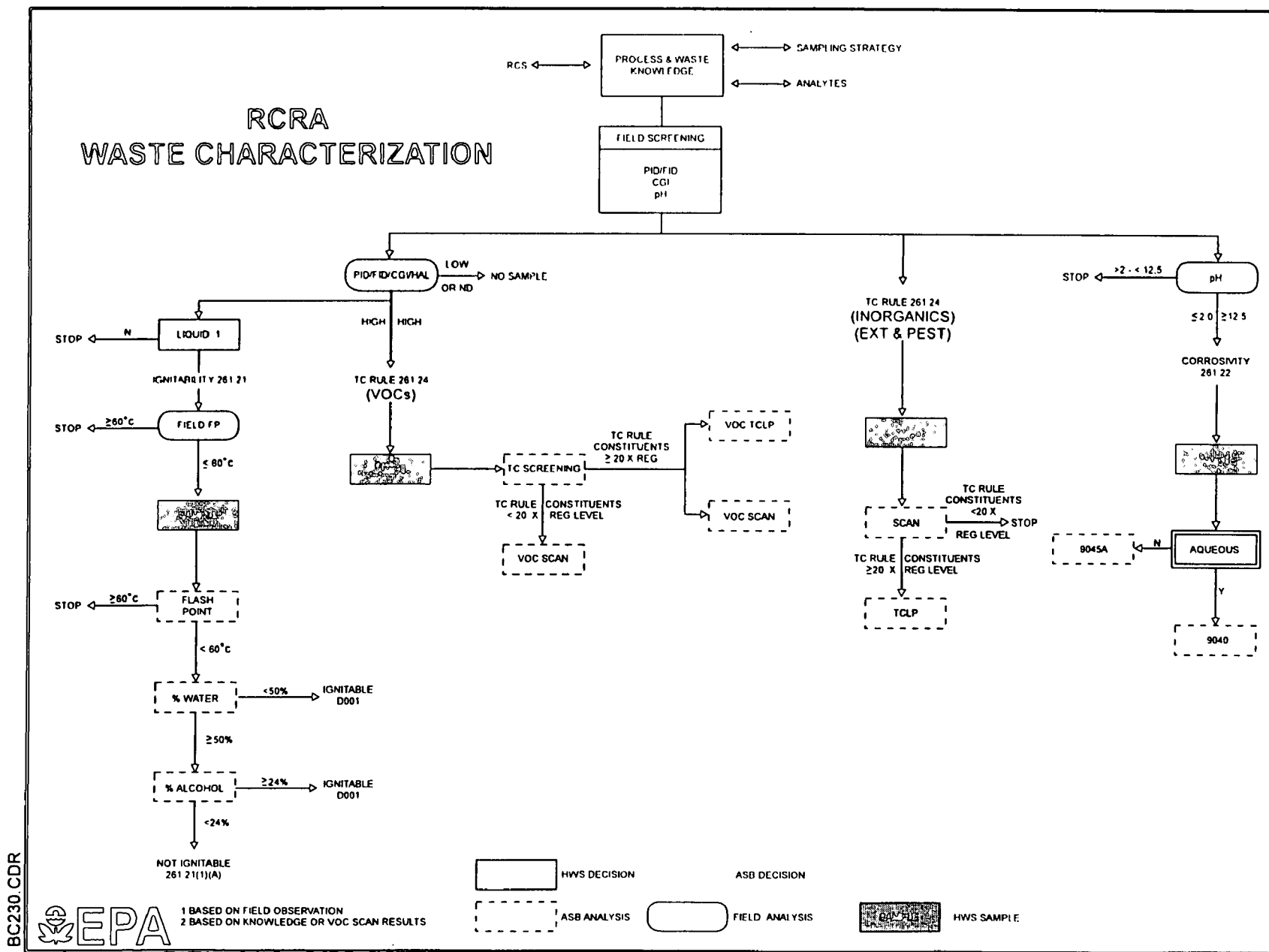
Other desired features of sampling equipment that should be considered during sample design are, the ability to access the desired sampling locations, the ability to maintain sample integrity, the reactivity of equipment with the waste, and the ability to properly decontaminate the sampling apparatus. In addition, analytical requirements such as the sample handling and preparation to correctly analyze physical samples need to be considered. For solidified wastes, samples will often be required to undergo particle size reduction (PSR) prior to chemical analyses.

Sampling equipment should be selected to accommodate all of the known physical characteristics of concern or chosen such that the effect of any sampling bias is understood. Often because of a lack of preliminary information, varying field conditions, or waste heterogeneity, a piece of equipment selected during the sampling design may be unsuccessful for collecting a particular waste sample and another piece of equipment will be required as a substitute. Any sampling bias or deficiencies resulting from the use of substituted equipment should be documented and reviewed with the data.

5.8.5 Field Screening

Field screening can be very effective in waste characterization and extremely valuable in selecting appropriate sampling locations and chemical analyses when little preliminary data exists. Field investigators routinely use observations of the physical characteristics of drum contents, air monitoring equipment, pH meters/paper, and field flash point analyzers to confirm preliminary data or to decide on sampling locations during waste investigations. Figure 5-1 (RCRA Waste Characterization) is a flow diagram that depicts the process that field investigators may use to decide which waste containers to sample and what analyses to perform on particular samples.

FIGURE 5-1
RCRA WASTE CHARACTERIZATION FLOW CHART



5.9 Wastewater Sampling Designs

Introduction

Wastewater sampling studies focus primarily on collecting wastewater samples of the influent or effluent at domestic and non-domestic facilities. The sampling activities are usually conducted for National Pollutant Discharge Elimination System (NPDES) compliance, compliance assistance, civil and criminal investigations, and water quality studies. The collection of wastewater samples is necessary in order to obtain reliable data that can support compliance or enforcement activities. Specific sampling criteria for the collection of wastewater samples is given in Section 9 of this SOP.

The main considerations in developing a wastewater sampling strategy are as follows:

- Type of study (Compliance Sampling Inspection, Diagnostic Evaluation, etc.).
- Regulated or target pollutants in the wastewater stream to be sampled
- Selection of the projected sampling locations to satisfy the study objectives.
- Quality control criteria of the parameters to be sampled (oil and grease samples need to be collected as grab samples, trip blanks are taken into the field for the collection of samples for volatile organic compound analyses, etc.).

Complexity of the sampling program will vary with a number of factors. Some primary factors are as follows:

- The number of sampling stations to be monitored. This will be dependent on NPDES permit requirements and the type of study (typically Toxic CSIs and DEs require a greater amount of sampling stations than a routine CSI).
- Special handling requirements of the target pollutants (sampling equipment for trace organic compounds require special cleaning procedures, etc.).
- Laboratory conducting the analyses (use of a contract laboratory may require shipping from the field, etc.).
- Accessibility to sampling stations
- Process and operation criteria of the source generator (e.g., batch operation versus continuous discharge)
- Coordination of participating organizations in the study (e.g., state assistance with the sample collection).
- The length of sampling activities will dictate logistical considerations (e.g., shipment of samples, additional supplies, etc.).

5.10 UST and UIC Sampling Designs

UST and UIC studies focus on determining the quality of the ground water in a target area. Sampling of the ground water in the target area provides the needed scientific data for regional decisions on impacted areas. The main considerations in developing a UST or UIC sampling strategy are as follows:

- Identification of the pollutants in the ground water
- Identification of the source generator.
- Delineation of the contamination plume

Complexity of the sampling program will vary based on a number of factors. Some primary factors are as follows:

- Size of the target area
- Hydrogeological conditions of the target area.
- Accessibility to potable and ground water monitoring wells.
- Process mode of the source generator responsible for the ground water contamination

Whenever possible, at least one background location (possibly more) should be selected to sample ground water quality representative of an area that is not impacted by any source generator. Background samples should be collected prior to collection of potentially contaminated samples. Enough sampling sites should be utilized to assure a representative sampling of ground water in the target area to adequately characterize the extent of ground water contamination.

Primary impact sampling locations, should be located downgradient of the source generator and at a distance near to the source generator to isolate the contributing process mode responsible for the ground water contamination.

5.11 Air Toxics Monitoring Designs

Ambient air monitoring strategies vary depending upon the monitoring objective. However, some elements are important for any air monitoring objective. Meteorology measurements should be taken concurrent with any major air monitoring effort. At a minimum, these measurements should include wind speed and wind direction.

At least one background sampling location (possibly more) should be selected to sample an air mass that is representative of the area before it is impacted by any emission from the site being monitored. Background samples should be collected concurrent with the site samples. An adequate number of sampling locations should be selected to assure representative sampling of the air mass, and provide enough data to adequately characterize the contaminant concentrations being emitted from the site. Generally, at a site with soil contamination, sampling should be conducted at the areas of high contaminant concentration, near the downwind fence lines, and/or at the fence lines near any residences.

Whenever possible, the sampling sites should be located in an open space and well away from any tall buildings. Attention should be given to avoiding potential local interference such as earth moving equipment, haul roads, etc.

Sampling methods for various ambient air pollutants are given in Section 14 of this SOP.

5.12 Data Quality Objectives

PERFORMANCE OBJECTIVE:

- To ensure that a proper level of QA/QC is performed to match the analytical effort of the study.
- To determine what practical limits are to be placed on the subsequent use of the analytical and field data

As defined in EPA's "Data Quality Objectives Process for Superfund, Interim Final Guidance" (8), Data Quality Objectives (DQO) are qualitative and quantitative statements derived from the outputs of each step of the DQO process. The DQO process offers a way to plan field investigations so that the quality of data collected can be evaluated with respect to the data's intended use. (For a detailed discussion of the complete DQO process, refer to the referenced guidance document.)

Depending on the study objective and DQOs, different field procedures and analytical methods may be acceptable. Data collected in the field include samples and site information. The methods by which samples are collected may limit the uses of the subsequent analytical data. The methods by which site information, such as physical measurements, photographs, field notes, etc., are collected, may reduce their accuracy. The manner in which sampling equipment is cleaned will also affect the DQO level of the data. Higher quality methods may be substituted for lower level work.

Field methodologies described in this SOP support the highest level of data gathering, unless stated otherwise. These are the standard methods to be used for all studies. Any deviations from these methods must be documented in the field logbook or the approved study plan. Investigators must be aware that such deviations in the field work may reduce the DQO level of the data, with a subsequent reduction in the data uses.

Occasionally, special analytical procedures may require specialized field procedures and equipment. The lead investigator must be aware that these procedures should be specified in the approved study plan prior to beginning the study.

There are four data categories. The first two are defined by Region 4; the latter two are in the "Interim Final Guidance"

- **Field Screening** -- This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling locations and health and safety support. Data can be generated regarding the presence or absence of certain contaminants at sampling locations.
- **Field Analyses** -- This level is characterized by the use of portable analytical instruments which can be used on site, or in a mobile laboratory stationed near a site. Depending upon the types of contaminants, sample matrix, and personnel skills, qualitative and quantitative data can be obtained.

- **Screening Data with Definitive Confirmation** -- These data are generated by rapid, less precise methods of analysis with less rigorous sample preparation. Sample preparation steps may be restricted to simple procedures such as dilution with a solvent, instead of elaborate extraction/digestion and cleanup. Screening data provides analyte identification and quantification, although the quantification may be relatively imprecise. At least 10% of the screening data should be confirmed using appropriate analytical methods and QA/QC procedures and criteria associated with definitive data. Screening data without associated confirmation data is not considered to be data of known quality.
- **Definitive Data** -- These data are generated using rigorous analytical methods, such as approved EPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. These methods produce tangible raw data (e.g., chromatograms, spectra or digital values) in the form of paper printouts or computer-generated electronic files. Data may be generated at the site or at an off-site location, as long as the QA/QC requirements are satisfied. To be definitive, either the analytical or total measurement error must be determined.

DQO information in field study plans should include:

- **Sampling locations** -- including background and/or control samples.
- **Sampling procedures** -- reference to this SOP or other guidance documents.
- **Sample type** -- surface water, ground water, soil, waste, GPS coordinates, etc
- **Use of data** -- characterize nature and extent of contamination, accurate sample locations, etc
- **Data types** -- field measurements and field analytical data level and laboratory analyses and laboratory analytical data levels
- **Field QA/QC** -- percentage of split and duplicate samples, trip blanks, rinse blanks, etc

5.13 Specific Sample Collection Quality Control Procedures

5 13.1 Introduction

This subsection provides guidelines for establishing quality control procedures for sampling activities. Strict adherence to all of the standard operating procedures outlined in this subsection form the basis for an acceptable sampling quality assurance program.

5 13 2 Experience Requirements

There is no substitute for field experience. Therefore, all professional and paraprofessional investigators shall have the equivalent of six months field experience before they are permitted to select sampling sites on their own initiative. This field experience shall be gained by on-the-job training using the "buddy" system. Each new investigator should accompany an experienced employee on as many different types of field studies as possible. During this training period, the new employee will be permitted to perform all facets of field investigations, including sampling, under the direction and supervision of senior investigators.

5 13.3 Traceability Requirements

All sample collection activities shall be traceable through field records to the person collecting the sample and to the specific piece of sampling equipment (where appropriate) used to collect that sample. All maintenance and calibration records for sampling equipment (where appropriate) shall be kept so that they are similarly traceable. See Sections 3.1 through 3.6 for specific procedures to be utilized that insure traceability.

5 13 4 Chain-of-Custody

Specific chain-of-custody procedures are included in Sections 3.1 through 3.6 of this SOP. These procedures will insure that evidence collected during an investigation will withstand scrutiny during litigation. To assure that procedures are being followed, it is recommended that field investigators or their designees audit chain-of-custody entries, tags, field notes, and any other recorded information for accuracy.

5.13 5 Sampling Equipment Construction Material

Sampling equipment construction materials can affect sample analytical results. Materials used must not contaminate the sample being collected and must be easily decontaminated so that samples are not cross-contaminated.

5 13.6 Sample Preservation

Samples for some analyses must be preserved in order to maintain their integrity. Preservatives required for routine analyses of samples collected are given in Appendix A of this SOP. All chemical preservatives used will be supplied by the Region 4 laboratory. All samples requiring preservation should be preserved immediately upon collection in the field. Samples that **should not** be preserved in the field are

- Those collected within a hazardous waste site that are known or thought to be highly contaminated with toxic materials which may be highly reactive. Barrel, drum, closed container, spillage, or other source samples from hazardous waste sites are not to be preserved with any chemical. These samples may be preserved by placing the sample container on ice, if necessary.
- Those that have extremely low or high pH or samples that may generate potentially dangerous gases if they were preserved using the procedures given in Appendix A.
- Those for metals analyses which are shipped by air shall not be preserved with nitric acid in excess of the amount specified in Appendix A.

All samples preserved with chemicals shall be clearly identified by indication on the sample tag that the sample is preserved. If samples normally requiring preservation were not preserved, field records should clearly specify the reason.

5 13.7 Special Precautions for Trace Contaminant Sampling

Some contaminants can be detected in the parts per billion and/or parts per trillion range. Extreme care must be taken to prevent cross-contamination of these samples. The following precautions shall be taken when trace contaminants are of concern.

- A clean pair of new, non-powdered, disposable latex gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come into contact with the media being sampled.
- Sample containers for source samples or samples suspected of containing high concentrations of contaminants shall be placed in separate plastic bags immediately after collecting, tagging, etc.
- If possible, ambient samples and source samples should be collected by different field teams. If different field teams cannot be used, all ambient samples shall be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples shall never be placed in the same ice chest as environmental samples. Ice chests or shipping containers for source samples or samples suspected to contain high concentrations of contaminants shall be lined with new, clean, plastic bags.
- If possible, one member of the field sampling team should take all the notes, fill out tags, etc., while the other members collect the samples.
- When sampling surface waters, the water sample should always be collected before the sediment sample is collected.

- Sample collection activities should proceed progressively from the least suspected contaminated area to the most suspected contaminated area.
- Investigators should use equipment constructed of Teflon®, stainless steel, or glass that has been properly precleaned (Appendix B) for collection of samples for trace metals or organic compounds analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern. Equipment constructed of plastic or PVC shall not be used to collect samples for trace organic compounds analyses.

5 13 8 Sample Handling and Mixing

After collection, all sample handling should be minimized. Investigators should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, investigators should ensure that melted ice cannot cause the sample containers to become submerged, as this may result in sample cross-contamination. Plastic bags, such as Zip-Lock® bags or similar plastic bags sealed with tape, should be used when small sample containers (e.g., VOC vials or bacterial samples) are placed in ice chests to prevent cross-contamination.

Once a sample has been collected, it may have to be transferred into separate containers for different analyses. The best way to transfer liquid samples is to continually stir the sample contents with a clean pipette or precleaned Teflon® rod and allow the contents to be alternately siphoned into respective sample containers using Teflon® or PVC (Tygon® type) tubing (and a siphon bulb to start the flow). Teflon® must be used when analyses for organic compounds or trace metals are to be conducted. Any device used for stirring, or tubing used for siphoning, must be cleaned in the same manner as other equipment (Appendix B). However, samples collected for volatile organic compound, oil and grease, bacteria, sulfides, and phenols analyses may not be transferred using this procedure.

It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample media. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

- 1 The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
- 2 Two quarters should then be mixed to form halves.
- 3 The two halves should be mixed to form a homogenous matrix.

This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.

5 13 9 Special Handling of Samples for Volatile Organic Compounds (VOCs) Analysis

Water samples to be analyzed for volatile organic compounds should be stored in 40-ml septum vials with screw cap and Teflon®-silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

The vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a convex meniscus. The cap is then applied and some overflow is lost, but the air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles. If any bubbles are present, repeat the procedure with another clean 40-ml vial. Since the VOC vials are pre-preserved, caution should be exercised when the vials are used as the collection device for surface water samples in order to prevent the loss of the preservative. When collecting water samples for VOCs, three 40-ml vials containing preservative should be filled with sample.

One 2-oz glass container with screw caps and Teflon®-silicon disks in the cap are used for the storage of soil and sediment samples for VOC analyses. Soil and sediment samples collected for VOC analyses should not be mixed. The sample container should be filled completely so that no head space remains in the sample containers.

5.13.10 Estimating Variability

Spacial Variability

The following spacial duplicate sampling procedures should be used during the collection of samples as a measure of variability within the area represented by the sample. Spacial duplicate grab and/or composite samples should be collected during all major investigations and studies conducted by the Branch. A "major study" would include all investigations where more than twenty (20) samples were collected, or those studies where the study objectives dictate that additional quality control samples be collected. No more than ten percent of all samples should be collected as spacial duplicates. These samples should be collected at the same time, using the same procedures, the same type of equipment, and in the same types of containers as the original samples, but collected from a different location within the area represented by the original. They should also be preserved in the same manner and submitted for the same analyses as the required samples. The collection of spacial duplicate composite samples requires that the sample aliquots be arrayed in a manner different from the original sample and spaced within the same area of representativeness. Data from spacial duplicates will be examined by the lead investigator to determine if the samples represent the areas intended in the project work plan.

Temporal Variability

When required, temporal variability at a given sampling location will be measured by collecting temporal duplicate samples. These samples will be collected from the same sampling location, using the same techniques and the same type of equipment, but at a time different from the original sample. The time selected for the temporal duplicate sample will be within the same span of time for which the original sample is designed to be representative in the project work plan. Data from temporal duplicates will be examined by the project leader to determine if samples represent the time span intended in the project work plan.

Sample Handling Variability

The effectiveness of sample handling techniques will be measured by collecting split and blank samples

Split Samples

Split samples will be collected by initially collected twice as much material as normally collected for a sample. After mixing, the material will be apportioned into two sets of containers. Both sets of containers will be submitted for analyses with one set designated as an "original sample", the other designated as a "split sample". Data from split samples will be examined by the Quality Assurance Officer to determine sample handling variability. On large studies (more than 20 samples), no more than 10 percent of all samples will be collected as split samples.

Blank Samples

The following blank samples will be prepared by the laboratory and obtained by the project leader prior to traveling to a sample site.

1. **Water Sample VOC Trip Blank** -- A water sample VOC trip blank is required for every study where water samples are collected for VOC analysis. Two sealed preserved (or unpreserved if appropriate) 40-ml VOC vials will be transported to the field. For routine studies these samples will be prepared by lab personnel. Investigators shall request that these samples be provided at least one week in advance of scheduled field investigations and inspections and never (except in emergency situations) less than two days in advance of scheduled field investigations and inspections. These samples should not be picked up earlier than the morning of departure for the scheduled inspection/investigation. These field blanks will be handled and treated in the same manner as the water samples collected for volatile organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-of-Custody Records as trip blanks.
2. **Soil Sample VOC Trip Blank** -- A soil sample VOC trip blank is required for every study where soil samples are collected for VOC analysis. The preparation and pick up of this sample will be the same as for the water sample VOC trip blank. One 2-oz. soil VOC vial will be transported to the field. This field blank will be handled and treated by Branch personnel in the same manner as the soil samples collected for volatile organic compounds analysis on that particular study. These samples will be clearly identified on sample tags and Chain-Of-Custody Records as trip blanks.

The following blanks are prepared in the field:

1. **Inorganic Sample Preservative Blanks** -- Metals and general inorganic sample containers filled with analyte-free water will be transported to the field and preserved and submitted for the same analyses as the other inorganic samples collected. These samples will be clearly identified as preservative blanks on sample tags and the Chain-Of-Custody Record(s). At least one preservative blank for each type of preserved sample should be collected at the end of routine field investigations. A minimum of one preservative blank should be prepared in the field at the beginning and end of all major field investigations that last more than one week.

- 2 Equipment Field Blanks -- When field cleaning equipment is required during a sampling investigation, a piece of the field-cleaned equipment will be selected for collection of a rinse blank. At least one rinse blank will be collected during each week of sampling operations. After the piece of equipment has been field cleaned and prior to its being used for sample operations, it will be rinsed with organic/analyte free water. The rinse water will be collected and submitted for analyses of all constituents for which normal samples collected with that piece of equipment are being analyzed
- 3 Organic/Analyte Free Water System Blanks -- When using a portable organic-free water generating system in the field, a sample of the water generated will be collected at least once during each week of operations. The collected water sample will be submitted for analyses of all constituents for which normal samples are being analyzed.
- 4 Material Blanks -- When construction materials are being used on a site in such a way as to have a potential impact on constituent concentrations in the sample, a sample of the materials will be submitted for analyses. An example of a situation where construction blanks are required is monitoring well construction. In this situation all materials used in well construction should be submitted for analyses (e.g., grout, sand, tap water, etc.)
- 5 Automatic Sampler Blanks -- In general, cleaning procedures outlined in Appendix B of this SOP should be adequate to insure sample integrity. However, it is the standard practice of the Branch to submit automatic sampler blanks for analyses when automatic samplers are used to collect samples for organic compounds and metals analyses. Automatic sampler blanks for other standard analyses shall be submitted at least once per quarter.

The Quality Assurance Officer will inform the project leaders and management when blank samples are found to be unacceptably contaminated. The Quality Assurance Officer will immediately initiate an investigation to determine the cause of the problem. The results of this investigation will be promptly reported to appropriate personnel so that corrective action and/or qualifications to the data can be initiated.

5 13 12 Special Quality Control Procedures for Water Samples for Extractable Organic Compounds, Pesticides, or Herbicides Analyses (Matrix Duplicate)

Duplicate water samples shall be submitted to the laboratory for extractable organic compounds, pesticides, and/or herbicides analyses from at least one sampling location per project and laboratory used. These samples should be collected from a location expected to be relatively free from contamination, since the samples will be used for laboratory quality control purposes. The duplicate samples should be clearly identified as "Duplicate Sample for Matrix Spike" on the sample tag, Chain-Of-Custody Record, in the field logbook, and on the Contract Laboratory Program (CLP) Traffic Report Form (if appropriate). This procedure shall be followed for all projects where water samples are collected for the indicated analyses.

5 13 13 Special Quality Control Procedures for EPA Contract Laboratories

On a case-by-case basis, field investigators may be required to collect split samples (or duplicate samples if appropriate) for analyses by both the Region 4 laboratory and contract laboratories. The split samples are to be submitted to the Region 4 laboratory using established procedures. The contract laboratory involved shall not be notified that samples were split, i.e., there should be no indication on Chain-Of-Custody Records or CLP Traffic Report Forms submitted to the contract laboratories that these samples were split with the Region 4 laboratory.

5.13.14 Special Quality Control Procedures for Dioxins and Furans

All samples collected for dioxins and furans analyses are analyzed by other EPA laboratories or through contract laboratories. The Region 4 laboratory does not conduct in-house analyses for dioxins and furans. The Region 4 laboratory should be consulted for the current quality control procedures for dioxin and furan samples prior to the sampling event.

5.14 Internal Quality Control Procedures

5.14.1 Introduction

The focus of this subsection is on Field Equipment Center (FEC) operations involving preparation of sampling and support equipment for field operations as well as for field data generated under the Specific Sample Collection Quality Control Procedures discussed in Section 5.13. Quality control checks of these operations insure that field sampling teams are provided with equipment that is suitable for sampling use, and that field sampling is conducted using proper procedures.

5.14.2 Traceability Requirements

Records, in the form of bound notebooks, will be kept by FEC personnel documenting the dates of operations and the person performing operations for the following:

- Organic/Analyte Free Water System Maintenance (Field and FEC Systems) -- Maintenance on field systems will be performed immediately following every major study, or at least once per calendar quarter. FEC system maintenance will be performed at least once per calendar quarter.
- Air Monitoring Instrumentation Checkouts -- Pre-loadout checks on air monitoring instrumentation will be recorded each time they are performed. Discrepancies will be immediately reported to the Branch Safety Officer.
- Self Contained Breathing Apparatus (SCBA) Checkouts -- Pre-loadout checks on SCBAs will be recorded when they are performed. SCBA checkouts will be performed at least once per calendar quarter in the absence of loadout requests. Any discrepancies will be reported immediately to the Branch Safety Officer.
- Other Equipment Maintenance -- Maintenance performed on equipment other than that listed above will be recorded in a logbook for miscellaneous field equipment. All required repairs will be reported to the FEC coordinator.
- Sampling Containers and Latex Gloves -- A record will be kept of shipments received of sampling containers and latex gloves. Containers and gloves will be recorded by lot numbers. Upon receipt, the Quality Assurance (QA) Officer will be notified. Containers and gloves within a received lot will not be used until they have been checked by the QA Officer.

All equipment cleaned and wrapped for field use will be marked with the date on which preparation was completed. Equipment will be stored in the FEC in specified areas to minimize the risk of contamination while awaiting use.

5 14 3 Specific Quality Control Checks

At least once per calendar quarter, the QA Officer will conduct the following checks and issue a written report on the results

- 1 Collect and submit for analyses samples of each lot of containers received during that quarter
Bottles from each lot will be tagged and sealed, then submitted for the following analyses

One-Gallon Amber -- metals, cyanide, extractable organics, and pesticides

8-oz. Glass -- metals, cyanide, extractable organics, and pesticides

1-Liter Polyethylene -- metals and cyanide.

Latex glove samples will be collected as rinse blanks using organic/analyte free water. The rinsate will be submitted for analyses of VOCs, metals, cyanide, extractable organics, and pesticides. A new glove will be rinsed for each parameter (e.g., one glove for VOC sample, another glove for metals, etc.) to avoid dilution of potential contaminants on the gloves.

- 2 Collect and submit for analyses a sample of water from the FEC organic/analyte free water system. The sample will be submitted for analyses of VOCs, metals, cyanide, extractable organics, and pesticides.
- 3 Collect and submit for analyses a sample of analyte-free water stored in one-gallon containers at the FEC. The sample will be submitted for analyses of metals and cyanide.
- 4 Collect and submit for analyses a rinsate blank of at least one piece of sampling or sample related equipment stored at the FEC. The sample will be submitted for analyses of VOCs, metals, cyanide, extractable organics, and pesticides.
- 5 Collect the results of field quality control samples from the project leaders for the quarter. Normally, field quality control samples consist of the following:
 - Field split samples (not to include inter-lab splits),
 - Water VOC trip blank samples,
 - Soil VOC trip blank samples,
 - Inorganic sample preservative blanks,
 - Equipment field rinse blanks,
 - Field organic/analyte free water system blanks, and
 - Material blanks

The QA Officer will evaluate all data received and immediately attempt to resolve any problems found. A written report will be issued on the quality control checks during each calendar quarter. The report will be submitted to appropriate personnel.

5.15 Investigation Derived Waste (IDW)

5 15 1 Types of IDW

Materials which may become IDW are

- Personnel protective equipment (PPE) -- This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc
- Disposable equipment -- This includes plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers (COLIWASAs), Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.
- Soil cuttings from drilling or hand augering.
- Drilling mud or water used for water rotary drilling.
- Ground water obtained through well development or well purging
- Cleaning fluids such as spent solvents and washwater.
- Packing and shipping materials

Table 5 15 1 lists the types of IDW commonly generated during investigations, and current disposal practices

5 15 2 Management of Non-Hazardous IDW

Disposal of non-hazardous IDW from hazardous waste sites should be addressed in the study plan. To reduce the volume for transportation back to the FEC, it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum

If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE, disposable equipment, and/or paper/cardboard wastes into the facilities' dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a nearby permitted landfill. On larger studies, waste hauling services may be obtained and a dumpster located at the study site. Non-hazardous IDW may also be buried on site near the contamination source, with the burial location noted in the field logbook.

Disposal of non-hazardous IDW such as drill cuttings, purge or development water, decontamination washwater, drilling muds, etc., should be specified in the approved study plan. It is recommended that these materials be placed into a unit with an environmental permit such as a landfill or sanitary sewer. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place these types of IDW into the facilities treatment system. It may be feasible to spread drill cuttings around the borehole, or if the well is temporary, to place the cuttings back into the borehole. Cuttings, purge water, or development water may also be placed in a pit in or near the source area. Monitoring well purge or development water may also be poured onto the ground downgradient of the monitoring well. Purge water from private potable wells which are in service may be discharged directly onto the ground surface.

The minimum requirements of this subsection are

- Liquid and soil/sediment IDW must be containerized and analyzed before disposal
- The collection, handling, and proposed disposal method must be specified in the approved study plan

5 15 3 Management of Hazardous IDW

Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan. Hazardous IDW must be disposed as specified in US-EPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed of in the source area from which they originated, if doing so does not endanger human health and the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to permit arrangements for proper containerization, labeling, transportation, and disposal/treatment in accordance with US-EPA regulations.

The generation of hazardous IDW should be minimized to conserve Branch resources. Most routine studies should not produce any hazardous IDW, with the exception of spent solvents and possibly purged ground water. Care should be taken to keep non-hazardous materials segregated from hazardous waste contaminated materials. The volume of spent solvents produced during equipment decontamination should be controlled by applying only the minimum amount of solvent necessary, and capturing it separately from the washwater.

At a minimum the requirements of the management of hazardous IDW are as follows:

- Spent solvents must be returned to the FEC for proper disposal or recycling.
- All hazardous IDW must be containerized. Proper handling and disposal should be arranged prior to commencement of field activities.

**TABLE 5.15.1
DISPOSAL of IDW**

TYPE	HAZARDOUS	NON-HAZARDOUS
PPE-Disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Double bag waste. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.
PPE-Reusable	Decontaminate as per Appendix B, if possible. If the equipment cannot be decontaminated, containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Decontaminate as per Appendix B.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	N/A
Soil Cuttings	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site manager for testing and disposal.
Groundwater	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site manager for testing and disposal.
Decontamination Water	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site manager for testing and disposal.
Disposable Equipment	Containerize in 55-gallon drum or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site manager for testing and disposal.
Trash	N/A	Double bag waste. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.

5.16 References

- 1 US-EPA, Guidance for the Data Quality Objectives Process (EPA QA/G-4, 1994)
- 2 ASTM, Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives (D-34.02.10-Draft)
- 3 ASTM, Standard Guide for the Generation of Environmental Data Related to Waste Management Activities (D-34.01.11-Draft)
- 4 Gilbert, Richard O., Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold Co., New York, NY, 1987.
- 5 ASTM, Standard Guide for General Planning of Waste Sampling.
- 6 US-EPA, Characterization of Hazardous Waste Sites - A Methods Manual, Volume 1 - Site Investigations (EPA 600/4-84/075)
- 7 Kittrell, F W., A Practical Guide to Water Quality Studies.
- 8 US-EPA, Data Quality Objectives Process for Superfund, Interim Final Guidance, (EPA540-R-93-071), September 1993

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 procedure for installing permanent monitoring wells is the hollow-stem

auger method. However, site conditions may not always be amenable to using the hollow-stem auger method. 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 order of preference; however, final selection should be based on actual site conditions.

6.3.1 Hollow-Stem Auger

This type of auger consists of a hollow, steel stem or shaft with a continuous, spiralled steel flight, welded onto the exterior side of the stem, connected to an auger bit and when rotated transports 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 centerplug. 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 spiralled 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 Rotary Methods

This method 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. 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.

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

When using air rotary, the air compressor should have an in-line organic filter system to filter the air coming from the compressor. The organic filter system should be regularly inspected to insure that the system is functioning properly. Air compressors that do not have in-line organic filter systems are not acceptable for air rotary drilling. A cyclone velocity dissipator or similar air containment system should be used to funnel the cuttings to one location instead of letting the cuttings blow uncontrolled out of the borehole. The conventional air rotary method does not control cuttings blowing out of the borehole, and is not acceptable unless the above mentioned cyclone velocity dissipator or similar containment system is employed. Any air rotary method that allows cuttings to blow uncontrolled out of the borehole and does not direct them to a discharge point with minimal disturbance is not acceptable. Air rotary that employs the dual-tube (reverse circulation) drilling system is acceptable since the cuttings are contained in the drill stems and blown to the surface through the cyclone velocity dissipator and to the ground with little surface disturbance.

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, 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 contaminants 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. 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, bentonite pellets, grouts, sand, etc., and the potable water to be used during drilling.

6.3 4 Other Methods

Other methods such as the cable-tool method, the jetting method, the boring (bucket auger) method, and various sonic drilling methods 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 should be of sufficient diameter so that well construction can proceed without major difficulties. To assure an adequate size, a minimum 2-inch annular space is required between the casing and the borehole wall (or the hollow-stem auger wall). For example, an 8-inch borehole is required to install a 4-inch outside diameter (OD) casing. However, if the inside diameter (ID) of the casing is 4 inches, the borehole will have to be larger than 8-inches to include the 2-inch annular space and the outside diameter (OD) of the casing (4 inch ID plus the casing wall thickness). The 2-inch annular space around the casing will allow the filter pack, bentonite pellet seal, and the annular grout to be placed at an acceptable thickness. Also, the 2-inch annular space will allow up to a 1.5-inch (OD) tremie tube to be used for placing the filter pack, pellet seal, and grout at the specified intervals. An annular space less than the 2-inch minimum will not be acceptable. When installing a well inside of hollow-stem augers, the inside diameter (ID) of the augers is the area to be considered when determining the 2-inch annular space.

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 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. The filter pack should be placed by the tremie or positive displacement method. Placing the filter pack by "pouring" may be acceptable in certain situations, which will be discussed in the next section.

6 4 4 Filter Pack Seal-Bentonite Pellet Seal (Plug)

A seal should be placed on top of the filter pack. This seal should consist of a 30% solids bentonite material in the form of bentonite pellets. Bentonite pellets are compressed to a density of 70-80 lbs/cu ft. The preferred method of placing bentonite pellets is by the positive displacement or the tremie method. Use of the tremie method minimizes the risk of pellets bridging in the borehole and assures the placement of pellets (also sand and grout) at the proper intervals. Pouring of the pellets (and filter pack materials) is acceptable in shallow boreholes (less than 50 feet) where the annular space is large enough to prevent bridging and to allow measuring (with a tape measure) to insure that the pellets have been placed at the proper intervals. In order to insure that the pellets have been placed at the proper intervals, the pellets should be tamped, with the appropriate tamping tool, while measuring is being conducted. The tamping process minimizes the potential for pellet bridging by forcing any pellets, that have lodged against the borehole wall, hollow-stem auger wall, or the well casing, down to the proper interval. The bentonite seal should be placed above the filter pack at a minimum of two feet vertical thickness. The hydration time for the bentonite pellets should be a minimum of eight hours or the manufacturer's recommended hydration time, whichever is greater. In all cases the proper depths should be documented by measuring and not by estimating. Other forms of bentonite such as granular bentonite, and bentonite chips have limited applications, and are not recommended for the bentonite seal unless special conditions warrant their use. Deviation from bentonite pellets for the seal, should not be acceptable unless approved by a senior field geologist. If for some reason, the water table is temporarily below the pellet seal interval, potable water (or a higher quality water) should be used to hydrate the pellets.

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.

The preferred grout to use should be a 30 % solids bentonite grout with a minimum density of 10 lb/gal. 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 frostline, whichever is greater. The tremie tube should have an option of a side discharge port or a bottom discharge port, to minimize damage to the filter pack and/or the bentonite pellet seal, during grout placement. The grout should be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. All grouts should be prepared in accordance with the manufacturers specifications. Bentonite grouts (not cement) should have a minimum density of 10 lbs/gal to ensure proper set-up. The density of the bentonite grouts should be measured while mixing and should not be pumped into the borehole until the minimum density of 10 lbs/gal is attained. 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. Drilling muds are not acceptable for grouting.

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. The protective casing should extend a minimum of 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.

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 formed pad and into the borehole (on top of the grout) in one operation making a contiguous unit. The protective casing is then installed into the concrete as described in the previous section. 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 6 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 sloped so that drainage will flow away from the protective casing and off of the pad. In addition, a minimum of one inch of the finished pad should be below grade or ground elevation to prevent washing and undermining by soil erosion. At each site, all locks on the outer protective casings should be keyed alike.

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. Steel rails and/or other steel materials can be used in place of steel pipe but approval must be granted by a senior field geologist prior to field installation.

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. 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 (preferably by the tremie method) up to the designated depth. After the filter pack has been installed, the bentonite pellet seal should be placed (preferably by the tremie method) directly on top of the filter pack up to the designated depth or a minimum of 2 feet above the filter pack whichever is greater. 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 greater. 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.

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.

Bedrock Wells

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 should be used. If the monitoring program calls for the analyses of only inorganic compounds, then PVC materials (Rigid PVC meeting NSF Standard 14 (NSF WC)) are acceptable. Generally, PVC materials are not acceptable for monitoring organic compounds because of their sorption and leaching properties. 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 (NSF 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 addition to material selection, the minimum inside diameter (ID) for well screens and casings used for permanent monitoring wells should be 2 inches. The wall thickness has to be considered when selecting the 2-inch well screen and casing, because a 2-inch ID screen or casing having a total wall thickness greater than 1/8 inch will make the outside diameter (OD) 2 1/4 inches which will reduce the required 2-inch annular space. This is especially true for PVC and Teflon. Schedule 5 stainless steel, which is commonly used for permanent monitoring wells has a very thin wall thickness (approximately 1/16 inch thick) which reduces the 2-inch annular space by only 1/8 inch. However, all minimum requirements for well design and installation should be adhered to when selecting the appropriate materials. For example, if the ID of the screen or casing is 2 inches and the OD is 2 1/2 inches, then the borehole will have to be at least 6 1/2 inches in diameter to satisfy the minimum requirements.

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 than 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, a more technical approach rather than an estimative approach should be taken in the design of filter packs and well screens for monitoring wells. 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. 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.

General steps to consider in designing a filter pack:

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 (C_u 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 30% 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 C_u 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.

- 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 quickly accessible for emergencies
- 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 are generally used to develop monitoring wells

1. Pumping;
2. Compressed air (with the appropriate organic filter system);
3. Bailing;
4. Surging;
5. Backwashing ("rawhiding"); and
6. Jetting.

These developmental procedures can be used, individually or in combination, in order to achieve the most effective well development. 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 compressed air normally should not be sampled for at least 48 hours after development so that the formation can dispel the compressed air and restabilize to pre-well construction conditions. 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 delineate 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. 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.

SECTION 7

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 15.8 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

$$V = 0.041 d^2 h$$

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). Ten NTUs is the goal for most ground water sampling objectives. This is twice the Primary Drinking Water standard of 5 NTUs. Stabilization occurs when pH measurements remain constant within 0.1 Standard Unit (SU), specific conductance varies no more than 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 may 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. The conditions of sampling should be noted in the field log.

TABLE 7.2.1
WELL CASING DIAMETER vs VOLUME

WELL CASING DIAMETER vs VOLUME (GALS.)/FEET of WATER	
CASING SIZE	GALLONS/FT of WATER
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.

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. The water is either discarded or contained and managed as investigation derived waste. 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, no purging is conducted. The sampling device is simply pushed to the desired depth and opened and the sample is collected and retrieved.

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.

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). Also, refer to the Potable Water Supply discussion in Section 2.8. 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 drain into the sample vials. 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.

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. The 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.

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 15.8. 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 8

SAMPLING OF POTABLE WATER SUPPLIES

PERFORMANCE OBJECTIVES:

- To collect a sample representative of the drinking water supply.
- To reduce the bias of system related variables (pumps, piping, holding tanks, etc.)

8.1 Introduction

The same sampling techniques used for wastewater, ground water, surface water, etc., (including thorough documentation of location, date, time, etc.) are to be used during potable water supply sampling. There are certain additional procedures which apply.

8.2 Sampling Site Selection

The following should be considered when choosing the location to collect a potable water sample

- Taps selected for sample collection should be supplied with water from a service pipe connected directly to a water main in the segment of interest.
- Whenever possible, choose the tap closest to the water source, and prior to the water lines entering the residence, office, building, etc., and also prior to any holding or pressurization tanks
- The sampling tap must be protected from exterior contamination associated with being too close to a sink bottom or to the ground. Contaminated water or soil from the faucet exterior may enter the bottle during the collection procedure since it is difficult to place a bottle under a low tap without grazing the neck interior against the outside faucet surface. If the tap is too close to the ground for direct collection into the appropriate container, it is acceptable to use a smaller (clean) container to transfer sample to a larger container.
- Leaking taps that allow water to discharge from around the valve stem handle and down the outside of the faucet, or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations
- Disconnect any hoses, filters, or aerators attached to the tap before sampling. These devices can harbor a bacterial population if they are not routinely cleaned or replaced when worn or cracked
- Taps where the water flow is not constant should be avoided because temporary fluctuation in line pressure may cause clumps of microbial growth that are lodged in a pipe section or faucet connection to break loose. A smooth flowing water stream at moderate pressure without splashing should be used. The sample should be collected without changing the water flow. It may be appropriate to reduce the flow for the volatile organic compounds aliquot to minimize sample agitation.

Occasionally, samples are collected to determine the contribution of system related variables (e.g., transmission pipes, water coolers, water heaters, holding tanks, pressurization tanks, etc.) to the quality of potable water supplies. In these cases, it may be necessary to insure that the water source has not been used for a specific time interval (e.g., over a weekend or a three- or four-day holiday period). Sample collection may consist of collecting a sample of the initial flush, collecting a sample after several minutes, and collecting another sample after the system being investigated has been completely purged.

When sampling for bacterial content, the sample container should not be rinsed before use due to possible contamination of the sample container or removal of the thiosulfate dechlorinating agent (if used). When filling any sample container, care should be taken that no splashing drops of water from the ground or sink do not enter into either the bottle or cap.

When sampling at a water treatment plant, samples are often collected from the raw water supply and the treated water after chlorination.

Obtain the name(s) of the resident or water supply owner/operator, the resident's exact mailing address, and the resident's home and work telephone numbers. The information is required so that the residents or water supply owner/operators can be informed of the results of the sampling program (See Section 2.2).

Sampling Technique (1)

The following procedures should be followed when collecting samples from potable water supplies:

1. Purge the system for at least 15 minutes. Ideally, the sample should be collected from a tap or spigot located at or near the well head or pump house and before the water supply is introduced into any storage tanks or treatment units. If the sample must be collected at a point in the water line beyond a pressurization or holding tank, a sufficient volume of water should be purged to provide a complete exchange of fresh water into the tank and at the location where the sample is collected. If the sample is collected from a tap or spigot located just before a storage tank, spigots located inside the building or structure should be turned on to prevent any backflow from the storage tank to the sample tap or spigot. It is generally advisable to open as many taps as possible during the purge, to ensure a rapid and complete exchange of water in the tanks.
2. After purging for 15 minutes, measure the turbidity (if appropriate), pH, specific conductivity, and temperature of the water. Continue to monitor these parameters until three consistent readings are obtained.
3. After three consistent readings have been obtained, samples may be collected.

8.3 Reference

- 1 Sampling for Organic Chemicals and Microorganisms in the Subsurface. United States Environmental Protection Agency, EPA-600/2-77-176, 1977.

SECTION 9 WASTEWATER SAMPLING

SECTION OBJECTIVE:

- To provide guidance for the proper collection of wastewater samples.

9.1 Introduction

The variety of conditions at different sampling locations require that considerable judgment be exercised regarding the methodologies and procedures for the collection of representative samples of wastewater. Each sampling location warrants attention commensurate with its complexity. There are, however, basic rules and precautions generally applicable to sample collection. Acceptable procedures are generally those outlined in the NPDES Compliance Inspection Manual (1). Some important considerations for obtaining a representative wastewater sample include:

- The sample should be collected where the wastewater is well mixed. Therefore, the sample should be collected near the center of the flow channel, at approximately 40 to 60 percent of the water depth, where the turbulence is at a maximum and the possibility of solids settling is minimized. Skimming the water surface or dragging the channel bottom should be avoided. However, allowances should be made for fluctuations in water depth due to flow variations.
- In sampling from wide conduits, cross-sectional sampling should be considered. Rhodamine WT dye (See Section 15.7 for procedures) may be used as an aid in determining the most representative sampling locations.
- If manual compositing is employed, the individual sample portions must be thoroughly mixed before pouring the individual aliquots into the composite container. For manual composite sampling, the individual sample aliquots should be preserved at the time of sample collection (2).
- When collecting samples or installing sampling equipment, field investigators should always wear a new pair of the appropriate protective gloves (disposable latex gloves, rubber gloves, etc.) to prevent contamination of the sample and reduce exposure to hazardous substances.

9.2 Site Selection

Where applicable, wastewater samples should be collected at the location specified in the NPDES permit (if the source has such a permit). In some instances the sampling location specified in the permit, or the location chosen by the permittee, may not be acceptable for the collection of a representative wastewater sample. In such instances, the investigator is not limited by permit specifications and may collect a sample at a more representative location. When a conflict exists between the permittee and the regulatory agency regarding the most representative sampling location, both sites should be sampled, and the reason for the conflict should be noted in the inspection or study report and field notes. Recommendations and reasons for a change in sampling locations should be given to the appropriate permitting authority.

9.2.1 Influent

Influent wastewaters are preferably sampled at locations of highly turbulent flow in order to ensure good mixing, however, in many instances the most desirable location is not accessible. Preferable influent wastewater sampling locations include: 1) the upflow siphon following a comminutor (in absence of grit chamber), 2) the upflow distribution box following pumping from main plant wet well, 3) aerated grit chamber, 4) flume throat; 5) pump wet well when the pump is operating; or 6) downstream of preliminary screening. When possible, influent samples should be collected upstream from sidestream returns.

9.2.2 Effluent

Effluent samples should be collected at the site specified in the permit, or if no site is specified in the permit, at the most representative site downstream from all entering wastewater streams prior to discharge into the receiving waters. If a conflict exists between the permittee and inspector regarding the source being sampled or the location of the most representative site, follow the procedures previously described under "Site Selection."

9.2.3 Pond and Lagoon Sampling

Generally, composite effluent wastewater samples should be collected from ponds and lagoons. Even if the ponds or lagoons have long retention times, composite sampling is necessary because of the tendency of ponds and lagoons to have flow paths that short circuit and changes the design detention time.

9.3 Sample Types

For NPDES sampling, two types of sampling techniques are used: grab and composite. For these procedures, the NPDES permit specifies the appropriate sample type. A complete description of all NPDES sampling procedures and techniques is presented in the NPDES Compliance Inspection Manual (1)

9.3.1 Grab Samples

Grab samples consist of either a single discrete sample or individual samples collected over a period of time not to exceed 15 minutes. The grab sample should be representative of the wastewater conditions at the time of sample collection. The sample volume depends on the type and number of analyses to be performed.

9.3.2 Composite Samples

Composite samples are collected over time, either by continuous sampling or by mixing discrete samples. A composite sample represents the average wastewater characteristics during the compositing period. Various methods for compositing are available and are based on either time or flow proportioning. The choice of a flow proportional or time composite sampling scheme depends on the permit requirements, variability of the wastewater flow or concentration of pollutants, equipment availability, and sampling location. The investigator must know each of these criteria before a sampling program can be initiated. If an investigator knows or suspects that there is significant variability in the wastewater flow or if the investigator knows nothing about the facility, a flow proportional sample is preferable. Otherwise, a time composite sample would be acceptable.

A time composite sample consists of equal volume discrete sample aliquots collected at constant time intervals into one container. A time composite sample can be collected either manually or with an automatic sampler.

A flow proportional composite sample can be collected using one of two methods. One method consists of collecting a constant sample volume at varying time intervals proportional to the wastewater flow. For the other method, the sample is collected by varying the volume of each individual aliquot proportional to the flow, while maintaining a constant time interval between the aliquots. Prior to collecting flow proportional samples, the facility's flow measuring system should be examined for proper installation and accuracy (see Section 18). If the facility's primary flow measuring device does not meet standard conditions (see Section 18), or is in an unsafe or inaccessible location, then the investigator may collect time composite samples. If the flow measurement system is acceptable, samples should be collected using the appropriate flow proportioning methods.

Flow proportional samples can be collected with an automatic sampler and a compatible flow measuring device, semi-automatically with a flow chart and an automatic sampler capable of collecting discrete samples, or manually.

9.4 Use of Automatic Samplers

9.4.1 Introduction

Automatic samplers may be used to collect composite or grab samples when several aliquots are to be collected at frequent intervals or when a continuous sample is required. For composite sampling applications, the automatic samplers may be used to collect time composite or flow proportional samples. In the flow proportional mode, the samplers are activated by a compatible flow meter. Flow proportional samples can also be collected using an automatic sampler equipped with multiple containers and manually compositing the individual sample portions proportional to the flow (1).

Automatic samplers must meet the following requirements.

- Sampling equipment must be properly cleaned to avoid cross-contamination which could result from prior use (see Appendix B for cleaning procedures)
- No plastic or metal parts of the sampler shall come in contact with the water or wastewater stream when parameters to be analyzed could be impacted by these materials
- The automatic sampler must be capable of providing adequate refrigeration during the sampling period. This can be accomplished in the field by using ice.
- The automatic sampler must be able to collect a large enough sample for all parameter analyses
- The individual sample aliquot must be at least 100 mls
- The automatic sampler should be capable of providing a lift of at least 20 feet and the sampler should be adjustable since the volume is a function of the pumping head
- The pumping velocity must be at least 2 ft/sec to transport solids and not allow solids to settle
- The intake line leading to the pump must be purged before each sample is collected
- The minimum inside diameter of the intake line should be 1/4 inch.
- An adequate power source should be available to operate the sampler for the time required to complete the project. Facility electrical outlets may be used if available
- Facility automatic samplers should only be used if 1) field conditions do not allow for the installation of EPA sampling equipment, and 2) the facility sampling equipment meets all of the requirements of this SOP

Specific operating instructions, capabilities, capacities, and other pertinent information for automatic samplers are included in the respective operating manuals.

9 4 2 Conventional Sampling (Inorganic Parameters)

Conventional sampling includes all inorganic parameters (e.g , BOD₅ , TSS, COD, nutrients, and metals) that can be collected using an automatic sampler.

New tubing (Silastic®, or equal, in the pump and either Teflon® or Tygon®, or equal, in the sample train) will be used for each sampler installation.

Installation procedures include cutting the proper length of tubing, positioning it in the wastewater stream, and sampler programming. Protective gloves should be worn to reduce exposure and to maintain the integrity of the sample.

For a time composite sample, the sampler should be programmed to collect at least 100-milliliter aliquots at a frequency that provides a representative sample and enough sample volume to conduct all required analyses.

For a flow proportional sample, the sampler should be programmed to collect a minimum of 100 milliliters for each sample aliquot with the interval predetermined based on the flow of the monitored stream.

At the end of the compositing period, the sample collected should be properly mixed and transferred into the respective containers, followed by immediate preservation, if required. For routine inspections, the permittee should be offered a split sample.

9 4 3 Metals

When an automatic sampler is used for collecting samples for metals analyses, the entire sampler collection system should be rinsed with organic/analyte free water, and an equipment blank should be collected. Approximately one gallon of rinse water should be pumped through the sample tubing into the composite container and discarded. Nitric acid must be added to the metals blank container for proper preservation. The sampler may then be positioned in the appropriate location and the sampler program initiated.

If the sampler tubing is attached to a metal conduit pipe, the sampler intake tubing should be carefully installed upstream and away from the conduit to prevent metals contamination. This can be accomplished by clamping the tubing upstream of the conduit using laboratory clamps and wrapping the submerged portion of conduit pipe with a protective barrier (e.g., duct tape).

9 4 4 Extractable Organic Compounds, Pesticides, and PCBs

When an automatic sampler is used for collecting samples for the analyses of extractable organic compounds, pesticides, and/or PCBs, the installation procedures include cutting the proper length of new Teflon® tubing, rinsing of the entire sampler collection system with organic/analyte free water, and collection of appropriate blanks for organic compounds analysis. For the organic/analyte free water rinse, approximately one-half gallon is initially pumped into the composite sample container and discarded. An additional one and one-half gallons are then pumped into the composite sample container for distribution into the appropriate blank container. Finally the collection tubing should be positioned in the wastewater stream and the sampler programmed and initiated.

9 4 5 Automatic Sampler Security

Field investigators should take whatever steps are necessary to prevent tampering with EPA equipment. A lock or custody seal may be placed on the sampler to detect tampering. However, this does not prevent tampering with the sample collection tubing. If necessary, seals may be placed on the sampling pole and tubing line to further reduce tampering possibilities.

9 4 6 Automatic Sampler Maintenance, Calibration, and Quality Control

To insure proper operation of automatic samplers, and thus the collection of representative samples, the following maintenance and calibration procedures should be used and any deviations should be documented in the log book.

Prior to being used, the sampler operation will be checked by Field Equipment Center personnel. This includes operation (forward, reverse, automatic) through three cycles of purge-pump-purge, checking desiccant and replacing if necessary, checking the 12-volt batteries to be used with the sampler, and repairing any item if necessary.

During each field trip, prior to initiating the automatic sampler, the rinse and purge-pump-purge cycle shall be checked at least once. The pumping volume should be checked at least twice using a graduated cylinder or other calibrated container prior to initiating the sampler. For flow proportional sampling, the flow pacer that activates the sampler should be checked to insure that it operates properly.

Upon return from a field trip, the structural integrity of the sampler should be examined and repaired, if necessary. The desiccant will be checked and replaced if appropriate. The operation (forward, reverse, automatic, etc.) will be checked and any required repairs will be made and documented. The sampler will then be cleaned as outlined in Appendix B.

The automatic sampler should be checked against the manufacturer's specifications and documented whenever one or more of the sampler functions appears to be operating improperly.

9.5 Manual Sampling

Manual sampling is normally used for collecting grab samples and/or for immediate in-situ field analyses. However, it can also be used in lieu of automatic equipment over extended periods of time for composite sampling, especially when it is necessary to evaluate unusual waste stream conditions.

The best method to manually collect a sample is to use the actual sample container which will be used to transport the sample to the laboratory. This eliminates the possibility of contaminating the sample with intermediate collection containers. If the water or wastewater stream cannot be physically reached by the sampling personnel or it is not safe to reach for the sample, an intermediate collection container may be used, from which the sample can be redistributed to other containers. If this is done, however, the container used to collect the sample must be properly cleaned (Appendix B) and must be made of a material that meets the requirements of the parameter(s) being investigated. Samples for oil and grease, bacteria, phenols, volatile organic compounds, and sulfides analyses must always be collected directly into the sample container.

In some cases it may be best to use a pump, either power or hand operated, to withdraw a sample from the water or wastewater stream. If a pump is used, it is imperative that all components of the pump that come in contact with the sample are properly cleaned (Appendix B) to insure the integrity of the

sample

In general, samples are manually collected by first selecting a location in the wastestream that is well mixed (Section 9.1) then dipping the container in the water or wastewater stream so the mouth of the container faces upstream. The container should not be overfilled if preservatives are present in the container.

9.6 Special Sample Collection Procedures

9.6.1 Organic Compounds and Metals

Trace organic compounds and metals detection limits are usually in the parts per billion or parts per trillion range, so extreme care must be exercised to insure sample integrity.

All containers, composite bottles, tubing, etc., used for sample collection for trace organic compounds and metals analyses should be prepared as described in Appendix B.

When possible, the sample should be collected directly into the appropriate sample container. If the material to be sampled cannot be physically reached, an intermediate collection device may be used. This should be a Teflon®, glass, or stainless steel vessel on a pole or rope or Teflon® tubing via a peristaltic type pump and a Teflon® vacuum container attachment which converts a sample container into a vacuum container. The device which is used should be cleaned as described in Appendix B.

9.6.2 Bacteriological

Samples for bacteriological analyses must always be collected directly into the prepared glass or plastic sample container. The sample container should be kept unopened until it is to be filled. When the cap is removed, care should be taken not to contaminate the cap or the inside of the bottle. The bottle should be held near the base and filled to within about one inch of the top without rinsing and recapped immediately. During sample collection, the sample container should be plunged with the neck partially below the surface and slightly upward. The mouth should be directed against the current. Appendix A lists preservation procedures and holding times.

When the sample container must be lowered into the waste stream, either because of safety or impracticality (manhole, slippery effluent area, etc.), care must be taken to avoid contamination.

9.6.3 Immiscible Liquids/Oil and Grease

Oil and grease may be present in wastewater as a surface film, an emulsion, a solution, or as a combination of these forms. Since it is very difficult to collect a representative sample for oil and grease analysis, the inspector must carefully evaluate the location of the sampling location. The most desirable sampling location is the area of greatest mixing. Quiescent areas should be avoided. The sample container should be plunged into the wastewater using a swooping motion with the mouth facing upstream. Care should be taken to insure that the bottle does not over fill during sample collection.

Because losses of oil and grease will occur on sampling equipment, an automatic sampler should not be used to collect samples for oil and grease analysis. Individual portions collected at prescribed time intervals must be analyzed separately to obtain the average concentrations over an extended period.

9.6.4 Volatile Organic Compounds

Samples to be analyzed for volatile organic compounds (VOCs) should be collected in 40-ml septum vials with screw caps with a Teflon® lined silicone disk in the cap to prevent contamination of the sample by the cap. The disks should be placed in the caps (Teflon® side to be in contact with the sample) in the laboratory prior to the beginning of the sampling program.

When sampling for VOCs, triplicate samples should always be collected from each location. The investigator should determine if the water to be sampled contains chlorine. If the water contains no chlorine, three pre-preserved 40-ml vials should be filled with the sample. The samples may be held for up to 14 days before analysis. When preservation is not feasible, samples can be held up to 7 days before analysis.

If the water contains chlorine, fill an 8-ounce sampling container with 2 drops of a 25% ascorbic acid solution and the water sample. Cap and mix thoroughly but gently by swirling to eliminate residual chlorine. Transfer the sample to three pre-preserved 40-ml vials (see Appendix A). The ascorbic acid and preservative must be added in this order and in two separate steps.

The 40-ml vials should be completely filled to prevent volatilization, and extreme caution should be exercised when filling each vial to prevent any turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles, if any are present, repeat the procedure using a new 40-ml vial.

Sampling containers with preservatives should be pre-labeled (i.e., P) prior to any field activities. This will reduce the chances of confusion during sampling activities by the investigation team. Sample preservation, containers, holding times, and sample volumes are listed in Appendix A.

9.7 Special Process Control Samples and Tests

During diagnostic evaluations, process control tests may be conducted to evaluate and troubleshoot the performance of the biological treatment processes of a municipal or industrial wastewater treatment facility. The EPA Activated Sludge Process Control Testing handbook is the standard reference for activated sludge process control testing (3). The manual includes a complete description of the step-by-step procedures for each test and the interpretation of the results. The six basic activated sludge process control tests are:

- Sludge settleability (settlerometer)
- Centrifuge spins
- Aeration basin DO profiles
- Oxygen uptake rate (OUR) measurements
- Mixed liquor microscopic examinations
- Sludge blanket depth (SBD) measurements

Additional references are available that provide a more comprehensive evaluation of the methods used to conduct a diagnostic evaluation (4, 5, 7, 8, and 9). Completion of the Sacramento Operation of Wastewater Treatment Plants course is highly recommended for all personnel prior to serving as the project leader on a Diagnostic Evaluation (6).

9.8 Supplementary Data Collection

While conducting wastewater sampling, the following information will also be obtained (if applicable)

- Field measurements -- pH, dissolved oxygen, conductivity, and temperature (see Section 16 for standard field analytical techniques).
- Flows associated with the samples collected -- continuous flows with composite samples and instantaneous flows with grab samples (Section 18).
- Diagrams and/or written descriptions of the wastewater treatment systems (if available)
- Photographs of pertinent wastewater associated equipment, such as flow measuring devices, treatment units, etc (keep photolog as specified in section 3.2)
- Process control information on the wastewater treatment process (if applicable)
- Completion of applicable forms required during specific investigations

All observations, measurements, diagrams, etc., will be entered in bound field logbooks or attached thereto (where applicable as specified in Section 3.5).

9.9 References

- 1 NPDES Compliance Inspection Manual, United States Environmental Protection Agency, Office of Environment and Compliance Assurance, September 1994
- 2 Code of Federal Regulations, 40 CFR, Part 136.3, Table II, (latest issue)
- 3 US-EPA, "Activated Sludge Process Control Testing", ESD, Water Compliance Unit, Athens, GA, 1990.
- 4 US-EPA, "Process Control Manual Aerobic Biological Treatment Facilities MD-14", EPA 430/09-77-006, Office of Water, Washington, D.C., 1977
- 5 Metcalf and Eddy, Inc. "Wastewater Engineering: Treatment, Disposal, Reuse", McGraw-Hill Book Co., New York, NY, 1991.
- 6 California State University - Sacramento, "Operation of Wastewater Treatment Plants - Volumes I, II, III", Sacramento, California.
- 7 US-EPA, "Retrofitting POTWs", EPA 625/6-89/020, Center for Environmental Research Information, Cincinnati, Ohio, 1989
- 8 "Operation Of Municipal Wastewater Treatment Plants", WEF Manual Of Practice No.11, Water Pollution Control Federation, Alexandria, Virginia, 1990
- 9 "Design Of Municipal Wastewater Treatment Plants", WEF Manual Of Practice No 8, Book Press, Inc., Brattleboro, Vermont, 1991

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 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 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.

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 11 SEDIMENT SAMPLING

PERFORMANCE OBJECTIVE

- To collect a representative sample of sediment from a surface water body

11.1 Introduction

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

The physical location of the investigator when collecting a sample may dictate the equipment to be used. Wading is the preferred method for reaching the sampling location, particularly if the stream has a noticeable current (is not impounded). However, wading may disrupt bottom sediments causing biased results. If the stream is too deep to wade, the sediment sample may be collected from a boat or from a bridge.

To collect a sediment sample from a streambed, a variety of methods can be used:

- Dredges (Peterson, Eckman, Ponar),
- Coring (tubes, augers)
- Scoops (BMH-60, standard scoop) and spoons

Regardless of the method used, precautions should be taken to insure that the sample collected is representative of the streambed. These methods are discussed in the following paragraphs.

11.2 Sediment Sampling Equipment

11.2.1 Scoops and Spoons

If the surface water body is wadeable, the easiest way to collect a sediment sample is by using a stainless steel scoop or spoon. The sampling method is accomplished by wading into the surface water body and while facing upstream (into the current), scooping the sample along the bottom of the surface water body in the upstream direction. Excess water may be removed from the scoop or spoon. However, this may result in the loss of some fine particle size material associated with the bottom of the surface water body. Aliquots of the sample are then placed in a glass pan and homogenized according to the quartering method described in Section 5.13.8 of this SOP.

In surface water bodies that are too deep to wade, but less than eight feet deep, a stainless steel scoop or spoon attached to a piece of conduit can be used either from the banks if the surface water body is narrow or from a boat. The sediment is placed into a glass pan and mixed according to Section 5.13.8 of this SOP.

If the surface water body has a significant flow and is too deep to wade, a BMH-60 sampler may be used. The BMH-60 is not particularly efficient in mud or other soft substrates because its weight will cause penetration to deeper sediments, thus missing the most recently deposited material at the sediment-water interface. It is also difficult to release secured samples in an undisturbed fashion that would readily permit subsampling. The BMH-60 may be used provided that caution is exercised by only taking subsamples that have not been in contact with the metal walls of the sampler.

11 2 2 Dredges

For routine analyses, the Peterson dredge can be used when the bottom is rocky, in very deep water, or when the stream velocity is high. The dredge should be lowered very slowly as it approaches bottom, since it can displace and miss fine particle size sediment if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where the bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high velocities. It should not be used from a bridge that is more than a few feet above the water, because the spring mechanism which activates the sampler can be damaged by the messenger if dropped from too great a height.

The Ponar dredge is a modification of the Peterson dredge and is similar in size and weight. It has been modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing turbulence around the dredge. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

The "mini" Ponar dredge is a smaller, much lighter version of the Ponar dredge. It is used to collect smaller sample volumes when working in industrial tanks, lagoons, ponds, and shallow water bodies. It is a good device use when collecting sludge and sediment containing hazardous constituents because the size of the dredge makes it more amenable to field cleaning.

11 2 3 Coring

Core samplers are used to sample vertical columns of sediment. They are particularly useful when a historical picture of sediment deposition is desired since they preserve the sequential layering of the deposit, and when it is desirable to minimize the loss of material at the sediment-water interface. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand push tubes to weight or gravity driven devices.

Coring devices are particularly useful in pollutant monitoring because turbulence created by descent through the water is minimal, thus the fines of the sediment-water interface are only minimally disturbed, the sample is withdrawn intact permitting the removal of only those layers of interest, core liners manufactured of glass or Teflon* can be purchased, thus reducing possible sample contamination, and the samples are easily delivered to the lab for analysis in the tube in which they were collected.

The disadvantage of coring devices is that a relatively small surface area and sample size is obtained often necessitating repetitive sampling in order to obtain the required amount of material for analysis. Because it is believed that this disadvantage is offset by the advantages, coring devices are recommended in sampling sediments for trace organic compounds or metals analyses.

In shallow, wadeable waters, the direct use of a core liner or tube manufactured of Teflon®, plastic, or glass is recommended for the collection of sediment samples. (Plastic tubes are principally used for collection of samples for physical parameters such as particle size analysis) Their use can also be extended to deep waters when SCUBA diving equipment is utilized. Teflon® or plastic are preferred to glass since they are unbreakable which reduces the possibility of sample loss. Stainless steel push tubes are also acceptable and provide a better cutting edge and higher strength than Teflon®. The use of glass or Teflon® tubes eliminates any possible metals contamination from core barrels, cutting heads, and retainers. The tube should be approximately 12 inches in length if only recently deposited sediments (8 inches or less) are to be sampled. Longer tubes should be used when the depth of the substrate exceeds 8 inches. Soft or semi-consolidated sediments such as mud and clays have a greater adherence to the inside of the tube and thus can be sampled with larger diameter tubes. Because coarse or unconsolidated sediments such as sands and gravel tend to fall out of the tube, a small diameter is required for them. A tube about two inches in diameter is usually the best size. The wall thickness of the tube should be about 1/3 inch for Teflon®, plastic, or glass. The inside wall may be filed down at the bottom of the tube to provide a cutting edge and facilitate entry of the liner into the substrate.

Caution should be exercised not to disturb the bottom sediments when the sample is obtained by wading in shallow water. The core tube is pushed into the substrate until four inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is being pushed will facilitate greater penetration and decrease core compaction. The top of the tube is then capped to provide a suction and reduce the chance of losing the sample. A Teflon® plug or a sheet of Teflon® held in place by a rubber stopper or cork may be used. After capping, the tube is slowly extracted with the suction and adherence of the sediment keeping the sample in the tube. Before pulling the bottom part of the core above the water surface, it too should be capped.

When extensive core sampling is required, such as a cross-sectional examination of a streambed (with an objective of profiling both the physical and chemical contents of the sediment), a whole core must be collected. A strong coring tube such as one made from aluminum, steel or stainless steel is needed to penetrate the sediment and underlying clay or sands. A coring device can be used to collect an intact sediment core from streambeds that have soft bottoms which allows several inches of penetration. It is recommended that the corer have a checkvalve built into the driving head which allows water and air to escape from the cutting core, thus creating a partial vacuum which helps to hold the sediment core in the tube. The corer is attached to a standard auger extension and handle, allowing it to be corkscrewed into the sediment from a boat or while wading. The coring tube is easily detached and the intact sediment core is removed with an extraction device.

Before extracting the sediment from the coring tubes, the clear supernatant above the sediment-water interface in the core should be decanted from the tube. This is accomplished by simply turning the core tube to its side, and gently pouring the liquid out until fine sediment particles appear in the waste liquid. The loss of some of the fine sediments usually occurs with this technique.

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SECTION 12

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 designing a soil sampling strategy, the appropriate equipment and techniques must be used to conduct the investigation This section discusses the sampling equipment available and collection methods which have been shown to be technically appropriate.

Manual techniques and equipment, such as hand augers, are usually used for surface or shallow, subsurface soil sampling. Power operated equipment is usually associated with collecting deep samples, but this equipment can also be used for collecting shallow samples when the auger hole begins to collapse, or when the soil is so tight that manual auguring is not practical. This section discusses the various sample collection methods employed by field investigators

12.2 Equipment

Soil sampling equipment used for sampling trace contaminants should be constructed of inert materials such as stainless steel Ancillary equipment such as auger flights, post hole diggers, etc. may be constructed of other materials since this equipment does not come in contact with the samples However, plastic, chromium, and galvanized equipment should not be used routinely in soil sampling operations Painted or rusted equipment must be sandblasted before use.

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 material. 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 auger hole begins to collapse or when the soil is so tight that manual auguring is not practical

12.3 Sampling Methodology

This discussion of soil sampling methodology reflects both the equipment used (required/needed) 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 torque 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 (Hand Operated) 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. Spoons, shovels, hand-augers, push tubes, and post-hole diggers, made of the appropriate material, may be used to collect surface soil samples. As discussed in the section on powered equipment, surface soil samples may also be collected in conjunction with the use of heavy equipment.

Surface samples are removed from the ground and placed in pans, where mixing, as appropriate (Section 5.13.8), occurs prior to filling of sample containers. Section 12.4.1 contains specific procedures for handling samples for volatile organic compounds analysis. If a thick, matted root zone is encountered at or near the surface, it should be removed before the sample is collected.

Subsurface Soils

Hand-augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger-buckets with cutting heads are pushed and twisted into the ground and 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 is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand-augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand-auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required. Some powered methods, discussed later, are not acceptable for actual sample collection, but are used solely to gain easier access to the required sample depth, where hand-augers or push tubes are generally used to collect the sample.

When a vertical sampling interval has been established, one auger-bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well as to collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a new bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole.

Another hand-operated piece of soil sampling equipment commonly used to collect shallow subsurface soil samples is the Shelby® or "push tube". This is a thin-walled tube, generally of stainless steel construction and having a beveled leading edge, which is twisted and pushed directly into the soil. This type of sampling device is particularly useful if an undisturbed sample is required. The sampling device is removed from the push-head, then the sample is extruded from the tube into the pan with a spoon or special extruder. Even though the push-head is equipped with a check valve to help retain samples, the Shelby tube will generally not retain loose and watery soils, particularly if collected at lower depths.

12.3.2 Powered Sampling Devices

Powered sampling devices and sampling aids may be used to acquire samples from any depth but are generally limited to depths of 20 feet or less. Among the common types of powered equipment used to collect or aid in the collection of subsurface soil samples are Little Beaver® type power augers; split-spoon samplers driven with a drill rig drive-weight assembly or hydraulically pushed using drill rig hydraulics; continuous split-spoon samplers; specialized hydraulic cone penetrometer rigs; and back-hoes. The use of each of these is described below.

Power Augers

Power augers are commonly used to aid in the collection of subsurface soil samples at depths where hand augering is impractical. This equipment is a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range. It is used to advance a hole to the required sampling depth, at which point a hand auger is usually used to collect the sample.

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.

When used in conjunction with drilling, split-spoon samplers are usually driven either inside a hollow-stem auger or inside an open borehole after rotary drilling equipment has been temporarily removed. The spoon is driven with a 140-pound hammer through a distance of up to 24 inches and removed. If geotechnical data are also required, the number of blows with the hammer for each six-inch interval should be recorded.

Continuous split-spoon samplers may be used to obtain five-foot long, continuous samples approximately 3 to 5 inches in diameter. These devices are located 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 until retrieval.

Cone Penetrometer Rigs

This method uses a standard split-spoon has been modified with a releasable tip which keeps the spoon closed during the sampling push. Upon arrival at the desired depth, the tip can be remotely released and the push continued. During the subsequent push, the released tip floats freely up the inside of the spoon as the soil core displaces it. Split-spoon soil samples, therefore, can be collected without drilling, as has historically been required, by simply pushing the device to the desired depth. This technique is particularly beneficial at highly contaminated sites, because cuttings are not produced as with drill rigs. The push rods are generally retrieved with very little residue. This results in minimal exposure to sampling personnel and very little contaminated residue is produced as a result of equipment cleaning.

Back-Hoes

Back-hoes are often utilized in shallow subsurface soil sampling programs. Samples may either be collected directly from the back-hoe bucket or they may be collected from the trench wall if proper safety protocols are followed. Trenches offer the ability to collect samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. Prior to collecting samples from trench walls, the wall surface must be dressed with a stainless steel shovel, spatula, knife, or spoon to remove the surface layer of soil which was smeared across the trench wall as the bucket passed. If back-hoe buckets are not cleaned according to the procedures described in Appendix B of this SOP, samples should be collected from material which has not been in contact with the bucket surface.

12.4 Special Techniques and Considerations

12.4.1 Collection of Soil Samples for Volatile Organic Compounds (VOC) Analysis

These samples should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with a hand auger, the sample for VOC analysis may be collected directly from the auger bucket or immediately after an auger bucket is emptied into the pan. The sample should be placed in the appropriate container with no head-space, if possible, as is the practice with water samples. Samples for VOC analysis are not mixed.

12.4.2 Dressing Soil Surfaces

Any time a vertical or near vertical surface, such as is achieved when shovels or back-hoes are used for subsurface sampling, is sampled, the surface should be dressed to remove smeared soil. This is necessary to minimize the effects of cross-contamination due to smearing of material from other levels.

12.4.3 Sample Mixing

It is extremely important that soil samples be mixed as thoroughly as possible to ensure that the sample is representative of the interval sampled. Soil samples should be mixed as specified in Section 5.13.8.

12 4 4 Special Precautions for Trace Contaminant Soil Sampling

The procedures outlined in Section 5 13.7 should be followed. All soil sampling equipment used for sampling for trace contaminants should be constructed of stainless steel where possible. Pans used for mixing should be made of Pyrex® (or equivalent) or glass. In no case will chromium, cadmium, or galvanized plated or coated equipment be used for soil sampling operations when inorganic contamination is of concern. Similarly, no painted or plastic equipment should be used when organic contaminants are of concern. All paint and primer must be removed from soil sampling equipment by sandblasting or other means before such equipment can be used for collecting soil samples.

12 4 5 Specific Sampling Equipment Quality Assurance Techniques

Drilling rigs and other major equipment used to collect soil samples should be identified so that this equipment can be traced through field records. A log book should be established for this equipment so that all cleaning, maintenance, and repair procedures can be traced to the person performing these procedures and to the specific repairs made. Sampling spoons, hand augers, Shelby tubes, and other minor disposable type equipment are exempted from this equipment identification requirement. All equipment used to collect soil samples should be cleaned as outlined in Appendix B and repaired, if necessary, before being stored at the conclusion of field studies. Equipment cleaning conducted in the field (Appendix B) or field repairs should be thoroughly documented in field records.

SECTION 13

SECTION 13 WASTE SAMPLING

SECTION OBJECTIVE:

- To describe equipment and procedures that can safely be used to collect waste samples

13.1 Introduction

Hazardous wastes are regulated by the US EPA under 40 CFR Parts 260-299. As a consequence, many of the methods that are used to manage, store, treat, and dispose hazardous wastes and potential hazardous wastes are of concern to both the regulators and the regulated community.

Samples are often required of regulated or potentially regulated materials. While it is understood that each facility and wastestream may present its own unique sampling and analytical challenges, this section will list equipment and procedures that have been used to safely and successfully sample specific waste units.

13.1.1 Safety

Sampling of waste units should be assessed for potential hazards by both the project leader and the site safety officer (SSO). It is the SSO's responsibility to enforce the site safety plan, and to ensure that procedures used during waste sampling are in accordance with Branch safety procedures and protocols found in Section 4. The procedures outlined in the Region 4 Field Health and Safety Manual (1) will be followed during sampling of all potentially hazardous wastes.

Sampling equipment contaminated during waste sampling investigations must be at a minimum cleaned with laboratory detergent and rinsed with tap water prior to returning the equipment from the field. Contaminated sampling equipment that is to be discarded must be properly disposed according to Section 5.15 and should be specified in the site-specific study plan.

13.1.2 Quality Control Procedures

In some instances, special decontamination procedures will be necessary and should be developed on a case-by-case basis according to the specific material encountered. Any cleaning procedures and equipment repairs conducted in the field which deviate from those specified in Appendix B or the study plan, should be thoroughly documented in the logbooks.

All air monitoring and field analytical/screening equipment should be checked and calibrated before being issued for field studies, as specified in Sections 16 and 17 of this SOP.

13.1.3 Collection of Auxiliary Information and Data

The collection of auxiliary information and data is particularly important when collecting waste samples. Any field analyses or field screening results should be recorded in a logbook as outlined in Section 3.5. Sketches of waste units, sampling locations, containers, tanks and ancillary equipment, markings/labels, etc., should be fully documented in logbooks. Photographs are extremely useful for recording this information and may be used during waste sampling operations. A field log of the photographs taken should be maintained as outlined in Section 3.2.2.

13.2 Waste Unit Types

Waste management units can be generally categorized into two types: open and closed. In practice, open units are larger than closed units. Open units include waste piles and surface impoundments whereas closed units include containers and tanks as well as ancillary tank equipment. Besides containers and tanks, sumps may also be considered closed units because they are designed to collect the spillage of liquid wastes and are sometimes configured as a confined space.

Although both may pose hazards, units that are open to the environment are generally less hazardous than closed units. Sampling of closed units is considered a higher hazard risk because of the potential of exposure to toxic gases and flammable/explosive atmospheres. Because closed units prevent the dilution of the wastes by environmental influences, they are more likely to contain materials that have concentrated levels of hazardous constituents. While opening closed units for sampling purposes, investigators shall use Level B personnel protective equipment, air monitoring instruments to ensure that the working environment does not contain hazardous levels of flammable/explosive gasses or toxic vapors, and follow the appropriate safety requirements stipulated in the site specific safety plan.

Buried waste materials should be located and excavated with extreme caution. Once the buried waste is uncovered, the appropriate safety and sampling procedures utilized will depend on the type of waste unit.

13.2.1 Open Units

While open units may contain many types of wastes and come in a variety of shapes and sizes, they can be generally regarded as either waste piles or surface impoundments. Definitions of these two types of open units from 40 CFR Part 260.10 are:

- Waste pile -- any non-containerized accumulation of solid, non-flowing hazardous waste that is used for treatment or storage and that is not a containment building
- Surface impoundment -- "...a facility or part of a facility which is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), which is designed to hold the accumulation of liquid wastes or wastes containing free liquids, and which is not an injection well. Examples of surface impoundments are storage, settling and aeration pits, ponds, and lagoons."

One of the distinguishing features between waste piles and surface impoundments is the state of the waste. Waste piles typically contain solid or non-flowing materials whereas liquid wastes are usually contained in surface impoundments. The nature of the waste will also determine the mode of delivering the waste to the unit. Wastes are commonly pumped or gravity fed into impoundments while heavy equipment or trucks may be used to dump wastes in piles. Once the waste has been placed in an open unit, the state of the waste may be altered by environmental factors (e.g., temperature, precipitation, etc.).

Surface impoundments may contain several phases such as floating solids, liquid phase(s), and sludges. Waste piles are usually restricted to solids and semi-solids. All of the potential phases contained in a waste unit should be considered in developing the sample design to meet the study's objective.

13.2.2 Closed Units

There are a variety of designs, shapes, sizes, and functions of closed units. In addition to the challenges of the various designs and the safety requirements for sampling them, closed units are difficult to sample because they may contain liquid, solid, semi-solid/sludge, or any combination of phases. Based on the study's design, it may be necessary to obtain a cross sectional profile of the closed unit in an attempt to characterize the unit. The following are definitions of types of closed waste units described in 40 CFR Part 260.10.

- Container -- any portable device in which waste is stored, transported, treated, disposed, or otherwise handled. Examples of containers are drums, overpacks, pails, totes, and roll-offs. Portable tanks, tank trucks, and tank cars vary in size and may range from simple to extremely complex designs. Depending on the unit's design, it may be convenient to consider some of these storage units as tanks for sampling purposes even though they meet the definition of a container.
- Tank -- a stationary device, designed to contain an accumulation of waste which is constructed primarily of non-earthen materials which provide structural support.
- Ancillary tank equipment -- any device including, but not limited to, such devices as piping, fittings, flanges, valves, and pumps that is used to distribute, meter, or control the flow of waste from its point of generation to a storage or treatment tank(s), between waste storage and treatment tanks to a point of disposal on-site, or to a point of disposal off-site.
- Sump -- any pit or reservoir that meets the definition of a tank and those troughs/trenches connected to it that serve to collect liquid wastes. (Note: some outdoor sumps may be considered open units/surface impoundments).

Although any of the closed units may not be completely sealed and may be partially open to the environment, the unit needs to be treated as a closed unit for sampling purposes until a determination can be made. Once a closed unit is opened, a review of the proposed sampling procedures and level of protection can be performed to determine if the personal protection equipment is suitable for the site conditions.

Samples collected from different waste units should not be composited into one sample container without additional analytical and/or field screening data to determine if the materials in the units are compatible and will not cause an inadvertent chemical reaction.

13.3 Equipment

Selecting appropriate equipment to sample wastes is a challenging task due to the uncertainty of the physical characteristics and nature of the wastes. It may be difficult to separate, homogenize and/or containerize a waste due to its physical characteristics (viscosity, particle size, etc.). In addition, the physical characteristic of a waste may change with temperature, humidity, or pressure. Waste streams may vary depending on how and when a waste was generated, how and where it was stored/disposed, and the conditions under which it was stored/disposed. Also, the physical location of the wastes or the unit configuration may prevent the use of conventional sampling equipment.

Given the uncertainties that a waste may present, it is desirable to select sampling equipment that will facilitate the collection of samples that will meet the study's objective, and that will not unintentionally bias the sample by excluding some of the sample population that is under consideration. However, due to the nature of some waste matrices or the physical constraints of the waste unit, it may be necessary to collect samples knowing that a portion of the desired population was omitted due to limitations of the equipment. Any deviations from the study plan or difficulties encountered in the field concerning sample collection that may have an effect on the study's objective, should be documented in a log book, reviewed with the analytical data, and presented in the report.

13.3.1 Waste Sampling Equipment

Waste sampling equipment should be made of non-reactive materials that will neither add to or alter the chemical or physical properties of the material that is being sampled. Table 13.3.1 lists some conventional equipment for sampling waste units/phases and some potential limitations of the equipment.

13.3.2 Ancillary Equipment for Waste Sampling

In addition to the equipment listed in Table 13.3.1 which provides the primary device used to collect various waste samples, ancillary equipment may be required during the sampling for safety and/or analytical reasons. Some examples of these types of equipment are glass mixing pans, particle size reducers, remote drum opening devices, and spark resistant tools. See Section 13.7 for particle size reduction procedures. Any influences that these types of ancillary equipment may have on the data should be evaluated and reported as necessary.

TABLE 13.3.1
SAMPLING EQUIPMENT for VARIOUS WASTE UNITS

Equipment	Waste Units/Phases	Limitations
scoop with bracket/conduit (stainless steel)	impoundments, piles, containers, tanks/liquids, solids, sludges	Can be difficult to collect deeper phases in multiphase wastes. Depth constraints
spoon (stainless steel)	impoundments, piles, containers/solids, sludges	Similar limitations as the scoop. Generally not effective in sampling liquids
push tube (stainless steel)	piles, containers/cohesive solids, sludges	Should not be used to sample solids with dimensions $> \frac{1}{2}$ the diameter of the tube. Depth constraints
auger (stainless steel)	impoundments, piles, containers/solids	Can be difficult to use in an impoundment or a container, or for solidified wastes
sediment sampler (stainless steel)	impoundments, piles/solids, sludges	Should not be used to sample solids with dimensions $> \frac{1}{2}$ the diameter of the tube
ponar dredge (stainless steel)	impoundments/solids, sludges	Must have means to position equipment to desired sampling location. Difficult to decon
COLIWASA or drum thief (glass)	impoundments, containers, tanks/liquids	Not for containers > 4 feet deep. Not good with viscous wastes
Mucksucker™, Dipstick™ (Teflon®)	impoundments, containers, tanks/liquids, sludges	Not recommended for tanks > 11 feet deep
bacon bomb (stainless steel)	impoundments, tanks/liquids	Not good with viscous wastes
bailer (Teflon®, stainless steel)	impoundments, tanks/liquids	Only if waste is homogeneous. Not good with viscous wastes
peristaltic pump with vacuum jug assembly (Teflon®)	impoundments, tanks/liquids	Cannot be used in flammable atmospheres. Not good with viscous wastes.
back-hoe bucket	piles/solids, sludges	May be difficult to access desired sampling location. Difficult to decon. Can lose volatiles
split-spoon	piles/solids	Requires drill rig.
roto-hammer	piles, containers/solids	Physically breaks up sample. May release volatiles. Not for flammable atmospheres

13.4 Waste Sampling Procedures

13.4.1 Waste Piles

Waste piles vary in size, shape, composition, and compactness, and may vary in distribution of hazardous constituents and characteristics (strata). These variables will affect safety and access considerations. The number of samples, the type of sample(s), and the sample location(s) should be based on the study's objectives. Commonly used equipment to collect samples from waste piles are listed in Table 13.3.1. All equipment should be compatible with the waste and should have been cleaned to prevent any cross contamination of the sample.

13.4.2 Surface Impoundments

Surface impoundments vary in size, shape, and waste content, and may vary in distribution of hazardous constituents and characteristics (strata). The number of samples, the type of sample(s), and the sample location(s) should be based on the study's objectives. Commonly used equipment to collect samples from surface impoundments are listed in Table 13.3.1. All equipment should be compatible with the waste and should have been cleaned to prevent any cross contamination of the sample.

Because of the potential danger of sampling waste units suspected of containing elevated levels of hazardous constituents, personnel should never attempt to sample surface impoundments used to manage potentially hazardous wastes from a boat. All sampling should be conducted from the banks or piers of surface impoundments. Any exception must be approved by the appropriate site safety officer and/or the Occupational Health and Safety Designee (OHSD).

13.4.3 Drums

The most frequent type of containers sampled for hazardous constituents or characteristics by field investigators are drums. Caution should be exercised by the field investigators when sampling drums because of the potential presence of explosive/flammable gases and/or toxic vapors. Therefore, the following procedures should be used when collecting samples from drums of unknown material:

1. Visually inspect all drums that are being considered for sampling for the following:
 - pressurization (bulging/dimples),
 - crystals formed around the drum opening,
 - leaks, holes, stains,
 - labels, markings,
 - composition and type (steel/poly and open/bung);
 - condition, age, rust, and
 - sampling accessibility.

Drums showing evidence of pressurization and crystals should be further assessed to determine if remote drum opening is needed. If drums cannot be accessed for sampling, heavy equipment is necessary to stage drums for the sampling activities. Adequate time should be allowed for the drum contents to stabilize after a drum is handled.

2. Identify each drum that will be opened (e.g., paint sticks, spray paint, cones, etc).

LEVEL "B" PROTECTION IS REQUIRED FOR THE FOLLOWING PROCEDURES.

- 3 Before opening, ground each metal drum that is not in direct contact with the earth using grounding wires, alligator clips, and a grounding rod or metal structure. If a metal drum is in an overpack drum, the metal drum should be grounded.
- 4 Touch the drum opening equipment to the bung or lid and allow an electrical conductive path to form. Slowly remove the bung or drum ring and/or lid with spark resistant tools (brass/beryllium).
- 5 Screen drums for explosive gases and toxic vapor with air monitoring instruments as bung or drum lid is removed. Depending on site conditions screen for one or more of the following
 - radioactivity,
 - cyanide fumes,
 - halogen vapors,
 - pH; and/or
 - flash point (requires small volume of sample for testing).

Note the state, quantity, phases, and color of the drum contents. Record all relevant results, observations, and information in a logbook or on a Drum Data Form. Figure 13-1 is an example of a Drum Data Form. Review the screening results with any pre-existing data to determine which drums will be sampled.

- 6 Select the appropriate sampling equipment based on the state of the material and the type of container. Sampling equipment should be made of non-reactive materials that will neither add or alter the chemical or physical properties of the material that is to be sampled.
- 7 Place oil wipe, sampling equipment, and sample containers near drum(s) to be sampled.

AIR MONITORING FOR TOXIC VAPORS AND EXPLOSIVE GASES AND OXYGEN DEFICIENT ATMOSPHERES SHOULD BE CONDUCTED DURING DRUM SAMPLING.

Liquids -- Slowly lower the COLIWASA or drum thief to the bottom of the container. Close the COLIWASA with the inner rod or create a vacuum with the sampler's gloved thumb on the end of the thief and slowly remove the sampling device from the drum. Release the sample from the device into the sample container(s) splitting each COLIWASA volume among the containers, if possible. Repeat the procedure until a sufficient sample volume is obtained.

Solids/Semi-Solids -- Use a push tube, bucket auger, or screw auger or if conditions permit a pneumatic hammer/drill to obtain the sample. Carefully use a clean stainless steel spoon to place the sample into container(s) for analyses.

- 8 Close the drums when sampling is complete. Segregate contaminated sampling equipment and investigative derived wastes (IDW) containing incompatible materials as determined by the drum screening procedure (Step #5). At a minimum, contaminated equipment should be cleaned with laboratory detergent and rinsed with tap water prior to returning it from the field. IDW should be managed according to Section 5.15.

FIGURE 13-1
DRUM DATA FORM

Date _____

Page _____

SAMPLE COLLECTED Y / N

PROJECT NO _____ SITE NAME _____
CITY _____ STATE _____

EPA DRUM ID# _____ OTHER DRUM ID# _____

DRUM OBSERVATIONS:

1) OVERPACK Y / N METAL / PLASTIC / OTHER _____
SIZE 85 / 55 / _____

2) DRUM METAL / PLASTIC / OTHER _____
SIZE 85 / 55 / _____
CONDITION: GOOD / FAIR / POOR
MARKINGS/LABELS _____

3) DRUM OPENING TEAM: _____

4) ESTIMATED VOLUME FULL / $\frac{3}{4}$ / $\frac{1}{2}$ / $\frac{1}{4}$ / EMPTY

5) PHYSICAL APPEARANCE OF DRUM CONTENTS:

COLOR _____ VISCOSITY: LOW / MED / HIGH
PHASED Y / N , DESCRIPTION _____
OTHER _____

6) AIR MONITORING RESULTS

PID	_____ ppm	EXPLOS	_____ %O ₂	_____ %LEL
FID	_____ ppm	HALOGEN	Yes _____	No _____
CN	_____ ppm	pH	_____	
RAD	_____ Mrem		_____	

7) FLASH POINT SAMPLE COLLECTED YES / NO
FLASH RESULTS AT 140°F YES / NO
HOT WIRE TEST FOR HALOGEN POS / NEG

8) SAMPLE COLLECTED YES / NO TIME _____
COLLECTOR(S): _____

13 4 4 Tanks

Sampling tanks is considered hazardous due to the potential for them to contain large volumes of hazardous materials and therefore, appropriate safety protocols must be followed. Unlike drums, tanks may be compartmentalized or have complex designs. Preliminary information about the tank's contents and configuration should be reviewed prior to the sampling operation to ensure the safety of sampling personnel and that the study's objectives can be achieved.

In addition to having discharge valves near the bottom of tanks and bulk storage units, most tanks have hatches at the top. It is desirable to collect samples from the top hatch because of the potential for the tank's contents to be stratified. Additionally, when sampling from the discharge valve, there is a possibility of a stuck or broken valve which could cause an uncontrolled release. Investigators should not utilize valves on tanks or bulk storage devices unless they are operated by the owner or operator of the facility, or a containment plan is in place should the valve stick or break. If the investigator must sample from a tank discharge valve, the valving arrangement of the particular tank must be clearly understood to insure that the compartment(s) of interest is sampled.

Because of the many different types of designs and materials that may be encountered, only general sampling procedures that outline sampling a tank from the top hatch are listed below:

- 1 All relevant information concerning the tank such as the type of tank, the tank capacity, markings, condition, and suspected contents should be documented in a logbook
- 2 The samplers should inspect the ladder, stairs, and catwalk that will be used to access the top hatch to ensure that they will support the samplers and their equipment

LEVEL "B" PROTECTION IS REQUIRED FOR THE FOLLOWING PROCEDURES.

- 3 Before opening, ground each metal tank using grounding wires, alligator clips, and a grounding rod or metal structure
- 4 Any vents or pressure release valves should be slowly opened to allow the unit to vent to atmospheric pressure. Air monitoring for explosive/flammable gases and toxic vapors should be conducted during the venting with the results recorded in a log book. If dangerous concentrations of gases evolve from the vent or the pressure is too great, leave the area immediately
- 5 Touch tank opening equipment to the bolts in the hatch lid and allow electrical conductive path to form. Slowly remove bolts and/or hatch with spark resistant tools (brass/beryllium). If a pressure build up is encountered or detected, cease opening activities and leave the area
- 6 Screen tanks for explosive/flammable gases and toxic vapors with air monitoring instruments. Depending on the study objectives and site conditions, conduct characteristic screening (e.g., pH, halogen, etc.) as desired. Collect a small volume of sample for flash point testing, if warranted. Note the state, quantity, number of phases, and color of the tank contents. Record all relevant results, observations, and information in a logbook. Compare the screening results with any pre-existing data to determine if the tank should be sampled.
- 7 Select the appropriate sampling equipment based on the state of the material and the type of tank. Sampling equipment should be constructed of non-reactive materials that will neither add to or alter the chemical or physical properties of the material that is to be sampled

- 8 Place oil wipe, sampling equipment, and sample containers near tanks(s) to be sampled

AIR MONITORING FOR TOXIC VAPORS, EXPLOSIVE GASES AND OXYGEN DEFICIENT ATMOSPHERES SHOULD BE CONTINUOUS DURING TANK SAMPLING.

Liquids -- Slowly lower the bailer, bacon bomb, Dipstick™, COLIWASA, or Teflon® tubing to the desired sampling depth (NOTE In work areas where explosive/flammable atmospheres could occur, peristaltic pumps powered by 12 V batteries should not be used) Close the sampling device or create a vacuum and slowly remove the sampling device from the tank. Release the sample from the device into the sample container(s). Repeat the procedure until a sufficient sample volume is obtained.

Solids/Semi-Solids - Use a push tube, bucket auger, screw auger, Mucksucker™, or if conditions permit a pneumatic hammer/drill to obtain the sample. Carefully extrude the sample from the sampling device or use a clean stainless steel spoon to place the sample into containers for analyses.

- 9 Close the tank when sampling is complete. Segregate contaminated sampling equipment and investigative derived wastes (IDW) containing incompatible materials as determined by the drum screening procedure (Step #6). At a minimum, contaminated equipment should be cleaned with laboratory detergent and rinsed with tap water prior to returning it from the field. IDW should be managed according to Section 5.15

13.5 Miscellaneous Contaminated Materials

Sampling may be required of materials or equipment (e.g., documents, building materials, equipment, etc) to determine whether or not various surfaces are contaminated by hazardous constituents, or to evaluate the effectiveness of decontamination procedures

Wipe or swab samples may be taken on non-absorbent surfaces such as metal, glass, plastic, etc. The wipe materials must be compatible with the solvent used and the analyses to be performed, and should not come apart during use. The wipes are saturated with either methylene chloride, hexane, or analyte free water depending on the parameters to be analyzed (consult with laboratory performing the analyses). Wipe samples should not be collected for volatile organic compounds analysis. Sampling personnel should be aware of hazards associated with the selected solvent and should take appropriate precautions to prevent any skin contact or inhalation of these solvents. All surfaces and areas selected for sampling should be based on the study's objectives. Typically, 10 cm by 10 cm templates are prepared from aluminum foil which are secured to the surface of interest. The prepared (saturated with solvent) wipe(s) is removed from its container with tongs or gloves, and used to wipe the entire area with firm strokes using only one side of the wipe. The wipe is then placed into the sample container. This procedure is repeated until the area is free of visible contamination or no more wipes remain. Care should be taken to keep the sample container tightly sealed to prevent evaporation of the solvent. Samplers must also take care to not touch the used side of the wipe. All requests for support from the Region 4 laboratory for wipe preparations and wipe analyses should be made well in advance of the scheduled sampling event. (Note if gloves are used to collect the wipe samples, control samples should be collected to determine if the gloves could potentially contribute constituents to the parameters of interest.)

For items with porous surfaces such as documents (usually business records), insulation, wood, etc., actual samples of the materials are required. It is therefore important, that during the collection and/or analyses of the sample that evidentiary material is not destroyed. Use scissors or other particle reduction device that have been cleaned as specified in Appendix B to cut/shred the sample. Mix in a glass

pan as specified in Section 5 13.8 The shredded, homogenized material is then placed in sample containers

13.6 Waste Sample Handling Procedures

Waste samples should not be preserved because of the potential for an inadvertent chemical reaction of the sample with the preservative. After the samples have been collected and containerized, the outside of the containers should be cleaned with water, paper towels, and/or oil wipes to remove any spilled sample from the exterior of the container. Sample containers should be identified with tags and sealed for custody purposes as specified in Section 3 as soon as possible. After the sample container has been tagged and sealed, each container should be placed in a separate plastic bag and secured with electrical tape before being placed in a cooler. Waste samples that are suspected of being acutely toxic or extremely hazardous should be placed in paint cans with absorbent materials prior to being placed in a cooler. Waste samples should not be placed on ice because of the potential of a sample being water reactive.

13.7 Particle Size Reduction

Particle size reduction of waste samples is periodically required in order to complete an analytical scan or the Toxicity Characteristic Leaching Procedure (TCLP) test. Samples that may require particle size reduction include slags, bricks, glass/mirror cullet, wire, etc. Method 1311 (TCLP) states "Particle size reduction is required, unless the solid has a surface area per gram of material equal to or greater than 3.1 cm², or is smaller than 1 cm in its narrowest dimension (i.e., capable of passing through a 9.5 mm (0.375 inch) standard sieve). If the surface area is smaller or the particle size larger than described above, prepare the solid portion of the waste for extraction by crushing, cutting, or grinding the waste to a surface area or particle size as described above" (55 FR 26990). The method also states that the surface criteria are meant for filamentous (paper, cloth, etc.) waste materials, and that "Actual measurement of the surface area is not required, nor is it recommended". Also, the loss of volatile organic compounds could be significant during particle size reduction.

Waste samples that require particle size reduction are often too large for standard sample containers. If this is the case, the sample should be secured in a clean plastic bag and processed using normal chain-of-custody procedures (Section 3). Note that the tags that will be required for the various containers should be prepared in the field and either inserted into or attached to the sample bag. The bag should then be sealed with a custody seal.

Because of the difficulty in conducting particle size reduction, it is typically completed at the Field Equipment Center (FEC). The following procedure may be used for crushing and/or grinding a solid sample.

- 1 Remove the entire sample, including any fines that are contained in the plastic bag and place them on the standard cleaned stainless steel pan.
- 2 Using a clean hammer, carefully crush or grind the solid material (safety glasses are required), attempting to minimize the loss of any material from the pan. Some materials may require vigorous striking by the hammer, followed by crushing or grinding. The material may be subject to crushing/grinding rather than striking.
- 3 Continue crushing/grinding the solid material until the sample size approximates 0.375 inch. Attempt to minimize the creation of fines that are significantly smaller than 0.375 inch in diameter.
- 4 Pass the material through a clean 0.375-inch sieve into a glass pan.
- 5 Continue this process until sufficient sample is obtained. Thoroughly mix the sample as described in Section 5.13.8 of this SOP. Transfer the contents of the glass pan into the appropriate containers.
- 6 Attach the previously prepared tags and submit for analyses.

13.8 REFERENCES

- 1 Field Health and Safety Manual, United States Environmental Protection Agency, Region IV, 1990 Edition
- 2 Title 40 Code of Federal Regulations, Parts 260-299, US-EPA, July 1, 1995
- 3 Standard Guide for Sampling Heterogeneous Wastes (Draft), ASTM Standard, D34 01 12
- 4 Test Methods for Evaluating Solid Waste - Physical/Chemical Methods (SW-846), Third Edition, Final (Promulgated) Update II, US-EPA, Office of Solid Waste and Emergency Response, Washington, D C , September, 1994.
- 5 Compendium of ERT Waste Sampling Procedures, US-EPA, EPA/540/P-91/008 (OSWER Directive 9360 4-07), January 1991
- 6 Characterization of Hazardous Waste Sites - A Methods Manual Volume I -Site Investigations, US-EPA, EMSL, Las Vegas, EPA-600/4-84-075, April 1985
- 7 Characterization of Hazardous Waste Sites - A Methods Manual Volume II -Available Sampling Methods, 2nd Edition, US-EPA, EMSL, Las Vegas, EPA 600/4-84-076, December 1984

SECTION 14 AMBIENT AIR MONITORING

PERFORMANCE OBJECTIVE:

- To present the standard operating procedures and sample collection methodologies for conducting air monitoring in ambient air.

14.1 Introduction

This section discusses the sample collection and analytical procedures used for air monitoring in Region 4. Air toxics as used in this SOP means air pollutants for which National Ambient Air Quality Standards have not been established.

14.1.1 Formaldehyde Sampling Using Dinitrophenylhydrazine Cartridges Using Method TO-11

The following is a synopsis of procedures which should be strictly adhered to for the handling and field use of dinitrophenylhydrazine (DNPH) cartridges for formaldehyde sampling. This summary is adapted from METHOD TO-11 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR. The following generic procedures should be adhered to at all times:

- Polyethylene or Nylon gloves must be worn whenever handling any of the DNPH cartridges (in the extraction laboratory, during preparation for shipment, during field set-up, in the field during preparation for return shipment, and in the laboratory during preparation for analysis and during analysis).
- Coated DNPH cartridges which have been prepared for longer than 90 days shall not be used.
- All padding material shall be either clean tissue paper or polyethylene-air bubble padding. Never use polyurethane foam, cardboard, or newspaper as padding material. DNPH cartridges which have been properly prepared for shipment may be shipped in cardboard containers or preferably in coolers with eutectic salt packs (Blue Ice).
- Chain-of-custody shall be maintained for all samples.
- A minimum of one trip blank shall be transported per one to ten samples collected.

Extraction Laboratory

Upon completion of preparation of the DNPH cartridges, both ends shall be plugged with polypropylene Luer® male plugs and each DNPH cartridge placed in a borosilicate glass culture tube with polypropylene screw caps (tightened). A serial number, expiration date, and a lot number label will be placed on each glass culture tube. The batches of culture tubes shall be placed in sealed friction-top metal containers which contain 1-2 inches of granular activated charcoal (or a pouch filled with a similar amount of charcoal) for storage in the refrigerator in the Air Laboratory. The culture tubes should be enclosed in

two Zip-Lock® bags to prevent contamination from charcoal dust.

Air Monitoring Team

The Air Monitoring Team will notify and keep the Region 4 laboratory informed as to the anticipated number of prepared DNPH cartridges needed for field use. On routine studies, the Air Monitoring Team will notify the laboratory of needs at least two weeks in advance of needed pick-up date. Only the number of DNPH cartridges needed for a maximum of 60 days (including trip blanks and extra DNPH cartridges for breakage) will be requested.

- On the date of shipment or when loading out for a study, the Air Monitoring Team will remove the sealed cans (which contain the DNPH cartridges sealed in glass culture tubes) from the refrigerator in the Air Laboratory. If only a small number of tubes are needed for a particular study, the correct number of tubes will be transferred to another, smaller, solvent-washed shipping can.
- An appropriate amount of packing material shall be placed in the metal container to prevent breakage of the glass culture tubes. A label shall be affixed onto each metal container listing the number of DNPH cartridges in the container. The metal containers should be shipped in coolers containing eutectic salt packs (e.g., Blue Ice) to maintain a temperature of approximately 4°C. The DNPH cartridges shall be shipped the same day they are packed.
- On each sampling date, the metal container(s) will be removed from the refrigerator or cooler for transport to the field. At each sampling location the metal container will be opened and one glass culture tube will be removed (wearing clean polyethylene or nylon gloves) and allowed to warm to ambient temperature before removing the DNPH cartridge from the glass culture tube. The plugged DNPH cartridge will be removed from the culture tube and the two Luer® end plugs will be removed from each end of the DNPH cartridge which will be immediately placed on the sampling train. The Luer® end plugs will be placed back into the glass culture tube and the cap placed on the tube and **tightened**. The culture tube will be left in the sampler enclosure at the site. The same procedure will be adhered to at each sampling location. A trip blank (in a sealed culture tube) will be placed in a sampler enclosure at one on the sites for the duration of a sampling event.

The sampler will be manually turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

- The operator should retrieve and secure the sample as soon as possible after the sampling period ends. The sampler should manually be turned on and allowed to run for two minutes and a final flowrate and the elapsed time from the time meter should be recorded on the sample data sheet. The exposed DNPH cartridge will then be removed from the sampling train (wearing clean polyethylene or nylon gloves). The two Luer® end caps will be removed from the glass culture tube and placed on the ends of the DNPH cartridge. The DNPH cartridge will be placed back into the glass culture tube, the lid tightened, and placed back into the metal container. The same procedure is to be followed at each sampling site.
- At the end of each day on which the samples are collected, the sealed metal can (which contains the exposed DNPH cartridges) shall be either placed in a refrigerator for storage overnight or placed in a cooler. The cooler will be used to transport the samples to the

laboratory The duration of the non-refrigerated period shall be kept to a minimum but absolutely not more than two days

Laboratory

Upon arrival of the metal container at the laboratory, the samples shall be stored in the metal container in a refrigerator until submitted to the chemist for extraction.

14.1.2 Volatile Organic Compounds (VOC) Sampling with SUMMA® Electropolished Stainless Steel Canisters Using Method TO-14

The following is a synopsis of procedures which should be strictly adhered to for the cleanup and use of Summa® canisters for sampling air for Volatile Organic Compounds (VOC) analysis. This summary is adapted from Method TO-14 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR. The following procedures must be followed in the preparation and use of Summa® canisters for collecting samples for VOC analysis

- All new Summa® canisters must be individually checked for contamination by the laboratory before use. One of each batch of 10 Summa® canisters that are subsequently cleaned must be analyzed to check for contamination.
- All sampler tubing, fittings, and wetted parts of valves must be solvent washed in hexane and heated to $> 100^{\circ}\text{C}$. These parts should then be assembled and flushed with nitrogen for at least 8 hours prior to use in the sample train or in the canister cleanup apparatus.
- Each canister's valve and fitting will be inspected for damage before cleaning. Any damaged valve will be replaced with a previously cleaned (see procedure above) valve. After replacing any valve, the canister will be cleaned and analyzed to verify that it is free of contamination.
- If any canister is used to sample a high concentration source, it must be cleaned and analyzed to verify it is free of contamination before it can be used again.
- Chain-of-custody must be maintained for all samples.

SUMMA® Canister Cleanup

The following cleanup procedure will be followed for the preparation of all Summa® canisters

- The canisters should initially be pressurized to > 2 atm with humidified nitrogen¹ then evacuated to 1 atm. This filling and evacuation sequence shall be repeated five times to dilute any residual contaminants. The addition of the water from the humidified nitrogen may also displace some of the more reactive contaminants that could adhere to active sites on the wall of the canister. After the fifth evacuation to 1 atm, the vacuum pump will be left on for a minimum of 3 hours or until a vacuum of < 150 millitorr is reached. The identification number of the canister, the date, and the final vacuum will be recorded in the canister cleanup logbook. After cleaning, the canister's valve should be capped with a Swagelok® plug. A label will then be affixed to the canister denoting the date it was cleaned and the name of the person who performed the cleaning.

1 (The nitrogen should be certified 99.999% pure by the manufacturer. A molecular sieve scrubber should be attached to the nitrogen line after the regulator to remove any trace impurities)

Sample Collection

Two types of samples for VOC analysis can be collected with Summa® canisters. The canister can be opened and allowed to fill rapidly to obtain a grab sample or filled slowly by using a flow controller to collect a time integrated sample. With either type of sample, the following general procedures should be followed:

- An EPA, pre-numbered sample tag should be tied to the handle of the Summa® canister prior to sampling.
- A Chain-Of-Custody Record should be completed detailing time of sampling, sampling interval, and signed by the person collecting the sample.
- After the sample has been collected, the Summa® canister should be capped, the pre-numbered EPA tag should be completed, and the canister should be placed in a shipping container with a copy of the Chain-Of-Custody Record and sealed with EPA sample custody tape.

Grab Sample Collection

Before a grab sample is collected for VOC analysis in a Summa® canister, the canister inlet valve should be fitted with a pre-cleaned stainless steel particulate filter. At the sample collection location, the main valve should be opened and the canister allowed to fill. After about one minute (when no audible sound of rushing gas can be heard), the main valve of the Summa® canister should be closed and capped.

Time Integrated Sample Collection

This sample collection method involves the use of a flow controller or a sampler containing a flow controller to slowly meter the flow of air entering a Summa® canister. With this method, a sample is collected over a longer period of time than with a grab sample. If a constant flowrate was maintained, the resulting sample will have a VOC content that is the average of the VOC concentrations during the sampling interval.

The following procedures should be followed to collect time integrated samples:

- All sampler systems should be checked for contamination prior to use or after any major repair. This is accomplished by metering zero air or nitrogen¹ to the inlet of the sampler. Excess zero air or nitrogen should be vented with a Swagelok® tee from the sampler inlet to atmosphere. The evacuated canister should then be filled at the normal sampling rate with the zero gas.
- The initial flowrate will be determined with a mass flow meter. The initial flowrate and initial vacuum (at least 29 inches of Hg) should be recorded on the sample data sheet. The flowrate should be adjusted so that at the end of the sampling interval the ending pressure of the canister is approximately 0.9 atm.
- The final flowrate should also be determined with a mass flow meter. The final flowrate and final vacuum should be recorded on the sample data sheets. The final vacuum should be between 5 inches and 1 inch of Hg. The final flowrate should be at least 1 scc/min.

After sample collection, all canisters should be double checked to verify that each has an EPA pre-numbered tag with all of the information filled out. Place the canister in a shipping container and seal the container with EPA sample custody tape.

14.1.3 Sampling for Semi-Volatile Organic Compounds (SVOC) Analysis with High Volume PUF Samplers Using Methods TO-4 & TO-13

The following is a synopsis of procedures which should be strictly adhered to for use of the High Volume Polyurethane Foam (PUF) sampling method for collecting samples for semi-volatile organic compound (SVOC) analysis including pesticides and polychlorinated biphenyls. This summary is adapted from Method TO-4 (pesticides and PCBs) and TO-13 (polynuclear aromatic compounds) of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

The following procedures must be followed during preparation of PUF sampling media when using the High Volume PUF method for collecting samples for SVOC analysis:

- All PUF sampling media should be pre-cleaned, loaded into High Volume PUF sample cartridges, and sealed in solvent washed cans by the extraction laboratory prior to use.
- Chain-of-custody shall be maintained for all samples.

PUF Cleaning

The Air Monitoring Team has responsibility for buying the PUF media and cutting the PUF plugs. PUF media should be specified as not containing any fire retardants. It should be stored in the dark to prevent photo-oxidation. It should be less than two years old, and should be stored in a pesticide free environment.

Care should be exercised in cutting the PUF. It should be thoroughly wet with tap water prior to cutting. A drill press and stainless steel PUF cutting die should be used. The drill press area should be free of oil and a polyethylene cutting block should be used to stop the die at the bottom of the drill press stroke (do not use wood). Water should be sprayed on the die to help prevent snagging as the PUF is cut. After the plugs are cut, they should be rinsed with tap water and followed by a rinse with analyte-free water. Finally, the excess water should be squeezed out.

The PUF/XAD-2 cartridges are assembled using a modified glass sleeve containing an extra-extra coarse frit to retain the XAD-2 resin in the following manner. A 3/4-inch layer of XAD-2 resin is poured on top of the frit followed by a 1 1/2-inch PUF plug to retain the XAD-2 resin.

The assembled PUF/XAD-2 cartridges are delivered to the extraction laboratory for cleaning and checking. The extraction laboratory will be given a minimum of three weeks notice for cleaning and checking the PUF/XAD-2 cartridges. The cleaned PUF/XAD-2 cartridges should be wrapped in aluminum foil and packed in metal cans cushioned by cleaned polyurethane foam to prevent breakage during shipment. Prepared PUF/XAD-2 sample cartridges that are pre-packed in solvent washed metal cans will be obtained from the extraction laboratory prior to sampling. The cans should be packed inside coolers which are lined with polyurethane foam for shipment.

Sample Collection

The following procedures will be followed for all High Volume PUF sampling

Nylon gloves will be used when handling all PUF cartridges and quartz particulate pre-filters. Assure that the red silicon upper and lower gaskets, located in the cartridge housing, are in place. Then remove the PUF cartridge from the shipping can, remove from the foil and insert the cartridge into the High Volume PUF sampler's chamber. The pre-filter should be installed in the filter holder using caution not to over tighten the fittings. The foil should be placed back in the shipping can. The can should be labeled with site ID, operators name, and sample date, and placed in the High Volume PUF sampler enclosure until the sample is collected.

The High Volume PUF sampler should be turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

The operator should retrieve and secure the sample as soon as possible after the sampling period ends. The sampler should then be manually turned on and allowed to run for two minutes. A final flowrate should be recorded on the sample data sheet. The final flowrate should be at least 150 liters per minute. The PUF cartridge should be removed, and the quartz pre-filter folded and placed in the top of the PUF cartridge. The PUF cartridge and pre-filter should be re-wrapped in the original aluminum foil and placed back in the shipping can. The can should then be tightly sealed. Complete the sample data sheet and Chain-Of-Custody Record and seal the shipping can with a sample custody seal. Finally, the shipping can containing the sample should be placed in a cooler containing frozen eutectic salt packs (at a nominal temperature of $\sim 4^{\circ}\text{C}$). When all samples are collected from all sites, the cooler should be sealed with sample custody tape for transport back to the laboratory.

Laboratory

Upon arrival of the metal container at the laboratory, the samples shall be stored in the metal container in a refrigerator until submitted for extraction.

14.1.4 Collecting Samples for Metals Analysis Using the High Volume Sampler

The following is a synopsis of procedures which should be strictly adhered to for the collection of samples for metals analysis in air. This summary is adapted from 40 CFR, PART 50, APPENDIX B - Reference Method For The Determination Of Suspended Particulate Matter In The Atmosphere (High Volume Method), and 40 CFR, PART 50, APPENDIX G - Reference Method For The Determination Of Lead In Suspended Particulate Matter Collected From Ambient Air.

The following procedures must be followed in preparation for collecting samples for metals analyses with the High Volume sampler.

- All filters used will be supplied by the EPA National Filter Distribution Program, and of the same quality as supplied to the State and Local Agency Air Monitoring Stations.
- Prior to use, all filters will be checked for pinholes, and desiccated at $15^{\circ}\text{C} - 30^{\circ}\text{C}$, $\pm 3^{\circ}\text{C}$, and less than 50 percent relative humidity, ± 5 percent, for at least 24 hours.

- A filter field blank will be taken to the field, but not exposed. Filter field blanks will be analyzed by the laboratory to determine the concentration of metals contained in the filter matrix. The number of filter blanks will be determined based on a minimum of one blank for each ten samples collected.
- Chain-of-custody must be maintained for all samples.

Sample Collection Procedures

Samples will be collected using the High Volume sampler as described, and operated in accordance with 40 CFR, PART 50, APPENDIX B.

- All flow calibration orifices will be traceable to a Primary Standard Rootsmeter. Flows will be corrected to EPA standard temperature and pressure (25°C and 760 mm Hg).
- Digital manometers used to determine flow rates will be checked against a U-Tube water manometer prior to use in each study.
- Air Monitoring Team personnel will remove a 2-inch strip of the exposed filter from one end and discard it. Two 1-inch strips will be cut from the same end and transported to the laboratory for analysis.

Integrated Sample Collection

The following procedures should be followed to collect time integrated samples:

- Initial and final flow rates will be determined with a calibrated orifice and a digital manometer.
- After the sample has been collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed.
- A Chain-Of-Custody Record should be completed which contains the time of sampling, the sampling interval, and the signature of the person taking the sample.

After sample collection, all sample envelopes will be placed in an appropriate container. An EPA custody seal will be placed on the container. Filters will be cut by the Air Monitoring Team and transported to the laboratory for analysis.

14.1.5 Sampling and Analysis of Mercury in Ambient Air Using Arizona Instrument® Mercury Dosimeter Tubes and the Model 511 Gold Film Mercury Vapor Analyzer

The following is a synopsis of procedures which should be strictly adhered to for the sampling and analysis of mercury (Hg) in ambient air. This summary is adapted from the Arizona Instruments® (AZI), Model 511, Gold Film Mercury Vapor Analyzer Manual.

The following generic procedures should be adhered to at all times:

- Chain-of-custody shall be maintained for all samples
- A minimum of one trip blank shall be transported one per ten samples collected
- All mercury dosimeter tubes shall be cleaned and analyzed each sampling day prior to use

Dosimeter Cleanup

Each dosimeter tube should be connected to the AZI® model 412 dosimeter controller and AZI® Gold Film Mercury Analyzer as shown in Figure 1 of the AZI® model 511 Mercury Analyzer Operation Manual. The mercury analyzer analysis cycle should be started and **immediately** afterward the dosimeter controller's START button should be depressed. This will cause the gold plated wire inside the dosimeter tube to heat up and liberate any elemental mercury that forms an amalgam on the gold plated wire inside the dosimeter. Continue this cycle until less than 2 ng of Hg is detected from the dosimeter tube. Remove the clean dosimeter tube from the dosimeter controller, tag it with the cleanup date and the operators name, and connect the inlet and outlet dosimeter ports together with a clean ~ 8-inch section of 3/16-inch ID x 1/16-inch wall Tygon® tubing (this effectively caps the dosimeter tube).

Sample Collection

Each sampling pump will be calibrated with a mass flow meter before and after each sampling event. Connect the dosimeter to the battery powered sampling pump with Tygon® tubing. Adjust the sampling pump to obtain a flowrate of 50 cc/min. The sampling interval should not extend beyond 8 hours. The following steps should be followed to collect each sample:

- Disconnect one end of the Tygon® tubing from the dosimeter tube and connect it to the battery powered sampling pump
- Program the pump to run the desired number of hours. Position the dosimeter tube inlet so that there is no obstruction of flow. Record the dosimeter tube number, site ID, sample date, start time, and initial flowrate on the sample data form
- As soon as possible after the sampling event, disconnect the Tygon® tubing from the sample pump and connect the loose end to the inlet of dosimeter tube. Record the elapsed time from the pump display. Check the ending flowrate with a mass flow meter and record it on the sample data form

Sample Analysis

Before any mercury analysis of dosimeter tubes, the AZI® model 511 should be calibrated. The AZI® model 511 should only be used under laboratory conditions. All glassware should be scrupulously cleaned and used exclusively for mercury analysis. All Tygon tubing that is used should be new. The following calibration procedure is adapted from the AZI® model 511 operation manual:

Calibration

- Calibration of the AZI® model 511 is accomplished by the reaction of a mercuric chloride standard solution with stannous chloride which liberates elemental mercury. The elemental mercury is sparged from an impinger for analysis in the mercury analyzer
- Before calibration, a film heat cycle should be initiated to clean the mercury analyzer sensor
- Fresh working 100 ng/ml mercuric chloride standards should be prepared daily from a 1000 ug/ml stock solution. From the 100 ng/ml working standard, calibration standards of 10 ng/ml, 20 ng/ml, and 40 ng/ml should be prepared. Use the procedure outlined in the AZI® operation manual to introduce the stannous chloride solution into the impinger containing the 40 ng/ml standard. IMMEDIATELY depress the SAMPLE START button on the analyzer. Use the calibration potentiometer to adjust the analyzer to read 40. Analyze the 10, 20, and 40 ng/ml standards to verify that the calibration curve is linear. All analyzer readings should be within 2 ng of the actual values of the standards. Record the readings in the logbook
- Once the mercury analyzer is calibrated, connect an exposed dosimeter tube to the model 412 dosimeter controller. Connect a zero filter to the inlet of the dosimeter tube. Simultaneously press the mercury analyzer SAMPLE START button and the dosimeter controller START button. Record the analyzer reading (in ng) in the logbook. Repeat this sequence three times and sum the values. This value is the total ng of mercury that was captured on the dosimeter tube
- Divide the sum of the mercury analyzer readings (in ng) by the total volume of air sampled (in liters) to give the concentration of mercury present in ug/M³

14.1.6 Sampling for Dioxin And Dibenzofuran Analyses with High Volume PUF Samplers Using Method TO-9

The following is a synopsis of procedures which should be strictly adhered to for use of the High Volume Polyurethane Foam (PUF) sampling method for collecting samples for polychlorinated dibenzo-p-dioxins and dibenzofurans analyses. This summary is adapted from Method TO-9 of the COMPENDIUM OF METHODS FOR THE DETERMINATION OF TOXIC ORGANIC COMPOUNDS IN AMBIENT AIR.

Since this method requires High-Resolution Mass Spectrometry which the Region 4 laboratory does not have, all sample media preparation and analysis will have to be contracted. At least one month's notice prior to sampling should be given to obtain a contract laboratory program (CLP) contract for any dioxin and dibenzofuran analysis. It is important that the contract specify a number of details to assure accurate results.

- All of the PUF media and a representative number of each batch of quartz pre-filters should be checked by the contract laboratory to assure that there is no contamination. Each PUF plug should be pre-spiked by the contract laboratory with dioxin and dibenzofuran surrogates as a check of the accuracy of the method.

- Each set of PUF plugs and quartz filters should be securely packed in sealed containers and in coolers to prevent damage during shipment. The sampling media should be shipped air freight to minimize the time between cleanup and sampling
- Chain-of-custody shall be maintained for all samples.

Sample Collection

The following procedure will be followed for the collection of all High Volume PUF samples for dioxins and dibenzofurans analyses

Nylon gloves will be used when handling all PUF cartridges and quartz particulate pre-filters. Assure that the red silicon upper and lower gaskets are in place in the PUF cartridge housing. Remove the PUF cartridge from the shipping can. Unwrap and insert the PUF cartridge into the High Volume (Hi-Vol) PUF sampler's chamber. Install the pre-filter in the filter holder using caution not to over tighten the fittings. The removed aluminum foil should be placed in the shipping container which then should be resealed. The container should be labeled with the site ID, the operators name, and the sample date, and placed in the Hi-Vol PUF sampler enclosure until the sample is collected. The Hi-Vol PUF sampler should be turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

The operator should retrieve and secure the sample as soon as possible after the sampling period ends. The sampler should then be manually turned on and allowed to run for two minutes and a final flowrate recorded on the sample data sheet. The final flowrate should be at least 150 liters/minute. The PUF cartridge should be removed, and the quartz pre-filter folded and placed in the top of the PUF cartridge. The PUF cartridge and pre-filter should be re-wrapped in the original aluminum foil and placed back in the shipping container and the container should be tightly sealed. Complete the sample data and sample custody sheets. Each shipping container should have a sample custody seal. Finally, the shipping container containing the sample should be placed in a cooler containing frozen eutectic salt packs (at a nominal temperature of $\sim 4^{\circ}\text{C}$). When all samples are collected from all sites, the cooler should be sealed with sample custody tape for shipment to the contract laboratory.

Contract Laboratory

Upon arrival of the metal container at the contract laboratory, the samples shall be stored in the metal container in a refrigerator until submitted for extraction.

14.1.7 Mercury Sampling Using Gold-Coated Glass Bead Tubes

The following is a synopsis of procedures which should be strictly adhered to for the handling and field use of gold-coated glass bead mercury sampling tubes.

The following generic procedures should be adhered to at all times.

- Polyethylene or Nylon gloves must be worn whenever handling any of the mercury sampling traps (in the laboratory, during preparation for shipment, during field set-up, in field during preparation for return shipment, and in the laboratory during preparation for analysis and during analysis)
- Pre-cleaned mercury sampling traps which have been prepared for longer than 60 days shall

not be used

- Chain-of-custody shall be maintained for all samples.
- A minimum of one trip blank shall be transported one per ten samples collected

Laboratory

Upon completion of preparation of the mercury sampling traps, both ends shall be plugged with Teflon male plugs, the plug connection wrapped in Teflon tape, and each trap placed in a plastic shipping tube. A serial number, expiration date, and a lot number label will be placed on each shipping tube. The batches of shipping tubes shall be placed in sealed lock-top plastic containers.

Air Monitoring Team

The Air Monitoring team will notify and keep the laboratory informed as to the anticipated number of prepared mercury sampling traps needed for field use. On routine studies, the Air Monitoring Team will notify the laboratory of needs at least two weeks in advance of needed pick-up date. Only the number of mercury sampling traps needed for a maximum of 60 days (including trip blanks and extra sampling traps for breakage) will be requested.

- On the date of shipment or when loading out for a study, the Air Monitoring team will remove the sealed plastic containers (which contain the mercury sampling traps sealed in plastic shipping tubes) from the Air Laboratory.
- An appropriate amount of packing material shall be placed in the shipping container to prevent breakage of the mercury sampling tubes.
- On each sampling date, the plastic container(s) will be removed from the refrigerator or cooler for transport to the field. At each sampling location the plastic container will be opened and one mercury sampling tube will be removed (wearing clean polyethylene or nylon gloves). The end plugs will then be removed from each end of the mercury sampling trap which will be immediately placed on the sampling train. The end plugs will be placed back into the shipping tube and the cap placed on the tube wrapped in Teflon tape. The shipping tubes will be left in the sealed plastic container. The same procedure will be adhered to at each sampling location. A trip blank will be opened, handled, and resealed at one site to evaluate potential passive contamination.

The sampler will be manually turned on and allowed to run for two minutes. An initial flowrate should be recorded on the sample data sheet. The timer should be set to turn the sampler on and off at the desired times.

- Air monitoring personnel should retrieve and secure the sample as soon as possible after the sampling period ends. The sample pump should be manually turned on and allowed to run for two minutes, and a final flowrate and the elapsed time from the elapsed time meter should be recorded on the sample data sheet. The exposed mercury sampling trap should then be removed from the sampling train wearing clean polyethylene or nylon gloves. The two end caps shall then be removed from the shipping tube and placed on the ends of the sampling trap. The sampling trap will be placed back into the shipping tube, the lid tightened, and placed back into the plastic container. The same procedure must be followed at each sampling site.

- At the end of each study, the samples will be transported to the laboratory

14.2 Criteria Pollutant Monitoring (Reference Monitors) for Air Pollutants for which National Ambient Air Quality Standards have been Established

14.2.1 Monitoring Ozone in Ambient Air

The following is a synopsis of procedures which should be strictly adhered to for the monitoring of ozone in air. This summary is adapted from 40 CFR Part 50, Appendix D -Measurement Principle and Calibration Procedure For The Measurement Of Ozone In The Atmosphere, and the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.7 (EPA-600/4-77-027a).

- Calibration systems will meet 40 CFR Part 50, Appendix D specifications for a Primary Standard Calibration Photometer
- Calibration systems will be verified against the National Institute of Standards and Technology (NIST) Standard Reference Photometer #10 before use.
- Monitor enclosures will meet the specifications of monitor reference/equivalent designation for temperature control
- Probes must meet the requirements stated in 40 CFR Part 58 for materials and sample residence time.
- All flow calibrations will be traceable to a primary standard. Flows will be corrected to EPA standard temperature and pressure (25°C and 760 mm Hg).
- Chain-of-custody must be maintained at all times.

Monitoring Procedure

Monitoring will be conducted using the procedure as described, and in accordance with 40 CFR Part 50, APPENDIX D

- Monitors will be calibrated at the beginning and end of each study, and at least quarterly during the study.
- Monitors will be calibrated after major maintenance or when a quality assurance (QA) check shows an out-of-control condition exists
- A zero/span check will be conducted daily on all monitors.
- Precision checks of all monitors will be conducted at least weekly.
- Quality assurance audits as specified in 40 CFR Part 58, Appendix A will be conducted quarterly, or at least once for short duration studies
- Data telemetry systems will be run in parallel with strip chart recorders. Strip charts will serve as a permanent record and diagnostic tool.

After completion of the study, all monitoring equipment will be returned for final check-out. All field documentation will be retained by the Air Monitoring Team.

14 2.2 Sampling of Particulate Matter in Ambient Air as PM₁₀

The following is a synopsis of procedures which should be strictly adhered to for the sampling of particulate matter as PM₁₀ in air. This summary is adapted from 40 CFR Part 50, Appendix J - Reference Method For The Determination Of Particulate Matter as PM₁₀ In The Atmosphere, and the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Section 2.11 (EPA-600/4-77-027a).

- All filters used will be supplied by the EPA National Filter Distribution Program, and of the same quality as supplied to the State and Local Agency Air Monitoring Stations
- Prior to use, all filters will be checked for pinholes, and desiccated at 15°C - 30°C \pm 3°C, and less than 50 \pm 5 percent relative humidity, for at least 24 hours
- Initial and final (exposed) filter weights will be determined by air monitoring personnel. One of ten filters will be reweighed as a quality assurance check. For batches less than ten, one filter will be reweighed.
- After sampling, filters will be desiccated as previously described.
- Chain-of-custody must be maintained for all samples

Sample Collection

Samples will be collected using the High Volume sampler as described, and operated in accordance with 40 CFR Part 50, Appendix J

- All flow calibration orifices will be traceable to a primary standard Rootsmeter. Flows will be corrected to EPA standard temperature and pressure (25°C and 760 mm Hg)
- Digital manometers used for flow rate determinations will be checked against a U-Tube water manometer prior to use in each study
- Volumetric flow controllers will be used on all PM₁₀ samplers. Flows will be determined using the manufacturer's flow rate table supplied with the controllers. Flow rate tables will be verified using a calibrated orifice on a routine basis, or at least annually.

Integrated Sample Collection

The following procedures should be followed to collect time integrated samples

- Initial and final flow rates will be determined with a digital manometer based on the manufacturer's flow rate look-up table
- After the sample is collected, the filter will be folded lengthwise and placed in a filter holder. The filter holder is then placed in an envelope and the envelope sealed
- A Chain-Of-Custody Record should be completed detailing the time of sampling and the sampling interval, and should be signed by the person collecting the sample

After sample collection, all sample envelopes will be placed in an appropriate container. An EPA custody seal will be placed on the container prior to transport to the Region 4 laboratory for final weighing

of filters

SECTION 15 FIELD PHYSICAL MEASUREMENTS

SECTION OBJECTIVE:

- Present the standard practices used for making field physical measurements,

15.1 Introduction

Field measurements of topographic features, water levels, time-of-travel, geophysical parameters, physical dimensions, etc., are frequently required during field investigations conducted by the Branch. The purpose of the investigation will determine the scope of these measurements.

All sampling locations used during field investigations should be depicted on an accurate drawing, topographic or other standard map, or be referenced in such a manner that the location(s) can be firmly established. The Region 4 library has a complete collection of 7.5 minute USGS (1:24,000 scale) topographic maps and a map copier is available.

Each field measurement made should be traceable to the person(s) making the measurement and to the field equipment used to make that measurement. Equipment maintenance and calibration records shall be kept in log books and field records so that the procedures are traceable. Time records shall be kept in local time using the hour format, with the time recorded to the nearest five minutes or less.

New employees should perform each of the physical field measurements described in this section under the supervision of a senior technical staff member at least once before being permitted to make these measurements on their own.

15.2 Horizontal Location Surveys

15.2.1 Introduction

Surveying is described as the art and science of determining the area and configuration of portions of the earth's surface, and representing them on maps. Generally, surveying can be divided into two categories or classes: horizontal control surveying and vertical control surveying. Horizontal control surveying pertains to the measurement of the relative difference in the horizontal location of two or more control points. Vertical control surveying involves the measurement of the relative difference in vertical location or elevation, of two or more control points and is presented in Section 15.3. This section discusses the standard procedures, techniques, and methods used to survey or locate sampling locations or site features horizontally. Basic surveying and field geology textbooks should be consulted for more detailed information on this topic (See References 1, 2, and 3).

Several field methods, from traditional or classical methods to Global Positioning System (GPS) techniques, may be used to horizontally locate sampling locations or various site features during field investigations. Traditional traverse methods used by the Branch utilize horizontal angle or direction

(azimuth/bearing) measurements and calculated horizontal distances from a starting point to a second point, and from the second to the third, and so forth to the last point. The last point in a traverse is usually a return to the starting point, thus making a closed loop. During a traverse for site control, sampling locations or site features may be located by employing various techniques at the traverse control points, e g , by angle (azimuth or bearing) and distance measurements from a control point, by angular intersection from two control points, by perpendicular offset from a line between two control points, by angle from one control point and distance from another control point, etc

GPS methods utilize radio frequency measurements with multichannel receivers of the signals from the global network of satellites that the Department of Defense has established. Measurements of the horizontal sampling locations or site features by GPS technology is based on the same principles used in traditional surveying methods. However, with GPS, hand held receivers measure distances to three or more satellites of known positions and triangulate the position of the sampling location, site feature, or point on earth. More fundamental information on GPS technology may be found in Reference 4.

Regardless of the method(s) used, horizontal location surveys should be based on established control points. A network of horizontally (and vertically) located control points has been established and is continually maintained by the National Oceanic and Atmospheric Administration (NOAA) through its National Ocean Survey (formerly U.S. Coast and Geodetic Survey). The old horizontal datum, called the North American Datum of 1927 (NAD27), has been replaced with the newer datum of 1983 (NAD83). The system of horizontal control points has established latitude and longitude positions and provides the basis for the coordinate grid systems used by many States.

When measuring horizontal angles, compensation should be made for the angle between true north and magnetic north. This angle is called the magnetic declination. Field surveying methods should be referenced to true north. The first step in this procedure is to determine the declination for the area of work from an isogonic map. Isogonic maps may be found in basic surveying and field geology textbooks.

Existing information on horizontal control stations or coordinate grid data and their exact locations may be obtained from local, state, or federal departments or agencies. Typically, engineering or public works departments of counties, cities, or towns may have data on file that is near the particular site being investigated. State or federal agencies which are good sources of useful data include:

- State highway or transportation departments
- State geodetic or land surveying offices
- State natural or water resources bureaus
- State geological surveys
- NOAA/National Ocean Survey
- United States Geological Survey
- Corps of Engineers, Department of the Army
- Soil Conservation Service
- Tennessee Valley Authority
- Bureau of Land Management

When exact locations of sampling points or other physical features at a site are needed, surveying methods must be based on existing control data. If unavailable at the time of the investigation, and if necessary, the site property boundary survey, legal description, and any physical property corners or monuments must be established by a professional Registered Land Surveyor (RLS). Often times, before or when the surveyor is at a site, the registered surveyor could be requested to set control data points for use. At a minimum, the registered surveyor would be asked to establish at least two control points upon which the elevation and the State Plane (SP) coordinates are set. Data on control points shall be of at least

third-order accuracy. Control points will be permanent markers set at locations that are unlikely to be disturbed by future site activities

If no existing control data exists in the site vicinity, an arbitrary point or points may be established at a permanent location, e.g., set a nail or spike beneath the ground or set a nail and cap in asphalt or foundation. Coordinates for those points (and, therefore all other points) should be determined at a later date. Location of all control data used and all field measurements should be recorded in the field logbook as outlined in Section 3.5

15.2.2 Equipment Available

The following equipment is available for field use in conducting horizontal surveys:

- Topcon GTS-2, total station theodolite/electronic distance meter (EDM)
- Trimble Pathfinder Pro XL 8 channel or 12 channel GPS receiver
- tripod(s)
- reflector prism(s)
- prism pole
- steel tape
- cloth tape
- right angle prism
- compass

15.2.3 Specific Equipment Quality Control Procedures

Field surveying methods using appropriate and available equipment should be made only by those personnel who have been trained to use them. Field investigators must be trained and checked out in surveying procedures by qualified staff before using this equipment.

Each piece of field equipment (as appropriate) should be numbered, and a log book should be kept containing maintenance and calibration records for the equipment. Maintenance and calibration procedures used for all surveying equipment are listed in the inspection logbooks.

Theodolite -- This equipment should.

- be serviced and calibrated by a qualified private service shop annually or sooner if damaged or suspected to be in error,
- be checked out using procedures outlined in basic surveying textbooks and appropriate users manuals before use (See References 1, 2, and 3), and,
- be cleaned and maintained using procedures outlined in basic surveying textbooks and appropriate users manuals during field use and before being returned to storage (See References 1, 2, and 3)

GPS Receivers -- This equipment should.

- be serviced and calibrated by the manufacturer if damaged or suspected to be in error,
- be checked out using procedures outlined in the appropriate users manuals before use, and,

- be cleaned and maintained using procedures outlined in the appropriate users manuals during field use and before being returned to storage.

Steel and Cloth Measuring Tapes -- The following procedures should be used for all measuring tapes

- Measuring tapes will be calibrated against an Invar steel surveyors chain or the theodolite/EDM both of which are traceable to the National Bureau of Standards (NBS) Those steel tapes that are not within 0.01 foot per 100 feet or cloth tapes not within 0.02 foot per 100 feet should be discarded
- All tapes should be checked for damage and should be cleaned before and after use

Compass -- All compasses should

- be checked for proper movement of the compass needle. If the compass needle movement is sluggish, the glass cover can be removed by prying a knife point under the spring washer. The copper wire on the needle is then moved until the needle lies level (Reference 3),
- be checked for proper alignment of clinometer level. The clinometer is checked by setting the clinometer to 0, and placing the compass on a surface that has been leveled exactly with either a carpenters level or a water tube level. If the horizontal level bubble on the clinometer does not rest at the center, the compass should be opened as previously described and the clinometer level vial should be moved and rechecked as appropriate. If the level vial becomes broken, the compass must be sent to the manufacturer to be repaired (Reference 3), and
- be cleaned after use and before storage. If the compass should become wet, the compass should be opened as previously described and the interior dried using a toothpick and a piece of soft cloth or soft paper. Compasses should not be used, exposed to, or stored in strong electrical fields (Reference 3)

Prism Poles and Reflector Prisms -- All of this equipment should:

- be checked for warpage and/or damage before use by sighting through the theodolite/EDM while the poles/prisms are rotated in two planes at 90° intervals. The bullseye bubble should be reset if needed, and
- be cleaned daily after use and before being returned to storage.

15.2.4 Procedures for Traversing

When traverse methods are used, at least two stations or control points of known horizontal location (expressed in terms of a local or State Plane coordinate system) must be in the site vicinity. These control points can usually be set for the specific site by a governmental agency or registered land surveyor.

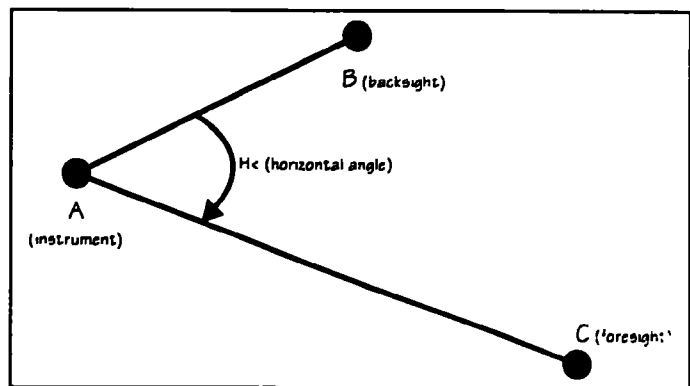
The total station theodolite, which measures horizontal angles, vertical and/or zenith angles, and slope distances, is set up over an existing control point. The theodolite is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads appropriately. Once the bullseye bubble is centered, the theodolite is rotated 90° at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The instrument is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman has either a range pole equipped with a reflector prism (single or triple) or a tripod with the reflector prism. The prism is used to reflect the signal from the electronic distance meter in the total station theodolite. While located over the point(s) whose location is desired, the rodman holds the range pole vertically by means of centering the bullseye bubble, or sets up the tripod and reflector prism similarly as stated above. The instrument man sights through the telescope on the theodolite, lines up the horizontal and vertical cross-hairs on the center of the prism, and records the horizontal angle ($H\angle$), vertical angle ($V\angle$), or zenith angle ($Z\angle$), and the slope distance (D_s) to the prism. The difference in location between the point where the theodolite is set up and the point where the prism is held is determined trigonometrically. A compass and measuring tape could also be used to reference field measurements to a map or vice versa.

The following examples depict some of the field measurements that must be considered and accounted for, the calculations that must be performed, and the conversions that must be made when traverse methods to horizontally locate sampling points or other site features are used.

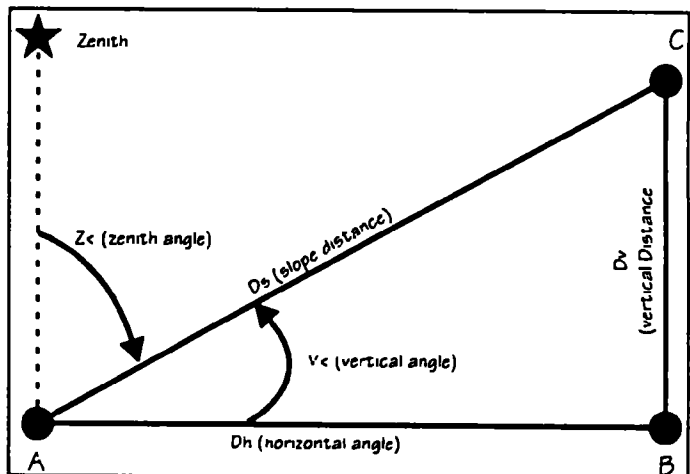
EXAMPLE 1, Horizontal Angles

Figure 15.2.1 illustrates that while the instrument is at point A (a control point), one reads the backsight angle (azimuth or bearing) to point B, then turns and measures the foresight angle (azimuth or bearing) to point C. The difference between the two angles is the interior angle included at the intersection of line AB and line AC, or the horizontal angle ($H\angle$). The field notation for the measurement of the angle above would be represented as angle B-A-C. Typically, the first column to the left in the field book is labeled (BS - \mp - FS) or Station and the second column is labeled $H\angle$ (see Example 5, Field Notation).



Example 1: Figure 15.2.1. Map view showing horizontal angle B-A-C

EXAMPLE 2, Vertical or Zenith Angles After the horizontal angle is determined, the vertical angle ($V\angle$) is measured (Figure 15.2.2) from point B to point C to determine the angle between the line of sight AC and the horizontal line AB. The vertical angle is the included angle between a line connecting two points of different elevations and a line horizontal to the earth's gravity. The vertical angle in Figure 15.2.2 is above the horizontal line AB and is also called an angle of elevation or positive angle and the field notation should be preceded by a + sign. If the vertical angle is below the horizontal line AB, it is called an angle of depression or negative angle and the field notation should be preceded by a - sign. Note that most theodolites measure the adjacent zenith angle instead of the vertical angle. A zenith angle is simply the included angle between a line connecting the point exactly overhead



Example 2: Figure 15.2.2. Side view showing vertical angle B-A-C.

and the point in question. For example: a zenith angle of 90° is a horizontal line or right angle and the complimentary vertical angle would be 0° . The vertical angle can be obtained by subtracting the zenith angle from 90° .

To determine the height of the point C, measure the slope distance (D_s) with the electronic distance meter from A to C. Using the theodolite or transit, measure the vertical angle between line AC and AB or the zenith angle. The height of point C would be obtained by the appropriate trigonometric formula:

$$D_v = (\sin V\angle) D_s$$

or

$$D_v = (\cos Z\angle) D_s$$

The horizontal distance (D_h), which is the distance used when drawing the map, would be obtained by the appropriate formula:

$$D_h = (\cos V\angle) D_s$$

or

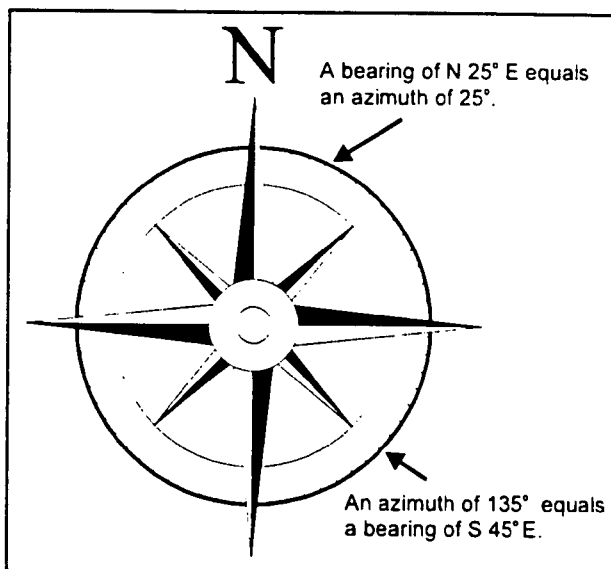
$$D_h = (\sin Z\angle) D_s$$

If the vertical distance to be measured was to the top of a building, tank, or other location where the measurement of the slope distance is impractical, simply measure the horizontal distance and determine the height by:

$$D_v = (\tan V\angle) D_h$$

The field notation for the third column from the left in the field book is labeled: $Z\angle$ or $V\angle$ and the forth column is labeled D_s/D_h (see Example 5 Field Notation).

EXAMPLE 3, Azimuths and Bearings: When surveying, personnel should be able to convert bearings to azimuths or azimuths to bearings. An azimuth is an angular direction based on the compass rose (Figure 15.2.3) which divides a circle into 360° . The direction of northeast is expressed as an azimuth of 45° . Its reciprocal azimuth or the southwest azimuth direction is 225° . An azimuth is always turned clockwise from north or 0° . A bearing is the direction turned, either clockwise or counter-clockwise, with respect to north or south (whichever is closer) on a compass. As a bearing, the direction of northeast is expressed as North 45° East, while its reciprocal, or reverse bearing, is expressed as South 45° West.



Example 3: Figure 15.2.3. Compass rose showing conversion between azimuths and bearings.

The following are examples of conversions:

BEARING TO AZIMUTHAZIMUTH TO BEARING

N25°E	25°	135°	S45°E
S15°E	165°	280°	N80°W
N89°53'57"W	270°06'03"	353°06'49"	N06°53'11"W
S10°18'W	190°18'	06°35'	N06°35'E

EXAMPLE 4, Coordinates When the rectangular grid coordinate points near a particular site are obtained, personnel should be able to convert rectangular coordinates to polar coordinates. This is important since through this conversion, the azimuths and distances between each point can be obtained and then used as the starting control points for the site control traverse. Computers or simple programmable or non-programmable calculators are extremely useful in providing precise results from the field surveying measurements. The following is an example of manual conversion from rectangular to polar coordinates.

The instrument is set up at JORDAN88 and given the rectangular coordinates

<u>Control Point</u>	<u>North (y)</u>	<u>East (x)</u>
JORDAN88	9302.24	5605.23
SONIA93	8811.19	5706.13

The relative change in location between the north and east coordinates (from JORDAN88 to SONIA93) respectively is

$$\Delta N = -491.05 \quad \Delta E = 100.90$$

The negative symbol for ΔN indicates the relative movement from JORDAN88 to SONIA93 downward (-) along the y axis. The positive symbol for ΔE indicates relative movement from JORDAN88 to SONIA93 to the right (+) along the x axis. Solving the formula (Pythagorean theorem)

$$c^2 = a^2 + b^2$$

The resulting distance between JORDAN88 and SONIA93 is $c = 501.31'$

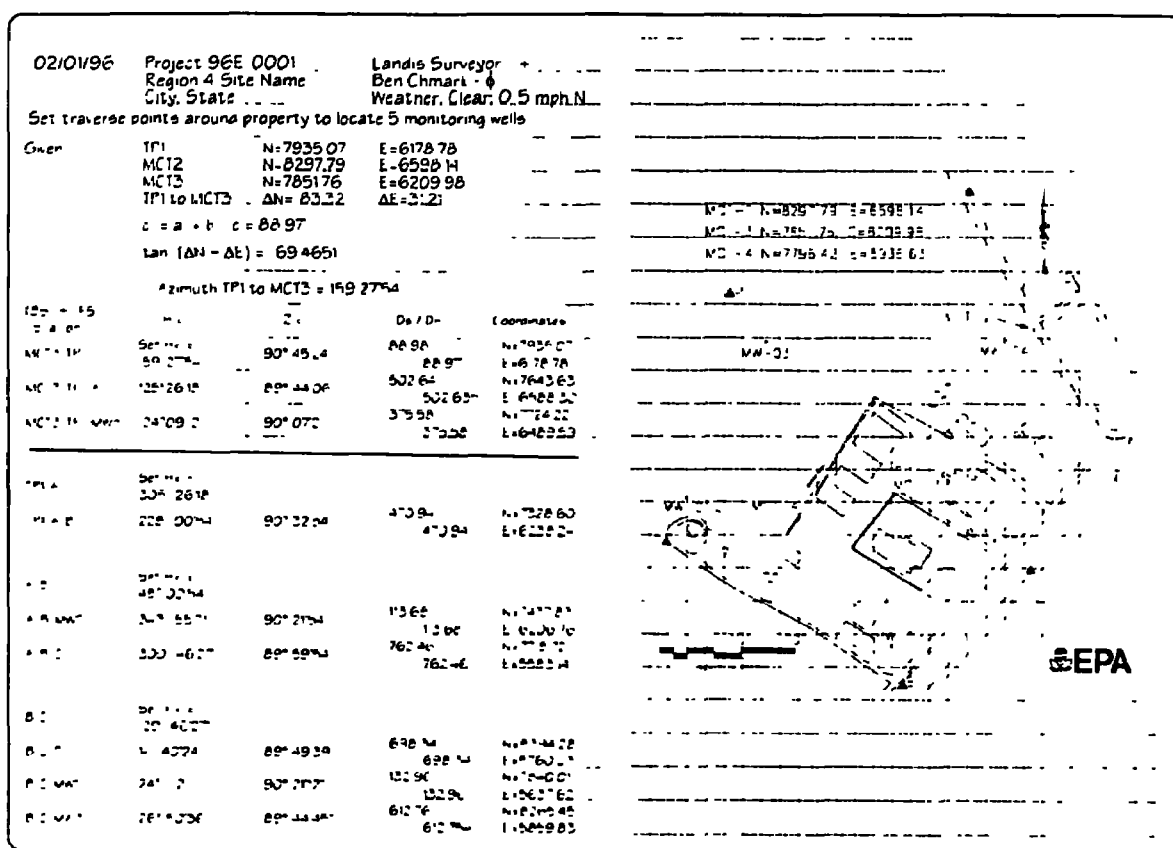
The azimuth is obtained by first computing the inverse tangent of the change in north divided by the change in east

$$\tan^{-1}(\Delta N - \Delta E) = -78.3886^\circ$$

Note: The trigonometric formula above always gives the angle measured from the east-west (x) axis. Depending on which quadrant that the angle points toward, the inverse tangent result that is obtained is either subtracted from 90° or 270° (DO NOT CHANGE THE SIGN). When using this procedure, it is wise to make a sketch showing the change in direction between the points relative to north. This will aid in visually and mentally seeing which geometric quadrant that the foresight angle falls in relation to the instrument. In the case above, this is a negative angle, expressed in decimal degrees, and is measured from the (x) axis and points into the southeast quadrant. The azimuth from JORDAN88 to SONIA93 is obtained by subtracting from 90° (e.g., $90^\circ - (-78.3886^\circ)$) and then converting to degrees, minutes, and seconds. The resulting azimuth from JORDAN88 to SONIA93 is 168°23'19". Note that the two negatives cancel. If the inverse tangent result pointed in the northeast quadrant direction, the azimuth would also be subtracted from 90° and converted to degrees, minutes, and seconds. On the other hand,

when the inverse tangent result points in the southwest or northwest quadrant direction, the angle would be subtracted from 270° (e.g., 270° - (inverse tangent result)) and then converted to degrees, minutes, and seconds

EXAMPLE 5, Field Notation: The following is an example of the field notations for a traverse to horizontally locate sampling points. Figures 15.2.4 and 15.2.5 show the field notations, on the left hand side of the field log book and some of the physical features, sampling points, and traverse control points that should be sketch on the right hand side of the field log book. The coordinates for each point are then determined and usually entered in red ink after the traverse is finished. If the original coordinates are from the old NAD27 datum, then the resulting coordinates should be converted to the new NAD83 datum. The official computer program, developed by the USGS, to convert latitude/longitude from the old NAD27 to the new NAD83 is called NADCON. Another program that is useful is CORPSCON which converts between coordinates and latitude/longitude from both NAD27 and NAD83 (it has NADCON built in as a subroutine)



Example 5 Figure 15.2.4 Traverse field notation with site map showing traverse points used to locate monitoring wells.

15.2.5 Procedures for Differential GPS

Differential GPS involves the use of two or more multichannel receivers. One or more receivers are used as the rover receiver(s) and usually only one is used as the base station. The base station and the rover(s) must be within 200 to 300 miles of each other (accuracy increases as separation between base and rover decreases) and have an unobstructed view of the sky. The base is set up at a control point of known horizontal location (usually expressed in terms of latitude, longitude, and elevation)

Triangulated coordinate positions from the satellites are recorded at the base, which will be compared to the actual control point coordinates for the development of a correction factor to be applied to other roving GPS units. Since the base station receiver and the rover receiver(s) synchronize with the satellites clocks, data must be recorded or logged by both at the exact same time in order for the correction factor to be applicable. Often times, base station data will be obtained via modem or disk after the field data collection by the rovers. It is therefore extremely important to coordinate the logistics and planning for using GPS techniques before leaving for the field.

All professional staff and field technicians must be trained in the use of the GPS equipment by qualified staff before using this equipment. Specific procedures on the operation and setup of the GPS equipment are described in detail in the operations manuals for each of the instruments. All instruments will be used consistent with the instructions contained within these manuals. A copy of each of the manuals will be maintained by a designated person.

02/01/96	Project 96E-0001	Landis Surveyor		
	Region 4 Site Name	Ben Chmark		
	City State	Weather Clear: 0.5 mph N		
185 - F5)	M	Z	Del On	Coordinates
185	Det H 185			
	194°40'24"			
186	67°36'15"	90°03'48"	715 66	N=8666 95
			715 66	E=6421 71
187	142°17'5"	89°45'33"	163 14	N=8265 20
			163 14	E=5859 80
188	Det H 188			
	24°36'5"			
189	143°27'09"	90°04'33"	409 08	N=8297 87
			409 08	E=6598 12
190	Det H 190			
	174°27'09"			
191	180°51'42"	89°56'24"	654 28	N=8297 78
			654 28	E=6598 12
192	248°56'39"	88°32'48"	85 63	N=8297 78
			85 63	E=6598 12
193	Det H 193			
	34°05'40"			
194	30°26'18"			N=8297 78
				E=6598 12
195	308°33'33"	91°03'36"	127 53	N=8297 78
			127 53	E=6598 12

Example 5 (continued)

Figure 15.2.5. Second page of traverse field notation.

15.3 Vertical Location (Elevation) Surveys

15.3.1 Introduction

The field of surveying that pertains to measuring the relative differences in elevation of two or more points is called "running levels" or "Leveling". The two most commonly used methods are Differential Leveling and Trigonometric Leveling. Differential leveling is the most precise and easiest method because it utilizes "level" measurements with simple addition and subtraction. Trigonometric leveling is slightly less precise and more difficult as it uses vertical angle and distance measurements combined with the principles of trigonometry. Global Positioning System (GPS) equipment can obtain elevation measurements, however this new technology is less accurate than horizontal measurements and is not recommended for vertical locations. This subsection discusses the standard procedures and techniques used to obtain differences in elevation and are described in more detail in basic surveying and field geology textbooks (See References 1, 2, and 3).

Regardless of the method(s) used, elevation surveys should be based on established control points. A network of vertically (and horizontally) located control data points has been established and is continually maintained by the National Oceanic and Atmospheric Administration (NOAA) through its National Ocean Survey (formerly U. S. Coast and Geodetic Survey). The system of vertical control points, or Benchmarks (B Ms), are referenced to a surface of fixed and precisely known elevation above mean sea level and is referred to as the datum or datum plane. The datum for vertical control (elevation) is called the National Geodetic Vertical Datum of 1929 (NGVD29), formerly known as the 1929 sea level datum, or the soon to be established North American Vertical Datum of 1988 (NAVD88).

Sources of existing information on benchmark data and their locations may be obtained from local, state, or federal departments or agencies. Typically, engineering or public works departments, counties, cities, or towns may have data on file that is near the particular site being investigated. State and federal agencies that are good sources of useful data include:

- State highway or transportation departments
- State geodetic or land surveying offices
- State natural or water resources bureaus
- State geological surveys
- NOAA/National Ocean Survey
- United States Geological Survey
- Corps of Engineers, Department of the Army
- Soil Conservation Service
- Tennessee Valley Authority
- Bureau of Land Management

When the exact elevations of sampling locations or other physical features are needed, benchmarks of precisely known elevation should be used when leveling. If necessary, a registered land surveyor could be requested to set at least two third-order accuracy vertical control points or benchmarks. The vertical control points should have established elevations referenced to NGVD29 or NAVD88.

If no benchmark is located in the site vicinity, an arbitrary temporary benchmark should be established on a permanent location, e.g., bridge wingwall, foundation, or a nail or spike in a tree or telephone pole. The elevation of the temporary benchmark (and, therefore all other points) could be determined at a later date. As with all field work, the location of benchmarks used should be shown on the site sketch map and all field measurements should be recorded in the field logbook as outlined in Section 3.5.

15 3 2 Equipment Available

The following equipment is available for field use in conducting elevation surveys in support of site investigations.

Differential Leveling

- Sokkia B20 or Lietz B2C, precision automatic level
- tripod
- telescoping level rod

Trigonometric Leveling

- Topcon GTS-2, total station theodolite/electronic distance meter (EDM)
- tripod(s)
- reflector prism(s)
- prism pole
- cloth or steel tape
- compass

15 3 3 Specific Equipment Quality Control Procedures

Field surveying methods using this equipment should be made only by those personnel who have been trained to use them. All field investigators must be trained and checked out in surveying procedures by qualified staff before using this equipment

Each piece of field equipment (as appropriate) should be numbered, and a log book should be kept containing all maintenance and calibrations made on the equipment. The specific maintenance and calibration procedures found in Section 15.2 3 should be used for all equipment listed above

15 3 4 Procedures for Differential Leveling

The level, or instrument, is set up by the instrument man at a location not more than 250 feet from the benchmark and at a height above the benchmark and the next point(s). The level is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads accordingly. Once the bullseye bubble is centered, the level is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The level is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman holds the rod as plumb (vertical) as possible on the benchmark so that the instrument man can read where the horizontal cross-hair in the telescope of the level intersects the graduations on the rod. The rodman "rocks" the rod in two planes, when instructed by the instrument man, to obtain a level reading. The rod is white with large red numbers which indicate the foot-marks and smaller black numbers which indicate the tenths of feet and has black graduations the entire length which indicate hundredths of feet. The instrument man sights through the telescope and takes the first rod reading which is called a backsight (denoted BS or + in the field log book). The backsight (+) reading added to the elevation of the benchmark gives the height of the level, or instrument, (denoted H.I. in the field log book). Next the rodman holds the rod on a point (called a turning point and denoted TP) of fixed but unknown elevation such as a nail in the ground, spike in a tree or telephone pole, or the top of a fire hydrant. The instrument

man then takes his second rod reading which is called a foresight (denoted FS or - in the field log book). If the foresight (-) reading is subtracted from the H.I., the result is the elevation of the point. That is, the difference between the first reading obtained from the benchmark and the second reading obtained from the point is the difference in elevation between the point and the benchmark. Note that the distance between each sighted reading should not ordinarily exceed 250 feet with turning point backsight and foresight distances deviating no more than 50 feet from one another.

The instrument man then goes ahead of the rodman, sets the level up as stated before and takes a rod reading (backsight) from the previous turning point. The rodman then moves ahead of the instrument man for a new turning point rod reading (foresight) and so forth until the desired final point is located vertically. Once the final point is located, the instrument man breaks the set up of the level (i.e., changes the H.I.) and re-levels the level. The instrument man and rodman then run levels from the last or final point to the first point or benchmark. This is called making a closed circuit or closed level loop.

When practical, leveling should be conducted to form a closed circuit. That is, the level circuit or loop should close back in close agreement to a benchmark by within 0.02 foot of the original reading or third order accuracy whichever is greater. If the level circuit does not close within these limits of accuracy, then the level circuit must be repeated until this accuracy is attained. Third order accuracy is defined by the formula: $0.05 \text{ foot} \times (\sqrt{\text{number of miles run}})$, which means for a one-mile level circuit, the closure should be within five hundredths of a foot. Figure 15.3.1 is an example of typical field notations for differential leveling.

02/01/96		Project 96E 0001		Land Surveyor -	
Region 4 Site Name		Ben Chmarr		Weather Clear, 0.5 mph N	
City State					
Station/Point	or BS	HI	or FS	Elevation	Remarks
B.M. 523	6.13	25.69		19.560	Top of brass cap in concrete man. marked B.M. 523 EL = 19.560
T.P. 1	2.24	21.02	6.1	19.52	Set nail in ground
T.P. 2			10.30	11.52	RR spike in telephone pole NW corner Athens St and Georgia Ave
M.W. 1			12.13	9.69	Top of casing at M.W. 1
G.S. 1			12.22	6.98	Ground shot at M.W. 1
T.S. 1			14.37	7.45	Water surface of cypress swamp
B.M. 1			12.54	9.22	Invert of weir 01 south of plant
(Break setup to run levels back)					
T.P. 3	7.99	19.4		11.52	RR spike in telephone pole NW corner Athens St and Georgia Ave
T.S. 2	9.59	20.72	2.22	11.19	Set nail in 24" oak for temporary bench mark 2
B.M. 523			1.23	19.55	Checked into B.M. 523 (off - 0.01)
Break setup - put instrument away					

Example 1 Figure 15.3.1 Field notation for differential leveling.

15.3.5 Procedures for Trigonometric Leveling

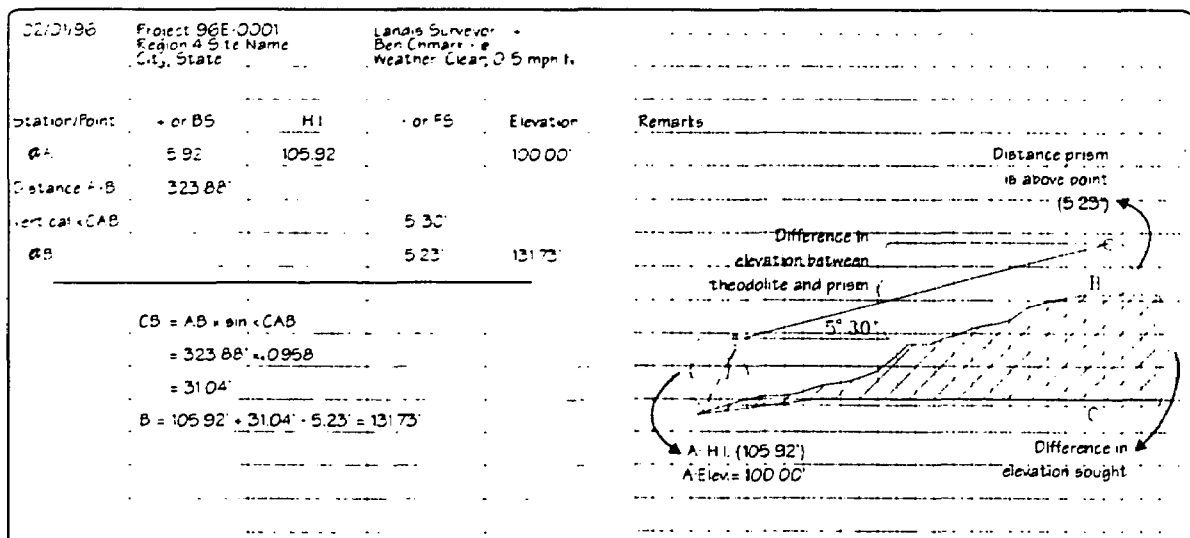
The total station theodolite, or instrument, is usually set up above a benchmark and the elevation of the instrument (H.I.) must be obtained. The theodolite is attached to the plate of the tripod by a fastening screw and the bubble in the bullseye level is centered, or brought level by adjusting the three-screw leveling heads accordingly. Once the bullseye bubble is centered, the theodolite is rotated 90 degrees at a time and the horizontal level bubble is checked and brought level using the three-screw leveling heads. The instrument is ready for use when, after repeated rotations, the bubble in the horizontal level remains exactly in the center or middle of its housing.

The rodman has either a range pole equipped with a reflector prism (single or triple) or a tripod with the reflector prism. The prism is used to reflect the signal from the electronic distance meter in the total station theodolite. While located over the point(s) whose elevation is desired, the rodman holds the range pole level by means of centering the bullseye bubble, or sets up the tripod by means of centering the bullseye bubble with the three-screw leveling heads. The instrument man sights through the telescope on the theodolite, lines up the horizontal and vertical cross-hairs on the center of the prism, and takes a reading of both the vertical angle ($V\angle$) and the distance to the prism. The difference in elevation between the theodolite and the prism is determined trigonometrically. A compass with a clinometer and a measuring tape could also be used for field measurements or as a map reference.

The following three examples graphically depict the distances that must be considered and accounted for when using the trigonometric leveling method to compute the vertical changes in elevation. The field notation for trigonometric leveling follows each example.

Example 2: The elevation at point A in Figure 15.3.2 is 100.00 ft. The instrument is set up 5.92 ft. above point A which makes the height of the instrument (H.I.) 105.92 ft. Given a slope distance (Ds) shot to the prism (distance AB) of 323.88 ft. and a positive vertical angle ($V\angle CAB$) of $5^{\circ}30'$, the difference in elevation between point C and point B is computed using the trigonometric formula:

$$\text{elevation difference} = \text{distance AB} \times \sin(V\angle)$$



Example 2: Figure 15.3.2. Trigonometric level notation showing side view when elevation of point desired is above instrument.

The method described in Figure 15.3.2 only accounts for the relative difference in elevation between the theodolite (H.I.) and the center of the prism. The distance that the prism is held above the point in question must be subtracted from the resulting elevation of the prism to obtain the elevation of the point. Substituting in the trigonometric formula:

$$\text{elevation difference} = 323.88 \text{ ft.} \times \sin(5^\circ 30') = 31.04 \text{ ft.}$$

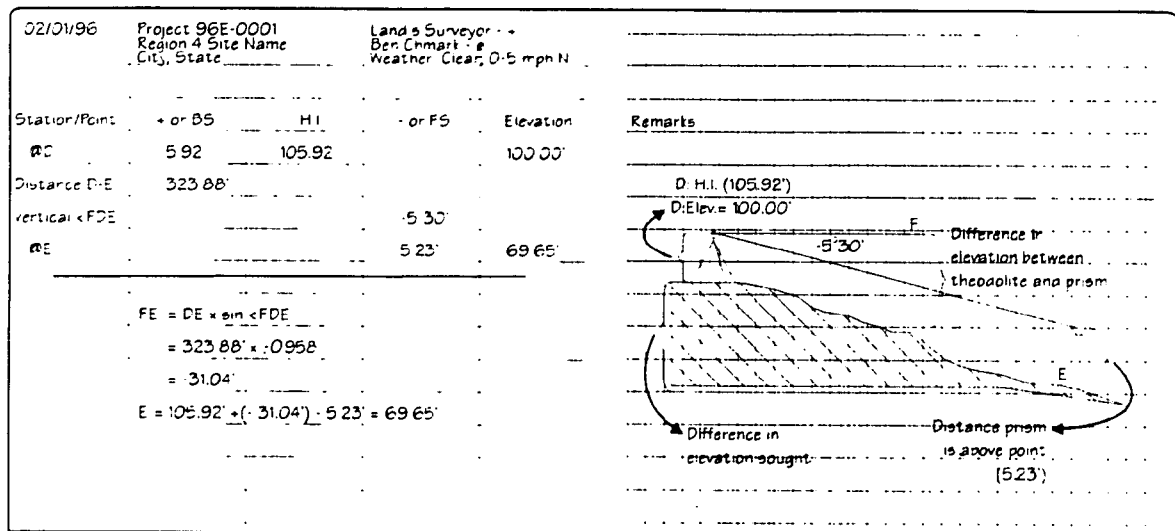
The elevation of point B is: $105.92 \text{ ft.} + 31.04 \text{ ft.} - 5.23 \text{ ft.} = 131.73 \text{ ft.}$

Example 3: The elevation at point D in Figure 15.3.3 is 100.00 ft. The instrument is set up 5.92 ft. above point D which makes the height of the instrument (H.I.) 105.92 ft. Given a slope distance (Ds) shot to the prism (distance DE) of 323.88 ft. and a negative vertical angle ($\angle FDE$) of $-5^\circ 30'$, the difference in elevation between point F and point E is computed by substituting in the trigonometric formula:

$$\text{elevation difference} = 323.88 \text{ ft.} \times \sin(-5^\circ 30') = -31.04 \text{ ft.}$$

The distance that the prism is held above the point in question must be subtracted from the resulting elevation of the prism to obtain the elevation of the point.

The elevation of point E is: $105.92 \text{ ft.} + (-31.04 \text{ ft.}) - 5.23 \text{ ft.} = 69.65 \text{ ft.}$



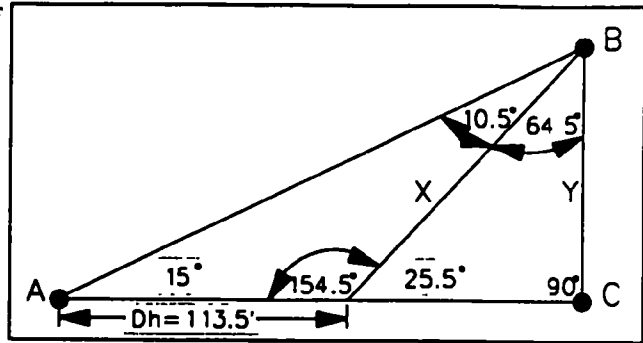
Example 3: Figure 15.3.3. Trigonometric level notation showing side view when elevation of point desired is below instrument.

Example 4 When the measurement of the slope distance is not possible, differences in elevation can be determined using the law of sines from trigonometry

$$\frac{\sin \alpha}{a} = \frac{\sin \beta}{b} = \frac{\sin \gamma}{c}$$

or

$$\frac{a}{\sin \alpha} = \frac{b}{\sin \beta} = \frac{c}{\sin \gamma}$$



Example 4: Figure 15.3.4. Spot elevation differences using law of sines.

Spot elevation differences can be determined by taking only three measurements (shown enclosed in the boxes of Figure 15.3.4) The measurements can be obtained with the total station theodolite or by using a compass (equipped with a clinometer) and a measuring tape. In Figure 15.3.4 the vertical angle ($V\angle$) is measured at two locations (A and midway between A and C) and the horizontal distance (Dh) between those two measurements is also measured. Since the sum of the interior angles of each triangle should equal 180° , all the other interior angles are calculated. Substituting the measurements into the law of sines and solving for x and y shown in Figure 15.3.4:

$$\begin{aligned} \frac{x}{\sin 15^\circ} &= \frac{113.5'}{\sin 10.5^\circ} & \frac{y}{\sin 25.5^\circ} &= \frac{161.36'}{\sin 90^\circ} \\ x &= \frac{(\sin 15^\circ) 113.5'}{\sin 10.5^\circ} & y &= \frac{(\sin 25.5^\circ) 161.36'}{1} \\ x &= 161.36' & y &= 69.4' \end{aligned}$$

Note that this method above only accounts for the relative difference in elevation between point A and the point in question, point B. If an instrument, such as a compass or theodolite, is used at point A, the H.I. at point A must be added to the resulting elevation of the point in question. The field notation would include the figure drawing, all field measurements, and all of the calculations.

15.4 Bathymetry

15.4.1 Procedures

Recording fathometers are used to provide bathymetric traces of water depths. Because water depths are time dependent (especially in tidal areas), the date and time of all traces should be noted. Operation manuals provide operation and calibration procedures to be followed. In particular, tide and draft adjustments provide datum calibration in regard to the respective tidal amplitude and sensor probe depth. During the initial setup of each survey, the fathometer calibration should be checked against a field measurement of water depth made using a graduated sounding line. All traces should be noted with transect description, chart speed, direction of travel, pertinent reference points, and Loran/GPS (if available) and then indexed to a site map. When working in tidal areas, a water stage recorder (see Section 15.5) should be positioned to provide a histogram of water levels to correlate with the bathymetric trace.

15.4.2 Equipment Available

The following equipment is available for bathymetric surveys:

- recording fathometers,
- water level recorder and/or referenced gaging station(s),
- calibrated sounding line(s), and
- Loran/GPS instrumentation

15.4.3 Specific Equipment Quality Control Procedures

All equipment used for bathymetric studies should be numbered and a record should be kept of all maintenance and calibration procedures. The following procedures should be used to maintain and calibrate bathymetric measurement equipment:

Recording Fathometers

These fathometers should be

- Calibrated and maintained according to the manufacturer's instructions before use. The chart speed should be checked against a reliable time source before the instrument is sent to the field.
- Checked in the field against a field measurement of water depth utilizing a calibrated sounding line.
- Cleaned daily after use and prior to being stored.

Sounding Lines

All sounding lines will be calibrated against a steel surveyors tape and should be accurate ± 3 percent.

15.5 Surface Water Stage/Tape Downs

15 5.1 Procedures

Water level recorders provide a time series record of water levels. When necessary, these instruments should be referenced to National Geodetic Vertical Datum (NGVD). All water level tracings should be noted with beginning and ending date and time, site location, stage scale, and time scale and initialed by the field investigators. Standard USGS staff gages should be employed at each water level recorder site to provide a reference and check on the recorder trace. Water stage should be recorded to the nearest 0.01 foot where possible.

Tape downs provide instantaneous water stage as referenced to a known elevation. An engineering tape is fashioned with a plumb bob to measure from a bridge deck or other reference point to the water surface. The plumb bob provides weight for the tape as well as providing a discernible contact with the water surface. All measurements should be to the nearest 0.05 foot accompanied by a date, time, and station location. The exact reference or point from which a tape down is measured should be permanently marked on the reference (wing wall or bridge rail by etching a reference with a chisel, etc.) and a complete description of the reference should be made in the field records.

Both of these procedures (water stage and tape downs) are predicated upon accurate references to established measuring points. As mentioned above, the NGVD is an established datum that provides correlation of water surface recordings to engineering structures (bridge, wing walls, sea wall caps, clarifier cat walks, etc.) When recording water level dynamics in relation to a particular flow device, the datum is established in relation to the flow device reference point. The flow through rectangular and V-notch weirs, for instance, are proportional to the water level referenced to the weir crest or, in the case of partially filled pipes, the flow rate is proportional to the depth of flow. Therefore, when employing a water level recorder or tape down on primary flow devices, the reference or datum is the weir crest or in the case of pipes, the invert (see Section 18, Flow Measurement).

15 5.2 Equipment Available

The following equipment is available for surface water stage/tape down measurements

- Model F Stevens Stage Recorder(s).
- Model A-71 Stevens Stage Recorder(s).
- Stevens Model GS-93 Endcoders and Loggers.
- ISCO flow meter(s) and Recorder(s).
- USGS staff gage(s), and
- Weighted steel measuring tapes.

15 5.3 Specific Equipment Quality Control Procedures

A log book will be kept of all equipment used for making water stage/tape down measurements. The following maintenance and calibration procedures should be used and recorded in the log book for all equipment used for water stage and tape down measurements.

Stevens Model A-71 and Model F Stage Recorders

These stage recorders should be

- Maintained according to the manufacturer's instructions. The time and vertical scale should be adjusted to read within two percent of full scale.
- Checked in the field by comparison with a staff gage. During field measurements, the vertical accuracy should check within 0.05 foot.
- Cleaned and maintained before storage.

Stevens Model GS-93 Endcoder

This instrument attaches to the A-71 and Model F stage recorders and uses solid state memory. The instrument stores water level data at programmable frequencies onto data cards. The Endcoder should

- Be maintained according to manufacturer's instructions and checked in the field by comparison with a staff gage. The vertical accuracy should check within 0.05 foot.
- Be cleaned and maintained before storage.

ISCO 1870, 2870, 3210, and 3230 Flow Meter and Recorder(s)

See specific quality control procedures for this equipment in Section 18, Flow Measurement.

USGS Staff Gage(s)

USGS staff gages should

- Be checked for damage, warpage, legibility, etc., before use. Any damaged or illegible staff gages should be discarded.
- Be cleaned after use before being stored.

Weighted Steel Measuring Tapes

Weighted steel measuring tapes should

- Be calibrated against the Invar steel surveyor's chain. The calibration should be within 0.01 foot per 10 feet of length.
- Be checked for damage before use, damaged tapes should be recalibrated or discarded.
- Be cleaned after use and prior to being stored.

15.6 Time-of-Travel

15.6.1 Introduction

Three principal methods are used to determine time-of-water-travel time in streams, i.e., surface floats, measurements of cross sectional velocity, and tracers such as dye.

A very rough method for preliminary estimates of time-of-water-travel consists of dropping sticks or other buoyant objects in the stream reach under observation, and noting the time required for them to float an estimated 10 feet or some other convenient distance. The velocity estimates are too inaccurate for use in interpretation of data or final reporting, but can be useful in preliminary planning of studies and in subsequent more precise measurements of time-of-water-travel.

Stream velocities at gaging stations, measured by the U. S. Geological Survey in developing rating curves, may be applied to the entire reach under observation to estimate time-of-water travel. This is somewhat more refined than the floating objects estimates, but can still be far from accurate. There rarely are more than one or two gaging stations in most stream reaches being studied. Stream channels generally are restricted at gaging stations and velocities there are generally higher than average velocities throughout the reach. Cross sectional velocities can also be determined at locations designated for a particular study.

Tracer dyes provide a direct and highly accurate method of determining time-of-travel. This is the preferred method if resources are available.

15.6.2 Procedures

Floats

Surface floats may be followed downstream and timed for known distances to determine time-of-water-travel. This requires the use of considerable judgment, for floats tend to travel into quiet or eddy areas, or to become stuck on tree limbs, the stream bank, or other obstacles. The floats must frequently be retrieved and returned to the stream current. The principal judgment factors are how long the floats should be left in quiet areas before retrieval and where they should be placed in the current.

Surface water velocity is greater than the average for the entire stream, and a correction factor must be applied to the surface velocity. An average velocity of about 85 percent of that of the surface velocity is a reasonable rule-of-thumb value.

Cross Section Measurements

The measurement of cross sectional velocities at frequent longitudinal intervals and the calculation of average velocity in the stream constitutes a time consuming method of obtaining time-of-water-travel.

The longitudinal intervals at which cross sections should be measured vary with the characteristics of the stream channel. One cross section per mile may be adequate for streams with reasonably uniform channels. Cross sections at every tenth of a mile may be desirable for streams with irregular channels.

Cross section measurement methods are described in detail in Section 18.

Tracers

The most accurate method of measuring time-of-travel involves following and measuring a tracer. Some conservative constituents such as salt, or radioisotopes may serve as tracers, however, Rhodamine WT dye is the most common tracer used. Rhodamine WT can be detected at concentrations as low as 0.01 ppb by a fluorometer.

Prior to injection into the stream, the concentrated dye is often diluted with stream water. This insures immediate maximum dispersion. Addition of concentrated dye without dilution may result in incomplete dispersion, particularly in shallow streams. Calibration curves should be developed for each study with particular emphasis on accounting for natural background fluorescence.

The dye should be distributed across the stream at the upstream point, as nearly instantaneously as possible. The ideal distribution produces a narrow band of tracer in a uniform concentration across the stream. The band of tracer mixes with water ahead of and behind it by diffusion, or longitudinal mixing, as it moves downstream to produce an increasingly wider band. The peak concentration remains near, but somewhat downstream of, the center line of the band and decreases as longitudinal mixing proceeds. The times-of-water-travel to downstream points are the differences between the time the dye was added to the stream and the times the centroid of the dye mass arrives at downstream points. The length of the dye cloud and the peak concentrations produces a measure of instream dispersion.

If Rhodamine WT dye is used as the tracer, peak concentrations from 1.0 to 50 ppb allow satisfactory definition of the dye concentration curve.

Most methods of calculating the dosage of dye needed at the upstream point involve estimates of one or more stream characteristics, such as flow, velocity, length of reach, volume in the reach, cross-sectional area, average depth, or the roughness coefficient "n" of Manning's formula. The USGS has produced excellent publications regarding time-of-travel techniques, i.e., "Measurement of Time-of-Travel and Dispersion by Dye Tracing" (5) and "Fluorometric Procedures for Dye Tracing" (6).

The stream should be sampled frequently as the dye arrives at the downstream point to define the tracer concentration versus time curve with special emphasis on the peak. The frequency may be varied from continuously or from once each minute to once every 30 to 60 minutes, depending on how wide the band of dye has become at the sampling point. The dye may be missed altogether by overestimating the time required for it to travel downstream. Much time may be wasted, on the other hand, waiting for it to arrive if the time-of-travel is underestimated. All information that will contribute to the best possible preliminary estimate of the time required should be used.

There are two primary methods by which the stream water can be sampled and analyzed for dye. A submersible pump can be used to pump the dye continuously through a fluorometer or the stream samples can be grabbed (either by hand or by automatic sampler) at specified frequencies and then placed into the fluorometer individually. With the "flow-through" version, a strip chart recorder connected to the fluorometer can be used to plot the tracer concentration versus time. Some fluorometers have internal data loggers to provide this function. Readings directly from the fluorometer scale or conversion to dye concentration can be manually plotted against time when the grab sampling technique is used.

A version of the grab sampling technique would be to use an automatic water sampler which discharges into separate bottles. The sampler is pre-set to collect samples at certain intervals, at the end of the sample collection time, the discrete samples should be analyzed and the concentration determined for each. The concentrations are then plotted against time.

For proper determination of travel times, samples should continue to be analyzed until the stream background concentration following the peak is measured. With a time versus concentration plot from background level to peak to background level, the centroid, and thus actual travel time, can be determined. The trailing edge of the dye cloud should generally be monitored until the instream tracer concentration is no more than 2 to 5 % of the peak concentration.

Prior to conducting tracer studies in freshwater systems, water supplies should be inventoried to insure that the dye tracer concentrations will not impart color to downstream public or private water supplies. Rhodamine WT concentrations in the dye cloud should be maintained below 10 ppb at water supply intakes.

15.6.3 Equipment Available

The following equipment is available for time-of-travel studies:

- fluorometers,
- tracer standards,
- automatic samplers,
- pumps,
- recorders,
- flow meters, and
- floats

15.7 Dilution Studies

15.7.1 Procedures

A great deal of the previous section (time-of-travel studies) applies to this section and USGS publications provide references to appropriate techniques, in particular "Measurement of Discharge by Dye-Dilution Methods" (7).

Dilution studies using tracer dyes evolved from "mass conservation" principles, i.e., a known mass of tracer is introduced at an upstream point, and after mixing with the water to be traced, this mass should be accountable at downstream locations. Rhodamine WT provides an adequate tracer for most investigations. This dye is slightly photoreactive. Decay rates (e^{-kt} where $k=0.034/\text{day}$ for exposure to full sunlight) are reported in the literature. Due to limited light penetration, actual rates are much lower than this value and can be established through on-site bottle tests. Other tracers either introduced into an upstream point or in some instances occurring at the upstream point are often used. The high degree of accuracy and detection ability of fluorometers plus the solubility properties of tracer dyes make them the technique of choice.

In dilution studies, the tracer dye is precisely metered into the waters to be traced and then monitored after mixing via a fluorometer at downstream stations. This series of events requires highly controlled metering rates and very accurate fluorometric analyses. State-of-the-art fluorometers make the dilution study program a valuable assessment tool.

Procedure

The principal of superposition as developed by Kilpatrick et al. of the USGS is a reliable method to determine dilution levels of wastewaters in receiving estuaries (8). A tracer dye is metered into the

wastewater stream during a tidal cycle. Successive slack tide measurements of dye concentrations in the estuary at selective distances from the outfall produce a series of concentration curves. By superposition, the accumulative concentration at each station provides a determination of the ultimate concentrations or steady-state concentration of a continuous discharge. By simple proportioning, with due regard to tracer photo decay, the dilution levels of the discharge can be produced for selective points in the estuary.

Calculation Procedure

$$C_u = \frac{(C_i)(e^{kt})(V_w)}{V_i}$$

Where

C_u = Ultimate concentration of wastewater at point of interest

C_i = Ultimate concentration of tracer (by superposition) at point of interest

t = Tidal days to ultimate concentration

e^{kt} = Photo decay of tracer

V_w = Wastewater discharge per tidal day

V_i = Volume dye released in tidal day

Example

Assume After 5 tidal days the tracer clears to the area of interest and,

$$C_i = 100 \text{ ppb}$$

$$k = 0.005 \text{ per tidal day (based on-site bottle tests)}$$

$$e^{kt} = 1.03 \text{ (ultimate concentrations obtained in 5 tidal days)}$$

$$V_w = 100,000 \text{ gal/tidal day}$$

$$V_i = 10 \text{ gal/for one tidal day}$$

$$\text{Then } C_u = 1,030,000 \text{ ppb}$$

or

$$= 0.103\% \text{ wastewater}$$

Investigations of industrial and municipal facilities for NPDES permit compliance require measurements of discharge rates. Often encountered during these investigations are flow measuring devices such as orifices and magnetic meters which are inaccessible for measurements of flow by standard equations relating to hydraulic head and structure size. The following provides a direct technique for

measurement of flow through these devices using dye tracers.

Calculation:

The discharge rate through any structure can be defined by the following mass balance equation:

MASS BALANCE EQUATION

$$(C_1) (q_1) = (C_2) (Q_2 + q_1)$$

$$Q_2 = \frac{(C_1) (q_1) - (C_2) (q_1)}{C_2}$$

Where:

Q_2 = pipe flow rate

C_2 = tracer concentration after mixing

q_1 = tracer injection rate

C_1 = tracer injection concentration

Assuming a constant discharge rate and complete mixing of the tracer in the waste stream, the task is (1) to inject into the waste stream a tracer at a constant rate and constant concentration and (2) to measure the concentration of the tracer after mixing with the waste stream.

It is suggested that at least three injection rates and resulting mixed tracer concentration measurements be used to calculate the discharge rate.

15.7.2 Equipment Available

The following field equipment is available for dilution studies:

- fluorometer,
- metering pump,
- tracer standards, and
- pumps.

15.7.3 Specific Equipment Quality Control Procedures

See previous section. The metering pump should be calibrated before and during use. Field calibration data should be recorded in the field records.

15.8 Ground Water Level Measurements

15.8.1 General

The measurement of the ground water level in a well is frequently conducted in conjunction with ground water sampling to determine the "free" water surface. This potentiometric surface measurement can be used to establish ground water flow direction and gradients. Total well depth and ground water level measurements are needed to determine the volume of water in the well casing prior to purging the well for sampling purposes.

All ground water level and total depth measurements should be made relative to an established reference point on the well casing and should be documented in the field records. To be useful for establishing ground water gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. For an isolated group of wells, an arbitrary datum common to all wells in that group may be used if necessary.

15.8.2 Specific Ground Water Level Measuring Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods (9). Method accuracies are noted for each of the specific methods described below.

- Electronic Water Level Indicators -- This instrument consists of a spool of dual conductor wire, a probe attached to the end, and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter light and/or buzzer attached to the spool will signal the contact. Penlight or 9-volt batteries are normally used as a power source. Measurements should be made and recorded to the nearest 0.01 foot.
- Weighted Tape -- This method is similar to the "bell sounder" method, except that any suitable weight, not necessarily one designed to create an audible pop, can be used to suspend the tape. The weight should, ideally, be made of a relatively inert material and should be easily cleaned. Measurements should be made and recorded to the nearest 0.1 foot.
- Chalked Tape -- Chalk rubbed on a weighted steel tape will discolor or be removed when in contact with water. Distance to the water surface can be obtained by subtracting the wet chalked length from the total measured length. The tape should be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. Measurements should be made and recorded to the nearest 0.01 foot. This method is not recommended if samples are to be collected for analyses of organic or inorganic contaminants.
- Other Methods -- There are other types of water level indicators and recorders available on the market such as the sliding float method, air line pressure method, and electrical and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells. Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot should not be used.

15 8.3 Total Well Depth Measurement Techniques

The bell sounder, weighted tape, or electronic water level indicators can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well. Care must be taken in these situations to ensure accurate measurements. All total well depth measurements must be made and recorded to the nearest 0.1 foot.

15 8.4 Equipment Available

The following equipment is available for ground water level and total well depth measurements:

- weighted steel measuring tapes
- electronic water level indicators

15 8.5 Specific Quality Control Procedures

Devices used to measure ground water levels should be calibrated against the Invar steel surveyor's chain. These devices should be calibrated to 0.01 foot per 10 feet length. Before each use, these devices should be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. These devices should be decontaminated according to the procedures specified in Appendix B prior to use at the next well. All calibration and maintenance data should be recorded in a log book.

15.9 References

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SECTION 16

FIELD MEASURABLE PHYSICAL/CHEMICAL CHARACTERISTICS

PERFORMANCE OBJECTIVES:

To measure physical/chemical characteristics of a sample that are representative of field conditions as they exist at the time of sample collection

- By selecting the appropriate meter/instrument(s)
- By properly calibrating each instrument(s)

16.1 Introduction

Temperature, specific conductance (conductivity), hydrogen-ion concentration (pH), turbidity, dissolved oxygen (DO), chlorine, salinity, flash point, and halogen test will be the parameters discussed in this section. The order in which the measurements are made is very important. The sections will be discussed in the most applicable order. References for each section can be found at the end of the section listed in order with respect to the meter discussed.

Numerous meters/instruments are commercially available. Some meters are capable of numerous measurements which may include pH, temperature, conductivity, DO, salinity, and turbidity, therefore, individual meters discussed here are not necessarily the only ones available. However, the setup and use of all instruments should follow a basic format to imply a consistency of use.

Regardless of the brand of meter used, all meters should be properly maintained and operated in accordance with the manufacturer's instructions and the calibration should be checked prior use.

16.2 Temperature

Temperature is a measure of hotness or coldness on a defined scale.

Three types of thermometers are available:

- Digital (thermo-couple) thermistor
- Glass bulb mercury filled
- Bi-metal strip/dial indicator

Calibration

Whichever type of thermometer is used, it should be calibrated semi-annually against a National Instrumentation Standards and Technology (NIST) certified thermometer.

Note: Thermistors should be checked against a mercury bulb thermometer prior to use and should agree within ± 0.5 °C.

Inspection

All thermometers should be inspected for leaks, cracks, and/or function prior to use

Note: A broken glass bulb-mercury filled thermometer can contaminate samples by the release of mercury vapors

Procedures (Make measurements in-situ when possible)

- 1 Clean the probe end with de-ionized water and immerse into sample
- 2 Swirl the thermometer in the sample
- 3 Allow the thermometer to equilibrate with the sample.
- 4 Suspend the thermometer away from the sides and bottom to observe the reading
- 5 Record the reading in the log book Report temperatures readings to the nearest 0.5 °C

Note: Always clean the thermometer prior to storage and/or use.

Units

Degrees Celsius (°C) or Degrees Fahrenheit (°F)

Conversion Formulas

$$^{\circ}\text{F} = (9/5 \text{ } ^{\circ}\text{C}) + 32 \quad \text{or} \quad ^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$$

16.3 Specific Conductance (Conductivity)

Conductivity is defined as the quality or power of conducting or transmitting

Meter(s) available:

- Wheatstone bridge meters are typically used for measuring conductivity.

Calibration

The meter should be calibrated in accordance with the manufacturer's instructions. A two-point standard should be used to insure the accuracy of the meter. Conductivity may be affected by temperature, therefore, temperature should be read first so that appropriate adjustments can be made in accordance to the manufacturer's instructions.

- 1 Check and record the temperature of the standard solutions.
- 2 Rinse the probe with analyte-free water before immersing it in the standard solution.
- 3 Immerse the probe in the first standard solution and record the results.

Note Make sure the meter is "ON".

- 4 Rinse the probe and immerse it into the second standard solution and record results.

Note If the meter is not accurate to within $\pm 10\%$ of the standards, correct the problem before proceeding.

Procedures

- 1 Collect the sample and check and record its temperature.
- 2 Correct the instrument's temperature adjustment to the temperature of the sample (if required).
- 3 Immerse the probe in the sample keeping it away from the sides and bottom of the container. It is important that the entire portion of the probe be wetted by the sample. This will be evident when some of the sample water is seen coming out of the small weep hole.
4. Record the results in a log book.
- 5 Rinse probe.

Units

Conductivity units are measured in micromhos per centimeter ($\mu\text{mhos/cm}$) at 25°C . Results should be reported to the nearest ten (10) units for readings below $1,000 \mu\text{mhos/cm}$ @ 25°C and to the nearest one hundred (100) units for readings above $1,000 \mu\text{mhos/cm}$ @ 25°C .

16.4 Hydrogen Ion Concentration (pH)

The pH is defined as the negative logarithm of the effective hydrogen-ion concentration or hydrogen-ion activity in grams equivalents per liter used in expressing both acidity and alkalinity on a scale which ranges from 0 to 14 with 7 representing neutrality.

Meter(s) available

- Orion Model 399A
- Orion SA 250 or 230A
- Hydrolab Surveyor II
- YSI 3530, 3500 Water Quality Monitoring System

Calibration (Follow manufacturer's instructions with the following as a minimum)

Note. The pH of the sample to be tested should be estimated either from historical data or by using a four-color pH indicator paper or equivalent. Using this information, the two buffering points for calibration can be determined.

- 1 Remove the meter from storage and allow it to equilibrate to ambient temperature
- 2 Use a thermometer and determine the temperature of the buffering solutions and record
- 3 Select either pH 4 and pH 7 or pH 7 and pH 10 solutions as described above
- 4 Rinse the probe with analyte-free water and immerse it into the first buffer (pH 7) and record
- 5 Rinse the probe with analyte-free water and immerse it into the second buffer and record
- 6 Rinse and store the probe in a container filled with analyte-free water

Procedures

- 1 Collect a sample Measure the temperature prior to measuring the pH

Note If the temperature of the sample differs by more than 2°C or approximately 4°F, refer to the manufactures instructions on how to adjust for temperature variations

Note When the pH meter response is slow, unstable, or non-reproducible, it may be necessary to check the conductivity. If the conductivity is lower than 20 to 30 $\mu\text{mhos/cm}$ then add 1 ml of 1M potassium chloride solution per 100 mls of sample Recheck the pH and record

- 2 Immerse the probe in the sample keeping it away form the sides and bottom of the sample container. Allow ample time for the probe to equilibrate with the sample
- 3 While suspending the probe away from the sides and bottom of the sample container, record the pH
- 4 Rinse the probe with analyte-free water and store it in a analyte-free water filled container until the next sample is ready

Operational check

- 1 While in use, periodically check the pH by rinsing the probe with analyte-free water and immersing it into the pH 7 buffer solution.
- 2 Perform a post calibration at the end of the day and record all findings.

Units

Units of pH are Standard Units (SU) and should be read in one-hundredths (0.01) and recorded in tenths (0.1)

Note: If the pH measurements are to be used for RCRA regulatory purposes and when the pH approaches the alkaline end ($\text{pH} \geq 11.0$) of the scale, the pH measurements should be made by a qualified analyst using laboratory quality equipment to control the sample at $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$.

16.5 Turbidity

A nephelometer/turbidimeter is used in comparing the turbidity of liquids by viewing light through them and determining how much light is eliminated.

Meter(s) available.

- Hach 2100P Turbidimeter

Calibration

- 1 Turn the meter "ON"
- 2 Rinse the sample cell 3 times with organic free or deionized water.
- 3 Fill the cell to the fill line with organic free or deionized water and then cap the cell
- 4 Use a non-abrasive lint-free paper or cloth (preferably lens paper) to wipe off excess water and streaks
- 5 Open the cover and insert the cell (arrow to the front) into the unit and close the cover
- 6 Press "READ" and wait for the 'light bulb' icon to go off. Record the reading
- 7 Using the Gelex standards, repeat steps 4, 5, and 6. Record all findings (no : anomalies)

Procedures

- 1 Collect a specific sample or use a portion of the sample that is collected for pH, temperature, or conductivity analysis, and pour off enough to fill the cell to the fill line (approximately $\frac{3}{4}$ full) and replace the cap on the cell
- 2 Wipe off excess water and any streaks with non-abrasive lint-free paper or cloth (lens paper)
- 3 Place the cell in chamber of the 2100P with the arrow towards the front and close the cover
- 4 Press "READ" and wait for the 'light bulb' icon to go off. Record the reading
- 5 Rinse the cell with organic-free or analyte-free water.
- 6 For the next sample, repeat Steps 1-5

Operational check

- 1 Periodically check the turbidity meter by using the standards provided
- 2 Perform a post calibration at the end of the day and record all findings

Units

Turbidity measurements are reported in nephelometric turbidity units (NTUs)

16.6 Salinity

Salinity is the measure of salts of the alkali metals or of magnesium found in water. This measurement is based on the direct proportionality between the magnitude of an induced electric current and the electrical conductivity of the water in which it is induced.

Meters available

- Beckman Model RS5-3 Portable Salinometer
- Hydrolab Surveyor II
- Scout
- Datasone Salinometer

Calibration/Maintenance.

- Follow the manufactures instructions
- Routinely check the Beckman meter against a resistor matched to the meter

Procedures

- The Beckman has an accuracy of ± 0.3 parts per thousand (ppt) salinity, ± 0.05 °C temperature, and ± 0.5 millimhos/cm specific conductance.
- The Hydrolab Surveyor II, Scout, and Datasone Salinometer have an accuracy of ± 0.7 ppt at 1% full scale conductance at ± 0.1 °C.
- These meters are suited for use in brackish to saline waters having a salinity range of 0 to 40 ppt

Units

Units are reported as salinity in the nearest tenth of a ppt (0.1 ppt)

16.7 Dissolved Oxygen (DO)

Meter available

- Membrane/electrode (ME) DO meter

The most common ME meters for determining the DO in water are dependent upon electrochemical reactions. Under steady-state conditions, the current or potential can be correlated with DO concentrations. Interfacial dynamics at the ME/sample interface are a factor in probe response and a significant degree of interfacial turbulence is necessary. For precision performance, turbulence should be constant.

Inspection

- Prior to field use, the membrane of the DO meter should be inspected for air bubbles and/or holes. If air bubbles or holes exist, replace the membrane.
- The membrane should be checked for dryness. If the membrane is dry, replace and soak it in analyte-free or analyte-free water prior to calibration of the meter.

Calibration

- Air calibrate according to the manufacturer's instructions, either in air saturated water or in a water saturated air environment.
- The ME meter can be checked and/or calibrated against the Winkler method if desired.

Procedures

- 1 When making measurements, be sure that the ME stirring apparatus is working.
- 2 Adjust the temperature and salinity compensators (if equipped).
- 3 Read the dial to the nearest 0.1 mg/l and record the measurement.

To Collect a Sample

- 1 When possible, measure the DO in-situ with a field probe; otherwise,
- 2 Collect the sample in a 300-ml BOD bottle and measure the DO with a laboratory type probe.

Note Special care should be exercised to avoid entrainment of atmospheric oxygen or loss of DO. The sample should be collected with a DO Dunker (APHA-type) for depths less than five feet below water surface (BWS). A Kemmerer type sampler is recommended for depths greater than five feet BWS.

- 3 If an APHA-type DO Dunker is not available and a shallow depth sample is needed, a bucket may be used to collect a sample of water. A siphon tube should be coiled into the bucket such that the fill end is nearest the bottom. Using a 300-ml BOD bottle, allow the siphoning sample to fill and overflow the bottle for a minimum of three volumes.

- 4 If a Kemmerer sampler is used, the BOD sample bottle should be filled to overflowing by inserting the outlet tube of the sampler to the bottom of the bottle. The tube should be withdrawn slowly as the bottle is allowed to overflow three times its volume. Care must be exercised to prevent turbulence or the formation of bubbles when filling the bottle.

Duplicate analyses should agree within ± 0.1 mg/l.

Units

Units should be reported in mg/l

Limitations

- Dissolved inorganic salts are a factor with the performance of DO probes

Note The presence of inorganic salts must be determined.

- Reactive gases which pass through the ME probes may interfere with the DO analysis. For example, chlorine will depolarize the cathode and cause a high probe output. Long-term exposures to chlorine will coat the anode with the chloride of the anode metal and eventually desensitize the probe. Hydrogen sulfide will interfere with the ME probes if the applied potential is greater than the half-wave potential of the sulfide ion.
- Dissolved oxygen ME probes are temperature sensitive, and temperature compensation is normally provided by the manufacturer (see manufacturers instructions).

16.8 Total Residual Chlorine

Meter(s) available

- Pocket colorimeter
- Hach DR-100 Colorimetric (DPD) kit -- n,n-diethyl-p-phenylenediamine (DPD) may be used for natural waters or waters treated with chlorine.

Note The Hach reagents and colorimeter or spectrophotometer are accepted by the US-EPA for NPDES monitoring if used in accordance with approved procedures. The pre-printed calibration scales provided by the manufacturer are based on factors developed under ideal conditions and are only acceptable if verified. The calibration scale must be initially verified using multiple standards and a blank. The calibration scale or curve must be verified at least daily using a blank and one **high** and one **low** standard representative of the linear working range. These standard checks must agree within $\pm 10\%$ of the original scale or a new curve must be prepared. Verification data should be recorded and maintained on file (See Standard Methods).

Use either 1-cm or 2.5-cm cells.

Inspection

- Each meter should be visually inspected before and after each use. Report any discrepancies to the FEC.
- Check the battery strength.
- Insure that the reagents are fresh before field trips.

Calibration

- The calibration scales must be calibrated onsite with a minimum of three points: a blank and two known standards that bracket the expected sample concentrations.

Note If the DPD kit is used, the method must adhere to the requirements set forth in Standard Methods.

Reagents/Standards

- DPD total chlorine powder packets

Note The packets deteriorate in the presence of moisture. The packets should be discarded if they have caked or have turned brown.

The DPD oxalate is very toxic. **DO NOT** handle with unprotected hands or ingest. If accidentally spilled on skin or ingested, seek medical attention immediately.

- Chlorine demand-free water (See Standard Methods, Method 4500 Cl for directions in preparing the ASTM Standard D1193 "Consumption of Potassium Permanganate")

- Potassium permanganate stock -- Prepare a stock solution containing 891 mgs/1000 mls
- Potassium permanganate working stock 10 ppm -- Prepare working stock solution containing 10 mg/l KMnO_4 by diluting 10 mls of D.8.5.4 stock solution to 1 liter

Note The stock should be stable for approximately 5 days if kept cool and away from light.

- Potassium permanganate calibration standards -- Prepare calibration standards from the working stock solution and/or KMnO_4 calibration standard solutions for each day of use

Note. KMnO_4 standards will fade rapidly (within 15 minutes) if chlorine demand-free water is not used

Calibration Standard (mg/l)	mls of Working Stock/100 mls
0.05	10.0 of 0.5 mg/l std
0.10	10.0 of 1.0 mg/l
0.5	5.0 of 10 mg/l
1.0	10.0 of 10 mg/l
2.0	20.0 of 10 mg/l

Procedures for total chlorine concentrations ranging between 0 - 2 $\mu\text{g/l}$

- 1 Fill a clean 2.5-cm cell to the 10-ml mark with a sample.

Note: The sample should have a pH between 6 and 7 SU. If necessary, adjust with 1N sulfuric acid or 1N sodium hydroxide

- 2 Open a DPD total chlorine powder packet and add the contents to the sample cell
- 3 Replace the cap on the cell and swirl to mix

Note It is not necessary for all of the particles to dissolve to obtain an accurate reading. The pH of the sample containing the DPD buffer packet must be between 6.2 and 6.5 SU.

- 4 Allow at least 3 minutes but not more than 6 minutes before moving to the next step (see and follow manufactures instructions for reaction times).
- 5 Open the light shield, turn the right set knob fully clockwise, and place the 1-cm cell in the left set position of the sample well holder. Press the cell down firmly to seat it in the holder.
6. Hold the button down. While doing this, adjust the left set knob to align the meter needle with the arrow at the extreme left of the scale.

- 7 Remove the cell from the holder.
8. Fill a clean 2.5-cm sample cell with the sample. Cap the cell and place it into the cell holder. Press it firmly to seat and close the light shield.
- 9 Set the colorimeter by holding the "ON" button down while adjusting the right set knob to zero. Open the light shield and remove the sample cell.
- 10 Fill a clean 1-cm sample cell with the solution from step 2, cap the cell, and place into the cell holder.
- 11 Press the "ON" button down and hold it until the meter stabilizes.
- 12 Read and record the mg/l of total chlorine from the upper (2.5-cm) scale.

Procedures for total chlorine concentrations ranging between 0 - 3.5 mg/l

- 1 - 6 Same steps as previously listed.
- 7 Rotate the cell to the right position
- 8 Fill a clean 1-cm sample cell with the sample, cap the cell, and place it into the cell holder
- 9 Set the colorimeter by holding the "ON" button down while adjusting the right set knob to zero. Open the light shield and remove the sample cell
10. Fill a clean 1-cm sample cell with the solution from step 2, cap the cell, and place it into the cell holder
- 11 Press the "ON" button down and hold it until the meter stabilizes.
- 12 Read and record the mg/l of total chlorine from the upper (1-cm) scale

Verification

- Duplicate chlorine residual analyses should agree within ± 0.01 mg/l

Units

- mg/l total chlorine

Limitations

- Do not use with or in the presence of any oxidizing agents, e.g., oxidized manganese interferes with the DPD reagent ($1 \mu\text{g/l MnO}_4^- \sim \mu\text{g/l Cl}_2$)

16.9 Flash Point

The following test method is to determine if a volatile material's flash point is within established limits

Apparatus

- ERDCO Rapid Tester Model RT-1, Flash Point Analyzer

Calibration

- The repeatability and reproducibility for this instrument are in accordance with the respective standards:

• p-xylene	78.0 ± 1.0°F
• n-butanol	97.9 ± 1.7°F
• n-undecane	145.4 ± 2.0°F
• n-hexadecane	270.5 ± 2.0°F

Operational Procedures.

- 1 Plug in the ERDCO and turn it on
- 2 Switch the rocker switch adjacent to the display to Fahrenheit or Celsius display.
- 3 Press the red temperature preset rocker switch and rotate the red temperature preset knob until the desired temperature appears in the display window (140°F for determining ignitability characteristics). Release the rocker switch and the actual instrument temperature will appear in the display window. The RED light next to the knob should come on indicating the heater is "ON"

Note The preset knob for test temperature may have to be reset as the test temperature is approached

- 4 If a glass bulb thermometer is used, coat the bulb with a heat transfer compound and insert it into the well in the left side of the test oven. Carefully secure the top of the thermometer in the channel
- 5 Open the control valve on the butane cylinder approximately 5 turns and install. Close the control valve and place the cylinder into the instrument's receptacle. Hook the hose to the valve
- 6 Open the control valve approximately one turn and light the pilot light located over the square hole in shutter lid. Adjust the pilot light for the minimum flame that will light the jet. Adjust the test jet for the flame to 4 mm width using the pinch valve knob

Note Immediately above the shutter is a 4 mm referenced milled lid.

- 7 Make sure that the shutter lid is latched (Closed). Inject 2 cc of the sample into the port between the shutter and the latch handle. Press the 1-minute timer rocker switch until the light goes on, then return the switch to center.
- 8 When the timer sounds, slide the shutter back slowly (taking about 2 seconds to do this). The material under test will either flash or not flash.

Note If a halo develops around the flame, this does not constitute a flash.

- 9 Lift the lid. Clean out any material which was being tested with Chem-wipes. Also clean the injection port with a pipe cleaner.

Shut Down Procedures

- 1 Close the control valve on the butane cylinder.
- 2 Disconnect the hose.
- 3 Open the control valve on the butane cylinder approximately 5 turns.
- 4 Turn the instrument off.
- 5 IMPORTANT - Clean the instrument (See step 9 above). Allow ample time for the instrument to cool down before storing.

16.10 Halogen Test

This method is used to qualitatively screen wastes for the presence of halogenated compounds

Test using copper wire and flame

Equipment:

- Propane fuel cylinder with a torch
- Igniter source (matches, flint/bar striker, etc.)
- Stainless steel rod approximately 1 foot long and 1/8 to 1/2 inch in diameter

Note. The smaller diameter rods cool down more quickly.

- Thermally resistant handle or thermally resistant gloves
- 16 or 18 gauge copper wire
- Wire cutters

Procedure

- 1 Wrap approximately 4 feet of copper wire around the tip of the rod
- 2 Clean the wire and rod tip using the flame of the propane torch.

Note When a blue flame with small yellow-orange streaks appears, the wire and rod are clean. Allow the copper wire to become "red" hot during the cleaning process (this takes from 1/2 to 1 minute)

- 3 Allow the rod and wire to cool for a minimum of 15 minutes.

Note: The wire and rod can be immersed in water to speed up the cool down time. This will not bias the results. Allow the water to evaporate completely and the rod tip should be cool to the touch before using it in the test.

CAUTION!

DO NOT IMMERSE A HOT ROD INTO A POTENTIALLY FLAMMABLE MATERIAL

- 4 Immerse the cooled wire and rod tip into the test material for approximately 10 seconds
- 5 Remove the wetted wire/tip from the test material and allow the excess material to drip back into the container

Note. Highly viscous material which sticks to the tip may produce a large flame

- 6 Place wetted wire into the flame and observe the color produced.

Note A bright green flame indicates the presence of halogenated material

16.11 References

Temperature

- 1 Standard Methods for the Examination of Water and Wastewater, 18th Edition p 2-59, Method 2550 B (1992)
- 2 Methods for Chemical Analyses of Water and Wastes, US-EPA, 170.1 (1983)

Specific Conductance (Conductivity)

- 3 Standard Methods for the Examination of Water and Wastewater, 18th Edition, p 2-43 Method 2510B (1992).
- 4 Annual Book of ASTM Standards, Vol 11.1, "Water," Standard D1125-91A, P 202
- 5 Methods for Chemical Analysis of Water and Wastes, US-EPA, 120.1 (1983).
- 6 Instruction Manual, SoluBridge® RB-5/RB-6, Beckman Instruments, Inc., Rev. January 1982
- 7 Surveyor II Operating Manual, Hydrolab Corporation, Rev. A February 1985
- 8 YSI Model 3560 Water Quality Monitoring System Instructions, July, 1988

Hydrogen Ion Concentration (pH)

- 9 Standard Methods for the Examination of Wastewater, 16th Edition, p. 429, Method 423 (1985)
- 10 Instruction Manual for Models 399 A/F, 399 A/L Analog pH Meter, and SA 250 and 230A, Orion Research Incorporated
- 11 Instruction Manual for Surveyor II, Hydrolab Corporation
- 12 Instruction Manual for YSI Water Quality Monitoring System for the Model 3530 pH Electrode Assembly
- 13 Annual Book of ASTM Standards, Part 31, "Water", Standard D1293-78(B).
- 14 Methods for Chemical Analysis of Water and Wastes, US-EPA, 150.1 (1983)
- 15 Procedure No 501, pH Measurement in Low Ionic Strength Solutions, Orion Application Information, Orion Research Incorporated.
- 16 Federal Register, Vol. 60, No 64, Tuesday, April 4, 1995 -- Rules and Regulations, 17001-17003

Turbidity

- 17 Operating procedures for the Hach 2100P Turbidimeter

Dissolved Oxygen

- 18 Standard Methods for the Examination of Water and Wastewater, 18th Edition, p 4-100, Method 4500-OC (1992)
- 19 Annual Book of ASTM Standards, Part 31, "Water," Standard D888-92(A)
- 20 Methods for Chemical Analysis of Water and Wastes, US-EPA, 360 1 (1983)
- 21 Methods for Chemical Analysis of Water and Wastes, US-EPA, 360 2 (1983)
- 22 Instruction Manual YSI Model 57, Dissolved Oxygen Meter, Science Division, Yellow Springs Instrument Company.

Chlorine - (DPT Colorimetric)

- 23 Annual Book of ASTM Standards, "Water," Standard D 1253-86(92)
- 24 Methods for Chemical Analysis of Water and Wastes, US-EPA, 330 1 (1983)
- 25 Methods for Chemical Analysis of Water and Wastes, US-EPA, 330 5 (1983)
- 26 Standard Methods for the Examination of Water and Wastewater, 18th Edition, Method 4500-CL D (1992)
- 27 Standard Methods for the Examination of Water and Wastewater, 18th Edition, p 4-100, Method 4500- CL G (1992)
- 28 Instruction Manual, DR 100 Colorimeter, Model 41100-02, DPD Method for Chlorine, Hach Company, June 1983

Salinity

- 29 Standard Methods for the Examination of Water and Wastewater, 18th Edition, p 2-47 Method 2520 B (1992).
- 30 Instruction Manual, RS5-3 Portable Salinometer, Beckman Instruments, Inc., Revised March 1973

Flash Point

- 31 Rapid Tester Model RT-1 Technical Manual, Operations and Service, November 1, 1989

SECTION 17
AIR MONITORING SAFETY EQUIPMENT
CALIBRATION PROCEDURES

17.1 Introduction

This section gives specific procedures to be followed when calibrating air monitoring instrumentation. Calibrations defined in these procedures will result in instrument response accuracy within the capabilities of the instruments. The following practices shall be followed with calibration gases:

- Calibrations should demonstrate proper operation of the monitor and insure that results give an acceptably accurate indication of conditions upon which to base safety decisions and actions.
- Calibration gases shall be certified by their supplier to be of a specified and known concentration.
- Concentrations of calibration gases shall be within a relevant range of response for the air monitors, but will not exceed any flammability or toxic exposure limits.
- Gas cylinders will not be sent to the field if they contain less than one-fifth of their full capacity. Cylinders below the required volume will be utilized in the warehouse for equipment check-out and maintenance.

Calibration mixtures and approximate concentrations for specific air monitors will be as follows:

CALIBRATION GASES		
MONITOR	GAS MIXTURE	CONCENTRATION
Combustible Gas	Pentane in Air	0.75%
Flame Ionization	Methane in Air	75 ppm
Photo-Ionization Detector	Toluene in Air	100 ppm

Calibration Equipment

All calibrations will consist of introducing a gas of known concentration into the monitor at atmospheric pressure. Under no circumstances will it be acceptable to attempt calibration when the monitor is measuring gas concentrations below or above atmospheric pressure.

To insure a stable pressure of the calibration gas, a calibration manifold system will be used. The manifold will consist of a "T" fitting, a Teflon® bag, Teflon® tubing, and fittings. The Teflon® bag is omitted for calibration of the OVA.

The calibration gas cylinder will be connected to the "T" fitting with Teflon® tubing so that the gas will flow directly through the top of the "T" into a Teflon® bag.

The "T" fitting and tubing will be purged with calibration gas prior to connection of the Teflon® bag. The bottom or side port of the "T" will be connected with Teflon® tubing to a stainless steel quick disconnect. Once the Teflon® bag has been filled with gas, the gas flow will be turned off. The monitor's probe will be connected to the manifold via the quick disconnect and allowed to sample the contents of the Teflon® bag.

Calibration Frequency

It is required that the monitors be calibrated each time they are turned on. More frequent calibrations are encouraged if the field investigators determine that field conditions and hazards are warranted. Frequent checking of monitor response or proper setting and operation of alarms is encouraged.

Prior to turning off the monitor, a post calibration check shall be performed. This check will follow the same procedures as the initial calibration except that no adjustments will be made to the monitor. Instead, the response will simply be logged in the field book.

Documentation

Calibrations should be documented in the field log book. The entry needs to include the following information:

CALIBRATION DOCUMENTATION	
Monitor's Identification Number	
Date of Calibration	
Time of Calibration	
Battery Check Response	
Alarm Response	
Instrument Response	
Calibration Gas Concentration	
Fuel Level (FID)	
Operator's Initials	

17.2 MSA Model 260 Combustible Gas and Oxygen Alarm

Introduction

The MSA Model 260 Combustible Gas and Oxygen Alarm is a hand-carried, battery operated instrument

- It is used to sample atmospheres for combustible gases or vapors and oxygen content and warn the user when pre-determined concentrations of either are reached
- The monitor will only detect combustible gases and vapors in air. It will **not** indicate the presence of combustible airborne mists or dusts such as lubricating oils, coal dust, or grain dust
- **THE LACK OF A RESPONSE ON THIS METER DOES NOT GUARANTEE THAT THE ENVIRONMENT IS SAFE.**

Operational Checks

- 1 Connect the probe line to the monitor's water drop-out bottle. Check the probe fitting and the water drop-out bottle fitting for tightness
- 2 Place the monitor's "ON-OFF" switch in the "HORN OFF" position
 - Note that the monitor's "% OXYGEN" and "% LEL" meters respond upscale, and then stabilize
 - Note that the oxygen alarm and LEL alarm lights are illuminated, the green flow indicator is flashing, and the "FLOW" indicator float is vibrating audibly.
- 3 Press the "RESET" button and observe that both "ALARM" lights go out
- 4 Press the "CHECK" button and record the battery reading from the "% LEL" meter
- 5 Set the "% OXYGEN" meter to read 20.8% using the "CALIBRATE O₂" knob. Set the "% LEL" meter to read zero using the "ZERO LEL" knob
- 6 Place the monitor's function switch to the "ON" position
- 7 Leak check the monitor by placing your thumb tightly over the probe line inlet. Observe that the monitor's pump stops. Observe also that when the "% OXYGEN" meter falls to approximately 19%, the "ALARM" light illuminates and the alarm horn sounds
- 8 Remove your thumb from probe inlet line. When "% OXYGEN" meter returns to 20.8%, press "RESET" button
- 9 Rotate the "ZERO LEL" knob clockwise until the "ALARM" light illuminates and the alarm horn sounds. This should occur at about 25% of LEL. Return the LEL meter to a reading of zero and reset the alarms

Calibration

- 1 Assemble a calibration manifold as described in Section 17.1. Upon introduction of the calibration gas to the monitor, the LEL response should be approximately 50%. Record the response.
- 2 Disconnect the monitor from the calibration manifold and reset the alarms.
- 3 Insure that the function switch is in the "ON" position and that the green flow indicator is steadily illuminated.
- 4 Attach the probe to the probe line.

17.3 Photovac Microtip Photoionization Detector

Note: Some microtips are NOT intrinsically safe

Introduction

The Photovac Microtip is a microprocessor controlled photoionization detector. The instrument normally operates with a 10.6 eV lamp, however 9.5 and 11.7 eV lamps are available as options. The detector is capable of measuring concentrations down to about 1 ppm sensitivity for certain compounds.

It is important to realize that this sensitivity is not achievable for all compounds. Some materials will result in a very low response on the PID in relation to their actual concentrations, while others will not respond at all to the detector's ionization energy. It **can not** be used to identify unknown substances, it can only quantify them. Winds and high humidity will affect measurement readings. Foggy or high humidity conditions can cause condensation on the lamp, thus affecting measurements.

As a general rule, the PID should **not** be used to monitor for low molecular weight hydrocarbon compounds whose structures contain only single bonds (methane, ethane, pentane, hexane, heptane, carbon tetrachloride, and hydrogen sulfide). The PID **should** be used to detect aromatics such as benzene, toluene, and styrene, aliphatic amines such as diethylamine; and chlorinated unsaturated compounds such as vinyl chloride and trichloroethylene.

- **THE LACK OF A RESPONSE ON THIS METER DOES NOT GUARANTEE THAT THE ENVIRONMENT IS SAFE.**
- **THE MICROTIP MODEL MP100 IS NOT INTRINSICALLY SAFE**
- **DO NOT USE A NONINTRINSICALLY SAFE MICROTIP IN CONFINED SPACES UNLESS CLEARED WITH AN EXPLOSIMETER**

Operational Information

Turn the instrument on by pressing the back of the power switch. The pump will start and the message "Warming up now, please wait" will be displayed. Within three minutes the following information will appear on the display:

Instrument Status	Current Detected	
Ready	Concentration	
	2000 ppm	
008	10.15	Feb 15
Event Number	Time	Date

The Microtip then operates automatically. The user reads the concentration directly from the display. The display updates itself each half second.

The minimum, maximum, and average concentrations measured in each 15-second period are automatically recorded in memory. The memory holds the last 12 hours of data. The concentration data can be retrieved from memory on the instrument's display or sent to a printer or computer in either tabular or a graphical format. Data are recorded by date, time, and by a user-entered event number. Data are played back by the user specifying a start and a stop event number.

The keypad is used to set up and calibrate the Microtip, and it allows the user to manipulate the concentrations measured and recorded by the instrument in various ways. The Microtip has 16 labelled keys for direct numeric entry and for using the instrument's functions. All information entered from the keypad and stored in data logging memory is retained when the instrument is switched off. The clock and calendar continue to operate and do not need to be reset the next time the instrument is used. If there are no options to the function then the key acts immediately. If there are options, then the display will indicate these. The currently selected option is displayed on the lower line. The user is prompted to display the other options by pressing the up arrow or down arrow keys. Pressing ENTER confirms that the displayed option is correct. If the function requires numeric input then the current value is displayed on the lower line. The user can change it on the display by pressing the numeric keys. Pressing ENTER confirms that the displayed value is correct. Some functions have multiple steps for options and/or numeric inputs. These are arranged so that the most frequently changed inputs are displayed first. Once the desired changes have been made the user can bypass the rest of the steps by pressing EXIT.

Following is a list of the keys and a description of their functions:

TUTOR

To assist the user in learning the key functions, the instrument has a built-in tutorial session which displays a two-line description of the function of each key. Pressing the TUTOR key begins a tutorial session and pressing the EXIT key twice ends the session. While in the tutorial session key presses have no effect on the instrument's operation.

DISPLAY

If a numerical display is shown, pressing DISPLAY will change it to a bar graph. If the bar graph is shown, pressing DISPLAY changes it to a numerical display. The bar graph range is selected with the SETUP key.

LIGHT

Backlighting can be of one of two intensities. The brighter lighting consumes more power and is recommended for use only in very dark locations. Pressing the LIGHT key switches the backlight on to high intensity, pressing it again decreases the intensity, and pressing it once more turns the backlighting off. Backlighting is not available on intrinsically safe instruments.

BATT

Pressing the BATT key displays the current battery level. The battery voltage will be shown for 15 seconds and then the display reverts to normal. The normal operating voltage range is 9 to 16 volts. When LoBat is displayed there is approximately 10 minutes of operation left. The battery pack must be replaced by a fully charged pack and the discharged pack should be recharged.

If operation is continued with a low battery pack, another message will appear indicating that the batteries are critically low. The Microtup will then turn off the detector lamp, the pump, and the backlighting (if activated). This reduces deep discharging of the battery pack and possible memory loss.

MAX

When pressed, the maximum concentration, the event during which it was encountered, the time and the date of the occurrence will be displayed. This is shown for 15 seconds and then the display reverts to normal. Pressing MAX and then CLEAR will reset the Max register. "Max Cleared" will be displayed with the current date and time. After 15 seconds the display reverts to normal. Recording of real time data is not interrupted when the MAX key is pressed or when the Max register is cleared.

CLEAR

CLEAR erases the last numerical entry. If a number is entered in error press CLEAR to erase the entry and re-enter the correct number. CLEAR used in conjunction with the MAX key resets the Max register.

EVENT

Each press of the EVENT key advances the Event number by one unit on the display. Press EVENT to help identify a particular sample or sampling location in memory. After Event 255, the Event counter resets to zero. Each time the instrument is turned on the Event number is automatically advanced by one unit. Recorded data are played and printed by specifying a start and stop Event number.

The instrument will record continuously for a period of 12 hours. After 12 hours it begins to overwrite existing data one event at a time. If a printed copy of the data is required, it should be downloaded at least once every 12 hours of operation.

EXIT

The EXIT key terminates all functions except DISPLAY, LIGHT, and EVENT. When EXIT is pressed the display reverts to normal. Most functions exit automatically if no key is pressed for 15 seconds. When EXIT is pressed during printing or graphing, the instrument stops sending information to the printer or computer. The printer will continue to print until its buffer is empty.

SETUP

The SETUP key allows the instrument to be set up for a specific application. The current date and time are also set with the SETUP key. Press SETUP and step through the options. Press ENTER to accept the displayed data or enter a numerical value using the keypad and then press ENTER. If no values are entered, the display reverts to normal.

To set up the instrument:

1. Press SETUP.
2. The first step sets the full scale range for the bar graph display, the graph output, the audio output, and the 1 volt analog output. Use the up and down arrow keys to select the 20,200 or 2,000 parts per million (ppm) range.
3. Next the Cal memory is selected. The instrument has five Cal Memories for regular operation and one for High Sensitivity operation. Only one Cal memory can be used at a time. Select Cal Memory 1 with the up and down arrow keys and press ENTER.
4. Next, enter the correct values for the current time. Press ENTER after each value.
5. Enter the numerical values for the day, month, and year. Again press ENTER after each selection.

The instrument is now set for operation.

AUDIO

To connect the headset, remove the dustcover from the I/O connector and plug in the headset. If a headset is being used, press AUDIO and use the arrow keys to select one of three options for audio output and press ENTER. The audio output can be turned off altogether. It can be set so there is audio output during an alarm condition only. The last option is a continuous audio signal with the tone being proportional to the detected concentration.

ALARM

The ALARM key displays the current alarm level and allows a new alarm level to be entered

- 1 Press ALARM.
- 2 The current alarm is displayed. If the value is correct (5 ppm) wait for the display to revert to normal in 15 seconds or press EXIT.
- 3 If a new value is to be set, enter the value, and press ENTER

When an alarm condition is detected the instrument status changes to "Alarm" and remains on until the alarm condition has passed

PLAY

The PLAY key plays back previously recorded data

- 1 Press PLAY. Two options are available. Pressing ENTER begins playback where it was last stopped. Press the SETUP (*) key to set the playback options
- 2 Select the start Event. If the selected Event is not available, the instrument begins at the closest higher Event. An Event may not be available if the EVENT key was pressed more than once in 15 seconds, or if the selected Event has been overwritten in the memory by more recent information
- 3 Next select which value is to be displayed, either the Minimum, the Average, or the Maximum, with the arrow keys and press ENTER
- 4 The data can be played back in either numerical or graphical display by pressing the DISPLAY key

When the instrument is playing back recorded data it is also measuring and recording real time concentrations even though the instrument status is "Play". If, during playback, an instrument status with a priority higher than that of "Play" is encountered in real time operation it will be displayed, but the play back will continue. The playback speed and direction can be selected using the arrow keys. The speed can be increased or decreased and the information can be viewed in the opposite direction as well. A forward arrow (>) appears in the display if data are being played forward or a backward arrow (<) if the data are being played in reverse. Press ENTER to freeze the display at any time and use the arrow keys to resume playback. Press EXIT to return to the normal display. The PLAY function provides a speed search to find the desired start and stop Event numbers for printing or graphing

CAL

The instrument must be calibrated against a dynamic standard in order to display concentrations in units equivalent to ppm. Clean outdoor air is suitable as Zero Gas. Assemble a calibration manifold as described in Section 17.1 using toluene as the calibration gas.

- 1 Press **SETUP** and check all display information. Select a Cal Memory (usually #1) with the arrow keys and press **ENTER**. Press **EXIT** to leave the Setup.
- 2 Press **BATT** and record battery voltage.
- 3 Press **ALARM** and set the alarm level to 5.0 and then press enter.
- 4 Press **CAL** and expose the instrument to Zero Gas. Press **ENTER** and the zero point is set.
- 5 The instrument then asks for the Span Gas concentration. Enter the known concentration from the span gas cylinder and press **ENTER**.
- 6 Connect the span gas fitting to the sample inlet.
- 7 Press **ENTER** and the sensitivity is set.
- 8 When the display reverts to normal, the instrument is calibrated and ready for use.

When the instrument is turned on, it will automatically calibrate itself to the data stored in the CAL Memory (usually #1) selected in Step 1. This instrument calibration is acceptable provided

- The site is not a level C or B site, and that no "hits" have been detected or are expected to be detected.
- The instrument responds to some ionizable material introduced to the sample inlet (i.e., a felt tip pen check).

17.4 Toxic Vapor Analyzer (TVA 1000A)

Introduction

The Toxic Vapor Analyzer (TVA 1000A) is a portable inorganic/organic vapor monitor. This analyzer uses both a flame ionization detector (FID) and a photoionization detector (PID) to sample and measure concentrations of gases.

Hydrogen Tank for the FID

When the TVA 1000A leaves the Field Equipment Center (FEC), the hydrogen tank will be full and the battery will be charged.

If the hydrogen tank (used to run the FID) has to be refilled during the field exercise, remember that the threads on the hydrogen tank are left-handed. Follow the same procedures for refilling this hydrogen tank as you would for refilling the hydrogen (used to run the FID) on the OVA.

Note that you must always screw the hydrogen tank into the unit when taking the TVA out of the carrying box. The TVA will not fit back in the box without taking the hydrogen tank out of the unit. Extra hydrogen tanks are available.

Operating Procedures

- 1 After you have recharged the battery and filled the hydrogen tank, install it in the instrument (left handed thread, turn counter-clockwise until resistance is felt).
- 2 Connect the sample probe, and turn the unit on.
- 3 If you want to use the FID, turn on the red HYDROGEN ON/OFF valve.
- 4 The TVA-1000A is user friendly/menu driven. To operate the TVA 1000A, follow the procedures listed in the next two tables. The instrument takes a few minutes to warm up.

To display a measurement on a PID unit, use the procedure below

TVA 1000A - PID DISPLAY		
ACTION	DISPLAY	DESCRIPTION
Press On	Battery OK NV RAM OK Date/Time OK Self Test OK	The TVA 1000A performs selftest diagnostics for approximately 15 seconds.
Wait 15 Seconds	Main Menu 1=Run 2=Setup 3=Info 4=PC Link/Memory	The main menu is displayed. When starting the instrument for survey, be sure to turn the pump on before selecting the run mode.
Press Control	Control Menu 1=Turn Pump On 2=Turn PID On	The main menu prompts you to make a selection.
Press 1	Main Menu 1=Run 2=Setup 3=Info 4=PC Link/Memory	The main menu is displayed again, but this time the pump is on. Since the pump is on, you can make a measurement. Note the prompt selections.
Press 1	PID 00.25%	The TVA 1000A presents the measurement information. Refer to the setup procedure in the Display Menus.

To power down the instrument, press and hold the OFF button.

To display a measurement on a FID-only or FID/PID unit, execute the following procedures

TVA 1000A - FID DISPLAY		
ACTION	DISPLAY	DESCRIPTION
Press On	Battery OK NV RAM OK Date/Time OK Self Test OK	The TVA 1000A performs selftest diagnostics for approximately 15 seconds
Wait 15 Seconds	Main Menu 1 = Run 2 = Setup 3 = Info 4 = PC Link/Memory	The main menu is displayed. When starting the instrument for survey, turn on the pump and ignite the FID before selecting 1 for run
Press Control	Control Menu 1 = Turn Pump On 2 = Turn PID On	The main menu prompts you to make a selection. To turn the pump on, press 1 NOTE: Choice "3" available only on FID/PID unit
Press 1	Main Menu 1 = Run 2 = Setup 3 = Info 4 = PC Link/Memory	The main menu is displayed again, but this time the pump is on. With the pump on, press the CONTROL key again to ignite the FID
Press CONTROL	Control Menu 1 = Turn pump on 2 = Ignite 3 = Turn PID on	Now that the pump is on, select 2 to ignite the FID. Before pressing the 2 key, turn on the gas valve and let the instrument run for at least 30 seconds
Press 2	Main Menu 1 = Run 2 = Setup 3 = Info 4 = PC Link/Memory	The main menu is displayed again. This time the pump is on and the FID is ignited. To make a measurement, select 1 for RUN
Press 1	PID 00.25% FID 00.25%	The TVA 1000A presents the measurements information. Refer to the setup procedure in the Display Menus

To power down this instrument, press and hold the OFF key. You must also shut the gas valve to avoid depleting the tank supply.

Calibration

To provide the specified accuracy, the instrument must be calibrated at the beginning of each workday.

The four steps involved in calibrating the TVA 1000A are.

- 1 Calibrate a Zero point using either a zero gas or clean ambient air. The Zero and BACKGROUND terms are used only for reference. Only one ZERO value is stored

Menu item 1 = Zero refers to a zero gas being used

Menu item 2 = Background refers to clean ambient air used for the zero

- 2 Calibrate a reference point, using a known span gas.

Menu item 3 = Span

- 3 Define to the instrument the actual concentration of gas provided in Step 2

Menu item 4 = Gas Concentration

- 4 Define the response sensitivity, using a response factor

Menu item 5 = Response Factor

Calibrate the TVA 1000A by taking an actual gas sample for ZERO and another actual gas sample for SPAN. The ZERO sample may come from either clean ambient air (display reads Backgnd) or from a calibration zero gas tank (display reads Zero). The SPAN sample must be a known concentration of calibration gas. Enter the concentration of span gas (display reads GasConc) and then assign a sensitivity level for the gas to be measured (display reads Response Factor).

Performing an accurate calibration requires the necessary calibration gas source, a clean zero source, and execution of the following procedures:

Note Prior to performing calibration, the instrument must be ON and warmed up for approximately 30 minutes. The pump must also be ON and, if the instrument is equipped with a FID, the flame must be ignited throughout the warmup period.

Accessing the Calibration Menu

- 1 From the MAIN menu display, press 2 = Setup
- 2 Select 5 = Other Settings, then 4 = User Options, and then select 3 = Cal Mode

The calibration modes are

AUTO Instrument analyzes the gas sample until values stabilize and then stores the final value. There is no measurement display during this process. The factory setting is AUTO.

MANUAL User monitors gas sample measurements (in counts) and presses ENTER to store the value.

The following steps assume the AUTO calibration mode.

- 3 From the SETUP menu display, press 1 = Calibration and follow the procedures for the appropriate calibration.

CALIBRATION MENU (For FID only, PID only, PID/FID)

1 = Zero 2 = Background

3 = Span 4 = GasConc

5 = Response

Zero or Background Zero Reference Point

- 1 From the CALIBRATION menu display, press 1 = Zero if zero is to be used for calibrating zero. Press 2 = Background if clean ambient air is to be used for zero. (Select one or the other).

Note If you have selected the MANUAL calibration option, the display will show the unscaled detector output values of the zero gas (expressed in counts) as of the last calibration. If you select the AUTO option, the count is not displayed.

If the instrument is a dual detector type (PID and FID), you can zero the PID and FID separately, both together, or one in zero gas and one in clean ambient air. To do so, follow the same procedure. However, it is suggested that you zero both detectors together.

If you press 1 = Zero, the display will show

FID-only

Zero Cal

Enter = Start

PID-only

Zero Cal

Enter = Start

PID/FID

Zero cal 1 = Both

2 = PID 3 = FID

- 2 To perform the actual ZERO procedure for

FID-only Press ENTER	or PID-only Press ENTER	or PID/FID Press 1, 2, or 3
Apply Zero Gas FID	Apply Zero Gas PID	Apply Zero Gas PID/FID
Enter = Start	Enter = Start	Enter = Start
Exit = Cancel	Exit = Cancel	Exit = Cancel

- 3 Apply the zero gas to the probe at ambient pressure (using a clean and labeled gas sampling bag) and then press ENTER

Calibrating FID	Calibrating... PID	Calibrating FID/PID
Zero Gas	Zero Gas	Zero Gas
Exit = Cancel	Exit = Cancel	Exit = Cancel

The instrument analyzes the zero sample

Calibrating . FID	Calibrating.. PID	Calibrating FID/PID
ACCEPTED	ACCEPTED	ACCEPTED

The ACCEPTED message appears for a brief time and is then replaced by the normal CALIBRATION menu

When the ACCEPTED message disappears and the CALIBRATION menu appears, the ZERO reference value is in non-volatile memory until the next calibration is performed. The date and time of this calibration are stored and accessed through the INFO menu

Note For optimum accuracy, re-zero the FID every time the hydrogen supply valve is turned on

Span Reference Point

To set the span reference point, execute the procedure described below. Note that the procedure is the same as that for setting the zero reference except that a span gas is used instead of a zero gas. The procedure is

- 1 From the CALIBRATION MENU display, press 3 = Span

Note If you have selected the MANUAL option for the calibration mode, the display will show the unscaled detector output values of the span media (expressed in counts) as of the last calibration. If you select the AUTO option, the count is not displayed.

If your instrument is a dual detector type (PID and FID), you can set the span reference for the PID and FID separately, both together, or one in one type of calibration gas and one in another type of gas. To do so, follow the same procedure.

When you press 3 = Span, the display will show.

FID-only	PID-only	PID/FID
Span Cal	Span Cal	Span Cal
Enter = Start	Enter = Start	Enter = Start

- 2 To perform the actual SPAN calibration for a

FID-only or Press ENTER	PID-only or Press ENTER	PID/FID Press Enter
Apply Span Gas	Apply Span Gas	Apply Span Gas
FID	PID	PID/FID
Enter = Start	Enter = Start	Enter = Start
Exit = Cancel	Exit = Cancel	Exit = Cancel

- 3 Apply the span gas to the probe at ambient pressure (using a clean and labeled gas bag) and then press ENTER

Calibrating	Calibrating	Calibrating
FID	PID	FID/PID
Span Gas	Span Gas	Span Gas
Exit = Cancel	Exit = Cancel	Exit = Cancel

The instrument analyzes the span sample

Calibrating .	Calibrating	Calibrating .
FID	PID	FID/PID
ACCEPTED	ACCEPTED	ACCEPTED

The ACCEPTED message appears for a brief time and is then replaced by the normal CALIBRATION menu

When the ACCEPTED message disappears and the CALIBRATION menu appears the SPAN reference value is stored. This value is stored in non-volatile memory. The date and time of this calibration are stored and can be accessed through the INFO menu

Define the Gas Concentration

- 1 From the CALIBRATION menu display, press 4 = Gas Conc.

Note At this time, the upper display (or two displays if unit has both FID and PID detectors) reads the concentration value of the span gas (expressed as %, PPM, or PPB) as of the last calibration. If this is the first time that the unit has been turned ON, the display reads 1%. With dual detector units, the lower displays prompt you to select the detector type to be calibrated, i.e., 1=Both, 2=PID, and 3=FID

Since this instrument has dual detectors you may choose to calibrate the PID and FID separately or together. The gas concentration values refer to the known concentration of the calibration span gases used

FID-only	PID-only	FID/PID
FID 1.00%	PID 1.00%	PID 1.00% FID 1.00%
Span Gas Conc Enter = New Calib	Span Gas Conc Enter = New Calib	Span Gas Conc 1 = Both 2 = PID 3 = FID

- 2 To change the gas concentration to a new value, press 1, 2, or 3. (The value that you enter must be the concentration of the actual span gas used for the span reference point). You will see

FID-only	PID-only	FID/PID
Enter Span Conc FID 00.00%	Enter Span Conc PID 00.00%	Enter Span Conc F&P 00.00%
Up/Dn = Next Unit	Up/Dn = Next Unit	Up/Dn = Next Unit Enter = Accept

Use the up and down keys to select %, PPM, PPB, and decimal point position, and then enter the numeric value for the known concentration

- 3 Press ENTER to store the new values into the instrument memory.
- 4 Press EXIT to return to the CALIBRATION menu. Gas concentration ranges are defined in the following table on the next page

GAS CONCENTRATION RANGES		
RANGE	UNITS	DISPLAY
5	%	DD DD
4	PPM	DDDDDD
3	PPM	DDDD D
2	PPM	DDD.DDD
1	PPB	DDDDDD

The range of the instrument is determined by the manner in which you enter the numeric value of the gas concentration (how you select the measurement units and place the decimal)

After you have entered the value for the gas concentration, enter the RUN mode. The instrument will auto-range (upward only) to select optimum range for displaying the measurement information. For example, if you entered a value in Range 3 and measured value changes to a high, the instrument will automatically switch to range 4. If it increases further, it will switch to Range 5. Note that the auto-ranging will not switch ranges in the down direction.

Define the Response Factor

Response Factor is the means by which the TVA 1000A automatically corrects for the direct reading of a single concentration of any gas other than 1. Refer to Foxboro for this response factor.

1. From the CALIBRATION menu display, press 5 = Response Factor.

Note: If the gas to be measured is not the same compound for which the respective detector was calibrated, the response factor may be something other than 1. Refer to Foxboro for this response factor.

At this time, two displays read the response factor (expressed as a ratio) as of the last calibration. Response Factor is a measure of sensitivity of the TVA to any compound referenced against the calibration span gas used for each detector.

$$\text{Response Factor} = (\text{Response to Gas to be Measured}) / (\text{Response to Cal Gas})$$

For example: PID=1.00 or FID=1.00 are displayed simultaneously with dual detector units. With dual detector units, the lower two displays prompt you to select the detector type to be calibrated, i.e., 1=Both, 2=PID, and 3=FID.

FID-only	PID-only	FID/PID
FID 1 00	PID 1 00	FID 1.00 PID 1 00
Response Factor	Response Factor	Resp FCT 1 = Both 2 = PID 3 = FID

- 2 To change the response factor to a new value, press 1, 2, or 3 and see

FID-only	PID-only	FID/PID
Enter Resp Fact	Enter Resp. Fact.	Enter Resp Fact
FID 00.00	PID 00 00	F&P: 00.00
Enter = Accept	Enter = Accept	Enter = Accept

Enter the appropriate response factor for your specific gas Refer to Foxboro for values for specific gases

- 3 Press ENTER to store the new values into the instrument memory.
- 4 Press EXIT to return to the CALIBRATION menu.

Alarm Levels

The TVA-1000 is supplied with three user-configurable alarms - HI Ceiling, Low Ceiling and STEL (short term exposure limit). When any one of these alarms is exceeded, an alarm message is displayed on the sidepack display only and an alarm tone is generated. Press EXIT to acknowledge the alarm message and sounder. Once acknowledged, the display returns to the live measurement with an upper case letter representing the alarm or alarm combination appearing to the right of the display.

ALARM TYPE	DESCRIPTION
Low Ceiling	This alarm is a warning that a lower level threshold has been exceeded. Once acknowledged, the letter L appears to the right of the live measurement for the appropriate detector.
High Ceiling	This alarm is a warning that a second, higher level, threshold has been exceeded. Once this alarm is acknowledged, the letter H appears to the right of the live measurement for the appropriate detector.
STEL	The Short Term Exposure Limit (STEL) indicates that measurements averaged over a 15-minute interval have exceeded the set alarm limit. Once this alarm is acknowledged, the letter S appears to the right of the live measurement for the appropriate detector.

The three alarm messages appear on the instrument display as follows:

Low Ceiling	High Ceiling	STEL Level
ALARM	ALARM	ALARM
Low Ceiling	High Ceiling	STEL Alarm Level
Alarm Exceeded	Alarm Exceeded	Alarm Exceeded
EXIT=CLR	EXIT=CLR	EXIT=CLR

NOTE: To display and change the alarm menus, the instrument must be ON but does not have to be warmed up.

Accessing the Alarm Menus

1. From the MAIN menu display, press 2 = Setup
2. From the SETUP menu display, press 2 = Alarms and follow the procedures for the appropriate alarm settings

STEL Level Alarm

- 1 From the ALARM LEVELS display, press 1 = STEL. The previous alarm settings for STEL alarm are then displayed as follows

FID-only	PID-only	PID/FID
FID 80 00 ppm STEL Alarm Enter = New Value	PID 80 00 ppm STEL Alarm Enter = New Value	PID 80.00 ppm FID 80 00 ppm STEL 1 = Both 2 = PID 3 = FID

- 2 To change the alarm level to a new value, press ENTER on a single detector instrument or 1, 2, or 3 on a dual detector instrument and see:

FID-only	PID-only	PID/FID
Enter STEL FID 000.00 ppm UP/Dn = Next Unit Enter = Accept	Enter STEL: PID 000.00 ppm UP/Dn = Next Unit Enter = Accept	Enter STEL P&F: 000.00 ppm UP/Dn = Next Unit Enter = Accept

Use the up and down arrow keys to select %, PPM, PPB, and decimal point position, then enter the numeric value for the alarm level desired.

- 3 Press ENTER to store new values into the instruments memory
- 4 Press EXIT to return to the ALARM LEVELS

Low Ceiling Alarm

- 1 From the ALARM LEVEL display, press 2 = Low Ceiling. The previous alarm settings for the Low Ceiling alarm are then displayed, as follows

FID-only	PID-only	PID/FID
Low Ceiling Alarm FID 80 00 ppm Enter = New Value	Low Ceiling Alarm PID 80 00 ppm Enter = New Value	P&F 80 00 ppm Low Ceiling 1 = Both 2 = PID 3 = FID

- 2 To change the alarm level to a new value, press ENTER on a single detector instrument or 1, 2, or 3 on a dual detector instrument and see

FID-only	PID-only	PID/FID
Enter Low Ceil FID 000 00 ppm UP/Dn = Next Unit Enter = Accept	Enter Low Ceil PID 000 00 ppm UP/Dn = Next Unit Enter = Accept	Enter Low Ceil P&F 000 00 ppm UP/Dn = Next Unit Enter = Accept

Use the up and down keys to select %, PPM, PPB, and decimal point position, and then enter the numeric value for the alarm level desired

- 3 Press ENTER to store the new values into the instruments memory
- 4 Press EXIT to return to the ALARM LEVELS

High Ceiling Alarm

- 1 From the ALARM LEVEL display, press 3 = High Ceiling The previous alarm settings for the High Ceiling alarm are then displayed, as follows

FID-only	PID-only	PID/FID
High Ceiling Alarm	High Ceiling Alarm	
FID 80 00 ppm	PID 80.00 ppm	P&F 80 00 ppm
Enter=New Value	Enter=New Value	High Ceiling 1=Both 2=PID 3=FID

- 2 To change the alarm level to a new value, press ENTER on a single detector instrument or 1, 2, or 3 on a dual detector instrument and see

FID-only	PID-only	PID/FID
Enter High Ceil	Enter High Ceil	Enter High Ceil
FID 000 00 ppm	PID 000.00 ppm	P&F. 000 00 ppm
UP/Dn=Next Unit	UP/Dn=Next Unit	UP/Dn=Next Unit
Enter=Accept	Enter=Accept	Enter=Accept

Use the up and down keys to select %, PPM, PPB, and decimal point position, and then type the numeric value for the alarm level desired

- 3 Press ENTER to store the new values into the instruments memory
- 4 Press EXIT to return to the ALARM LEVELS

17.5 Century Model OVA-128 Organic Vapor Analyzer

Introduction

The Century Model OVA-128 Organic Vapor Analyzer (OVA) is designed to detect organic compounds in air

- It uses a hydrogen flame ionization detector (FID) as its detection principle. This detector allows the monitor to respond to a wide variety of organic compounds, but limits its sensitivity to around 10 ppm under ideal circumstances. The OVA's best response is to single-bonded hydrocarbons such as methane and dichloroethane.
- THE LACK OF A RESPONSE ON THIS METER DOES NOT GUARANTEE THAT THE ENVIRONMENT IS SAFE

Operational Checks

- 1 Connect the hand readout unit's electrical and pneumatic fittings to the side pack assembly
- 2 Connect probe to the hand readout unit
- 3 Place the "PUMP" switch in the ON position. Check the battery's condition by placing the "INSTR" switch to the BATT position and observe the response on the hand readout unit
- 4 Place the "INSTR" switch in the ON position.
- 5 Set the "Calibration Switch" to the "X10" position
- 6 Use the "CALIBRATE" knob to set the readout to a reading of 6. Using the Alarm Level Adjustment Knob on the back of the readout, obtain an audible response to the reading of 6
- 7 Set the "Calibration Switch" to the "X1" position
- 8 Use the "CALIBRATE" knob to set the readout to a reading of 0, and check to insure that the flame-out alarm is audible
- 9 Place the "PUMP" switch in the ON position and observe that the "SAMPLE FLOW RATE" indicator shows flow
- 10 Open the "H₂ TANK VALVE" and the "H₂ SUPPLY VALVE" one turn each. Allow fuel to flow for about 1 minute
- 11 Press ignitor button and hold until readout unit indicates ignition
- 12 Use "CALIBRATE" knob to set readout to a reading of 0
 - Note: a small positive offset above 0 may be necessary to prevent activation of the flame-out alarm

Calibration

- 1 Assemble a calibration manifold as described in Section 17.1 using methane as the calibration gas. (Remember to omit the use of a Teflon® bag.)
- 2 Set the "CALIBRATION SWITCH" to the appropriate position for the concentration of the calibration gas (usually X10).
- 3 Connect the instrument's probe to the calibration manifold and allow it to sample the calibration gas.
- 4 The readout should indicate a value which is close to the concentration of the calibration gas plus any offset which may have been added.
- 5 Place the "CALIBRATION SWITCH" in the "X1" position before entering the site.

17.6 HNu Model PI 101 Photoionization Detector

Introduction

The HNu model PI 101 is designed to detect primarily organic compounds in air. It uses a photoionization detector (PID) as its method of operation. The instrument is capable of measuring concentrations down to about 1 ppm sensitivity for certain compounds.

- It is important to realize that this sensitivity is not achievable for all compounds. Some materials will result in a very low response on the PID in relation to their actual concentrations, while others will not respond at all to the detector's ionization energy.
- As a general rule, the PID should **not** be used to monitor for low molecular weight hydrocarbon compounds whose structures contain only single bonds (methane, ethane, pentane, hexane, heptane, carbon tetrachloride, and hydrogen sulfide). The PID should be used to detect aromatics such as benzene, toluene, and styrene, aliphatic amines such as diethylamine, and chlorinated unsaturated compounds such as vinyl chloride, and trichloroethylene.
- THE LACK OF A RESPONSE ON THIS METER DOES NOT GUARANTEE THAT THE ENVIRONMENT IS SAFE.

Operational Checks

1. Connect the probe to the meter case of the instrument.
2. Place the function/range switch in the "BATT" position and note the meter's response.
3. Place the function/range switch in any of the three range positions. Listen closely to the probe for a humming sound which indicates that the sample fan is operating.

Calibration

1. Place the function/range switch in the "STANDBY" position. Use the "ZERO" potentiometer to adjust the meter reading to zero.
2. Assemble a calibration train as described in Section 17.1 using toluene as the calibration gas.
3. Place the instrument's function range switch in the appropriate range for the calibration gas (usually 0-200).
4. Connect the instrument's probe to the calibration manifold and allow it to sample the calibration gas.
5. The readout should indicate close to the concentration of the calibration gas. If not, use the "SPAN" potentiometer to adjust the meter to the appropriate response.
6. Place the function/range switch in the "0-20 ppm" position before entering the site.

17.7 Ludlum Model 3 Radiation Survey Meter

Introduction

The Ludlum Model 3 is a portable radiation survey meter. The instrument is set for 900 volt Geiger-Mueller Tube (GMT) measurement of beta and gamma radiation. The range of the meter is from 0 to 200 milliroentgen per hour. It is important that the operator realizes that this meter will not respond to most alpha radiation.

- THE LACK OF A RESPONSE ON THIS METER DOES NOT GUARANTEE THAT THE ENVIRONMENT IS SAFE.

Operational Checks

- 1 Place the multifunction switch in the "BAT" position and note the meter's reading
- 2 Place the multifunction switch in the "X0.1" position, the F/S switch in the "S" position, and the "AUDIO" switch in the "ON" position. Note that an audible clicking sound can be heard while the meter is counting. After a few seconds, press the "RES" button and note that the meter returns to zero.

Calibration

- 1 Read and record the background radiation level
- 2 Place the GMT probe flat against the casing of a certified Sr90 standard
- 3 Adjust the multifunction switch until the meter reading remains on scale
- 4 Read and record the meter's response
- 5 Calculate the detector's efficiency as follows

$$E = \frac{\text{Meter Reading} - \text{Background}}{\text{Activity}}$$

- 6 Check to insure that the calculated efficiency is within ± 0.1 of the efficiency rating placarded on the meter
- 7 Set the multifunction switch to "X0.1" before entering the site

17.8 MiniRAE

Introduction

The MiniRAE (RAE) is a programmable photoionization detector (PID) that measures organic vapors in hazardous environments. It incorporates a sampling pump and data download capabilities for continuous toxic monitoring, site survey, and leak detection. The RAE can measure double-bonded organic vapors with its supplied 10.6 eV gas discharge lamp. The RAE is calibrated with toluene.

- The RAE is intrinsically safe.
- Only key steps are listed below. Almost all set-up functions on the RAE have been pre-set. The keys you will need to press will generally deal with calibration.
- The battery on the RAE drains slowly even when turned off. If the unit has not been charged for 4-5 days, the battery voltage will be low. If the unit is left to charge overnight, it will automatically shut itself off when fully charged.
- Only operate the RAE in the survey mode. The RAE has been pre-set to automatically start in the survey mode.

Operating Procedures

1 Power On/Off

To Turn On the RAE press the [on] key. The audio buzzer will beep once and the display will show "HG-x xx" or "Su-x xx" to indicate the operating mode and software version number. The unit will then go through a self-diagnostic routine to check the key components of the unit. A "diag" message will be displayed with a red back light turned on while the self-diagnostic routine is executing. The red LED and back light will flash once and the buzzer will beep once to ensure that they are functional. The sampling pump will be turned on and start to draw air sample.

To turn Off the RAE press the [on] key. The message "off" will flash on the LED display. press the [enter] key to confirm and the unit will be turned off. Pressing any other key will return the unit to normal operation.

- 2 The RAE can display five different readings: instantaneous gas concentration, STEL, TWA, and peak and battery voltage. Most of these functions have either been pre-set or do not apply to most Branch surveys. Only press [enter] to scroll through each display.
- 3 Alarm Signal - The built-in microcomputer constantly updates and monitors real time gas concentrations and compares it with the programmed alarm limits. **Whenever the concentration exceeds any of the preset limits (5 ppm), the alarm buzzer and red flashing LED will be activated immediately to warn the user of the alarm condition.**

Whenever the battery voltage falls below 5.5 volt (6.3v or higher is normal) or the UV lamp or sensor module fails, the unit will also activate the buzzer and red LED alarm signal.

In the Survey Mode, the alarm signal is proportional to the level of the gas concentration. Therefore, when the gas concentration exceeds preset limits (5 ppm), the alarm signal may vary from a single beep and a single flash per second to a rapid 7 beeps and 7 flashes per second when the high threshold level has been exceeded. The higher frequency of alarm signal indicates higher gas concentrations.

- 4 **Back Light** - The LCD display is equipped with a red LED back light to assist the readings under poor lighting conditions. This back light can be turned on by pressing the [up] key. When the back light is already on, pressing the [up] key will turn it off.
- 5 **Charging the RAE** - On the back side of the RAE is a battery charging jack which is normally covered by a protective rubber cover. Open the rubber cover and connect the AC adapter (or the automotive DC charging adapter, depending on the power source to the charging jack). There is a bi-colored LED inside the LED window which will provide an indication of the charging status.

Red	- battery is being charged
Green	- charging is completed
No light	- bad connection or defective battery

Plug in the AC (or DC) adapter which will turn on the red charge status LED first. If the battery is fully charged, it will turn to green quickly. A completely discharged battery will be charged to its full capacity within 10 hours.

Calibration

In the survey mode, the user may re-calibrate the RAE. This is a two-point calibration process using **Zero Gas** and a **Standard Reference Gas**.

- 1 First, a zero gas which contains no detectable organic vapors is used to set the zero point (CO).
- 2 Second, a standard reference gas is used to set the second point of reference (C1).

Zero gas Calibration

Use a gas bag (1 liter) and zero concentration gas from your air box.

- 1 Fill the gas bag with zero concentration gas. Zero gas calibration option is the 5th menu option. Display shows CO xxx.x where x.xxx is the gas reading based on current calibration of the instrument.
- 2 Attach the gas bag to the inlet tube and open the bag so that the instrument can begin pumping the zero concentration gas. The display should be reading zero.
- 3 If this reading is not zero, press the [enter] key to zero it. If the reading still shows a small value after a few seconds, press the [enter] key again to zero it. Repeat this process until the reading is stabilized around zero or 0.1 ppm. This completes the zero gas calibration. Press the [menu] key to exit zero gas calibration while the bag is still on the instrument.

Enter Standard Calibration Gas Value

- 1 Enter standard gas value option is the 6th menu option
- 2 If the concentration of the standard calibration gas to be used is the **same** as the displayed value, press [enter] key 4 times to accept the displayed calibration value one digit at a time and move to the next step
- 3 If the concentration of the standard calibration gas to be used is **different** from the displayed value, the user needs to enter the new value. Starting from the left most digit of the displayed value, use the [up] or [down] arrow key to change the digit value and [enter] to confirm the digit
- 4 Now the standard calibration gas value is entered.

Display shows a flashing message of "GAS ON" to remind the user to turn on the standard calibration gas bottle now. After the gas bottle is turned on, press [enter] key to continue the standard calibration procedure

Standard Gas Calibration Procedure

- 1 Insert the instrument probe into the calibration gas bag (bag should be at least 1 liter) that is filled with toluene.
- 2 Display shows a flashing message of "GAS ON".

Press the [enter] key, the display should show CAL.. for about 30 seconds while the instrument performs calibration. Afterwards, the display shows C1 xxx x where C1 indicates that this is the standard calibration gas and xxx x is the actual gas reading in ppm based on the new calibration data

Note The reading should be very close to the value of the calibration gas. If the reading is higher or lower than the standard gas value and continues to rise slowly, it means that the calibration gas has not yet stabilized. Wait a few seconds until the reading stabilizes and then press the [enter] key again. Every time the [enter] is pressed, the instrument measures the current gas concentration and calibrate accordingly

- 3 Press the [menu] key to exit the standard gas calibration procedure and move to next menu item
- 4 Disconnect the calibration gas bag

SECTION 18 FLOW MEASUREMENT

18.1 Introduction

The measurement of flow with surface water and wastewater sampling is essential to almost all water pollution control activities. Activities such as water quality enforcement studies, NPDES permit compliance monitoring, water quality monitoring, municipal operation and maintenance investigations, planning, and research rely on accurate flow measurements. The importance of obtaining accurate flow data cannot be overemphasized, particularly with respect to enforcement investigations since these data will be used as evidence in enforcement cases. NPDES permits often limit the quantity (mass loading) of a particular pollutant that may be discharged, and the calculation of mass loadings are also frequently necessary for water quality studies and other purposes. As much attention and care should be given to flow measurement in the design of a sampling program as to the collection of samples and their subsequent laboratory analysis.

The basic objectives of this section are to:

- outline standard practices with respect to wastewater flow measurements during water enforcement and NPDES compliance monitoring activities and other studies where wastewater flow measurements are required,
- outline standard practices for obtaining surface water flow measurements during water quality surveys,
- present acceptable, commonly used flow measurement techniques; and
- present general and specific quality assurance procedures for flow measurement equipment and techniques.

A complete discussion of all available flow measurement techniques and the theory behind them is beyond the scope of this section. However, most of the commonly used techniques are covered in general terms. A comprehensive list of references is included at the end of this section and a detailed discussion of flow measurement techniques may be found in the references.

18.2 Wastewater Flow Measurement

18.2.1 Introduction

The USDI Water Measurement Manual (1) is a standard reference for details on checking the installation of primary open channel flow devices. Basic guidance for making wastewater flow measurements and a basic description of all acceptable wastewater flow measurement systems are given in the NPDES Compliance Inspection Manual, September 1984 (2). This manual shall be used as Branch guidance for such measurements.

18.2.2 Site Selection

It is the field investigator's responsibility to insure that the wastewater flow measurement system or technique used measures the total wastewater discharged (described by the NPDES permit, if applicable). All recycled wastewaters must be accounted for so that any reported flows accurately reflect the volume of wastewaters discharged. The location of the wastewater flow measurement equipment should satisfy these criteria, be consistent with NPDES permit requirements, and measure the actual flow.

18.2.3 Flow Measurement Systems

Flow may be measured on an instantaneous or a continuous basis. A typical continuous system consists of a primary flow device, a flow sensor, transmitting equipment, a recorder, and a totalizer. Instantaneous flow measurements can be obtained without using such a system.

The heart of a typical continuous flow measurement system is the primary flow device. This device is constructed to produce predictable hydraulic responses which are related to the flow rate of water or wastewater through it. Examples of such devices include weirs and flumes which relate water depth (head) to flow, Venturi and orifice type meters which relate the differential pressure to flow, and magnetic flow meters which relate induced electric voltage to flow. Standard primary flow devices have undergone detailed testing and experimentation, and their accuracy has been verified.

A flow sensor is required to measure the particular hydraulic responses of the primary flow measurement device and transmit them to the recording system. Typically, sensors include ultra-sonic transmitters, floats, pressure transducers, capacitance probes, differential pressure cells, electromagnetic cells, etc. The sensor signal is generally converted using mechanical, electromechanical, or electronic systems into units of flow which are recorded directly on a chart or transmitted into a data system. Systems which utilize a recorder are generally equipped with a flow totalizer which displays the total flow on a real time basis.

Studies that need continuous flow measurements require a complete system. Instantaneous flow measurements do not necessarily dictate the use of any portion of such a system. Techniques which are described later in this Section are available for measuring instantaneous flows with portable equipment.

An important consideration during wastewater studies is that the investigator may want to obtain continuous flow data at a facility where only instantaneous flow data are being measured. If an open channel primary flow device is utilized for making instantaneous measurements, only the installation of a portable field sensor and recorder is necessary. If, on the other hand, the facility being investigated does not utilize a primary flow device, and a continuous flow record is desired, a portable primary flow device will have to be installed. Field investigators have both open channel equipment and closed conduit flow meters available for field use. These devices should be installed according to the manufacturers

specifications

Wastewater flow measurement systems are generally very accurate. Any system that cannot measure the wastewater flow within ± 10 percent of the actual flow is considered unacceptable for use in measuring wastewater flow.

18.2.4 Use of Existing Flow Measurement Systems

The installation of systems to measure wastewater flows can be a time consuming task, particularly if a primary device is not available. Therefore, field personnel can use existing facility primary flow devices and flow measurement systems when the accuracy of these devices and the system can be verified. The objective of this section is to outline the responsibilities of field personnel in verifying the accuracy of existing primary flow devices and systems.

The field investigator must verify that any existing facility flow measurement system (including primary flow device) utilized to measure wastewater flows conforms with recognized design and installation standards, and any deviation from standard conditions shall be thoroughly documented. The accuracy of the primary flow device should be checked by making an independent flow measurement. If there is no usable or existing primary flow measuring device or if the device has been mislocated, the investigator shall attempt to install a portable primary flow device.

If the discharger's flow measurement system is accurate within ± 10 percent of the actual flow, the investigator can use the installed system. The accuracy of flow sensors and recorders for open channel flow devices can be checked by making an instantaneous measurement utilizing the primary flow device and comparing this against the recorder reading. In addition, EPA flow equipment can be installed to check facility totalizer readings. The chart recorder should be checked to verify that the time and scale are correct. When closed conduit systems must be checked, inspectors can use an independent flow measurement as a check (e.g., Polysonic closed pipe flow meter).

If non-standard primary flow devices are being used, data supporting the accuracy and precision of the methods being employed should be provided by the discharger. Deficiencies should be recorded by the investigator and the discharger should be informed that the equipment should be calibrated as soon as possible.

18.2.5 Specific Techniques

This section outlines and familiarizes the field investigator with the most commonly used methods for wastewater flow measurements and the primary devices that will be encountered during field studies. Volumetric and dilution techniques are presented at the beginning of this section, since they are applicable to both open channel and closed conduit flow situations. The remaining methods are grouped under categories dealing with open channels and closed conduits. The general method of checking individual primary flow devices is given, where applicable. Several estimation techniques are presented. However, it should be recognized that flow estimates do not satisfy NPDES permit monitoring requirements unless the permit specifically states that this is permissible. The following methods are included only to enable the field investigator to make accurate flow estimates when necessary.

Volumetric Techniques

Volumetric flow measurement techniques are among the simplest and most accurate methods for measuring flow. These techniques basically involve the measurement of volume and/or the measurement

of time required to fill a container of known size

Vessel Volumes

The measurement of vessel volumes to obtain flow data is particularly applicable to batch wastewater discharges. Accurate measurements of the vessel volumes and the frequency that they are dumped are all that is required. An accurate tape to verify vessel dimensions and a stop watch are the only required field equipment. The NPDES Compliance Inspection Manual (2) is a useful reference on the equations for calculating volumes of various containers.

Sump Pumps

This measurement is made by observing the sump levels when the pumps cut on and off and calculating the volume contained between these levels. This volume, along with the number of pump cycles, will give a good estimate of the daily wastewater flow. The inspector must also account for the quantity of wastewater that flows into the sump during the pumping cycle.

Bucket and Stop Watch

The bucket and stop watch technique is particularly useful for the measurement of small wastewater flows. It is accurate and easy to use. The only equipment required to make this measurement is a calibrated container (bucket, drum, tank, etc.) and a stop watch. A minimum of 10 seconds to fill the container is recommended. Three consecutive measurements should be made, and the results should be averaged.

Dilution Methods

Dilution methods for water and wastewater flow measurements are based on the color, conductivity, fluorescence, or other quantifiable property of an injected tracer. The dilution methods require specialized equipment, special attention to detail by the investigator, and are time consuming. However, these techniques offer the investigator

- a method for making instantaneous flow measurements where other methods are inappropriate or impossible to use,
- a reference procedure of high accuracy to check in-situ those primary flow devices and flow measurement systems that are non-standard or are improperly installed, and
- a procedure to verify the accuracy of closed conduit flow measuring systems

The Turner Designs nomograph (3), the NPDES Compliance Inspection Manual (2), and the U S Geological Survey publication (4) outline recommended reference procedures. The dilution method utilizing Rhodamine WT dye is the preferred reference procedure to be utilized by inspectors when verifying the accuracy of flow measurement systems.

18.2.6 Open Channel Flow Measurements

The measurement of wastewater flow in open channels is the most frequently encountered situation during field investigations. An open channel is defined as any open conduit, such as a channel or flume,

or any closed conduit, such as a pipe, which is not flowing full. The most commonly encountered methods in measuring open channel wastewater flows are described in this section. Several flow estimation techniques are also presented.

The measurement accuracies quoted in this section apply only to the specific method or to the primary flow device being discussed. The total error involved in a continuous flow measurement system, which is the sum of the errors of each component, is beyond the scope of this discussion. The reader is referred to the list of references at the end of this chapter for such a discussion.

Weirs

A weir is basically defined as an overflow structure built according to specific design standards across an open channel to measure the flow of water. The theory of flow measurements utilizing weirs involves the release of potential static energy to kinetic energy. Equations can be derived for weirs of specific geometry which relate static head to water flow (discharge). Weirs are generally classified into two general categories, broad crested and sharp crested.

Broad crested weirs take the following form, $Q = CLH^{3/2}$. Values for the coefficient C are given in hydraulic handbooks (5, 6). Unless such weirs have been independently calibrated, they are usually not accurate enough for wastewater flow measurements.

Sharp crested weirs are constructed in a wide variety of shapes and the most commonly encountered are V-notch, rectangular, and Cipolletti weirs. If such weirs are constructed as outlined in the USDI Water Measurement Manual (1), they are considered standard primary flow devices.

All weirs should be inspected to determine if the weir installation and construction conform to the conditions given in the USDI Water Measurement Manual (1), and provide a uniform influent flow distribution and that the weir is placed squarely across the channel perpendicular to the direction of flow. Useful tools for checking weir construction and installation include a carpenter's level, a framing square, a measuring tape, a staff gage, or surveyors level and rod. Problems observed during the inspection or study should be noted in the field records or log book.

A set of weir tables is necessary for calculating flows. The USDI Water Measurement Manual (1), the Stevens Water Resource Data Book (7), and the ISCO Open Channel Flow Measurement Handbook (8) contain a complete set of tables.

Flumes

The conditions that must be met in a flume are similar to those that occur at a weir or spillway crest since water passing through the throat should not be impeded by downstream conditions (e.g., constrictions, bends in channel, obstructions). There are several types of flumes (e.g., Palmer-Bowlus, Cutthroat, H, and Trapezoidal) but the most widely used is the Parshall flume. The Parshall flume is considered a standard primary flow device when constructed and installed as outlined in the USDI Water Measurement Manual (1). A complete discussion of other types of flumes is given in references 9, 10, 11, and 12.

All flumes should be inspected to determine if entrance conditions provide a uniform influent flow distribution, the flume dimensions conform to those given in the USDI Water Measurement Manual (1), the floor of the flume at the throat section is level, and the throat section walls are vertical. Useful tools for checking the construction and installation of Parshall (and other) flumes include a carpenter's level, a

framing square, and a measuring tape. The flume should be closely examined to determine if it is discharging freely. If there is any question about free discharge, the downstream head (H_b) should be measured and compared to the head at the proper location (H_a) in the converging section. A staff gage is useful for making head measurements. Any problems observed during the inspection or study should be noted in the field log book.

A set of flume tables is necessary for calculating flows. The USDI Water Measurement Manual (1), the Stevens Water Resources Data Book (7), and the ISCO Open Channel Flow Measurement Handbook (8) contain a complete set of tables. The explanatory material accompanying these tables should be read and understood before they are used. In many cases, tabulated flow values are given for measured heads that are not within the usable measurement range.

Open Flow Nozzles

Open flow nozzles such as parabolic or Kennison nozzles are factory calibrated and are ordinarily supplied as part of a flow measurement system. Calibration and installation information for each nozzle should be supplied by or obtained from the manufacturer. The accuracy of these devices is reported to be often better than ± 5 percent of the indicated flow (10). A framing square is useful for checking the installation. A volumetric flow measurement may be used to check accuracy of this device if flow volumes are not excessive.

Velocity-Area Method

The basic principal of this method is that the flow in a channel (cubic feet/second) is equal to the average velocity (feet/second) times the cross sectional area (square feet) of the channel. The velocity of the water or wastewater is determined with a current meter. The area of the channel is either measured or calculated using an approximation technique. The USGS mid-section method and the stream gaging techniques described in the USGS publication, Discharge Measurements at Gaging Stations (9) is standard practice. This technique shall be used (where appropriate) as an independent flow measurement to verify the accuracy of existing flow measurement systems.

Slope-Area Method

The slope-area method consists of using the slope of the water surface, in a uniform reach of channel, and the average cross-sectional area of that reach, to estimate the flow rate of an open channel. The flow rate is estimated from the Manning formula (5, 6).

18.2.7 Closed Conduit Flow Measurements

The accuracy of closed conduit flow measuring devices shall be checked when necessary, by making an independent flow measurement, preferably using a dilution technique.

Venturi Meter

The Venturi meter employs a conversion of static head to velocity head whereby a differential is created that is proportional to flow. The typical accuracy of a Venturi meter is at 1 to 2 percent (10, 11, 12, and 13).

Orifice Meter

The orifice meter is a pressure differential device that measures flow by the difference in static head. Orifice meters require from 40 to 60 pipe diameters of straight pipe upstream of the installation. They can be accurate, e.g., within 0.5 percent, although their usable range is limited (10).

Flow Nozzle

The basic principle of operation is the same as that of the Venturi meter. The flow nozzle has an entrance section and a throat, but lacks the diverging section of the Venturi meter. Flow nozzle accuracies can approach those of Venturi meters (10).

Electromagnetic Flow Meter

The electromagnetic flow meter operates according to Faraday's Law of Induction where the conductor is the liquid stream, and the field is produced by a set of electromagnetic coils. The accuracy of the device is within ± 1 percent of full scale (10).

Other Closed Conduit Devices

References for other closed conduit flow measurement methods such as acoustic flow meters, trajectory methods, pump curves, and water meters can be found in the NPDES Compliance Inspection Manual (2).

18.3 Surface Water Flow Measurements

18.3.1 Introduction

Surface waters are considered to be open channels for flow measurement purposes. All of the techniques utilized by field investigators to measure open channel flows have been discussed in the wastewater flow measurement portion of this section. Except for very small surface streams, the installation of primary flow devices is not practical. Most surface water flow measurements are made utilizing classical stream gaging techniques. These techniques involve the use of the velocity-area open channel technique which was discussed in the wastewater portion of this section. Branch personnel shall use the techniques outlined in the USGS publication Discharge Measurements at Gaging Stations (9) to

- select the flow measuring site
- perform stream gaging, and
- calculate flow

18.3.2 Techniques

Whenever possible, stream studies shall be conducted utilizing existing permanent stream gaging stations operated by the USGS, the U. S. Army COE, or other federal or state agencies. These permanent gaging stations have established water stage-discharge relationships that permit the flow to be obtained from water stage measurements. Staff gage or recorder readings of water stage at these stations may be converted to flow by using the rating curve for that gaging station. The rating curve is generally available

from the operator of the permanent gaging station. An additional benefit of utilizing these permanent gaging stations is that long-term flow records are generally available. These long-term flow records are invaluable in planning water quality studies and assessing data trends.

Where permanent gaging stations do not exist, surface water flow will have to be measured utilizing classical stream gaging techniques. If a station is to be used more than one time during a water quality survey, a rating curve should be developed for that station. This may be done by making a series of independent flow measurements and simultaneous tape down or staff gage measurements for that station at different water levels. The rating curve is developed utilizing the same measurement section each time. At least two (preferably three) flow measurement-tape downs should be made. The flow measurements used to develop the rating curve must bracket the lowest and highest flows encountered during the study. A tape-down rating curve is constructed by plotting the tape-down measurements versus flows on a piece of semi-log graph paper.

18.4 General Quality Assurance Procedures

Techniques and procedures for making wastewater and surface water flow measurements are outlined in this section. The USDI Water Measurement Manual (1), the USGS publication Discharge Measurements at Gaging Stations (9), the EPA NPDES Compliance Inspection Manual (2) and a set of weir and flume tables shall be supplied to all field investigators. However, the measurements of wastewater and water flows require considerable experience. Therefore, no field investigator shall make flow measurements until they have had at least six months of actual field experience and has performed these measurements under the supervision of a senior field investigator.

Wastewater flow shall be expressed in million gallons per day (mgd) or the metric equivalent (m^3/day). Stream flow shall be expressed in cubic feet per second (second feet) or the metric equivalent (m^3/sec). Time records associated with flow measurements shall be kept in local time, shall be made in the 2400 hour military time format, and shall be recorded to the nearest five minutes.

All flow measurements conducted shall be thoroughly documented in field records. All measurements shall be traceable both to the individual making the measurements and the equipment utilized.

A log of all maintenance, calibrations, and repairs for each piece of flow measuring equipment shall be established. The log shall be kept in such a manner that all maintenance and calibrations performed on the equipment are traceable to the person performing them and to the calibration standard utilized. All equipment shall be numbered, or the US-EPA property or serial number shall be used to facilitate identification.

18.5 Equipment

The equipment available for the measurement of surface water or wastewater flows is categorized as follows: water level/stage hardware and recorders, velocity measuring equipment and assemblies, and direct flow measurement equipment and instrumentation.

The hardware available to determine the rise and fall of a water surface with time (the water stage) includes the following recording devices: Stevens Model F horizontal drum recorders, Stevens Model A-71 continuous strip chart recorders, Stevens Encoder Recorders, and ISCO Model 2870, 3210, and 3230 flow meters. Non-recording equipment available includes vertical staff gages and tape-down systems (see Section 15).

Instruments and equipment available to make velocity cross-sectional area measurements include current meters and sounding (depth) equipment. The current meters available are the vertical-axis mounted Price AA and Price pygmy meters (including direct readout meters), and ENDECO solid state memory current meters. Sounding (determination of depth) is accomplished using Ratheon or Lorance recording fathometers or with a standard top setting wading rod. Width measurements are made using a Lee-Au galvanized steel tag line which is segmented into equal divisions of length by metal beads or steel tapes.

The equipment available for direct flow measurement includes the following primary devices available for installation. V-notch weir plates and rectangular weir plates. The corresponding conversion of water level to flow rate can be accomplished instantaneously from stage/staff gage readings corresponding to the primary flow device in use, or by instantaneous readings of the available recording flow meter systems. The continuous recording systems presently available are the ISCO Model 2870, 3210, and 3230 recording flow meters.

The Polysonics Ultrasonic Flowmeter (Model UFM84P) is available for measuring flows in closed pipes. The largest size pipe that can be measured is a 90-inch pipe. The pipe must be flowing completely full and not contain large amounts of air pockets. A coupling jelly is spread on the face of two transducers, and the transducers are mounted opposite each other on the outside of the pipe. The meter must then be calibrated according to the manufacturer's instructions.

18.6 Specific Equipment Quality Control Procedures

A log book shall be kept of all equipment utilized for measuring water flows, water stage/tape downs, velocity measurements, flow recordings, etc. The following maintenance and calibration procedures shall be implemented.

Stevens Model A-71 and Model F Stage Recorders

See specific equipment and quality control procedures in Section 15.5

ISCO Model 1870 and 2870 Recording Flow Meters

The recording flow meters shall be thoroughly tested annually to insure that the accuracy, resolution, and precision are within the technical specifications as established by the manufacturer. This shall be accomplished by operating the instruments in a controlled test environment for a period not less than 24 hours. The test environment shall consist of a controlled atmospheric temperature, power source, and water level/head. Operation during the testing period shall be according to the manufacturer's instruction manual. The functions that shall be tested include flow meter totalizer accuracy, flow recorder tracing accuracy, and chart speed accuracy.

In addition to the above annual testing program, an abbreviated testing procedure shall be conducted on the flow meters and recorders which will include a check of the following functions: flow meter and recorder response to changing heads as shown on the meter's liquid level indicator and the recorder's flow indicator, and bubble rate adjust response. The flow meters and recorders shall be checked through the abbreviated procedure prior to field use.

The following routine maintenance procedures shall apply whenever the equipment is returned from the field: the exterior of the meter and recorder case should be cleaned with soapy water (Appendix B), the front panel desiccant and external desiccant cartridges should be reactivated (only if needed), the bubble line should be inspected and cleaned, and sensors shall be cleaned.

Vertical Staff Gages and Tape Down Systems

See specific equipment and quality control procedures in Section 15.5.

Price AA and Price Pygmy Current Meters

All meters shall be examined before and after each discharge measurement. The examination shall include the meter cups or vanes, pivot and bearing, and shaft for damage, wear, or faulty alignment. Meter balance and alignment shall be checked prior to each use in the field (9). Meters shall be cleaned and oiled daily when in use. Surfaces that shall be cleaned and oiled on a yearly basis are the pivot bearing, pentagear teeth and shaft, cylindrical shaft bearing, and thrust bearing at the cap.

Top Setting Wading Rod

This equipment shall be cleaned and examined before and after each discharge measurement. The examination shall include a check on the sliding rod and lock set mechanism.

Lee-Au Tag Line

This equipment shall be inspected for damage and cleaned before and after each discharge measurement. The accuracy of the tag line will be checked initially and then once per year utilizing the Invar steel surveyors chain. The tag line(s) shall be accurate to 0.1 foot per 100 feet. Any tag lines that do not conform to this accuracy specification shall be repaired, recalibrated, or discarded. Yearly maintenance shall include an inspection for potential breaks, a thorough washing, and a finish oiling.

V-Notch and Rectangular Weir Plates

These plates shall be cleaned and examined before and after each field installation. Construction and condition of weir plates shall conform to recognized standards (2). The plates shall be cleaned with a soapy wash water, followed by a distilled water rinse. The weir plates will be inspected to insure that the upstream edge of the plate remains sharp.

18.6 REFERENCES

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- 12 Wells, E A and H B Gotaas, "Design of Venturi Flumes in Circular Conduits," American Society of Civil Engineers, 82, Proc Paper 928, April 1956
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APPENDIX A
RECOMMENDED CONTAINERS, HOLDING TIMES, & PRESERVATION

ANALYTICAL GROUP	Soil/Sediment			Water/Wastewater ¹			Waste		
	Cont	Pres	Hold	Cont	Pres	Hold	Cont	Pres	Hold
BIOLOGICAL									
Bacteriological ²	--	--	--	B	I	6hr	--	--	--
Toxicity, Acute	--	--	--	CU	I	2	--	--	--
Toxicity, Chronic	--	--	--	CU	I	2	--	--	--
INORGANICS									
pH ³	8G	NA	--	--	--	--	8G	NA	N
Dermal Corrosion	--	--	--	--	--	--	8G	NA	N
Flashpoint	--	--	--	--	--	--	8G	NA	N
BTU Content	--	--	--	--	--	--	8G	NA	N
Ash Content	--	--	--	--	--	--	8G	NA	N
Residual Chlorine ⁴	--	--	--	SM	NA	I	--	--	--
Turbidity	--	--	--	SM	I	2	--	--	--
Conductivity	--	--	--	SM	I	28 ¹¹	--	--	--
Temperature ⁵	--	--	--	SM	NA	I	--	--	--
BOD ₅	--	--	--	HP ²	I	2	--	--	--
Solids Series	--	--	--	HP	I	7	--	--	--
Settleable Solids	--	--	--	HP	I	2	--	--	--
Nutrients (N,P)	8G	I	NS	HP	S/I	28	--	--	--
Chloride	--	--	--	LP	NA	28	--	--	--
Ortho-P	8G	I	NS	LP	I ⁶	2	--	--	--
Dissolved P	--	--	--	LP	S ⁷ /I	28	--	--	--
COD	8G	I	NS	LP	S/I	28	--	--	--
Alkalinity	--	--	--	LP	S/I	28	--	--	--
Color	--	--	--	GP	I	2	--	--	--
Oil & Grease ⁸	--	--	--	LG	S/I	28	--	--	--
Metals	8G	I	180	LP	N	180	8G	NA	180

ANALYTICAL GROUP	Soil/Sediment			Water/Wastewater ¹			Waste		
	Cont	Pres	Hold	Cont	Pres	Hold	Cont	Pres	Hold
Mercury	8G	I	180	LP	N	28	8G	NA	180
Metals - TCLP	8G	I	360 ¹²	LP	I	360 ¹²	8G	NA	360 ¹²
Metals - EP	8G	I	360 ¹²	LP	I	360 ¹²	8G	NA	360 ¹²
Chromium VI	--	--	--	LP	I	1	--	--	--
Cyanide	--	--	--	LP	A ³ /C ⁶ /I	14	8G	NA	14
Sulfides	--	--	--	LP	Z/C ⁷ /I	7	--	--	--
Sulfates	--	--	--	LP	I	28	--	--	--
Nitrite	--	--	--	LP	I	2	--	--	--
Nitrate	--	--	--	HP	I	2	--	--	--
Hardness	--	--	--	LP	N	180	--	--	--
Fluoride	--	--	--	LP	NA	28	--	--	--
ORGANICS									
VOCs [*]	2G	I	14	V	B ⁸ /I	14/7 ¹⁰	8G	NA	14
VOCs - TCLP [*]	2G	I	28 ¹³	V	I	28 ¹³	8G	NA	28 ¹³
Extractables ¹⁶	8G	I	54 ¹⁸	GG	I ⁹	47 ¹⁷	8G	NA	54 ¹⁸
Extractables - TCLP	8G	I	61 ¹⁴	GG	I	61 ¹⁴	8G	NA	61 ¹⁴
Dioxins ²⁰	A	I	75 ¹⁵	LA ³	I ¹⁰	75 ¹⁵	A	I	75 ¹⁰
Percent Alcohol	8G	I	NS	GG	I	NS	8G	NA	NS
Phenols	--	--	--	LA	S/I	28	--	--	--
Org Halide (TOX)	8G	I	28	LA	S/I	28	--	--	--

General Footnotes:

Cont - Container

Pres - Preservation

Hold - Holding Time (days)

* - Grab sample only, unless indicated a grab or composite is acceptable.

1 - Consult 40 CFR Part 136 Table II - Required Containers, Preservation Techniques, and Holding Times for latest requirements

19 - Including pesticides, herbicides and PCBs

20 - Consult local laboratory for most recent dioxin container and preservation requirements.

Containers:

- B - Bacteriological container
 - CU - Cubitainer one gallon or 2 gallon
 - 8G - 8 oz widemouth glass (Teflon lid)
 - 2G - 2 oz widemouth glass (Teflon septum lid)
 - LP - One liter polyethylene
 - GG - One gallon amber glass (Teflon lid)
 - V - 40 ml glass (Teflon septum lid)
 - SM - Stormore 500 ml polyethylene
 - LG - One liter widemouth glass (Teflon lid)
 - GP - Gallon polyethylene
 - HP - Half-gallon polyethylene
 - LA - One liter amber glass (Teflon lid)
 - A - 500 ml widemouth amber glass (Teflon lid)
-
- 2 - Use GP for BOD with multiple parameters
 - 3 - Collect 2 sample containers (LA) per sample plus 4 at one location for matrix spike

Preservatives:

- A - Ascorbic acid
 - B - Sodium bisulfite
 - C - NaOH
 - H - HCl
 - I - Ice (4°C)
 - N - 50% HNO₃ (pH < 2.0 S U)
 - NA - Not applicable
 - S - 50% H₂SO₄ (pH < 2.0 S U)
 - Z - Zinc acetate
-
- 4 - Filter on-site
 - 5 - Only with residual CL₂
 - 6 - To pH > 12.0 S U
 - 7 - To pH > 9.0 S U
 - 8 - With residual CL₂ mix sample in 8 oz glass container with 8 drops 25% ascorbic acid
 - 9 - With residual CL₂ mix sample with 0.008% sodium thiosulfate
 - 10 - With residual CL₂ mix sample with 80 mg of sodium thiosulfate per liter

Holding Times: in days unless noted otherwise

- NS - Not Specified
 - N - Indefinite
 - 1 - Immediate (within 15 minutes - 40 CFR 136 Table II)
-
- 11 - Determine on-site if possible
 - 12 - 360 days - 180 days to extraction plus 180 days to analysis
 - 13 - 28 days - 14 days to TCLP extraction plus 14 days to analysis (7 days if not preserved following extraction)
 - 14 - 61 days - 14 days to TCLP extraction, 7 days to solvent extraction, 40 days to analysis
 - 15 - Method 8290 specifies 30 days to extraction plus 45 days to analysis
 - 16 - 7 days if not preserved
 - 17 - 47 days - 7 days to extraction, 40 days to analysis

18 - 54 days 14 days to extraction, 40 days to analysis

Shipping Note:

When samples are to be shipped by common carrier or sent through the United States mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of 40 CFR, Part 136, Table II, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric Acid (HCL) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater), Nitric acid (HNO₃) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater), Sulfuric acid (H₂SO₄) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater), and Sodium Hydroxide (NaOH) in water solutions at concentrations of 0.08% by weight or less (pH about 12.30 or less). This footnote is wholly reproduced from 40 CFR 136.3, which is definitive.

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. Alternative field decontamination procedures may be substituted as outlined in Section 5.12 when samples are to be analyzed for data uses at a lower DQO level. 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:

- Soap 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.
- Solvent 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.
- Tap water may be used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.
- Analyte free water (deionized water) 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 available, samplers should be flushed at the next sampling location with the substance (water) to be sampled, but 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 Fultz® Pump Cleaning Procedure

CAUTION - To avoid damaging the Fultz® pump:

- Never run pump when dry
- Never switch directly from the forward to the reverse mode without pausing in the "OFF" position

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

- 1 Pump a sufficient amount of soapy water through the hose to flush out any residual purge water
- 2 Using a brush, scrub the exterior of the contaminated hose and pump with soapy water. Rinse the soap from the outside of the hose with tap water. Rinse the hose with analyte-free water and recoil onto the spool.
- 3 Pump a sufficient amount of tap water through the hose to flush out all the soapy water (approximately one gallon)
- 4 Pump a sufficient amount of analyte-free water through the hose to flush out the tap water, then purge with the pump in the reverse mode
- 5 Rinse the outside of the pump housing and hose with analyte-free water (approximately 1/4 gal)
- 6 Place pump and reel in clean plastic bag

B 2 6 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 7 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 8 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 of sufficient size so that drilling activities can proceed without having to stop and obtain additional water

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 not 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 may be found 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. Alternative cleaning procedures may be substituted as outlined in Section 5.12 when samples are to be analyzed for data to be used at a lower DQO level. 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. FEC personnel should notify the Hazardous Waste Disposal Officer in writing each month of the amount (in gallons) of each type (either Recovery or Disposal) of solvent.

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 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 outlined in Appendix B.2.3. Approximately one percent of all such containers cleaned will be subjected to this procedure.

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 precleaned, 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 Glass Sequential Sample Bottles

- 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 Replace bottles in covered, automatic sampler base and cover with aluminum foil for storage

These ISCO® 1680 glass sequential sample bottles are not to be used for collecting samples for GC/MS (or equivalent) analyses. The ISCO® 1680 bottles may be used for collecting samples for GC/MS (or equivalent) analyses if the cleaning procedures outlined in Section C.3.7 are used.

C 3 7 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 8 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 9 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 precleaned 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 Dry overnight in the drying oven.
- 5 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
- 5 Wrap equipment in aluminum foil (with tab for easy removal) seal in plastic, and date

C 5 2 Fultz® Pump

CAUTION: To avoid damaging the Fultz pump:

- Never run pump when dry
- Never switch directly from forward to reverse mode without pausing in the "OFF" position

Cleaning

- 1 Pump a sufficient amount of hot soapy water through the hose to flush out any residual purge water
- 2 Using a brush or scrub pad, scrub the exterior of the contaminated hose and pump with hot soapy water. Rinse hose with analyte free water and recoil onto the spool
- 3 Pump a sufficient amount of tap water through the hose to flush out soapy water (approximately one gallon)
- 4 Pump a sufficient amount of analyte-free water through the hose to flush out the tap water, then empty pump and hose by placing pump in reverse. Do not allow pump to run dry
- 5 Rinse the pump housing and hose with analyte free water
- 6 Place pump and reel in clean polyethylene bag or wrap in clean polyethylene film. Ensure that

a complete set of new rotors, two fuses and a set of cables are attached to the reel

C 5 3 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 4 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 Rinse with tap water
- 4 Rinse with analyte free water
- 5 Completely air dry
- 6 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 5 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 6 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 7 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 8 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 9 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 10 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 11 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 12 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 13 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 14 SCBA Facemasks

CAUTION: Facemasks should be inspected for wear or damage. If, after consultation with the Safety Officer, the facemask cannot be repaired, it should be discarded.

- 1 Wash facemask 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 facemask thoroughly inside and out with tap water
- 3 Hang facemask up until completely dry
- 4 Place facemask in plastic bag and return to SCBA case.

C 5 15 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 16 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 17 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 precleaning 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 precleaning 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 precleaned, 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 precleaned, 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 precleaned, 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 prepreserved 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 unpreserved 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 air waybill) 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)

APPENDIX E

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 Fultz® Pump

E 2.1 Introduction

The Fultz® pump is a small 24-volt DC submersible pump suitable for purging most 2-inch and some 4-inch wells and is available in two different diameters, 1.75 inches and 2.5 inches. Operating depths for these pumps range from approximately 135 feet to 150 feet. Maximum pump rates range from approximately 1.5 gallons per minute, at shallower depths, to less than 0.5 gallon per minute at the maximum operating depth. For a given depth, the 2.5-inch pump has a slightly higher pumping rate than smaller diameter pump. The pump housing for each pump is constructed of 304 stainless steel and houses a high efficiency electric motor and Teflon® gears (rotors). Water is pulled through a fine-mesh stainless steel screen on the pump head by the meshing rotors and is positively displaced through the discharge hose.

As supplied from the manufacturer, power for the pump is supplied by an internal power pack comprised of four 6-volt gel cell batteries. The manufacturer also offers an external power pack, containing the same array of batteries as the internal supply, and a 24-volt DC generator as optional power sources. It has been found that the pumps operate at higher rates and for longer periods of time when powered either with the generator or with two 12-volt car or motorcycle batteries connected to provide 24 volts.

E 2.2 Operation

Control Panel Switch Functions

The following is a list of switch functions found on the control panel of the Fultz® pump.

- **ON** Supplies power from selected power source to pump motor.
- **OFF** Turns pump off.
- **INTERNAL** Selects the internal battery array as the power source for the pump. Note: Because the external sources are more reliable and provide longer service, the internal batteries have been removed from all pumps.
- **EXTERNAL** Selects an external power source. Source must be plugged into the front panel at exterior source plug.
- **FORWARD** Selects forward operating mode, used to pump water from the source.
- **REVERSE** Selects reverse operating mode, used to empty water from hose through pump head and to flush silt from pump screen, when clogged.

CAUTION: Always turn the power off before changing direction of pump to prevent damage to unit or fuse failure.

Purging Procedures

The following steps detail the operation of the Fultz® pump when used for purging monitoring wells. This pump is not used for sampling.

1. Select external power source to be used. If a generator is used, plug in to external source jack and place generator as far from the well as possible in the downwind direction. If 12-volt batteries are used, connect batteries with provided cables to provide 24 volts. Bridge the positive post of one battery to the negative post of the other. Next, place the red clip from the main supply cable (the long cable which plugs into the face of the control panel of the pump) on the remaining positive post and place the black clip on the remaining negative post.
2. Check pump head to make sure pump and electrical connections are secure.
3. Lower pump into well, placing pump head no more than one or two feet below the top of the water column.
4. Turn pump on and make sure REVERSE/FORWARD switch is in FORWARD position. If the polarity of the power connection is reversed, the amp meter will deflect to the left and the pump will be running opposite of the selected direction. Make the appropriate change.
5. During normal operating conditions, the pump should pull no more than 1.5 to 2.0 amps. Newly replaced rotors may temporarily pull slightly more amps. Check amp meter on control panel to make sure that the pump is operating in this normal range.
6. Listen to the pump, as this is an indication of the amount of water over the pump. As the water level is pulled down, the pitch of the sound will increase and become louder. If the water level is pulled down, lower the pump another one or two feet and continue to listen to the sound of the pump.
7. If the water level is rapidly lowered, caution must be observed as the pump is lowered in the vicinity of the bottom of the well. In this region, be sure to observe the clarity of the water and the amps being registered on the amp meter. If the water becomes extremely turbid and the amps increase beyond the acceptable range, these are indications that the pump has been lowered into silt at the bottom of the well. If this occurs, the pump should be momentarily reversed to dislodge the silt from the screen and rotors. If more volume is required to fully evacuate the well under these conditions, a bailer may be a more appropriate choice for the remainder of the purge.
8. After completing the required purge, remove the pump from the well and reverse the motor to empty the pump and hose of all contained water. The pump should be switched off as soon as the last water is discharged, since running the pump dry may damage the rotors. This water should be collected with the other purge water and handled appropriately. The pump and wetted portion of the hose may now be decontaminated prior to use at the next sampling location.

E 2 3 Tips and Precautions

The following tips and precautions should be observed for best performance and operating conditions

- 1 Watch the hose for kinks as the pump is lowered into the well, particularly checking what remains on the hose frame. Kinks will decrease pump performance and will generally manifest themselves as decreased output with higher amp meter readings. Persistent kinked areas can be repaired by several wraps of duct tape to "round" the hose and provide reinforcement. Badly kinked hose should be "red-tagged" for replacement.
- 2 Before going to the field, the pump's performance should be checked. At zero head, a properly operating Fultz® pump should pump 1.1 to 1.2 gallons per minute. If much less than 1.1 gallons per minute is pumped, the rotors should be replaced and the pump rechecked. Worn rotors do not merely decrease the pump rate, they also reduce the operating head of the pump.
- 3 Make sure spare fuses are available. The 1.75-inch diameter pump heads require 2.5 amp fuses. The 2.5-inch diameter pump heads require 5 amp fuses.

E 2 4 Rotor Replacement

Remove the five screws that hold the pump head on. Carefully rotate the pump cover at the wire, exposing the rotors. With needle-nose pliers, grip each rotor by a tooth and pull it out. Replace with new rotors by pushing them into place with your thumb. Be careful not to shave off the sides of the teeth on the pump body. Replace the pump cover and five screws. Gently snug the screws into place and back them off one turn. Place the pump in a bucket of water and, while running, gradually tighten the screws. This will wear off any burrs on the rotors and give the best performance.

E 2 5 Trouble Shooting

<u>No Power to Pump</u>	1	Loose connection to power supply.	1.	Make sure clips on battery are snug
	2	Water leakage into motor	2	Return to factory
<u>Pump Output Reduced</u>	1	Hose kinked	1	Straighten hose
	2	Rotors worn	2	Replace rotors
	3	Intake clogged	3	Reverse pump direction to clear
	4	Power supply low	4	Replace batteries
	5	Silt or sediment in water	5	If too bad, discontinue pump use
<u>High Amp Meter Reading</u>	1	Pump out of water	1	Lower pump into water column
	2	Silt or sediment in water	2	Watch amp reading If it exceeds the recommended operating range, reverse direction of pump to clear intake If this does not work, discontinue pumping and use bailer

E.3 Large Diameter Electric Submersible Pumps

E 3 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 3 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 3 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 3 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 3 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 3 6 Trouble Shooting

<u>No Power to Pump</u>	1 Loose connections at pump	1 Check wiring at pump Repair as needed (Generator Off ¹)
	2 Cord unplugged at generator	2 Plug pump back in
<u>Generator Running, No Pump Output</u>	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
<u>Sluggish Discharge</u>	1 Sediment or other material clogging screen	1 Remove material from screen.
	2 Kinked hose	2 Unkink hose

E.4 QED® Bladder and Purge Pumps

E 4 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 4 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 4 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 4 4 Trouble Shooting

<u>Compressor running.</u> <u>no pressure on discharge cycle</u>	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
<u>Compressor running.</u> <u>pressure low.</u> <u>no water discharged</u>	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.5 Small Diameter Electric Submersible Pumps

E 5 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 5 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 5 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 5 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, then 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 5 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 5 7 Trouble Shooting

<u>Generator Running.</u> <u>No Pump Output</u>	1	Loose connection at pump.	1. Check wiring at pump Repair as needed (Generator off ¹¹)
	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

APPENDIX F

REGIONAL TECHNICAL SUPPORT FOR CRIMINAL INVESTIGATION SEPA REGION 4

The Division provides technical support to the Region 4, Office of Criminal Enforcement, Criminal Investigations Division (CID), for those investigations requiring the collection of samples, laboratory analyses, or technical information. These procedures address how technical support is requested by CID and provided by the Division. Detailed technical procedures will be referenced to the various Standard Operating Procedures and Quality Assurance Manuals utilized by the Division.

The primary objectives of support for criminal investigations are to provide accurate, complete, admissible, and defensible reports and data for case development and subsequent legal proceedings.

F.1 Technical Assistance Required by CID

The CID under the direction of a Special Agent-in-Charge (SAIC) conducts criminal investigations in Region 4 pursuant to Federal environmental laws and regulations. The technical assistance requirements for criminal cases vary from investigation to investigation. To assist the SAIC in identifying the type and scope of technical assistance required, a Technical Coordinator position has been established in the Regional Office. The Technical Coordinator's primary function is to provide technical advice to the SAIC and Case Agents. It is the responsibility of the Technical Coordinator to assure that requests for technical support are directed to the appropriate Regional Program and Divisional offices. After a decision has been made by the SAIC to initiate a criminal investigation, the Technical Coordinator will discuss the case with the Division Director or his designated representative. The Division Director in consultation and with the concurrence of the Deputy Regional Administrator (DRA) will decide whether technical support will be provided by the Division.

Following a decision that technical support will be provided by the Division, the SAIC will prepare a written request addressed through the DRA to the Division Director. Copies of the request will be routed to the appropriate Regional program offices.

Prior to conducting the investigation, the Technical Coordinator will discuss the case with Division personnel, and will inform the Case Agent of any technical requirements that may influence project planning. Also, it is the responsibility of the Technical Coordinator to inform Division personnel of the presence of any known situations that would pose health risks or otherwise interfere with their operations. The Technical Coordinator in consultation with the Case Agent will discuss with Division personnel the progress or scheduled analyses and the potential need for additional analyses. Information regarding the need to alter work schedules so as to meet changing Grand Jury or Federal Court dates will be transmitted immediately from the Technical Coordinator to the Division. When work schedules must be delayed, the technical reasons for the delay will be communicated from the Technical Coordinator to the Case Agent.

Upon completion of analyses and report preparation and, prior to presentation of the results to a Grand Jury or Federal Court, the Technical Coordinator will arrange for an audit and inventory of evidence and files in the Division's possession. A copy of the inventory will be provided to the Case Agent, to be used in selecting and preparing trial exhibits.

F.2 Project Requests

All requests for support for criminal investigations shall originate with the CID in the Regional Office. Any information obtained by Division staff regarding potential criminal activity shall be immediately referred to the Region 4 SAIC. Direct requests from any other Federal agency, State agency or local agency shall be referred to the Region 4 SAIC for appropriate action.

Prior to an official request from CID, an informal contact shall be made with the Division Director or the appropriate Division Branch or Section Chief concerning the availability of resources and expertise necessary for providing the requested technical support. If support can be provided, the SAIC shall prepare an official request to the Division Director, through the DRA (with copies to the appropriate Branch) or Section Chief. In routine criminal investigations when priorities prohibit an immediate response, the RA/DRA will determine an appropriate course of action. If the RA/DRA determines that providing the requested technical support will be in the best interest of the Region, the support will be provided and adjustments will be made to other commitments. Technical support may begin immediately after receiving concurrence from the RA/DRA. The SAIC is responsible for notifying appropriate regional organizational units, e.g., Office Directors, Division Directors, etc., of potential or on-going investigations receiving technical assistance from the Division or the technical divisions at NEIC.

All emergency requests shall be handled expeditiously. In such instances, the requested assistance may be provided immediately upon being notified by the SAIC that verbal approval has been obtained from the DRA. However, all such requests shall be followed by a written request from the SAIC, through the DRA to the Division Director.

F.3 Project Coordination

Once the decision has been made to provide technical support, the Division Director or the Deputy Director shall assign the project to the appropriate Branch/Section for assignment of a project leader. The project leader will be responsible for coordinating with the Case Agent to obtain necessary background information to determine logistical requirements, skill needs, laboratory support, etc. The project leader will coordinate all necessary activities with ORC, DOJ, FBI, trial attorney, etc. at the direction of the Case Agent.

The project leader shall discuss the technical and workload requirements with their immediate supervisor. A core team shall then be selected which will conduct the study and/or coordinate analytical support. When required, additional staff will be assigned from other Sections or Branches with the approval of the appropriate Branch Chief or Division Director. Once a core team has been selected, initial planning for the investigation shall begin under the direction of the Project Leader and in concert with the Case Agent and with the prosecutors if they are already involved in the matter.

F.4 Project Planning

After the appropriate or available background material has been obtained, specific assignments will be given to each member of the core team for development of a study plan. Concurrently, the Project Leader shall discuss analytical requirements and time-frames with local laboratory personnel. The study plan and site-safety plan shall be assembled under the direction of the Project Leader and submitted to the core team, appropriate management, and Case Agent for review and concurrence. The time-frame for receiving comments will depend upon the urgency of the investigation, but in no cases should exceed 10

working days. During emergencies an investigation may be conducted without the preparation of a detailed study plan. However, during these situations, a memorandum shall be prepared by the Project Leader briefly describing the technical work to be accomplished and stating that the investigation will strictly conform to appropriate Standard Operating Procedures and Quality Assurance Manuals.

A final study plan will be prepared once all appropriate comments are received by the Project Leader. In general, these study plans should contain the following elements. However, upon advice of the Case Agent, the content and format of any study plan may be substantially changed to meet the needs of the particular investigation.

- Introduction -- a brief history, a statement of the problem to be investigated and what specific laws may have been violated.
- Objectives -- a statement as to what the investigation is to accomplish and how the information is to be used.
- Scope -- a definition of the limits of the study.
- Study Procedures -- the specific plan to collect the required information (not field methodology).
- Analytical Requirements -- an estimate of the number of samples to be collected, required analyses and which laboratory(s) will analyze the samples.
- Logistics -- an estimate of manpower requirements and a general description of specific functions of project personnel, special equipment, use of mobile laboratories, etc.
- Time Schedule -- a statement outlining when the study will be conducted, analytical results will be available, the draft report will be written, and the final report will be completed.
- Methodology -- specific field techniques to be employed. A statement that the techniques in the Division's Standard Operating Procedures and Quality Assurance Manuals will be employed shall be included. The use of any techniques not included in the Standard Operating Procedures and Quality Assurance Manuals shall be thoroughly justified and must produce evidence which can withstand objections by the defense.
- Safety Plan -- a safety contingency plan will be included.

F.5 Field Investigation

The field investigation will be conducted under the direct supervision of the project leader and the general supervision of the Case Agent responsible for the criminal investigation. All of the objectives set forth in the study plan should be met as well as any on-scene changes or additional activities requested by the Case Agent. The project leader and the Site Safety Officer (SSO) shall have responsibility for enforcing the provisions of the safety plan. The study will be conducted conforming to the requirements and objectives of the study plan and appropriate Standard Operating Procedures and Quality Assurance Manuals. Any deviations from the study plan or the appropriate Standard Operating Procedures and Quality Assurance Manuals must be approved and documented by the project leader. The deviations must produce evidence which can withstand objections by the defense.

During the field study, the project leader or designee is responsible for seeing that all chain-of-custody and quality control procedures for sampling, flow monitoring, field analyses, record-keeping, etc. are followed. However, the field personnel must understand and follow the chain-of-custody and quality control procedures relative to their assignments. Following completion of the field activities, the Project Leader or designee shall account for all field documentation, such as field logbooks, sample tags, and chain-of-custody records, and verify that they are complete. Sample tags will remain on the sample containers in the custody of the local laboratory until relinquished to the court or final disposition of the case.

F.6 Laboratory Support

Upon delivery of samples to the local laboratory, the samples shall be immediately transferred via chain-of-custody procedures, from the Project Leader or designee to the laboratory sample custodian or designee. After receipt of samples, the laboratory sample custodian shall immediately transport the samples to the sample custody room. The laboratory sample custodian shall document the condition of the samples and verify the uniformity of information on the sample tags and chain-of-custody records prior to placing the sample tags in the sample custody room. All sample handling, sample preparation, and analyses shall be in strict conformance with the appropriate Standard Operating Procedures and Quality Assurance Manual.

The laboratory coordinator shall notify the Project Leader as results become available. Final analytical data shall be reported directly to the Project Leader after all QA/QC procedures have been completed. Any analytical problems or deviations concerning holding times, analytical procedures, etc. shall be reported to the Project Leader. When requested by the Case Agent, this information will be documented in a memorandum stamped "CONFIDENTIAL", and transmitted to the Project Leader, Technical Coordinator, and Case Agent.

F.7 Final Report

The project leader is responsible for preparing a final investigative report. A draft report shall be prepared for internal review by the core team members and the Case Agent. The draft report may also be reviewed by other appropriate staff, i.e., supervisors and technical experts. All draft reports shall be destroyed upon completion of a final report.

A final investigative report will be prepared by the project leader. This report shall contain factual information and observations but shall not contain conclusions, recommendations, or personal opinions. At the request of the Case Agent, a memorandum will be prepared containing conclusions, recommendations, or personal opinions. When this is done, the memorandum will be stamped "CONFIDENTIAL" on each page and delivered to the Case Agent. The final report(s) shall be delivered to the Case Agent who shall be responsible for its ultimate distribution.

F.8 Document Control

The core team members are responsible for the initial collection and maintenance of all documents, records, and evidence obtained during the field investigation. As required by the project leader, all documents, records and evidence obtained during the field investigation shall be delivered to the project leader who shall immediately construct an inventory of them. If requested, the project leader will deliver

all such records to the Case Agent

All original analytical data and supporting documentation, e.g., chromatograms, mass spectra QA/QC records, calculations, etc., shall be maintained by the local laboratory according to their Standard Operating Procedures and Quality Assurance Manual. If requested, copies of all records shall be provided to the Case Agent. Dissemination of such records shall only occur under Federal court order, as directed by DOJ, or as directed by the prosecuting attorney. Laboratory personnel shall construct a project file of all laboratory data and supporting documentation immediately after completing analyses and reporting of data to the project leader. An inventory of that file will be prepared and furnished to the Project Leader and the Case Agent.

All documents, records, evidence, etc. retained will be maintained in a locked filing cabinet or a secure area.

F.9 Sample Disposal

All excess samples and/or sample containers shall be maintained in the sample custody room until written authorization for sample disposal is received from the Case Agent. Because of lack of space in the sample custody room, the Case Agent shall expeditiously inform the laboratory when samples can be disposed. Sample disposal procedures shall be as described in the appropriate Standard Operating Procedures and Quality Assurance Manual.

