

ATTACHMENT E
TRAINING AND QUALIFICATIONS PLAN

**UNIVERSITY OF ARIZONA
PAGE TROWBRIDGE RANCH LANDFILL
AZD 980 665 814**

PERMIT ATTACHMENT E (APPLICATION APPENDIX Q)

The following is a list of changes made to the application document for the final Arizona Hazardous Waste Management Act Permit:

Section 4.f: Updated “Appendix E” to “Appendix F-1”.

Section 5: Removed highlighted text from last page (AMEC revised file 5/2/12).

Exhibit 1: Removed highlighted text from last page (AMEC revised file 5/2/12).

ATTACHMENT E (Application APPENDIX Q)

TRAINING PLAN

**TRAINING AND QUALIFICATIONS PLAN
FOR
PAGE-TROWBRIDGE RANCH LANDFILL**

**North 32°36' 26.87"
West 110°53' 45.83"
(Soil Vapor Extraction Array)**

**University of Arizona
Department of Risk Management Services
Township 9 South, Range 14 East, Gila and Salt River
Base and Meridian, Southern Half of Section 27 and Northern Half of Section 34
Pinal County, Arizona
EPA ID NO. AZD980665814**

REVISED MARCH 2012

TRAINING AND QUALIFICATIONS PLAN

The Training and Qualifications Plan is designed to address the requirements of 40 CFR 270.14(b) (12), 40 CFR 264.16, 40 CFR 264.179 and 40 CFR Subpart CC. This plan also addresses the training and medical monitoring requirements of 29 CFR 1910.120, the OSHA Standard for Hazardous Waste Operations. The general approach and philosophy of the training program is to utilize a combination of classroom instruction and supervised on-the-job training to provide employees with the knowledge necessary to perform the sampling protocols and emergency procedures for the Page-Trowbridge Ranch Landfill (PTRL) in a manner that maintains compliance and protects health, safety and the environment.

1. OUTLINE OF TRAINING AND QUALIFICATIONS PLAN

The major components of the Training and Qualifications Plan are hiring qualifications and job descriptions, initial training upon hiring, medical monitoring, and ongoing training of current employees. Exhibit 1 provides an outline of each of these program components and the various training topics associated with each other.

2. JOB DESCRIPTIONS

There are several job titles within the university personnel system that have significant job responsibilities involving the management of hazardous waste. These include the Assistant Vice President for Risk Management, Director of Occupational and Environmental Health and Safety, Environmental Safety Officer, Hazardous Waste Supervisor, and Hazardous Waste Specialist. Exhibit 2 includes copies of each of these job descriptions, outlining specific responsibilities of each position and the training required for the job description.

3. TRAINING DIRECTOR

The Training Director for the UA hazardous waste program is the Hazardous Waste Supervisor. This position is responsible for ensuring that all required training is completed on schedule, and that records are kept up to date. The Training Director, although highly knowledgeable about hazardous waste issues, typically does not conduct all of the training him/herself, but utilizes a variety of resources to accomplish this task. These resources include other Risk Management staff such as the Industrial Hygienists, the Occupational Safety Officer, and others with specific knowledge. Additional resources include video tapes and printed reference materials available from the Risk Management in-house library. Professional development courses offered at conferences and by professional organizations are also used to complete training requirements.

3.a. Training Director Qualifications

The Training Director receives the annual 8 Hour HAZWOPER Refresher, 8 Hour HAZWOPER Supervisor Training independently from outside vendors to segregate his training from internal training he provides to other PTRL staff. Train the Trainer, instructional technology or adult education themed classes are required every three years to maintain competency in training skills. Course curriculum, instructional methodology, hands-on exercises and other components of all UA environmental compliance training is developed to meet the criteria outlined in ANSI standard *ANSI/ASSE Z490.1-2009 Criteria for Accepted Practices in Safety, Health, and Environmental Training*.

4. TRAINING CONTENT

4.a. Regulatory Overview

This session covers in detail the regulatory status of PTRL as a closed disposal facility. An overview is conducted of major environmental regulatory programs and how they affect PTRL. Of paramount importance in this discussion are the Resource Conservation and Recovery Act (RCRA), and its subsequent amendments. Other regulatory programs reviewed during this session include the Comprehensive Environmental Compensation and Liability Act (CERCLA), and OSHA Hazardous Waste Operations Standard (HAZWOPER).

During this session, new employees are provided historical documentation to read that outlines previous compliance inspections, notices of violation, and the responses to those notices. This provides an excellent perspective on the types of typical compliance problems that have arisen during the operation of the program.

The Site Health and Safety Plan is introduced and discussed during this session.

The Site Inspection Report and Procedure is discussed with emphasis on the need for walking the perimeter, the cell caps and recording any deficiencies in writing and photograph. The Inspection Form is reviewed. The discussion includes potential deficiencies and a consensus is reached to ensure consistent inspections by authorized personnel. The Assistant Vice President for Risk Management, Director of Occupational and Environmental Health and Safety, Environmental Safety Officer, Hazardous Waste Supervisor are authorized to perform the required inspections but all employees who work at PTRL receive the training.

4.b. Hazardous Materials Chemistry and Toxicology

This session includes a review of the basic hazard classes of waste interred at PTRL, and the chemical characteristics that define these various hazards. The principal characteristics of concern include corrosivity, ignitability, reactivity, and toxicity. Descriptive hazard terms are also explained, including pH, vapor pressure, flashpoint, LEL/UEL, oxidizers, reductants, and pyrophoric and peroxidizable compounds. A variety of references and videotapes are also used in this session. An important component of this portion of the training is to teach employees how and where to locate specific hazard information needed to properly handle issues that may arise while at PTRL.

The Toxicology component of this review concentrates on acute and chronic health hazards of the waste types typically generated from university activities. Important concepts that must be well understood include dose, routes of entry, acute vs. chronic, and exposure standards such as Permissible Exposure Limits (PEL), Threshold Limit Values (TLV), and Immediately Dangerous to Life and Health (IDLH). In addition to these concepts, definitions are explained for terms such as carcinogen, mutagen, teratogen, and time-weighted-average.

4.c. Sampling Protocols

This session introduces general principles of sampling based on the following guidance documents: *Region 4 U.S. Environmental Protection Agency Science and Ecosystem Support Division Groundwater Sampling October 28, 2011* and *Arizona Department of Environmental Quality Soil Vapor Sampling Guidance July 10, 2008*. These guidance documents are included as Exhibit 4 to this Training and Qualifications Plan. A complete step-by-step instruction on the groundwater and soil vapor sampling protocols is included. Equipment, sampling containers and pre-sampling event activities are discussed. Hands-on instruction is given with sample containers and equipment to provide familiarity with container handling. This session is followed by additional instruction that is performed during on-the-job activities.

4.d. Safety and Accident Prevention

Due to its remote location safety is a paramount concern at PTRL. This session provides specific information to employees on how to conduct their activities safely and efficiently without incident. Topics include fire prevention, proper lifting, and preventing heat related incidents. Employees are also given specific instructions for action to be taken in the event of an accident or injury in the workplace, including identifying locations of emergency medical assistance if needed.

Employees also receive training on the proper selection and use of personal protective equipment including protective eyewear, gloves and steel toed boots.,

Hazardous waste personnel are enrolled in the UA Medical Surveillance Program. Personnel are required to complete a Medical Questionnaire and undergo a physical exam prior to participating in hazardous waste management activities including PTRL sampling events

Employees are made aware of their rights under OSHA, specifically the HAZWOPER Standard (29 CFR 1910.120), and are encouraged to immediately report any safety concerns to their supervisor without fear of reprisal.

The medical monitoring program in place for hazardous waste employees is discussed in detail to describe the frequency and content of medical exams, and how the results will be reported and maintained.

4.f. Emergency Response and Contingency Plan Training

Employees are advised of the types of emergencies that can occur during the sampling events at PTRL, and the appropriate response to each. Topics include response to fire, explosion, or other accident that threatens health or the environment.

The Contingency Plan (Appendix F-1) is reviewed in detail to explain who the designated Emergency Coordinators are, and what criteria are specified for implementation of the Plan. Various scenarios are outlined in a discussion setting to enhance individual knowledge and awareness of the events that are likely to be associated with different emergencies.

5. TRAINING PLAN IMPLEMENTATION

All new employees shall not work at PTRL until all training requirements have been completed. This process is typically completed within the first two weeks of employment, but in no case shall this process take longer than 90 days from the start of employment. A certificate of completion will be awarded at the conclusion of training. An example of the certificate is included as Exhibit 3. All records of training completion are maintained at the HWMF Office, 1548-2 N. Ring Rd., Tucson, AZ, 85719. Training records are maintained with employment records for a minimum of three years after termination. Medical monitoring records are maintained for a minimum of 30 years after termination.

All training is repeated annually for all staff members who work at PTRL, or are designated as Emergency Coordinators in the Contingency Plan. Additionally, the Director and supervisors work to identify additional training opportunities as they become available. These include professional seminars, conferences, and membership in professional organizations with applicable interests.

EXHIBIT 1

Training Program Outline

TRAINING PROGRAM OUTLINE

I. Regulatory Overview

- A. UA PTRL Regulatory Status
 - 1. Closed TSDF Status
 - 2. Discussion of Compliance History
- B. Applicable Regulatory Programs
 - 1. Resource Conservation and Recovery Act (RCRA)
 - 2. Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
 - 3. OSHA Hazardous Waste Operations Standard (HAZWOPER)
- C. Site Health and Safety Plan
- D. Site Inspection Procedure and Report

II. Hazardous Materials Chemistry and Toxicology

- A. Chemistry of Hazardous Materials
 - 1. Chemical nomenclature
 - 2. Incompatibility
 - 3. Definitions
 - a. Corrosive
 - b. Ignitable
 - c. Reactive
 - d. Toxic
 - 4. Reaction rate
 - 5. Chemical equilibrium
 - 6. Definitions/explanations of specific terms
 - a. pH
 - b. Vapor pressure
 - c. Flashpoint, LEL/UEL
 - d. Oxidizers/reductants
 - e. Pyrophoric materials

- f. Peroxidizable compounds

B. Toxicology of Hazardous Materials

- 1. Routes of entry to the body
- 2. Dose/response relationships
- 3. Acute vs. chronic exposure
- 4. Definitions/explanations of specific terms
 - a. Toxicity
 - b. Carcinogen
 - c. Mutagen
 - d. Teratogen
 - e. Time weighted average
 - f. Others as applicable
- 5. Latency effects
- 6. Exposure standards
 - a. Threshold limit values (TLV)
 - b. Permissible exposure limits (PEL)
 - c. Immediately dangerous to life and health (IDLH)

C. Hazards of Specific Materials

- 1. Halogenated hydrocarbons
- 2. Ketones/alcohols
- 3. Metals
- 4. Reactives
- 5. Pesticides

III. Sampling Protocols

A. Sampling QA/QC

- a. Sampling Method
- b. Sampling Equipment Maintenance and Calibration
- c. Control Samples (trip blanks, field blanks)
- d. Standard Operating Procedures
- e. Chain of Custody, Transportation, Sample Holding Times

B. Sampling Protocols

- 1. Groundwater Detection Monitoring Plan
 - a. General Principles of Sample Collection
 - 1. Groundwater Sampling – EPA Science

and Ecosystem Support Division Region 4
Operating Procedure 10/28/11

- a. Volatile Organic Compounds
 1. Sample Bottles/Preservatives
 2. Container Handling During Sampling

2. Soil Vapor Monitoring Well Procedure
 - a. General Principles of Sample Collection
 1. Soil Vapor Sampling Guidance – ADEQ 7/10/08
 - a. Well Purging
 - b. Container Handling During Sampling
3. Soil Vapor Extraction System Sampling Procedure
 - a. General Principles of Sample Collection
 1. Soil Vapor Sampling Guidance – ADEQ 7/10/08
 - a. Container Handling During Sampling

IV. Safety and Accident Prevention

- A. General Safety Considerations
 1. Fire prevention and response
 2. Proper lifting techniques
 3. Maintenance of work areas and equipment
 4. Accident reporting and investigation
 5. First aid and emergency medical resources
- B. Personal Protective Equipment
 1. Skin protection
 - a. Gloves-types and limitations
 - b. Safety eyewear-types and limitations
 - c. Proper footwear
- C. Medical Monitoring Program
 1. Requirements of 29 CFR 1910.120
 2. Frequency and content of examinations
 3. Results reporting
 4. Recordkeeping

V. Emergency Response and Contingency Plan Training

- A. Types of Emergencies and Response
 1. Fire

2. Explosion
3. Chemical release
4. Criteria to shutdown PTRL activities

B. Emergency Equipment

1. Emergency Response Equipment Inventory
2. Equipment inspection, maintenance, and replacement
3. Communication and alarm systems
4. Environmental monitoring equipment

C. Contingency Plan

1. Criteria for implementation of the Contingency Plan
2. Evacuation routes and notification
3. Emergency coordinators
4. Reporting and recordkeeping
5. Coordination with outside response agencies

REGULATORY COMPLIANCE
TRAINING REQUIREMENTS

HAZARDOUS WASTE

40CFR265.16 **RCRA** (Applicable to LQG and TSDF)

<u>Worker</u>	<u>Initial</u>	<u>Annual Refresher</u>	<u>Certification</u>
New	No Specific Hours	No Specific Hours	Instructor
Current	Previous Experience	No Specific Hours	Instructor
Emergency Responder	Part of Initial	No Specific Hours	Instructor

UA Personnel Affected

Assistant Vice President for Risk Management
Director, Occupational and Environmental Health and Safety
Environmental Safety Officer
Hazardous Waste Supervisor
Hazardous Waste Specialist

29CFR1910.120 **OSHA** (Applicable to LQG and TSDF)

<u>Worker</u>	<u>Initial</u>	<u>Annual Refresher</u>	<u>Certification</u>
New	24 Hours	8 Hours	Instructor
Current	Previous Experience	8 Hours	Instructor
Emergency Responder	As Necessary	As Necessary	Instructor

UA Personnel Affected

Assistant Vice President for Risk Management
Director, Occupational and Environmental Health and Safety

Environmental Safety Officer
Hazardous Waste Supervisor
Hazardous Waste Specialist

HAZWOPER

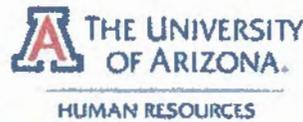
29CFR1910.120 **OSHA** (Site Cleanup)

<u>Worker</u>	<u>Initial</u>	<u>Annual Refresher</u>	<u>Certification</u>
General Worker	40 Hours Offsite & 3 Days Onsite (Supervised)	8 Hours	Instructor/Site Supervisor
Occasional Worker	24 Hours Offsite 1 Day Onsite (Supervised)	8 Hours	Instructor/Supervisor
Low-Hazard Worker	24 Hours Offsite	8 Hours	Instructor
Supervisor	Same As Worker & 8 Hours Specialized	8 Hours	Instructor
Emergency Responder	Not Specified, But Need Training Prior To Response Work	Annual "Rehearsal" of Emergency Response Plan	Not Necessary

UA Personnel Affected

Occasional Worker (Page Ranch)
Assistant Vice President for Risk Management
Director, Occupational and Environmental Health and Safety
Environmental Safety Officer
Hazardous Waste Supervisor
Hazardous Waste Specialist

EXHIBIT 2
Job Descriptions



THE UNIVERSITY OF ARIZONA
DEPARTMENT OF HUMAN RESOURCES
CLASSIFIED STAFF EMPLOYEE JOB DESCRIPTION

Job Code: 20730
Title: Hazardous Waste Specialist
Pay Grade: 51
Pay Range (min/mid/max): \$39,173/\$48,628/\$59,948
FLSA: Non-exempt

Purpose of Classification:

Plans, organizes, coordinates and schedules use of hazardous waste accumulation facility and controls hazardous waste disposal techniques used on campus.

Distinguishing Characteristics:

This is third in a series of four classifications and is distinguished from the Environmental Compliance Technician, Lead in that the incumbent is responsible for planning, coordinating, scheduling and controlling hazardous waste disposal. Works with hazardous waste daily and may be exposed to air contamination or hazardous materials in the case of a spill or accident.

Example of Duties:

- Collects, transports, segregates, accumulates and performs initial disposal of hazardous waste for various university departments; determines proper method of accumulation and disposal based on hazard classes and compatibility of chemicals; packages documents and labels waste for shipment to appropriate disposal facilities pursuant to disposal facility, state and federal requirements.
- Maintains accumulation facility records and data base on all accumulated hazardous waste streams.
- Coordinates the collection of campus-generated hazardous chemical/radioactive waste; assists in the collection and preparation for final disposal of infectious/biohazardous waste.

- Advises faculty, staff and students regarding proper hazardous waste management techniques and provides technical assistance upon request for campus departments.
- Responds to hazardous waste releases on campus using appropriate clean-up and safety methods.
- Analyzes and tests unknown hazardous waste streams to identify type of classification and allow for proper disposal.
- Presents educational or training sessions to faculty, staff and students regarding hazardous materials and waste management handling techniques.
- Identifies and prepares for disposal of asbestos materials.
- May supervise or monitor work activities of subordinates.
- Operates and maintains the elementary neutralization and waste water treatment systems and related equipment necessary in managing waste for proper disposal.

Knowledge, Skills, and Abilities:

- Knowledge of local, state and federal rules and regulations on hazardous materials management.
- Knowledge of hazardous materials management practices and techniques.
- Knowledge of chemical compatibilities and hazard classes.
- Skill in analyzing hazardous waste.
- Ability to effectively communicate.

Minimum Qualifications:

- Bachelor's degree in Chemistry, Safety or Industrial Engineering or related field AND two years experience in hazardous materials management; OR,
- Six years hazardous materials management experience; OR,
- Any equivalent combination of experience, training and/or education approved by Human Resources.
- Possession of a current State of Arizona Type C driver's license upon employment.

Prepared: 10/01/1990

Revised: 03/13/2006



THE UNIVERSITY OF ARIZONA
DEPARTMENT OF HUMAN RESOURCES
CLASSIFIED STAFF EMPLOYEE JOB DESCRIPTION

Job Code: 20733
Title: Hazardous Waste Supervisor
Pay Grade: 61
Pay Range (min/mid/max): \$46,329/\$57,419/\$70,715
FLSA: Exempt

Purpose of Classification:

Plans, organizes and directs the university hazardous waste and environmental compliance sampling programs.

Distinguishing Characteristics:

This is fourth in a series of four classifications. It is distinguished from the Hazardous Waste Specialist in that incumbents have a greater degree of expertise, responsibility and independence in performing duties. Incumbents supervise Environmental Compliance Technicians and Leads, coordinate a hazardous waste landfill program and coordinate a waste water program.

Example of Duties:

- Supervises two or more full-time employees, or their equivalent, on a regular basis.
- Makes decisions regarding hiring, evaluation, promotion and termination of employees, or makes related recommendations that are given particular weight.
- Coordinates, prioritizes and schedules activities related to the collection, processing, storage, transportation and disposal of university generated hazardous waste; coordinates the hazardous waste land fill program.
- Coordinates an environmental sampling program which includes hazardous materials, wastewater, groundwater and soil, ensuring federal, state and local regulatory requirements are met.

- Generates and maintains appropriate documentation and recordkeeping to meet environmental regulations.
- Advises faculty, staff and students regarding proper waste management techniques and provides recommendations for appropriate action upon request.
- Coordinates response to chemical hazardous materials incidents at university facilities, directing appropriate resources of staff, equipment and expertise to properly and safely mitigate hazards and address the emergency.
- Develops and presents educational training sessions to faculty, staff and students regarding hazardous waste handling and other environmental compliance programs.
- Advises management of the status of ongoing environmental compliance activities and makes recommendations for appropriate actions.
- Interacts with hazardous waste disposal vendors to facilitate efficient, cost effective and timely off-site transportation and disposal of hazardous wastes.
- Researches treatment and disposal technologies to identify viable methods required to meet anticipated regulatory changes and/or proper handling of atypical, difficult to dispose of waste materials.

Knowledge, Skills, and Abilities:

- Knowledge of supervisory practices and principles.
- Knowledge of local, state and federal rules and regulations on hazardous materials and environmental sampling.
- Knowledge of hazardous materials and environmental sampling management practice and techniques.
- Skill in supervising personnel and allocating appropriate resources to address simultaneous multiple program requirements.
- Ability to effectively communicate.

Minimum Qualifications:

- Bachelor's degree in Chemistry, Safety or Industrial Engineering or related field AND three years experience in hazardous materials management; OR,
- Seven years hazardous materials management experience; OR,
- Any equivalent combination of experience, training and/or education approved by Human Resources.
- Possession of a current Arizona Type C driver's license upon employment.

Prepared: 10/01/1990

Revised: 03/13/2006



THE UNIVERSITY OF ARIZONA
DEPARTMENT OF HUMAN RESOURCES
CLASSIFIED STAFF EMPLOYEE JOB DESCRIPTION

Job Code: 20780
Title: Health / Safety Officer
Pay Grade: 63
Pay Range (min/mid/max): \$54,576/\$68,220/\$81,864
FLSA: Exempt

Purpose of Classification:

Plans, organizes and directs university safety program. Enforces compliance with state and federal health, safety and fire codes and reduces or prevents safety hazards, dangers or accidents in areas of hazardous materials, fire, life, occupational and/or industrial hygiene safety.

Distinguishing Characteristics:

This is second in a series of two classifications. It is distinguished from the Health/Safety Specialist in that incumbents typically oversee a safety program that is broad in scope, including all areas mentioned and work independently making decisions affecting program with little guidance. Incumbents may be exposed to hazardous or dangerous situations in course of work.

Example of Duties:

- Interprets and evaluates university compliance with applicable safety codes.
- Develops, recommends and implements policy on health/safety protection; develops accident prevention and loss control systems and programs and ensures implementation throughout campus.
- Reviews construction plans for new and existing buildings to ensure compliance with fire, health and safety codes and carries through completions.
- Coordinates with architects, engineers and construction managers to discuss safety precautions and requirements, recommendations and code analysis.

- Monitors safety inspection program; evaluates program maintenance and determines priority of existing hazard correction; makes random visits with inspectors.
- Monitors worker's compensation program; oversees investigations; analyzes trends to identify problem areas and recommend action to reduce risk and financial loss.
- Advises, coordinates with and provides technical guidance to university staff, faculty and administrators regarding safety codes, policies and procedures.
- Maintains relationship with regulatory agency representatives to remain current on changing standards and interpretations; serves as contact person for university.
- Develops and implements health/safety educational programs or activities to improve awareness of safety and protection procedures.
- Conducts or directs studies and statistical analysis to identify hazards and evaluate potential for loss; prepares report on findings.
- Supervises and coordinates work activities of one to two Health/Safety Specialists.
- Ensures required licenses or registrations are maintained for hazardous materials.
- Compiles budget estimates and information for special projects.

Knowledge, Skills, and Abilities:

- Knowledge of the principles and practices of occupational safety.
- Knowledge of federal, state and local laws and regulations governing safety procedures and policies.
- Skill in interpreting and applying federal, state and local safety laws and regulations.
- Skill in developing safety policies.
- Skill in investigating and analyzing accidents and their causes.
- Ability to effectively communicate.

Minimum Qualifications:

- Bachelor's degree in Industrial Engineering or related field AND four years experience in safety, fire prevention, environmental health, industrial hygiene or related field, which includes one year of supervisory experience; OR,
- Eight years experience in safety, fire prevention, environmental health, industrial hygiene or related field, which includes one year of supervisory experience; OR,

- Any equivalent combination of experience, training and/or education approved by Human Resources.

Prepared: 10/01/1990

Revised: 03/13/2006

POSITION DESCRIPTION

TITLE: Director of Occupational and Environmental Health & Safety (OEHS)

REPORTS TO: Assistant Vice President for Risk Management Services (AVP)

PURPOSE: This position assists the AVP with the management of Risk Management Services programs and activities. Primary function is to provide oversight management of all occupational and environmental health and safety programs. Specific responsibilities include serving as the University Fire Marshal, Building Safety Officer, and Emergency Coordinator. Manages and supervises assigned programs and personnel. The Director is authorized to act in the AVP's capacity in his/her absence.

DIRECTION RECEIVED: The Director of OEHS works under general supervision from the AVP to accomplish the goals of the Risk Management Services Department.

TYPICAL RESPONSIBILITIES AND DUTIES:

- The Director OEHS manages, supervises and coordinates programs for occupational and environmental health and safety. This includes oversight of programs for environmental compliance, occupational safety and health, building safety, and loss prevention.
- The Director OEHS is responsible for the management of physical safety programs in all university facilities and operations. This includes programs such as fire safety, construction plan review and coordination, building inspection, special event safety, and building safety improvements.
- Serves as the University Fire Marshal. This Director OEHS is the primary liaison to the Office of the State Fire Marshal and the Tucson Fire Department. As the University Fire Marshal, this position is designated the campus authority for code compliance, under delegated authority from the State Fire Marshal.
- The Director OEHS is responsible for coordinating RMS involvement with emergency preparedness and planning response on campus. Works closely with the University Manager of Emergency Preparedness and University Police Dept. to provide RMS input to planning and response efforts.
- Reviews the status and progress of assigned safety programs, recommends to the AVP suggested policy changes, priority changes, or budget modifications to enhance overall program effectiveness as necessary.
- Monitors regulatory proposals and new regulations at the local, state, and federal level. Assesses impact to university operations, develops plans for compliance, and recommends steps for institutional response to new regulatory requirements.
- Supervises assigned personnel, sets priorities and goals, evaluates performance, and implements appropriate corrective action.
- Represents RMS on committees, task forces, and project teams as assigned by the AVP to provide Risk Management Services input to these activities.

- The Director OEHS is authorized to act in the same capacity as the AVP in the AVP's absence.

KNOWLEDGE AND SKILLS REQUIRED:

- Requires considerable knowledge of regulatory requirements applicable to safety in a university environment, primarily those associated with OSHA, EPA, Uniform Building Code, Uniform Fire Code, and the Office of the State Fire Marshal.
- Requires certification by the International Fire Code Institute as a Certified Fire Code Inspector. This qualifies the position to be appointed and designated as a Deputy State Fire Marshal by the State Fire Marshal.
- This position requires excellent oral and written communication skills. Must be able to communicate effectively with personnel at all levels of the organization.
- Must be able to manage multiple priorities, plan activities, and make immediate adjustments to accommodate emergencies and other unplanned events.
- Must be familiar with the higher education environment, the types of risk management, safety, and loss prevention issues inherent to this environment, and the tools and techniques necessary to implement safety efforts among faculty, staff, students, and administrators.

MINIMUM QUALIFICATIONS:

Education: Bachelor's Degree from an accredited college or university.

Experience: Ten years of progressively more responsible work experience; including at least five years consists of professional safety management experience.

PREFERRED QUALIFICATIONS:

- A Bachelor's Degree in safety management or industrial hygiene is preferred. Other science, engineering or applicable technology degree fields may be considered acceptable if combined with highly applicable experience in a university setting. An applicable graduate degree may substitute for no more than half of the required relevant experience.
- Ten years of progressively more responsible work experience, including a minimum of five years of professional experience with environmental health and safety management issues in a teaching and research university setting is preferred.
- Professional certification as a Certified Industrial Hygienist or Certified Safety Professional.

JOB DESCRIPTION

JOB TITLE: Assistant Vice President for Risk Management Services

REPORTS TO: Senior Associate Vice President for Business Affairs

MAJOR FUNCTION:

Responsible for planning, organizing, budgeting and supervising all functions of the Department of Risk Management Services, which includes environmental health and safety, loss control, regulatory compliance, and insurance coordination on behalf of the University of Arizona.

RESPONSIBILITIES INCLUDE:

Administration of a multi-source (state and local) annual budget to fund all applicable departmental programs. Advises university administration of new risk management issues and regulatory requirements that will have operating and financial impacts to the institution. Manages the development of plans and programs to achieve and maintain regulatory compliance.

Manages a staff of professionals with expertise in occupational and environmental health and safety as well as insurance coverage and claims management. Management responsibilities include staff organization and evaluation, training and development, affirmative action, strategic planning for staffing needs, workload monitoring, and coordinating supervision and delegation.

Monitors and continuously updates a comprehensive program to identify sources of loss exposure and to minimize frequency and severity of losses. Components of this program include occupational and environmental health and safety, asset protection, regulatory compliance, general liability loss prevention, building and fire safety, fleet safety, and loss prevention training. Also coordinates with affiliated units on management of medical malpractice exposures and employment liability.

Manages and evaluates the university's statutory insurance program for property, liability and workers compensation as provided through the Arizona Department of Administration, Risk Management Division. Coordinates with legal counsel and ADOA-RMD to monitor litigation involving the university. Prepares agency response to the Arizona Joint Legislative Budget Committee for Rule 14 liability claim and lawsuit settlements.

Represents the university as principal liaison to the following agencies:

- U.S. Environmental Protection Agency
- Arizona Dept. of Administration – Risk Management Division
- Arizona Department of Environmental Quality
- Arizona State Fire Marshal
- Arizona Division of Occupational Safety and Health
- Pima County Wastewater Management Department
- Pima County Department of Environmental Quality
- Pima County Local Emergency Planning Committee
- Tucson Fire Department

RESPONSIBILITIES, continued

Serves as the primary emergency coordinator as required by the Resource Conservation and Recovery Act and has authority to commit all available resources to address environmental emergencies.

Identifies, prioritizes, and recommends campus safety improvements as part of the building renewal and construction decision package process. Serves as part of the staff support team to the Space Committee which allocates funds for university construction projects.

Maintains internal contact with administrative and academic units to assess the performance of loss control efforts and to identify potential problems or hazards at the earliest possible stage. In addition to the supervising Senior Associate Vice President, significant internal contacts include: Office of General Counsel, Human Resources, Procurement and Contracting, Facilities Management, Planning Design and Construction, Vice President for Research, Dean of Students, University Police Department, Campus Health Service, Office of Radiation, Chemical and Biological Safety, College Deans and Academic Department Heads. Coordination is also required with affiliate organizations, including University of Arizona Healthcare and the University of Arizona Foundation.

POSITION QUALIFICATIONS:

Ten years experience with increasing responsibility for the management and strategic direction of a multi-disciplined loss control and insurance management program. Must possess strong knowledge of environmental health and safety issues, and risk exposures that impact colleges and universities. Must possess an excellent understanding of insurance issues, especially statutory self-insurance, and applicable contract law as defined by State of Arizona statutes. Must have experience in organizing and directing the activities of a professional staff. Experience in a higher education academic environment is highly desirable, but not mandatory if prior professional experience is appropriately related.

EDUCATION REQUIREMENTS:

Bachelor's Degree from an accredited university in a scientific/technical field such as engineering, chemistry, biology, **OR** a business management degree, which couples training in finance and insurance concepts with applicable health/safety administration experience.

A Master's Degree in Safety, Environmental Science, or Business Administration is preferable, but not mandatory if the Bachelor's Degree is coupled with highly applicable work experience.

If the educational background is principally scientific or technical, then there should be a combination of graduate coursework and experience in the business management arena to develop management and financial skills.

Professional certifications such as Associate in Risk Management (ARM), Certified Risk Manager (CRM) or similar certifications of technical expertise are desirable, but not mandatory.

EXHIBIT 3

Example of Training Certificate

THE UNIVERSITY OF
ARIZONA[®]
TUCSON ARIZONA

SAMPLE
COPY

PRESENTS THIS CERTIFICATE TO

STEVEN C. HOLLAND

IN RECOGNITION OF PARTICIPATION IN

Page-Trowbridge Ranch Landfill Compliance Training per 40 CFR 264.16


COORDINATOR
CET, CAN

Steven C. Holland

DIRECTOR

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A RISK MANAGEMENT AND SAFETY PROGRAM

Exhibit 4

1. Arizona Department of Environment Quality – Soil Vapor Sampling Guidance, July 10, 2008 (19 pages)
2. Environmental Protection Agency Region 4 – Groundwater Sampling Operating Procedure, October 28, 2011 (32 pages)

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ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

SOIL VAPOR SAMPLING GUIDANCE

July 10, 2008

Soil Vapor Sampling Guidance

1. **Scope and Application**
2. **Definitions**
3. **Considerations When Planning for Soil Vapor Sampling**
 - 3.1 **Temporal Variations in Soil Vapor Concentrations**
 - 3.2 **Conditions Unsuitable for Collection of Soil Vapor Samples**
 - 3.3 **Tests to Determine if Soil Vapor Sampling is Practicable**
 - 3.4 **Confirmation Sampling**
4. **Installation Methods**
 - 4.1 **Sample Through Rods (also known as temporary probes)**
 - 4.2 **Permanent Probes**
 - 4.3 **Equilibration Time**
5. **Sampling and Analysis**
 - 5.1 **Sampling Containers**
 - 5.2 **Sample Collection**
 - 5.3 **Analysis**
 - 5.4 **Data Quality Objectives (DQOs)**
 - 5.5 **Quality Assurance/Quality Control**
6. **Relating Soil Vapor Concentration to Total Soil Concentration**
 - 6.1 **Three-phase Partitioning Equation**
 - 6.2 **List of Default Values for Soil Matrix**
 - 6.3 **Test Methods Required to Change Soil Matrix Default Values**
 - 6.4 **List of Chemical Default Values (K_{oc} and H_o) for Selected VOCs**
7. **Procedure References**

Disclaimer: Please note that the information is intended as general guidelines and not specific recommendations for all sites. Site-specific considerations, professional judgment, and regulatory requirements will dictate the methods and procedures used at any particular site.

Soil Vapor Sampling Guidance

1. Scope and Application

- 1.1 This guidance describes procedures for collection of active soil vapor samples and does not address procedures for collection of passive soil vapor samples.
- 1.2 This guidance is intended to detail sampling procedures to ensure delivery of soil vapor samples to the laboratory that will yield reliable and consistent results that are representative of actual conditions.

2. Definitions

- 2.1 Dead Volume – volume of the sampling probe and the connected sampling tubing and equipment. The boring volume is not included in the calculation of dead volume, because the probe tip sand-pack space is assumed to have been allowed to equilibrate with surrounding soil formation before soil vapor sampling occurs.
- 2.2 Internal Volume – dead volume plus probe tip sand-pack volume.
- 2.3 Probe Driving System – hydraulic or hammer system used for installation of soil vapor sampling probes.
- 2.4 Soil Vapor Monitoring Well – a well constructed specifically to sample soil vapor from the vadose zone.
- 2.5 Soil Vapor Sample – a sample of soil vapor representative of the vadose zone at the sampled location.
- 2.6 Soil Vapor Sampling Port – any mechanical device (usually a ball valve with a hose barb) that allows a representative soil vapor sample to be collected from a soil vapor monitoring well.
- 2.7 Soil Vapor Sampling Probe – any mechanical device that allows a representative sample of soil vapor to be collected from specified sampling depth.
- 2.8 Vapor Equilibration – the condition where vapor concentration entering a sampling probe is 95% or greater of vapor concentration in surrounding soil.

3. Considerations when Planning for Soil Vapor Sampling

The collection and analysis of soil vapor samples, along with any existing soil and groundwater data or any reasonably obtainable data (e.g., soil solids and groundwater

data), is useful for the objectives of site characterization, determination of potential pathways of exposure for health risk, optimization of remedial or mitigation systems design, and confirmation of compliance with remedial goals.

3.1 Temporal Variations in Soil Vapor Concentrations

Variations in soil vapor concentrations due to temporal effects are principally due to temperature changes, precipitation, and activities within any overlying structure. Variations will be greater the closer the samples are to the surface and are lessened with increasing depth. There are a number of available studies on the temporal variation in soil vapor concentrations and more are currently underway or planned in 2007 by the EPA and independent groups. The results of these studies have shown that short-term variations in soil vapor concentrations at depths four feet or deeper are less than a factor of two and seasonal variations in colder climates less than a factor of five.

Larger variations in soil vapor concentrations may be expected in areas of greater temperature variation and during periods of heavy precipitation as described below.

- Temperature: Effects on soil vapor concentrations due to actual changes in the vadose zone temperature will be minimal.
- Precipitation: Infiltration from rainfall can potentially impact soil vapor concentrations by displacing the soil vapor, dissolving volatile organic compounds, and by creating a “cap” above the soil vapor. In most settings, infiltration from large storms only penetrates into the uppermost vadose zone. Soil vapor samples collected at depths greater than 3 to 5 feet below ground surface (bgs) under foundations or areas with surface cover are unlikely to be significantly affected. However, soil vapor samples collected closer to the surface (<3 feet) with no surface cover may be affected. If the moisture has penetrated to the sampling zone, it typically can be recognized by difficulty in collecting soil vapor samples. If high vacuum readings are encountered when collecting a sample, or drops of moisture are evident in the sampling system or sample, measured values should be considered as minimum values. Measurement of percent moisture of the soil may also be useful if shallow sampling is performed during or shortly after significant rainfall (>1.0 inch).
- Pressure: Barometric pressure variations are unlikely to have a significant effect on soil vapor concentrations at depths exceeding three to five feet bgs and only a minor effect (less than a factor of 2) at shallower depths unless a major storm front is passing through the area. A recent study in Wyoming (Luo et al., 2006) has shown little to no relationship between barometric pressure and soil vapor oxygen concentrations.

Human induced influences to pressure are likely to have a bigger effect upon soil vapor concentrations. For example, pressure changes resulting from the on-off cycling of an overlying building’s heating or HVAC system and the ventilation of the structure due to open doors and windows can greatly influence soil vapor concentrations at locations near the building. In colder climates, greater impacts are most likely in the winter season.

Literature suggests that temporal variations in the radon concentrations are typically less than a factor of two and seasonal effects less than a factor of five. (Vapor Intrusion Pathway: A Practical Guideline, January 2007 Interstate Technology and Regulatory Council)

3.2 Conditions Unsuitable for Collection of Soil Vapor Samples

3.2.1 Soil vapor samples should not be collected if:

- a. The groundwater is very close to the ground surface (i.e., < 3 feet);
- b. Chemical(s) of concern is/are not volatile; and
- c. Moisture or unknown material is observed in the sample stream or sample container.

Please note that due to increased diffusivity, advective flow, and temperature fluctuations at near surface boundaries, the collection of a soil vapor sample in near surface soils is not useful for the purpose of calculating total soil solid VOC concentrations.

3.3 Tests to Determine if Soil Vapor Sampling is Practicable

Some soil types (i.e., clay or silty clays) may not be conducive for soil vapor collection. Tests to ascertain if soil vapor can be collected from the soils are outlined below.

3.3.1 As a qualitative test, a gas-tight syringe could be connected to the soil-vapor-sampling tubing to determine if a sample can be withdrawn. Please note that the soil-vapor-sampling tubing must have a volume of less than the gas-tight syringe for a meaningful result.

3.3.2 Another test that can be performed to determine if soil vapor sampling is practicable at a site is as follows:

- a. Install a T-connection at the end of the soil-vapor-sampling tubing;
- b. Connect a vacuum gauge to one branch of the T-connection;
- c. Connect a syringe fitting and a 60-mL or larger syringe to the remaining branch of the T-connector;
- d. With the syringe connected, pull the plunger back to the full-scale reading and hold in that position; and then
- e. Monitor the vacuum created at the full draw position and during relaxation.

If the vacuum does not relax within a few minutes to an hour, it is unlikely that soil vapor sampling is practicable at that particular location and other locations in the subsurface with similar soil characteristics.

3.4 Confirmation sampling

Soil vapor samples used to verify completion of remedial actions must verify that residual contaminant concentrations are at or below the corrective action standard for each chemical of concern in the contaminated soil as determined under A.A.C. R18-7-201 *et seq.* (please refer to Section 6). The soil vapor samples must be collected throughout all areas previously reporting soil solid concentrations for chemicals of concern above applicable corrective action standards.

4. **Installation Methods**

This section provides useful construction information and details for installation methods.

4.1 Sample Through Rods (also known as temporary probes)

This method is advantageous if only one sampling round is required. Also, less material is placed in the ground, minimizing disturbance of the in-situ vapor and decreasing the need for collection of blanks.

The following construction details should be considered for the collection of a sample through rods:

- a) Seal probes at the surface with bentonite before sampling;
- b) Utilize small diameter rigid tubing (such as Teflon or Nylon) rather than flexible tubing (such as Tygon, and both low and high density polyethylene) when sampling VOCs, due to flexible tubing's tendency to leak and significant adsorption/losses seen when using this material; and
- c) When using direct-push borings for the installation of soil-vapor-sampling probes, avoid lateral movement of the probes once they are in the ground to prevent atmospheric air from entering the sampling system.

4.2 Permanent Probes

The following construction details should be considered for the installation of permanent probes:

- a. Use short discreet sampling intervals (e.g., 6 to 12 inches);
- b. Color code or tag tubing of probes at the surface to be sure that the sampling depth is easily identifiable for future sampling events;

- c. Complete and seal permanent probes at the ground surface (e.g., road boxes, locked caps, vapor-tight valves).

When using auger, air rotary, or roto-sonic drilling methods for the installation of soil-vapor sampling probes, the following should be considered:

- a. Install sampling probes with sand-pack intervals of approximately 1 foot;
- b. Seal each sampling interval with bentonite or grout above and below the sand pack in the annulus of the boring. Care should be taken to ensure that the seal material does not intrude into the sand pack;
- c. If dry bentonite is placed in the boring, care should be taken to fully hydrate the bentonite. Placing the bentonite in small increments (e.g., < 6 inches) followed by water is helpful. Alternatively, the bentonite can be added using a combination of dry and hydrated bentonite, or in slurry form if the boring is of sufficient diameter; and
- d. For deeper probes, down-hole support rods may be necessary during probe installation, especially for tubing sized greater than 1/8-inch OD..

4.3 Equilibration Time

During probe installation, subsurface conditions are disturbed. For probes installed with hollow stem, air rotary, or roto-sonic drilling methods, purge volume test, leak test and soil vapor sampling should not be conducted for at least 48 hours (depending on site lithologic conditions and stage of investigation) following probe installation. When utilizing sample through rods, a 20 to 30 minute equilibration time is recommended.

5. **Sampling and Analysis**

5.1 Sampling Containers

The sample containers chosen for a specific site will depend on the sampling equipment and analytical requirements. The ultimate storage container should be selected prior to the initial sampling.

5.1.1 Examples of different sample containers include:

- a. Tedlar™ bags;
- b. Stainless steel canisters (e.g., Summa™ canisters); and
- c. Gas-tight syringes

All of the above listed sample containers are relatively simple to fill. Tedlar™ bags have a 72 hour holding time. Stainless steel canisters have a 30 day holding time. Syringes are typically utilized for on site analysis and the holding time should be as short as possible (less than 5 minutes for plastic syringes and less than 15 minutes for glass syringes). The transferring of samples to different container types for the purpose of extending holding times is not recommended.

5.1.2 Storage and Shipping Considerations

- a. Do not put sample on ice;
- b. Do not store sample exposed to light (keep sample in dark place); and
- c. Keep sample at standard temperature and pressure as much as practicable.
- d. Tedlar samples are not to be shipped by airplane.

5.2 Sample Collection

5.2.1 Sample Collection Flow Rates

Flow rates should not exceed approximately 100 - 200 ml/min and vacuums should be maintained to below 10 inches of water, if practical. Also, consider the following:

- a. Minimizing the sample collection flow rate for near groundwater situations to prevent groundwater from entering the sample container;
- b. Measuring and recording the vacuum at which the samples were collected for each sampling probe;
- c. Monitoring the vacuum during sampling with an in-line gauge; and
- d. Use of a calibrated flow controller supplied by the lab to provide a consistent flow rate for each sample collected. One flow controller should be used for each sample collected.

5.2.2 Sample Collection Procedure

The following are examples of sample collection procedures utilizing different types of sample containers:

- a. Collection using Tedlar™ bags:
 1. A “T-coupling” should be used to place the Tedlar™ bag in the sampling system ahead of the purging equipment used to purge vapor from the

system. Appropriate compatible connecting threads will be required in order to use the Tedlar™ bag;

2. Attach sample tubing to a vacuum box and pump;
3. Label the bag accordingly and keep it in a dark area with the temperature as near as possible to the soil temperature at the time sampled (to avoid condensation) as much as practicable until analysis occurs. The sample collected in a Tedlar™ bag should be analyzed as soon as possible after collection;
4. Open the valve on a clean dry Tedlar™ bag and attach it to the inside of the vacuum box;
5. Close the vacuum box, close stopcock (3-way valve) between vacuum box and pump, then turn the pump on; and
6. Allow Tedlar™ bag to fill to 50 – 70% of capacity (do not overfill), shut off the pump, close the toggle switch (to prevent loss of sample), open the stopcock, and remove Tedlar™ bag from the vacuum box.

b. Collection using stainless steel canisters (e.g., Summa™ canisters):

1. Prior to sampling, check with the laboratory regarding canister post sampling vacuum requirements. Laboratories may require certain residual vacuum in the canister to conduct laboratory QA/QC procedures.
2. A “T-coupling” should be used to place the stainless steel canister in the sampling system ahead of the purging equipment used to purge vapor from the system. Appropriate compatible connecting threads will be required in order to use the stainless steel canisters;
3. A manometer (or similar type of vacuum gauge) should be used to verify that the stainless steel canister, used in the field, arrived from the laboratory with the proper vacuum, stainless steel canisters must also arrive from the laboratory with certification indicating that the canisters have been properly pre-cleaned and evacuated. Empty stainless steel canisters may not be stored for more than 30 days prior to sample collection. Once filled, the stainless steel canisters should be properly labeled and packaged for transport to the off-site laboratory. (Note: Only stainless steel canisters can be shipped by air freight to an analytical laboratory for analysis and should be analyzed within 30 days after sample collection.);

4. Open the stainless steel canister valve by rotating it counter-clockwise 1-2 rotations. You may hear soil vapor rushing (hissing sound) into the canister;
5. Allow the canister to equilibrate for 30-60 seconds and close the valve (hand tighten, over tightening may result in leakage and loss of sample);
6. Close the sampling port ball valve (open the valve all the way then close it down) then remove the sampling line from the sampling port and the canister;
7. Attach the vacuum pressure gauge to the canister. Check and record the vacuum pressure. It is recommended that for monitoring/confirming canister pressures not to rely on analog style gauges that a laboratory may provide;
8. Remove the vacuum pressure gauge and replace the canister valve cap; and
9. Complete the sample label (Note: Labeling should be done on the tag attached to the canister), do not write on the outside of the stainless steel canister itself.

5.3 Analysis

Analysis of vapor samples can occur in the field (mobile laboratory) or at a fixed laboratory setting. Use of a mobile laboratory for vapor analyses can be practical in terms of data collection when field decisions need to be made, especially during the investigative process. The intention of analyses in the field is to ensure a good data set that provides results in real time that adequately represents conditions at the site. A good field data set should result in less time spent during the site investigation process.

The following analytical methods are acceptable for soil vapor analysis:

For VOCs:

- a. 8260B (Modified for Vapor)
- b. 8021B (Modified for Vapor)
- c. TO-15

5.4 Data Quality Objectives (DQOs)

Data quality objectives (DQOs) will vary with both the stage of investigation and the intended use of the data collected from soil vapor sampling. During screening or the initial stages of investigation, DQOs will be less stringent than those for confirmation of remediation or risk assessment for indoor air vapor intrusion. DQOs will determine the sampling method, the type of sample collected, the frequency of sample collection,

sampling location, the number of samples to be collected, and the specific quality assurance (QA) and quality control (QC) necessary, both in the field as well as in the laboratory. Following DQOs will ensure that the data is useable for the intended purpose.

The most important QA/QC activities and parameters include:

- a. Sampling method
- b. Sampling equipment maintenance and calibration
- c. Control samples, i.e., trip blanks, field blanks, method blanks
- d. Standard Operation Procedures (SOPs)
- e. Analyses method appropriate for target compounds
- f. Sample holding times and transportation conditions
- g. Analyses method with required practical quantitation level
- h. Laboratory QC samples

5.5 Quality Assurance/Quality Control

5.5.1 Sampling QA/QC

Solid quality assurance and quality control procedures start with organized planning. A well thought out work plan will help to ensure that soil vapor samples are collected in a manner resulting in data of known quality. Stated data objectives and quality control techniques are essential to the work plan. There are several quality control procedures to ensure collection of representative samples. The following are some of those quality control procedures that should be considered:

a. Purging

Purging is utilized to obtain a sample that represents equilibrated vapor concentrations of soil surrounding the sampling probe. The initial purge testing should be conducted in an area where positive detections are most likely to occur. The purged volume selected should be consistent for all sample locations across the site. Please consider the following procedure with respect to purging:

- 1) Remove three to five internal volumes of a sample system. This should ensure that vapor concentration entering a sampling container is 95% or greater representation of vapor concentration in surrounding soil; or
- 2) If vapor equilibration has occurred, remove one to five dead volumes;

The number of dead volumes requiring removal may be based on procedures such as:

- 3) Analyzing the purged vapor with a field vapor analyzer (PID or FID) until the concentrations of total hydrocarbons stabilize, or use field instruments to measure respiration gases (e.g., O₂, CO₂) and assess consistency across sequential purged volume samples; or

- 4) Conducting a purged volume test to determine the number of dead volumes to remove that corresponds to the highest recovered vapor concentrations.

Please note that care should be taken not to collect a sample under non-equilibrium conditions generated by high purge rates.

b. Leak Testing

Consider conducting a leak test where leakage may be a concern (e.g., shallow sample intervals, large sample volumes).

The following is a procedure for checking belowground sampling equipment for leaks:

- 1) Use oxygen as a qualitative test for a high-end indicator of short-circuiting. Elevated oxygen measurements in soil vapor analytical results may indicate significant short-circuiting. This, though, may not be true for shallow depths or in areas where there is only halogenated VOC contamination); and
- 2) Use tracer compounds (e.g., helium, butane, propane, isopropanol) to conduct leak tests (helium is recommended as a leak tracer for projects using TO-15 (fixed lab) analysis). For example, the tracer is applied at the surface where air could enter the soil vapor probes. When using a tracer gas, a shroud is needed to keep the tracer gas in contact with the probe during the testing.

The soil vapor sample is analyzed for the tracer compound using a method that can achieve less than 10 µg/L detection limit. Care should be taken that the tracer compound of interest and other co-existing volatile compounds in the tracer media are not target compounds of interest in soil vapors investigated at the site. A discussion of advantages and disadvantages regarding different tracers can be found in Appendix D (pages D-9 and 10) of the January 2007 ITRC Vapor Intrusion Pathway: A Practical Guideline.

Leak testing of the sampling train (aboveground sampling equipment) may be performed by a variety of methods:

- 1) Use tracer compounds as described above; or
- 2) Use a vacuum test where the system is closed, a vacuum applied, and the vacuum is observed over a period time to ascertain if there are system leaks.

c. Decontaminating Aboveground Equipment

Clean aboveground sampling equipment should be used for all parts of the soil vapor sample collection. This can be implemented by using disposable parts, or using proper procedures to clean reusable equipment. Please consider the following:

- 1) External sampling equipment parts should be washed in the field between samples if reused; and
- 2) Tubing should not be re-used for samples where lower concentrations are expected once it has been used to collect samples where higher concentrations are expected.

5.5.2 Analysis QA/QC

All soil vapor analysis should be performed by a laboratory that is certified by Arizona Department of Health Services (ADHS) and maintains a Quality Assurance Plan. Quality Control Procedures for analysis performed with soil vapor sampling should follow good laboratory practices and criteria within the specified methods and at a minimum include the following quality control criteria:

- a. Detection Limit Study
- b. Method Blank
- c. Calibration
- d. Calibration Verification
- e. Surrogates
- f. Duplicate
- g. Second Source Standard

When QC criteria fall outside specified control limits, the analysis should be qualified using Arizona data qualifiers. Any event that cannot be described by the data qualifiers must be documented in a case narrative which must be included with the final report. Using the Arizona data qualifiers does not automatically qualify the data as acceptable to ADEQ. ADEQ expects that data reported utilizing these qualifiers, unless stated otherwise, is useable, scientifically valid and defensible.

5.5.3 Other Soil Vapor Analytes

Chemicals of interest for soil vapor sampling are specific for the type of contaminant release and breakdown products. They include both volatile organic and inorganic compounds, as well as some semi-volatile organic compounds. The method selected for laboratory analysis should be consistent with the stage of investigation and remediation, the volume of sample that is practical to collect, and the DQO's. Analysis

of all samples collected to demonstrate compliance with regulatory requirements should be conducted by a laboratory licensed by the ADHS using an ADHS approved method.

The following table lists the types of compounds, methods, and ADHS approval status. The laboratory should be consulted for specific target list compounds, as well as detection limits. If a particular method is desired for compliance sampling which is not currently approved by ADHS, please contact ADEQ to begin approval for the method using A.A.C. R9-14-610(C).

Table 5.1 Analytical Methods

Compounds	Method	ADHS Certified
Chlorinated VOCs and Petroleum VOCs BTEX/MTBE	TO-14A	Yes
Chlorinated VOCs and Petroleum VOCs	TO-15	Yes
VOCs	8260	*
VOCs	8021	No

*** - ADHS has begun the working on the process for certifying Method 8260**

6. Relating Soil Vapor Concentration to Total Soil Concentration

Calculation of total soil concentrations using the method outlined below will vary depending on the input choice of chemical and physical values, such as soil adsorption coefficients (K_{oc}) and soil organic carbon fractions (f_{oc}). In this section, ADEQ provides a list of default values and methods to derive alternative values to be utilized in the three-phase partitioning equation outlined in Section 6.1. The listed default values are appropriate for use throughout much of Arizona and are conservative values so as to be protective of public health and the environment.

6.1 Three-phase Partitioning Equation

The following three-phase partitioning equation is accepted by ADEQ for the calculation of total soil concentrations which may occur in situ for a chemical. The equation is based on a standard soil partitioning equilibrium model which assumes that a fourth phase, non-aqueous phase liquid (NAPL) is not present. Therefore, at soil concentrations exceeding the 3-phase saturation limit, measured soil vapor concentrations are inapplicable for calculating total soil concentrations using this equation. The equations used that govern the equilibrium partitioning between phases are the linear sorption partitioning equation normalized with respect to organic carbon (Karichoff et al., 1979) and Henry's Law:

$$C_t = \frac{C_g [K_{oc}f_{oc}\rho_b/H_o + \theta_w/H_o + (\theta_t - \theta_w)]}{\rho_b}$$

where,

- C_t – Total concentration in soil ($\mu\text{g}/\text{kg}$)
- C_g – Concentration in soil vapor ($\mu\text{g}/\text{L}$)
- f_{oc} – Mass fraction of natural soil organic carbon content (g-organic carbon/g-soil)
- K_{oc} – Soil organic carbon-water partitioning coefficient (ml/g)
- ρ_b – Dry Bulk Density (kg/L)
- H_o – Henry's Law Constant (dimensionless)
- θ_t – Total soil porosity (volume of voids/volume total)
- θ_w – Volumetric Water Content (volume of water/volume of soil)

6.2 List of Default Values for the Soil Matrix

Fraction of Organic Carbon in Soil (f_{oc}). A default input for fraction of organic carbon in soil of 0.006 (0.6%) is selected for use in the equation.

Soil Dry Bulk Density (ρ_b). A default input for dry bulk soil density of 1.5 kg/L is selected for use in the equation. Dry bulk-densities for basin-fill deposits typically range from 1.3 to 1.8 kg/L. The 1.5 kg/L value is within this range.

Total Soil Porosity (θ_t). A total soil porosity of 0.43 (43%) is selected is selected for use in the equation and was based on a default soil particle density (ρ_s) of 2.65 kg/L [$\theta_t = 1 - \rho_b/\rho_s = 0.43$].

Soil Volumetric Water Content (θ_w). A default volumetric water content of 15% (0.15) is selected for use in the equation. Volumetric water content in basin-fill deposits typically range from 5 to 25 percent. The 15% value is within this range.

6.3 Test Methods Required to Change Soil Matrix Default Values

This section specifies procedures and requirements to derive site-specific input parameters for use in the three-phase partitioning equation. Site-specific values may be substituted for one or more of the following four input parameters: soil dry bulk density, soil organic carbon content, total soil porosity, and soil volumetric water content.

Deriving soil organic carbon fraction (f_{oc}). ASTM Method D2974 or other methods approved by ADEQ may be used to derive site-specific soil organic carbon fraction values. Soil samples used to measure site-specific soil organic carbon content must be

collected from uncontaminated soil in lithologic zones that are representative of where the soil-vapor contamination is present. All laboratory measurements shall be based on methods that do not include inorganic carbon in the measurements.

Deriving soil dry bulk density (ρ_b). ASTM Method D2049 or D2937 or other methods approved by ADEQ may be used to derive site-specific soil bulk density values.

Deriving total soil porosity (θ_t). ASTM Method D4404 or other methods approved by ADEQ may be used to derive site-specific total soil porosity values.

Deriving soil volumetric water content (θ_w). ASTM Method D2216 or other methods approved by ADEQ may be used to derive soil volumetric water content values.

6.4 List of Chemical Default Values (K_{oc} and H_o) for Selected VOCs

Soil organic carbon-water partitioning coefficients (K_{oc}) and dimensionless Henry's Law constants (H_o) are provided for the following VOCs (see table below). These values, taken from *Soil Screening Guidance* (US EPA, 1996), are accepted by ADEQ for use in the three-phase partitioning equation. The chemicals shown are not a complete list of all potential VOCs encountered in contaminant releases, but represent those commonly encountered, those with greater potential to exist in the vapor phase, or those with greater toxicity relative to other VOCs.

Alternative K_{oc} and H_o values can be substituted for the values listed in the table below if those alternative values more accurately represent conditions encountered at a site. Sources for these values may be obtained from the *Superfund Chemical Data Matrix* (US EPA, most current editions) and the most recent version of Estimation Programs Interface Suite™ (US EPA, 2007) available at <http://www.epa.gov/opptintr/exposure/pubs/episuite.htm>. Alternative K_{oc} and H_o values based on scientific literature are subject to ADEQ approval.

Compound	K _{oc} (L/kg) ¹	H _o (dimensionless) ²
Benzene	5.89E+01	2.28E-01
Bromodichloromethane	5.50E+01	6.56E-02
Bromoform	8.71E+01	2.19E-02
Carbon disulfide	4.57E+01	1.24E+00
Carbon tetrachloride	1.74E+02	1.25E+00
Chlorobenzene	2.19E+02	1.52E-01
Chloroform	3.98E+01	1.50E-01
1,2-Dibromoethane (EDB)	2.81E+01	2.90E-02
1,1-Dichloroethane	3.16E+01	2.30E-01
1,2-Dichloroethane (DCA)	1.74E+01	4.01E-02
1,1-Dichloroethene	5.89E+01	1.07E+00
<i>cis</i> -1,2Dichloroethene	3.55E+01	1.67E-01
<i>trans</i> - 1,2=Dichloroethene	5.25E+01	3.85E-01
1,2-Dichloropropane	4.37E+01	1.15E-01
1,3-Dichloropropene	4.57E+01	7.26E-01
Ethyl benzene	3.63E+02	3.23E-01
Methyl bromide	1.05E+01	2.56E-01
Methylene chloride	1.17E+01	8.98E-02
Styrene	7.76E+02	1.13E-01
1,1,2,2- Tetrachloroethane	9.33E+01	1.41E-02
Tetrachloroethene (PCE)	1.55E+02	7.54E-01
Toluene	1.82E+02	2.72E-01
1,1,1-Trichloroethane	1.10E+02	7.05E-01
1,1,2-Trichlorethane	5.01E+01	3.74E-02
Trichloroethene (TCE)	1.66E+02	4.22E-01
1,2,4-Trimethylbenzene	3.72E+03	2.30E-01
1,3,5-Trimethylbenzene	8.19E+02	3.20E-01
Vinyl acetate	5.25E+00	2.10E-02
Vinyl chloride	1.86E+01	1.11E+00
Xylenes (total) ³	3.86E+02	2.76E-01

Ref: U.S. EPA Soil Screening Guidance: User's Guide, 2nd Edition (July 1996)

¹ - K_{oc} = organic carbon partition coefficient

² - H_o = Dimensionless Henry's Law Constant (HLC[atm-m]*41(25°C))

³ - K_{oc} and F_{oc} values for total Xylenes represent average of values for *ortho*-, *meta*-, and *para*-Xylenes.

A soil vapor unit conversion table is supplied below.

Soil Vapor Unit Conversion Factors*		
Unit	To Convert To:	Multiply by:
µg/L	mg/m ³	1
µg/m ³	mg/m ³	0.001
Ppbv	µg/m ³	MW/24
µg/m ³	Ppbv	24/MW
Ppmv	mg/m ³	MW/24
Ppbv	mg/m ³	MW/24,000
µg/L	µg/m ³	1000
µg/m ³	µg/L	0.001
µg/L	Ppbv	24,000/MW
µg/L	Ppmv	24/MW
Ppbv	Ppmv	0.001
Ppmv	Ppbv	1000

*At standard temperature and pressure.

µg/L micrograms per liter
 mg/m³ milligrams per cubic meter
 µg/m³ micrograms per cubic meter
 ppbv parts per billion by volume
 MW molecular weight
 ppmv parts per million by volume

7. Procedure References

Atlantic RBCA Version 2.0 for Petroleum Impacted Sites in Atlantic Canada, User Guidance, Appendix 9 – Guidance for Soil Vapour and Indoor Air Monitoring Assessments

California Regional Water Quality Control Board, California Department of Toxic Substances Control. Advisory – Active Soil Gas Investigations January 28, 2003.
Hartman, Blayne (2006). Part 4 – “How to Collect Reliable Soil-Gas Data for Risk-Based Applications, Specifically Vapor Intrusion: Updates on Soil-Gas Collection and Analytical Procedures.” LUSTLine Bulletin 53 September 2006

Karichoff, S.W., D.S. Brown, and T.A. Scott. 1979. Sorption of hydrophobic pollutants on natural sediments. *Water Resources Research* 13, no. 3: 241–248.

Luo, H., P. Dahlen, P. Johnson, T. Creamer, T. Peargin, P. Lundegard, B. Hartman, L. Abreau, and T. McAlary. 2006. “Spatial and Temporal Variability in Hydrocarbon and Oxygen Concentrations Beneath a Building Above a Shallow NAPL Source.” Presented at Remediation of Chlorinated and Recalcitrant Compounds, Monterey, Calif.

U.S. EPA Soil Screening Guidance: User’s Guide, 2nd Edition (July 1996)

Vapor Intrusion Pathway: A Practical Guideline, January 2007, Interstate Technology and Regulatory Council.

Wilson, L. H., P. C. Johnson, and J.R. Rocco (2005). Collecting and Interpreting Soil Gas Samples from the Vadose Zone: A Practical Strategy for Assessing the Subsurface-Vapor-to-Indoor-Air Migration Pathway at Petroleum Hydrocarbon Sites. API Soil Gas Sampling May 2005 Pre-Publication Version.

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Groundwater Sampling**

Effective Date: October 28, 2011

Number: SESDPROC-301-R2

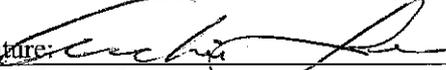
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This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
<p>SESDPROC-301-R2, <i>Groundwater Sampling</i>, replaces SESDPROC-301-R1.</p> <p>General: Corrected any typographical, grammatical and/or editorial errors.</p> <p>Title Page: Changed Enforcement and Investigations Branch Chief from Antonio Quinones to Archie Lee. Changed Field Quality Manager from Laura Ackerman to Bobby Lewis.</p> <p>Revision History: Changed Field Quality Manager to Document Control Coordinator.</p> <p>Section 1.2: Added the following statement: Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.</p> <p>Section 1.3: Omitted reference to the H: drive. Changed the Field Quality Manager to the Document Control Coordinator.</p> <p>Section 1.4: Updated references.</p> <p>Section 3: Section 3 was reorganized and rewritten to include discussions of purging strategies and inclusion of detailed procedures for micro-purging and lack of purging for “no purge” sampling situations.</p> <p>Section 3.2.1.1.2: Temperature was removed as a required chemical parameter stabilization criterion.</p>	<p>October 28, 2011</p>
<p>SESDPROC-301-R1, <i>Groundwater Sampling</i>, replaces SESDPROC-301-R0.</p> <p>General Corrected any typographical, grammatical and/or editorial errors.</p> <p>Title Page Changed title for Antonio Quinones from Environmental Investigations Branch to Enforcement and Investigations Branch</p> <p>Section 1.3 Updated information to reflect that the procedure is located on the H: drive of the LAN. Clarified Field Quality Manager (FQM) responsibilities.</p>	<p>November 1, 2007</p>

<p>Section 1.4 Updated referenced operating procedures due to changes in title names. Alphabetized and revised the referencing style for consistency.</p> <p>Section 1.5.1 Corrected the title of the Safety, Health, and Environmental Management Program Procedures and Policy Manual.</p> <p>Section 1.5.2, 4th bullet Added references to the CFR and IATA's Dangerous Goods Regulations.</p> <p>Section 2.5 Updated referenced operating procedures due to changes in title names.</p>	
<p>SESDPROC-301-R0, Groundwater Sampling, Original Issue</p>	<p>February 05, 2007</p>

TABLE OF CONTENTS

1	General Information	7
1.1	Purpose.....	7
1.2	Scope/Application	7
1.3	Documentation/Verification.....	7
1.4	References.....	7
1.5	General Precautions.....	9
1.5.1	Safety	9
1.5.2	Procedural Precautions.....	9
2	Special Sampling Considerations	11
2.1	Volatile Organic Compounds (VOC) Analysis	11
2.2	Special Precautions for Trace Contaminant Groundwater Sampling.....	11
2.3	Sample Handling and Preservation Requirements.....	12
2.4	Quality Control	13
2.5	Records.....	13
3	Groundwater Sampling Methods – Purging	14
3.1	General.....	14
3.2	Purging Methods and Strategies.....	14
3.2.1	Traditional Multiple Volume Purge	14
3.2.1.1	<i>Purging and Purge Adequacy</i>	14
3.2.1.1.1	<i>Purge Volume Determination</i>	14
3.2.1.1.2	<i>Chemical Parameter Stabilization Criteria</i>	16
3.2.1.1.3	<i>Purge Adequacy Considerations</i>	17
3.2.2	“Tubing-in-Screened-Interval” Method.....	17
3.2.2.1	<i>Purge Criteria</i>	18
3.2.2.1.1	<i>Placement of Pump Tubing or Intake</i>	18
3.2.2.1.2	<i>Conditions of Pumping</i>	18
3.2.2.1.3	<i>Stability of Chemical Parameters</i>	18

3.3	Equipment Considerations for Purging.....	18
3.3.1	Wells without Plumbing or In-Place Pumps	19
3.3.1.1	<i>Purging with Pumps</i>	19
3.3.1.1.1	<i>Peristaltic Pumps</i>	19
3.3.1.1.2	<i>Submersible Pumps</i>	20
3.3.1.2	<i>Purging with Bailers</i>	21
3.3.2	Wells with In-Place Plumbing.....	21
3.3.2.1	<i>Continuously Running Pumps</i>	21
3.3.2.2	<i>Intermittently or Infrequently Running Pumps</i>	22
3.3.3	Temporary Monitoring Wells.....	22
3.3.3.1	<i>General Considerations</i>	22
3.3.3.2	<i>Purging When Water Level Is Within Limit of Suction</i>	22
3.3.3.3	<i>Purging When Water Level Is Greater Than Limit of Suction</i>	23
3.3.3.4	<i>Considerations for Direct Push Groundwater Sampling</i>	23
3.4	Field Care of Purging Equipment	23
3.5	Investigation Derived Waste	24
4	Groundwater Sampling Methods – Sampling	25
4.1	General.....	25
4.2	Sampling Wells with In-Place Plumbing	25
4.3	Sampling Wells without Plumbing, Within the Limit of Suction.....	25
4.3.1	Equipment Available	25
4.3.1.1	<i>Peristaltic Pump, Direct from Pump Head Tubing</i>	25
4.3.1.2	<i>Peristaltic Pump/Vacuum Jug</i>	26
4.3.1.3	<i>RediFlo2® Electric Submersible Pump (with Teflon® Tubing)</i>	27
4.3.1.4	<i>Bailers.....</i>	27
4.4	Sampling Wells without Plumbing, Exceeding the Limit of Suction	27
4.5	Micro-Purge or No-Purge Sampling Procedures.....	28
4.5.1	Sampling with Pumps	28
4.5.2	HydraSleeves™	28
4.5.3	Passive Diffusion Bags	29
4.5.4	General Considerations for Micro-Purge or No-Purge Sampling	29

4.6 Sample Preservation29

4.7 Special Sample Collection Procedures30

4.7.1 Trace Organic Compounds and Metals30

4.7.2 Order of Sampling with Respect to Analytes30

4.7.3 Filtering.....30

4.8 Specific Sampling Equipment Quality Assurance Techniques.....32

4.9 Auxiliary Data Collection.....32

4.9.1 Well Pumping Rate – Bucket/Stop Watch Method32

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting groundwater samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling groundwater samples in the field. On the occasion that SESD field personnel determine that any of the procedures described are either inappropriate, inadequate or impractical and that another procedure must be used to obtain a groundwater sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Columbia Analytical Services, Lab Science News, Passive Diffusion Devices & Polyethylene Diffusion Bag (PDB) Samplers.

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

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

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

SESD Guidance Document, Design and Installation of Monitoring Wells, SESDGUID-001, Most Recent Version

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

SESD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

SESD Operating Procedure for Field Temperature Measurement, SESDPROC-102, Most Recent Version

SESD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

SESD Operating Procedure for Groundwater Level and Well Depth Measurement, SESDPROC-105, Most Recent Version

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, Most Recent Version

SESD Operating Procedure for Pump Operation, SESDPROC-203, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Potable Water Supply Sampling, SESDPROC-305, Most Recent Version

The Interstate Technology & Regulatory Council, Technology Overview of Passive Sampler Technologies, Prepared by The Interstate Technology & Regulatory Council Diffusion Sampler Team, March 2006.

United States Environmental Protection Agency (US EPA). 1975. Handbook for Evaluating Water Bacteriological Laboratories. Office of Research and Development (ORD), Municipal Environmental Research Laboratory, Cincinnati, Ohio.

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

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

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

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

US EPA. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting groundwater samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Always sample from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for cross-contamination to occur during sampling.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.

- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader and placed in the project files.

2 Special Sampling Considerations

2.1 Volatile Organic Compounds (VOC) Analysis

Groundwater samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two-week holding time, whereas unpreserved samples have only a seven-day holding time. In the great majority of cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the groundwater has a high amount of dissolved limestone, i.e., is highly calcareous, there will most likely be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles. This will render the sample unacceptable. In this case, unpreserved vials should be used and arrangements must be confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected.

Samples for VOC analysis must be collected using either stainless steel or Teflon® equipment, such as:

- Bailers must be constructed of stainless steel or Teflon®
- RediFlo2® submersible pumps used for sampling should be equipped with Teflon® sample delivery tubing
- Peristaltic pump/vacuum jug assemblies should be outfitted with Teflon® tubing from the water column to the transfer cap, which should also be constructed of Teflon®

2.2 Special Precautions for Trace Contaminant Groundwater Sampling

- A clean pair of new, non-powdered, disposable 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 in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.

- Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area if sampling devices are to be reused. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Clean plastic sheeting will be placed on the ground at each sample location to prevent or minimize contaminating sampling equipment by accidental contact with the ground surface.
- Samplers must use new, verified certified-clean disposable or non-disposable equipment cleaned according to procedures contained in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) for collection of samples for trace metals or organic compound analyses.

2.3 Sample Handling and Preservation Requirements

1. Groundwater samples will typically be collected from the discharge line of a pump or from a bailer, either from the pour stream of an up-turned bailer or from the stream from a bottom-emptying device. Efforts should be made to reduce the flow from either the pump discharge line or the bailer during sample collection to minimize sample agitation.
2. During sample collection, make sure that the pump discharge line or the bailer does not contact the sample container.
3. Place the sample into appropriate, labeled containers. Samples collected for VOC, acidity and alkalinity analysis must not have any headspace. All other sample containers must be filled with an allowance for ullage.
4. All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by ASB personnel prior to departure for the field investigation. All other chemical preservatives required for the remaining suite of analytes will be supplied by ASB personnel and will be added to the samples by SESD field personnel or other authorized persons. The adequacy of sample preservation will be checked after the addition of the preservative for all samples except for the samples collected for VOC analysis. If additional preservative is needed, it should be added to achieve adequate preservation. Preservation requirements for groundwater samples are found in the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), Most Recent Version.

2.4 Quality Control

If possible, a control sample should be collected from a location not affected by the possible contaminants of concern and submitted with the other samples. This control sample should be collected as close to the sampled area as possible and from the same water-bearing formation. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by pumps, bailers or other sampling equipment.

2.5 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in SESD Operating Procedure for Control of Records, SESDPROC-002. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with SESD Operating Procedure for Logbooks, SESDPROC-010 and SESD Procedure for Sample and Evidence Management, SESDPROC-005.

3 Groundwater Sampling Methods – Purging

3.1 General

Purging is the process of removing stagnant water from a well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation that is representative of actual aquifer conditions. In order to determine when a well has been adequately purged, field investigators should monitor, at a minimum, the pH, specific conductance and turbidity of the groundwater removed during purging and, in the case of permanent monitoring wells, observe and record the volume of water removed.

There are several purging strategies that may be used, depending on specific conditions encountered for given well sampling situations. When a specific well is characterized, based on the field investigators experience and knowledge, as having fairly typical water levels, depths and purge volumes, as determined according to the procedures in Section 3.2.1, below, SESD will normally use the multiple volume purging procedures and equipment described in Sections 3.2.1 and 3.3 of this procedure for purging the well.

When the traditional multiple volume purge method is considered and it is determined that excessive quantities of IDW would be generated using this method, it may be appropriate, under very limited and specific circumstances, to use an alternate method that reduces the time and amount of purge water to be removed prior to sampling the well. The field project leader will select the alternate method only after careful consideration of the conditions presented by the well and the impact these conditions have on all aspects of the sampling event (time required to sample, quantities of IDW requiring management, etc.).

The alternate purge procedures or sampling strategies available are the “Tubing-in-Screened Interval” method and the MicroPurge or No-Purge methods. These are described and discussed in Sections 3.2.2 and 4.5 of this operating procedure, respectively.

3.2 Purging Methods and Strategies

3.2.1 Traditional Multiple Volume Purge

3.2.1.1 Purging and Purge Adequacy

3.2.1.1.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. Specific methodology for obtaining these measurements is found in SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105).

Once this information is obtained, the volume of water to be purged can be determined using one of several methods. One is the equation:

$$V = 0.041 d^2h$$

Where: h = depth of water in feet

d = diameter of well in inches

V = volume of water in gallons

Alternatively, the volume of standing water in the well and the volume of three water columns may be determined using a casing volume per foot factor for the appropriate diameter well, similar to that in Table 3.2.1. The water level is subtracted from the total depth, providing the length of the water column. This length is multiplied by the appropriate factor in the Table 3.2.1, corresponding to either the single well volume or the triple well volume, to determine both the single well volume and triple well volumes, in gallons, for the well in question. Other acceptable methods include the use of nomographs or other equations or formulae.

TABLE 3.2.1: WELL CASING DIAMETER VOLUME FACTORS

Casing Diameter (inches)	Gallons/ft, One Water Column	Gallons/ft, Three Water Columns
1	0.04	0.12
2	0.16	0.48
3	0.37	1.11
4	0.65	1.98
5	1.02	3.06
6	1.47	4.41
7	1.99	5.97
8	2.61	7.83
9	3.30	9.90
10	4.08	12.24
11	4.93	14.79
12	5.87	17.61

With respect to volume, an adequate purge is normally achieved when three to five well volumes have 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.

3.2.1.1.2 Chemical Parameter Stabilization Criteria

With respect to the ground water chemistry, an adequate purge is achieved when the pH and specific conductance of the ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs) (twice the Primary Drinking Water Standard of 5 NTUs). Although 10 NTUs is normally considered the minimum goal for most ground water sampling objectives, lower turbidity has been shown to be easily achievable in most situations and reasonable attempts should be made to achieve these lower levels. (Note: Because groundwater temperature is subject to rapid changes when collected for parameter measurement, its usefulness is subject to question for the purpose of determining parameter stability. As such, it has been removed from the list of parameters used for stability determination. Even though temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters during well purging, as it may be needed to interpret other chemical parameter results in some situations.)

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and specific conductance varies no more than approximately 5 percent. Other parameters, such as dissolved oxygen (DO), may also be used as a purge adequacy parameter. Normal goals for DO are 0.2 mg/L or 10% saturation, whichever is greater. DO measurements must be conducted using either a flow-through cell or an over-topping cell to minimize or reduce any oxygenation of the sample during measurement. Oxidation Reduction Potential (ORP) should not be used as a purge stabilization parameter but may be measured during purging to obtain the measurement of record for ORP for the sampling event.

There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes, for example, may be sufficient. See the SESD Operating Procedures for Field pH Measurement (SESDPROC-100), Field Specific Conductance Measurement (SESDPROC-101), Field Temperature Measurement (SESDPROC-102), Field Turbidity Measurement (SESDPROC-103), Field Measurement of Dissolved Oxygen (SESDPROC-106) and Field Measurement of Oxidation-Reduction Potential (SESDPROC-113) for procedures for conducting these measurements.

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

3.2.1.1.3 Purge Adequacy Considerations

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 and recorded, during collection of the sample from the recovered volume, as the measurements of record for the sampling event.

For wells with slow recovery, attempts should be made to avoid purging them to dryness. This can be accomplished, for example, by slowing the purge rate. As water enters a well that has been purged to dryness, it may cascade down the sand pack and/or the well screen, stripping volatile organic constituents that may be present and/or introducing soil fines into the water column.

It is particularly important that wells be sampled as soon as possible after purging. If adequate volume is available immediately upon completion of purging, the well must be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells which have a slow recovery should be scheduled so that they can be purged and sampled in the same day, after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

3.2.2 “Tubing-in-Screened-Interval” Method

The “Tubing-in-Screen” method, sometimes referred to as the “Low Flow” method, is used primarily when calculated purge volumes for the traditional purging method are excessive and present issues related to timely completion of the project and/or management of investigation derived waste.

3.2.2.1 Purge Criteria

3.2.2.1.1 Placement of Pump Tubing or Intake

The peristaltic pump tubing or intake point of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. By definition, this method cannot be applied for purging with a bailer.

3.2.2.1.2 Conditions of Pumping

Prior to initiation of pumping, a properly decontaminated well sounder should be lowered into the well being sampled to monitor the static water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. If this condition cannot be met, then one of the other methods should be employed.

3.2.2.1.3 Stability of Chemical Parameters

As with the traditional purging method described in Section 3.2.1, it is important that all chemical parameters be stable as defined in Section 3.2.1.1 prior to sampling.

3.3 Equipment Considerations for Purging

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 utilized by Branch personnel will usually consist of peristaltic pumps and variable speed electric submersible pumps, but may also include bladder pumps or inertial pumps. The pump of choice is usually a function of the well diameter, the depth to water, the depth of the well 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. For wells where the water level is below the limit of suction (approximately 25' to 30', and/or where there is a large volume of water to be purged, the variable speed electric submersible pump would be the pump of choice. SESD Operating Procedure for Pump Operation (SESDPROC-203) contains the use and operating instructions for all pumps commonly used during SESD 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. Bailers, if improperly used, may also strip volatile organic compounds from the water column being sampled. If a bailer is used, it should be a closed-top Teflon® bailer.

3.3.1 Wells Without Plumbing or In-Place Pumps

For permanent monitoring wells, the depth to water (water level) and depth of the well (total depth) should be determined before purging. Caution should be exercised during this procedure to prevent cross-contamination between wells. This is a critical concern when samples for trace organic compounds or metals analyses are collected. See SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) for cleaning procedures for well sounders. After cleaning, the well sounding device should be protected to keep it clean until its next use.

3.3.1.1 Purging with Pumps

3.3.1.1.1 Peristaltic Pumps

The following step-by-step procedures describe the process of purging with a peristaltic pump:

1. Cut a length of standard-cleaned (SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) Teflon® tubing, equal to the well depth plus an additional five to ten feet. 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 Teflon® tubing into the well until the end of the tubing is just below the surface 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 the tubing detach 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. If the pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well, 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 and readiness for sampling, as described in Section 3.

3.3.1.1.2 Submersible Pumps

When a submersible pump is used for well purging, the pump itself is lowered into the water column. The pump must be cleaned as specified in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

The pump/hose assembly 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 aquifer conditions. It is recommended that the pump not be lowered more than three to five feet 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 drawdown. After the pump is removed from the well, the hose and the pump should be cleaned as outlined in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

3.3.1.2 Purging with Bailers

Standard-cleaned (SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) closed-top Teflon® bailers with Teflon® coated stainless steel leaders and new nylon rope are lowered into the top of the water column, allowed to fill, and removed. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. The use of bailers for purging and sampling is discouraged because the correct technique is highly operator dependent and improper use may result in an unrepresentative sample.

3.3.2 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 ground water sample representative of aquifer conditions. Among the types of wells identified in this section, two different approaches are necessary.

A permanent monitoring well with an in-place pump should, in all respects, be treated like a monitoring well without a pump. One limitation is that in most cases the in-place pump is “hard” mounted, that is, the pump is suspended in the well at a pre-selected depth and cannot be moved up or down during purging and sampling. In these cases, well volumes are calculated, parameters are measured and the well is sampled from the pump discharge, after volume removal and parameter conditions have been met.

In the case of the other types of wells, i.e., municipal, industrial and residential supply 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.

3.3.2.1 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.

3.3.2.2 Intermittently or Infrequently Running Pumps

If the pump runs intermittently or infrequently, best judgment should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Generally, under these conditions, 15 to 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 should be considered the measurements of record for the event.

3.3.3 Temporary Monitoring Wells

3.3.3.1 General Considerations

Procedures used to purge temporary ground water monitoring wells differ from permanent wells because temporary wells are installed 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 a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler or a Hydropunch® sampler. As such, the efforts to remove several volumes of water to replace stagnant water do not necessarily apply because stagnant water is not present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply, to the extent possible, standard permanent monitoring well purging criteria to it to re-achieve aquifer conditions.

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 conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low stress purging techniques using variable speed peristaltic pumps.

3.3.3.2 Purging When Water Level Is Within Limit of Suction

In situations where the elevation of the top of the water column is within the limit of suction (no greater than about 25 feet head difference between the pump and the water level), a variable speed 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 rate is drawing down the water level in the well. If the water level remains the same, secure the tubing at the surface to maintain this pumping level.

If drawdown is observed on initiation of pumping, reduce the pump speed and attempt to match the drawdown of the well. Sustained pumping at these slow rates will usually result in a relatively clear, low turbidity sample. If the drawdown 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.

3.3.3.3 Purging When Water Level Is Greater Than Limit of Suction

In situations where the elevation of the water table is greater than the limit of suction, peristaltic pumps cannot be used to purge temporary wells. If the temporary well is a ScreenPoint15® sampler with small diameter probe rod riser, the only practical choices for water removal are a small diameter bailer, a small diameter bladder pump or an inertial pump. If the well is to be used strictly for VOC screening, it may be acceptable to use the bailer to bail as much sediment from the well as possible prior to sampling. If metals are the analytes of concern, the bladder pump is the best choice for lowering the turbidity of the water column prior to sampling, followed next by the inertial pump. For larger diameter temporary wells, two-inch diameter or greater, bailers and the Grundfos® RediFlo2 may be used although excessive silt or other "fines" may present problems with the operation of the pump.

3.3.3.4 Considerations for Direct Push Groundwater Sampling

With many of the direct push sampling techniques, purging is either not practical or possible, therefore, no purging is conducted. The sampling device is simply pushed or driven to the desired depth and opened and the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses, i.e., the subject procedure may yield a turbid sample that is not appropriate for metals analyses.

3.4 Field Care of Purging Equipment

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 accidentally

come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. 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 large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible 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.

3.5 Investigation Derived Waste

Purging generates quantities of purge water or investigation derived waste (IDW), the disposition of which must be considered. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for guidance on management or disposal of this waste.

4 Groundwater Sampling Methods – Sampling

4.1 General

Sampling is the process of obtaining, containerizing, and preserving (if required) a 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 elastomeric products which may cause chemical interferences with the sample. Their principle of operation may also render them unacceptable as a sample collection device. 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.

4.2 Sampling 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 or physical/chemical treatment system 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 as specified in the ASBLOQAM. It may be necessary to use a secondary container, such as a clean 8 oz. or similar size sample jar or a stainless steel scoop, to obtain and transfer samples from spigots with low ground clearance. Also, refer to the discussion in the SESD Operating Procedure for Potable Water Supply Sampling (SESDPROC-305), Sec. 4.2, Potable Water Samples Collected from Wells with In-Place Plumbing. Potable well measurements for pH, specific conductance and turbidity, and possibly temperature, if warranted, should be recorded at the time of sample collection.

4.3 Sampling Wells Without Plumbing, Within the Limit of Suction

4.3.1 Equipment Available

The pump of choice for sampling ground water within the limit of suction is the variable-speed peristaltic pump. Its use is described in the following sections. Other acceptable alternatives that may be used under these conditions are the RediFlo2® electric submersible pump (with Teflon® tubing) and a closed-top Teflon® bailer.

4.3.1.1 Peristaltic Pump, Direct from Pump Head Tubing

Samples for some constituents, primarily inorganic analytes such as metals and cyanide, may be collected directly from the pump head tubing. This method is acceptable under the following conditions:

- The pump head tubing must be changed between sampling locations;

- The pump head tubing must be either be certified clean according to SESD's internal quality control program described in Section 3.2 of the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011) or
- An equipment rinsate blank is collected by pumping de-ionized water through a piece of the tubing.

4.3.1.2 Peristaltic Pump/Vacuum jug

It is not acceptable to collect samples for organic compound analyses through the flexible tubing used in the pump head. When collecting samples for organic compound analyses it is necessary to use a vacuum container, placed between the pump and the well for sample collection. The following step-by-step procedures describe the process of sampling with a peristaltic pump and vacuum jug (see note following these procedures for collection of VOC samples):

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 1-liter sample container) within a few minutes. If water does not begin to flow into the container within several 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 (limit of suction).
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. Because the 1-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 SESD

Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

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

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 “soda straw” method. The “soda straw” method involves allowing the tubing to fill, by either lowering it into the water column (A) or by filling it via suction applied by the pump head (B). If method (A) is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vial. If method (B) is used, after running the pump and filling the tubing with sample, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials. Avoid completely emptying the tubing when filling the sample vials when using method (B) to prevent introducing water that was in contact with the flexible pump head tubing. Either method is repeated, as necessary, until all vials are filled.

4.3.1.3 RediFlo2® Electric Submersible Pump (with Teflon® Tubing)

After purging has been accomplished with RediFlo2® electric submersible pump, the sample may be obtained directly from the pump discharge, provided that Teflon® tubing was used for the sample delivery line. The discharge rate of the pump should be reduced during volatile organic compound sample collection to minimize sample disturbance. Note, if the RediFlo2® electric submersible pump is used for sampling, the pump must undergo a full external and internal cleaning. In addition, pump rinsate blanks must be collected, at the appropriate frequency, to demonstrate that the pump has been adequately cleaned between wells.

4.3.1.4 Bailers

New bailer rope should be attached to the bailer via a Teflon® coated stainless steel wire. (If a bailer was used to purge the well, it may also be used to sample the well and new bailer rope is not required between purging and sampling). The bailer should be gently immersed in the top of the water column until just filled. At this point, the bailer should be slowly removed and the contents emptied into the appropriate sample containers.

4.4 Sampling Wells without Plumbing, Exceeding the Limit of Suction

All methods described previously in Section 4.3.2.1.3, RediFlo2® Electric Submersible Pumps, and Section 4.3.2.1.4, Bailers, are suitable sample methods where the water table is too deep to consider the use of a peristaltic pump for sampling.

4.5 Micro-Purge or No Purge Sampling Procedures

The Micro-Purge or No Purge sampling procedures are usually employed when it necessary to keep purge volumes to an absolute minimum. Among the Micro-Purge or No Purge procedures that might be employed are:

- Low pump rate sampling with peristaltic or submersible pumps (typical Micro-Purge sampling),
- HydraSleeve™ or
- Passive diffusion bag (PDB) sampling

The use of these procedures is acceptable only when the site hydrogeology is well understood, with respect to the hydraulic conductivity of geologic materials within the well screen interval. The underlying assumption, when employing these procedures, is that the formation in which the well is screened has a high hydraulic conductivity ($K > 10^{-5}$ cm/sec, for example), resulting in a state of equilibrium existing between the water standing in the screened interval and the formation water in which the well is screened. In this situation, the well is considered to be in a perpetually “purged” state and purging is not required.

These procedures are generally impractical for SESD to implement because of the general lack of hydrogeologic information for the sampled wells and the real necessity, in some cases, that the pumps be pre-deployed to overcome issues related to turbidity resulting from pump placement prior to sampling.

4.5.1 Sampling with Pumps

The peristaltic pump tubing or intake point of the submersible pump is placed in the approximate mid-portion of the screened interval of the well or other interval selected by the field team leader. If turbidity and its impact on metals analyses are a concern, a period of time sufficient should be allowed to mitigate effects of pump or tubing placement. After it has been determined that sampling may proceed, the pump is turned on and operated at a rate that does not cause significant drawdown of the water column, as measured using a water level sounder. During sampling, sufficient water to supply enough volume for the analytes of concern and the purge parameters is pumped. Purging should continue until purge parameters stabilize, generally three consecutive stable sets of readings, before samples are collected.

4.5.2 HydraSleeves™

HydraSleeves™ are grab sampling devices that are deployed in a closed configuration then opened in the desired interval for sample collection. The following is a summary of its operation:

1. Sampler placement - Reusable weight is attached and the HydraSleeve™ is lowered and placed at the desired position in the well screen. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. Well is allowed to return to equilibrium.

2. Sample collection - The reed valve opens to allow filling when the sampler is moved upward faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler up and down to sample a shorter interval. There is no change in water level, and only minimal agitation during collection.
3. Sample retrieval - When the flexible sleeve is full, the reed valve closes and the sampler can be recovered without entry of extraneous overlying fluids. Samples are removed by puncturing the sleeve with the pointed discharge tube and draining the contents into containers for sampling or field measurement.

4.5.3 Passive Diffusion Bags

Passive diffusion bag (PDB) samplers are bags comprised of low-density polyethylene (LDPE) plastic and containing analyte-free water, preferably with no headspace. The bags are deployed, with stainless steel weights, to the desired sample interval and are allowed to equilibrate with the water at the point of deployment in the well. A deployment period of a minimum of 14 days is recommended to ensure equilibration prior to removal.

After 14 days, the bags are opened with a puncture device or other cutting implement and the contents transferred to containers for sampling or field measurement.

4.5.4 General Considerations for Micro-Purge or No-Purge Sampling

When using the Micro-Purge method, it may be advisable to deploy the tubing or pump in advance of sample collection. Introducing the tubing or pump into the screened interval is likely to dislodge sediment and other fines that have settled or bridged on the well screen material and the gravel pack media behind the screen. If sampling is conducted immediately, turbidity issues may render this method impractical from a parameter stability standpoint.

HydraSleeves™ and PDBs must be evaluated for appropriateness for analytes of concern.

4.6 Sample Preservation

After sample collection, all samples requiring preservation must be preserved as soon as practical. Consult the ASBLOQAM 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. Samples requiring reduced temperature storage should be placed on ice immediately.

4.7 Special Sample Collection Procedures

4.7.1 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 the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205 or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206). 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 other than a peristaltic pump.

4.7.2 Order of Sampling with Respect to Analytes

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

4.7.3 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, 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 the SESD Guidance Document, Design and Installation of Monitoring Wells (SESDGUID-001).

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 USEPA 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 (groundwater 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 colloiddally-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; 2) Filtration of Ground Water Samples for Metals Analysis; and 3) Ground Water Sampling - A Workshop Summary. See Section 1.4, References, for complete citation for these documents.

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; 2) Handbook for Evaluating Water Bacteriological Laboratories; and 3) Microbiological Methods for Monitoring the Environment, Water and Wastes. See Section 1.4, References, for complete citation for these documents.

4.8 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground water samples shall be cleaned as outlined in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) and repaired, if necessary, before being stored at the conclusion of field studies. Cleaning procedures utilized in the field or field repairs shall be thoroughly documented in field records.

4.9 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 levels measured according to the SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105), well volume determinations (Section 3.1.1, Purging and Purge Adequacy), pumping rates during purging (see below), and occasionally, drillers or boring logs. This information should be documented in the field records.

4.9.1 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.