MASTER
QUALITY ASSURANCE PROJECT PLAN

of the
Hazardous Waste Remediation Bureau
Waste Management Division
New Hampshire Department of Environmental Services

This document serves as the QAPP for all sites being investigated and/or remediated through contracts administered by the HWRB and any sampling by HWRB staff.

EQA RFA# 13027

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Master Quality Assurance Project Plan (QAPP) of the Hazardous Waste Remediation Bureau (HWRB), Waste Management Division (WMD), New Hampshire Department of Environmental Services (NHDES), November 2012, EQA RFA# 13027

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DISTRIBUTION LIST

Upon approval and implementation of this Master Quality Assurance Project Plan (QAPP) for the Hazardous Waste Remediation Bureau (HWRB), the original shall be kept with the HWRB Quality Assurance (QA) Coordinator; with a copy placed with the New Hampshire Department of Environmental Services (NHDES) QA Manager.

The control version of this document is the electronic version viewed on-line only. If this is a printed copy of the document, or any part of the document (e.g., text, standard operating procedures), it is an uncontrolled version and may or may not be the version currently in use.

The current official version of the HWRB Master QAPP will be available on the NHDES website[1]. Other links may be provided as seems appropriate.

The following people will be notified of the location of the official (most current) version of the HWRB Master QAPP by email:

- All HWRB Personnel
- The contact person for each contractor approved by NHDES to perform work for the HWRB
- The contact person for each contractor approved by the responsible parties to perform work at Superfund Sites in New Hampshire
- Others, as required

[1] *http://des.nh.gov/organization/divisions/waste/hwrb/documents/hwrb_master_qapp.pdf*

LIST OF ACRONYMS

ASTM	ASTM International
CC	Cubic Centimeter
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CGI	Combustible Gas and Oxygen Detector
COC	Chain of Custody
COPC	Contaminant of Potential Concern
DOD	Department of Defense
DQO	Data Quality Objectives
EHP	Environmental Health Program
ELAP	Environmental Laboratory Accreditation Program
EMD	Environmental Monitoring Database
Env-A	Air Program Rules
Env-C 300	Laboratory Accreditation Rules
Env-Hw	Hazardous Waste Rules
Env-Or	Oil & Remediation Program Rules
Env-Ws	Drinking Water Rules
EPA	Environmental Protection Agency
FID	Flame ionization detector
FSS	Federal Sites Section of the Hazardous Waste Remediation Bureau
GMZ	Groundwater Management Zone
GPS	Global Positioning System
HASP	Health and Safety Plan
HWRB	Hazardous Waste Remediation Bureau
ID	Inside Diameter
ISO	International Standards Organization
l	Liter
LFS	Low Flow Sampling
MDL	Method Detection Limits
ml	Milliliter
MtBE	Methyl Tert-Butyl Ether
NAPL	Non-Aqueous Phase Liquid
NCP	National Contingency Plan
NHDES	New Hampshire Department of Environmental Services
NHDHHS	New Hampshire Department of Health & Human Services
NHDPHS Lab	NHDHHS Public Health Services Laboratory Services Unit
NIST	National Institute of Standards & Technology
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NPL	National Priorities List
NTU	Nephelometric Turbidity Units
OD	Outside Diameter
ORCB	Oil Remediation & Compliance Bureau

LIST OF ACRONYMS – Continued

ORP	Oxidation Reduction Potential
OSHA	Occupational Safety and Health Administration
PEHB	Permitting & Environmental Health Bureau
PIC	Public Information Center
PID	Photoionization Detector
PM	Project Manager
POE	Point of Entry
PQO	Project Quality Objectives
PRP	Potentially Responsible Party
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAC	Quality Assurance Coordinator
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
QSM	Quality Systems Manual
RDL	Reporting Detection Limits
RI/FS	Remedial Investigation and Feasibility Study
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SOP	Standard Operating Procedure
SRP	Site Remediation Program
Teflon	Teflon®
USEPA	United States Environmental Protection Agency
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compounds
WMD	Waste Management Division

1.0 INTRODUCTION

This generic Master Quality Assurance Project Plan (QAPP) has been prepared to ensure that all sample collection and data generation activities associated with the HWRB yield data that are of adequate quality for their intended use. This document serves as the QAPP for all sites being investigated and/or remediated through contracts administered by the HWRB and any sampling by HWRB staff. This QAPP may also be adopted by sites being investigated and/or remediated through contracts administered by Region 1 of the United States Environmental Protection Agency (EPA) or the responsible parties, if appropriate and all parties agree. This QAPP does not intend to apply to sites which are contaminated primarily with petroleum products and administered by the Oil Remediation & Compliance Bureau (ORCB) or the Methyl tert-Butyl Ether (MtBE) Remediation Bureau. Nor does it cover any laboratory's quality assurance programs other than in general terms.

This master QAPP is composed of standardized elements covering routine components of a project from planning, through implementation, to assessment. Information not covered in this QAPP will be included in sampling and analysis plans (SAPs), which will be site-specific and written as needed. See **Appendix F** for an example of a SAP outline. These plans will include at a minimum: site maps, sample locations, site-specific organizational chart, the number and type of environmental data collection activities; data quality objectives specific to applicable action levels and data quality criterion; data validation, documentation including a quality control section, and any non-routine data collection/measurement activities not included in this Master QAPP; and will be approved by the appropriate Project Manager, with a copy provided to the NHDES QA Manager.

All procedures must be in accordance with applicable professional technical standards, EPA requirements, the New Hampshire Department of Environmental Services (NHDES) Administrative Rules, specific Waste Management Division (WMD) requirements, other applicable government regulations or guidelines; and specific project goals and requirements.

1.1 Overview of the Hazardous Waste Remediation Bureau

The HWRB deals with releases of hazardous substances and is part of the Site Remediation Program which is responsible for overseeing the cleanup of contaminated sites. The major objective of the HWRB is to investigate and clean up contaminated sites and return those sites to productive use.

The HWRB is divided into two main sections: a State Sites Program, and a Federal Sites Program. The State Sites Program comprises a Brownfields section and a Groundwater Remediation Permitting section. The Federal Sites Program comprises a Superfund Sites Management section and a Department of Defense Sites section.

Contractors are procured using standard State of New Hampshire practices as outlined in RSA 21-I:22. For specific sites, contractors are selected by the Program Manager based on their availability, their skills related to the issues found at the site and the recommendations of the Project Manager. Work-Scopes are typically written by the contractor based on input from the Project Manager and cover what the Project Manager is requiring the contractor to do. SAPs are typically written by the

contractor or the HWRB Quality Assurance Coordinator (QAC) and cover how the contractor is going to accomplish what was required in the Work-Scope. SAPs are typically written when sampling is required. The Project Manager approves Work-Scopes and SAPs, with input from the Quality Assurance Coordinator. See **Appendix F** for an example of a SAP outline.

1.2 Project Organization, Responsibilities and Communication Pathways

A graphic illustration of the project organization and communication pathways can be found in **Appendix A**. These are considered to be general pathways of communication and do not restrict communication between all parties, as necessary. The roles and responsibilities are described in greater detail in **Appendix A**.

- The Quality Assurance Manager (QAM) is the key NHDES individual responsible for quality assurance (QA). The QAM reports to the Commissioner's Office and communicates directly with the QA Coordinator (QAC).
- The QA Coordinator reports to the HWRB Administrator and is the liaison between the QA Manager and all other HWRB personnel. When the New Hampshire Division of Public Health Laboratory (NHDPHS Lab) or the current NHDES Contract Lab is used, the QA Coordinator is the liaison between each lab and the Project Manager. The QA Coordinator reviews the Superfund sampling reports received from the NHDPHS Lab for quality control.
- The section supervisors report to the HWRB Administrator and interact directly with the Project Managers, the QA Coordinator, the contractor, and EPA.
- The Project Managers report to the section supervisors and coordinate activities with the QA Coordinator, contractor, NHDPHS Lab, the NHDES Contract Lab, the Environmental Health Program (EHP) for their assessment of possible health effects, and EPA.
- The contractor coordinates activities directly with their staff, the Project Manager, the QA Coordinator, and the appropriate laboratory.
- When the NHDPHS Lab is used, the lab typically reports the State Site analytical results to the appropriate Project Manager and Superfund analytical results to the QA Coordinator, after having audited the results in accordance with their standard operation procedures (SOPs).
- When the current NHDES Contract Lab is used, the lab typically reports the analytical results to the QA Coordinator, Project Manager, and the contractor, after having audited the results in accordance with their SOPs. Refer to the SAP for specific requirements.
- The Environmental Health Program (EHP) in the Permitting & Environmental Health Bureau (PEHB) reports risk assessment determinations to the appropriate Project Manager and may communicate with QA personnel or the contractor as necessary.
- EPA communicates with the QA personnel, the Administrator, the section supervisors and the Project Managers.

1.3 Project Description

Assessment and remedial activities at hazardous waste sites may include the following:

- Initial Site Assessments.
- Historical Phase IA/IB Archaeological Sensitivity Assessments.
- Phase II and III Site Assessments.
- Risk Characterization/Assessment.
- Groundwater Management Zone Permitting.
- Groundwater Permit Monitoring.
- Remedial Action Plan Preparation.
- Bench/Pilot Testing of Proposed Remedial Approach.
- Remedial Action Implementation.
- Long Term Monitoring.

Site characterization activities involving sampling and analytical testing may include, but not be limited to, the following Phase II Investigation activities:

- Geophysical Surveys.
- Test Pit Explorations.
- Test Borings/Installation of Monitoring Wells.
- Hydrogeological testing.
- Soil Gas Surveys.
- Soil, Gas, and Groundwater Sampling.
- Surface Water and Sediment Sampling.
- Vapor Intrusion Studies.

Each SAP shall include a description of the anticipated tasks based on the NHDES-approved Work-Scope for that project. See **Appendix F** for an example of a SAP outline.

In general, the contaminants of concern are volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) and metals. Other contaminants shall be investigated as appropriate.

1.4 Quality Assurance Objectives

The primary QA objective for all projects is to ensure that all measurements are representative of actual site conditions and that all data resulting from field, sampling, and analytical activities be comparable and generated in a scientifically valid and legally defensible manner. It is important that the data collected are of known and documented quality. Any party generating data under this program has the responsibility to implement minimum procedures to ensure that the precision, accuracy, completeness, and representativeness of the data are known and documented.

The use of accepted, published sampling and analysis methods, as well as the use of standardized units, aid in ensuring the comparability of the data. The SOPs, as included in **Appendix C** of

this project plan, have been developed to meet this objective. In addition, it is important that all Site monitoring wells are locked at all times or within a secure locked area to ensure the integrity of the well, any samples collected and the chain of custody.

Data quality objectives (DQOs) are qualitative or quantitative statements developed by the data user to specify the quality of the data needed from a particular activity to support specific decisions. The DQOs are the starting point in designing a sampling program. The DQO development process matches sampling and analytical capabilities to the data targeted for specific uses and ensures that the quality of the data meets project requirements. Specific DQOs will be discussed in the SAP as they are unique to each project.

General DQOs include the following:

- To produce an accurate description of conditions at the site.
- To allow an objective assessment of exposure pathways and risks to receptors.
- To evaluate the risk to human health and the environment in accordance with current regulatory standards, (e.g., detection limits must be sufficiently low to compare to the regulation or statute that governs the sampled media).
- To establish long-term trends in contaminant levels to support future site management decisions.
- To evaluate the effectiveness of a treatment system or other remedial strategy.

In general, the objectives of long-term environmental monitoring are to monitor the effectiveness of the remedial action in achieving risk reduction.

Long-term groundwater monitoring is a component of the remedial alternatives selected for many sites. The project quality objectives (PQOs) for long-term groundwater monitoring are used to evaluate the concentrations of contaminants of potential concern (COPC) and natural attenuation processes in groundwater in order to:

- Verify that groundwater containing COPCs in excess of the remediation goal concentrations does not migrate past the Groundwater Management Zone (GMZ) compliance boundaries.
- Verify reductions in COPC concentrations, on-going natural attenuation processes for the plumes in which the natural attenuation alternative has been selected, and plume attenuation rates.
- Determine if the remedial alternatives are operating properly and successfully.
- Determine when groundwater concentrations no longer exceed criteria protective of human health.

General DQOs for geologic data are in conformance with professional standards and agency requirements, completeness, and consistency with known information about the site and its environs.

Some specific geologic/hydrologic/hydrogeologic data types:

- Soil textures/classifications, stratigraphy, bedrock types, fracture patterns: recorded in several types of boring logs and test pit logs; for bedrock (uncommon) direct measurement of dip & strike and/or analysis of aerial photography for bedrock fracture patterns.
- Geophysical investigation records (e.g., ground-penetrating radar, electromagnetic detection).
- Hydraulic conductivity, porosity/effective porosity, groundwater flow patterns (in 2 or 3 dimensions), flow rates & velocities (especially for groundwater), and fate analysis of plumes.
- Occurrence/extent/thickness of non-aqueous-phase liquids ("NAPLs"), both light ("LNAPL") and dense ("DNAPL").
- Monitoring well construction logs (more a necessary record than "data").

Note that all data points of all types must be accurately located in 3-dimensional space. The expected accuracy for global positioning system (GPS) data collection activities shall be recorded in the SAP and in accordance with site needs. For instance, collecting GPS data on a cluster of wells that are within three feet of each other may require more data points and greater accuracy in order to distinguish the separate wells on a map, versus locating a building on the site.

The HWRB will accept the limits of precision and accuracy for analytes that have been established by the NHDPHS Lab and the current NHDES Contract Lab unless otherwise noted in a SAP. In general, the HWRB will accept the Method Detection Limits (MDLs) and the Reporting Detection Limits (RDLs) established by these two labs, however, the Project Managers may request alternate limits to meet their quality objectives. Alternate limits requested by Project Managers will be documented in the SAP.

When outside laboratories are used it is the Project Manager's responsibility to ensure that the laboratory's quality assurance program, including the lab's MDLs, RDLs and limits of precision and accuracy for any quality control sample, support their DQOs and PQOs.

At a minimum, each SAP shall contain a summary table of analytical test methods, laboratory RDLs and regulatory action limits for all compounds tested on site. See **Appendix G**: Example Table - Site Analytes, Regulatory Standards and Lab Criteria.

1.5 Training, Personal Protection and Safety

Personnel shall have received training in accordance with Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120 (e) including annual refresher courses. All training shall be documented. Training records shall be maintained by the employer of the staff and be available upon request. Standard safety practices shall be employed, and appropriate protective clothing shall be worn during all site visits.

Appropriate and effective health and safety practices shall be integrated into all daily operations to promote safe and healthful working conditions. At a minimum, procedures shall comply with OSHA and other applicable local, State, and Federal laws and regulations.

1.6 Documentation and Records

Upon approval and implementation of this Master QAPP, the original shall be kept with the HWRB QA Coordinator and a copy shall be provided to the NHDES QA Manager. The current official version of the Master HWRB QAPP will be available on the NHDES website[2]. Paper copies generated for use on a particular job are not considered official copies.

Please note that this is a dynamic document and subject to revision. At a minimum, this QAPP will be reviewed annually, and updated if necessary, as part of the NHDES Quality Assurance Program[3]. This document shall be valid for a period of up to five years from the official date of approval.

The QA Coordinator will notify all HWRB personnel and the contact person for each contractor of any revisions to this QAPP by email.

All HWRB Project Managers will be required to review this QAPP and sign the "QAPP Project Personnel Log Sheet" which documents that they have reviewed this QAPP and will follow the procedures as described.

The contact person for each contractor will be required to review this QAPP and sign the "QAPP Project Personnel Log Sheet," which documents that they have reviewed this QAPP and that their company will follow the procedures as described.

The "QAPP Project Personnel Log Sheet" is found in **Appendix I** of the QAPP. The original signed log sheet is kept with the HWRB QA Coordinator.

1.6.1 Documentation of Field Activities

Field personnel shall use field logbooks and/or pre-printed field worksheets to accurately document all field activities: on-site conditions, field measurements, sample collection information, field instrument maintenance and calibration information, global positioning system (GPS) coordinates and other pertinent site-related information during monitoring activities. All information shall be recorded in permanent ink (black ink is preferred; red ink and Sharpie® pens are not acceptable). Refer to **Appendix E** for Well Sampling Worksheet currently being used by the HWRB.

[2] *http://des.nh.gov/organization/divisions/waste/hwrb/documents/hwrb_master_qapp.pdf*

[3] http://des.nh.gov/organization/commissioner/p2au/pis/qap/index.htm

The field notes shall include a description of field conditions that includes, as a minimum:

- Site location.
- Date, start, and finish times of the work and weather conditions.
- Name and initials of person making entry.
- Names of other personnel or visitors present, if any.
- Purpose and summary of proposed work effort.
- Details of any deviation from the field operations plan or standard operating procedures, including who authorized the deviation.
- Field observations.
- Sampling equipment used (including make, model and serial number) and equipment calibration documentation (including standards used, lot numbers and expiration dates).
- Field screening methods, if used, and a description of screening locations.
- Field screening results; identifying samples with both field and fixed lab analyses.
- Fixed laboratory sample identification number, sample type (composite, grab), sample matrix (e.g., aqueous, soil, sediment), time of sampling, sample analysis, and sample locations shown on a near-scale map relative to a fixed landmark.
- Sample handling, packaging, labeling, and shipping information (including destination).
- Location, description and unique identifier for all photographs taken in association with the field activity.
- GPS coordinates, as appropriate.
- Any other pertinent information.

Information recorded in other site documents (e.g., sampling worksheets) will not be repeated in logbooks except in summary form.

Any corrections to the logbook or other written documentation shall be initialed and dated. All corrections shall be shown as a single line “strike out” through the original. The unused bottom portion of each page shall be lined-out, initialed, and dated.

1.6.2 Technical Reports of Field Activities

Technical reports documenting the findings of site sampling work shall be submitted to NHDES. The type, number and contents shall be determined by the NHDES Project Manager and specified in the SAP.

Each report may include, but is not limited to, the following information:

- Summary of sampling activities.

- A copy of the complete laboratory report, including the chain of custody forms and applicable data validation reports.
- A list of equipment used, including make, model and serial number.
- All calibration information including the calibration log which contains the standards used, lot numbers, expiration dates, calibration checks, etc.
- A copy of all field sampling sheets and logbook pages.
- Site map.
- Data summary tables of the compounds of concern detected at each sampling location during the current sampling event, highlighting any compounds that exceed any applicable standards and cleanup goals.
- Data summary tables showing the history of the compounds of concern detected at each sampling location, highlighting any compounds that exceed any applicable standards and cleanup goals, with graphs of the same.
- Water level and elevation table(s) showing historical data.
- Groundwater potentiometric surface map.
- Isoconcentration contour maps for Site compounds of concern.
- A quality assurance/quality control (QA/QC) section. See below for specifics;
- Recommendations for any remedial action.
- Recommendations for future modifications to the current monitoring program or to the SAP, if appropriate.

In addition, the report should include the following geological data as appropriate:

- Back-up geologic data: Boring/test pit logs, well construction logs, geophysical investigation data sheets. Drilling or other exploration methods must be specified. How the depth to bedrock is determined must be specified.
- The report should state what survey/locating methods are used. For elevations, a statement as to the vertical datum (e.g., NGVD or ad-hoc on site benchmark) used; the location of the benchmark used should be shown. If locations are plotted on a base map previously prepared, the source of the base map needs to be specified.
- The system of soil texture classification should be specified, such as the “Unified Soil Classification System” (USCS).
- State what method is used to generate contour maps.
- State what historical records (geologic & soil maps, agency files, historical aerial photos, etc.) are to be reviewed.
- The method of measuring hydraulic conductivity, like any field test method, should be specified. Note that this key parameter can usually only be realistically measured to the nearest order of magnitude. (It can range from 10^{2} to 10^{-11} cm/sec).

1.6.2.1 Quality Assurance/Quality Control Section of Report

This section should include general statements summarizing whether or not the quality control criteria in the SAP and QAPP were met in the field and in the lab. List any QA/QC problems and how they were resolved. Anything unusual that will affect the quality or usability of the data shall be noted.

If the quality control criteria was not met:

- How does that affect the usability of the data?
- Can the data be used? If not, why not?
- Was any corrective action needed and what, if any, measures were taken?
- What changes are recommended for the future?

Examples of possible issues:

- Were contaminants found in the equipment blanks?
- Were any sample containers broken in transport to the lab?
- Did the lab report any difficulties or issues?
- Were the sample tags mixed up in the field if the results look abnormal?

1.6.3 Document Handling and Retention Times

In order to comply with Waste Management Division Submittal Guidelines[4], the Department requests that all reports be submitted electronically though OneStop[5]. You may call 603-271-7379 for assistance. All draft documents must specify "Draft" in the title.

All site related reports and project plans including QAPPs, SAPs, laboratory reports, site sampling reports, and annual reports shall be submitted and maintained in electronic project files and reviewed by the appropriate Project Manager to evaluate the usability of the data and ensure compliance with the elements of this QAPP. Copies of the lab reports and pertinent information shall be provided to the EPA Project Manager, upon request.

Information collected for enforcement or litigation purposes shall be held in a separate confidential electronic file unless specifically released to the open file by the New Hampshire Department of Justice.

Electronic project files shall be located on the NHDES computer network server and available to view on the OneStop website[6]. These files are backed up on a regular basis by the Office of Information Technology. Additional information is provided in Chapter 7, section 7.6, Network

[4] http://des.nh.gov/organization/divisions/waste/orcb/documents/electronic_submittal_guidelines.pdf

[5] https://www2.des.state.nh.us/OnestopDataProviders/DESLogin.aspx

[6] http://des.nh.gov/onestop/index.htm

Management, Data Back Up, Data Recovery Procedures, and Virus Protection of the current NHDES Quality Management Plan (QMP)[7].

Retention and archiving of records is done in accordance with specific statutory or regulatory requirements (additional guidance is provided in Chapter 6 of the current NHDES QMP). See **Appendix J** for the current HWRB Records Retention Policy.

Contractor records shall be maintained for seven (7) years following completion of the project. At the end of the retention period, the Contractor shall offer the records to the State. If the State declines to accept the records, the records become the property of the Contractor.

1.6.4 Sample Identification

All sample labels will include a site identifier, location of sample, and indication of the needed test/analysis. Samples being entered into the NHDES Environmental Monitoring Database (EMD) shall follow the specifications below, otherwise, samples shall be identified in a unique way such that the site, sample location, media and desired analysis is clear; so that relevant samples and documentation can be found and sorted easily.

If sample results are to be entered into the EMD, sample identification must be compatible with the EMD format using a designated NHDES station identification (ID). It is the HWRB Project Manager's responsibility to provide the contractors with the correct station IDs. New station IDs must conform to the EMD requirements and must be fifteen (15) characters or less; all letters must be uppercase. For the federal (Superfund) sites, the site prefix and underscore is included in the fifteen characters (e.g., "KMC_" as in "KMC_MW-3010"). The station IDs can only be added to the database by certain qualified personnel at this time. See the Program Manager for the correct personnel for this task.

- Sample duplicates are typically identified by adding "DUP" (in capital letters) to the end of the station ID. There must be one space between the sample ID and DUP (example "KMC_MW-3010 DUP"). The "space DUP" will not affect the fifteen (15) character name. If blind duplicates are required, the duplicate sample will be given a separate station ID. The station ID of the original sample must appear as the "Alias ID" of the duplicate station ID in the EMD to ensure that the samples are correctly associated with each other. Blind duplicates must be properly identified in the SAP. In cases where blind duplicates are required, the alias information should be redacted from the copy of the SAP that is provided to the lab.
- Equipment Blanks (Field Blanks) must be labeled "EQUIP BLANK" (in capital letters) without any other designation. This is an EMD requirement. The equipment from which the equipment blank was collected must be indicated in the comments section of the chain of custody form. The description of the equipment blank must be as short as possible so the laboratory can include the description on the sample's analytical results sheet.

[7] http://des.nh.gov/organization/commissioner/pip/publications/co/documents/r-co-06-3.pdf

- Trip Blanks must be labeled "TRIP BLANK" (in capital letters) without any other designation. There should only be one trip blank per chain of custody form except when trip blanks require different preservatives, such as for VOCs and for some 1,4-dioxane methods, for the same batch of samples (e.g., VOCs typically require hydrochloric acid and 4º C +/- 2º C; whereas some 1,4-dioxane methods only require 4º C +/- 2º C).

1.7 Data Assessment

All data generated shall be reviewed by the contractor and the Project Manager to ensure that the data has met the objectives and requirements of this QAPP and that the results are technically valid, reliable and usable.

Geologic data will be assessed by the project professional for conformance with professional standards and agency requirements, completeness, and consistency with known information about the site and its environs. The project professional will signify this review by affixing his/her Professional Engineering or Geologist stamp on the report.

Sampling and analytical results shall be reviewed to determine if:

- Corrective action is necessary.
- The sampling plan should be revised.
- The site should be re-sampled.

In order to ensure that the data has met the objectives and requirements of this QAPP and that the results are technically valid, reliable and usable, data shall be reviewed and compared with relevant documentation such as:

- Available historical data.
- Laboratory MDLs and RDLs.
- Standards established in site-specific records of decisions (RODs), if applicable.
- Standards and methods established in the current New Hampshire Certified Administrative Rules[8], including but not limited to, the Contaminated Sites Management Rules (Env-Or 600), which contain the Ambient Groundwater Quality Standards (AGQS) and the Soil Remediation Standards; Drinking Water Quality Standards (Env-Dw-700); Surface Water Quality Regulations (Env-Wq 1700); and Ambient Air Quality Standards (Env-A 300).
- Current Waste Management Division requirements such as the requirements for VOC analysis"[9] concerning the updated "Full list of Analytes for Volatile Organics", and the lower reporting limit for 1,4-dioxane[10].

[8] http://des.nh.gov/organization/commissioner/legal/rules/index.htm

[9] http://des.nh.gov/organization/divisions/waste/hwrb/documents/voc_changes.pdf

- Current Department Policies, including but not limited to, the Risk Characterization and Management Policy[11].
- Other pertinent documents as needed.

If data of questionable quality is reported or other quality control issues are uncovered, the Project Manager shall report the issues to the QA Coordinator and/or QA Manager. The Project Manager, with input from quality assurance personnel, shall determine the usefulness of data in question and, at minimum, shall summarize that data concerns in the report for which the data was generated.

The need for corrective action, including the collection of new or additional samples, shall be determined based on the data quality objectives for the project and with input from quality assurance and other appropriate personnel. If corrective action is necessary, it will be carried out as described in Section 1.8 - Corrective Action.

The lab performs validation of test data in accordance with their procedures. The level of data validation, such as Tier I and Tier II validation, shall be identified in the site-specific SAP by the Project Manager in consultation with the QA Coordinator. For guidance on data validation, please refer to the EPA New England Environmental Data Review Program, found on the EPA website[12].

It is the contractor's responsibility to ensure that all sampling procedures and techniques are conducted in accordance with the SAP and the QAPP. This can best be achieved by the use of field audits. When long term monitoring is required, field audits on each sampling procedure/activity shall be conducted by the contractor at the beginning of the first sampling event and periodically thereafter to ensure that the sampling procedures and techniques are conducted in accordance with the QAPP. Field audits shall also be conducted if the field team is changed from one sampling round to the next or the scope of work for the project changes significantly from one sampling round to the next. If corrective action is necessary, it will be carried out as described in Section 1.8 - Corrective Action.

EPA and/or NHDES quality assurance personnel shall periodically conduct separate field audits and review field methods, analytical procedures and/or document tracking and record keeping practices to ensure compliance with the elements of this QAPP. When long term monitoring is required, field audits on each sampling procedure/activity shall be conducted by NHDES quality assurance personnel, preferably once the contractor has completed their initial field audit and made any appropriate corrections, and periodically thereafter to ensure that the sampling procedures and techniques are conducted in accordance with the QAPP. Field audits shall also be conducted if the field team is changed from one sampling round to the next or the scope of work for the project changes significantly from one sampling round to the next. Both the

[10] http://des.nh.gov/organization/divisions/waste/hwrb/sss/hwrp/documents/report-limits14dioxane.pdf

[11] http://des.nh.gov/organization/divisions/waste/hwrb/sss/hwrp/guidance_documents.htm

[12] http://www.epa.gov/region1/oeme

NHDES and contractor project managers, along with the contractor's QA officer, should be present during the EPA and /or NHDES audits (unless the audits are unannounced).

1.8 Corrective Action

Corrective actions must be taken as soon as possible when data or field procedures are found to be of questionable quality. Any suspected problems shall be brought to the attention of the NHDES Project Manager and the QA Coordinator.

The need for corrective action may be identified in many ways. The corrective action steps are:

- Identification and definition of the problem.
- Investigation of the problem.
- Determination of the cause of the problem and appropriate corrective action (this may include the need for additional training).
- Implementation of the corrective action.
- Verification that the problem has been corrected.
- Modification of procedures, as necessary, to prevent recurrence.
- Documentation of the events.

2.0 MONITORING AND SAMPLING PROCEDURES

This section focuses on sampling and testing for chemical parameters, describes the overall design of the field program and includes the specific information necessary to conduct the monitoring and sampling components of the program. Monitoring and sampling procedures, sample handling and custody requirements, analytical method requirements, and the quality control (QC) requirements are presented below and in the associated appendices. Some of this discussion (e.g., design of sampling methods, chain-of-custody procedures) is applicable for other data-related purposes, such as testing for physical soil properties or for geological/geotechnical parameters.

2.1 Generic Sampling Strategies and Procedures

Sampling situations may vary with the media encountered during site sampling projects and projects may be of a simple or complex nature. Liquid, solid phase media and/or vapor phase media may occur in containers, drums, tanks, soils, sediments, pore water, wastewaters, runoff waters, surface waters, waste piles, lagoons, ponds, sludges, well points, piezometers and overburden and bedrock monitoring wells. The composition of media being sampled will vary considerably in the volume, size, physical state, and hazardous/chemical properties. In addition the site situation may have specific factors that affect sampling tasks, such as: accessibility, climate, waste generation/handling, transitory events and other site hazards.

Sampling personnel shall be responsible for collecting representative samples of impacted, or potentially impacted, media at sampling site locations and to ensure they are obtained in accordance with sampling procedures/methods found herein, in the SAP, and other approved reference documents.

The Project Manager is responsible for determining the number of samples and the method of sample collection in accordance with standard operating procedures, site conditions, and project requirements. Economic/financial resources/constraints, time allocation, availability of personnel, equipment, site conditions and sample variability are factors the Project Manager shall consider and review in the development of a SAP.

Examples of acceptable sampling methods are: simple random sampling, stratified random sampling, systematic random sampling, composite sampling; grab sampling, biased and unbiased sampling, low flow purging and sampling, modified low flow purging and sampling, diffusion bag sampling, discreet interval sampling (such as with a Hydrasleeve or Kemmerer), the snap-sample technique and groundwater/surface water interface sampling (pore water sampling). These methods are explained herein and in the referenced documents. See **Appendix C** for the current SOPs in this QAPP.

Depending on circumstances and needs, it may not be possible or appropriate to follow the SOPs exactly in all situations due to site conditions, equipment limitations, and limitations of the standard procedures. When it's necessary to perform an activity that does not have a specific SOP, or when the SOP cannot be followed, existing SOPs may be used as general guidance or SOPs similar to those found in this QAPP may be adopted if they meet the data quality objectives of the project. All modifications or adoptions shall be approved by the Project Manager and documented in the SAP. Any modifications made in the field shall be documented along with the justification and included in the final report of the event.

Refer to the current New Hampshire Code of Certified Administrative Rules, Env-Or 600 Contaminated Site Management[13], Env-Or 610.02 (e) for a list of documents containing environmental sampling methods not found in **Appendix C**, Standard Operating Procedures of this QAPP. Those documents are also listed in the References section at the end of this document and identified with an asterisk (*).

2.2 Sampling Equipment

The choice of sampling equipment and sample containers will depend upon the media being sampled and site considerations. The sampling equipment shall be selected to ensure that a representative sample is collected. **Appendix B** Sampling Equipment / Field Equipment has a list of equipment most commonly used, however, additional equipment may also be used as needed. Sampling equipment shall be clean (decontaminated) before use to minimize the potential for cross-contamination and whenever possible, new/unused sampling equipment shall be utilized. The HWRB requires that a fiberglass measuring tape or other accurate measuring device be used when measuring and installing tubing.

[13] http://des.nh.gov/organization/commissioner/legal/rules/documents/env-or600.pdf

The SAP shall require pertinent information, including the make, model and serial number, on all equipment necessary for field sampling and health and safety purposes to be documented. Copies of the operating instruction manuals and calibration procedures shall be kept with the equipment and in the contractor/HWRB files. The SAP shall require that all manufacturers' equipment manuals and any manufacturer-provided repair kits will be on-site at all times during the sampling event.

2.3 Decontamination

See **Appendix C** for the Decontamination SOP. Lab personnel can assist in determining an appropriate solvent. Disposable sampling equipment shall be discarded after completing the sampling task and not reused. Decontamination of equipment generates investigative derived waste (contaminated rinse liquids, sludge, etc.) that may need to be containerized onsite until proper disposal arrangements are made. The Project Manager will use professional judgment and guidance documents such as the Guide to Management of Investigation-Derived Wastes, EPA 93-45303fs-s, January 1992[14], on a site by site basis to determine if the levels of contamination are sufficiently low so that disposal at a hazardous waste facility is not necessary, and shall document it in the SAP.

2.4 Instrument Calibration and Maintenance

In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested and inspected according to the manufacturer instructions. All of the instruments shall be calibrated, and have the calibration checked, according to the SOP in the SAP prior to the sampling event (up to a week) and at the beginning of each sampling day at the Site to ensure they are working properly. The calibration is checked after each calibration to ensure the instrument was calibrated properly. The calibration shall be checked again at the end of the day of use to ensure that the instruments have remained in calibration throughout the day. In addition, should any erratic or illogical readings occur between calibrations, the instrument shall be recalibrated in order to ensure that representative measurements are obtained. All calibration, check values and maintenance activities shall be documented on a calibration log in a manner that is traceable to the equipment. Refer to the Calibration of Field Instruments SOP in **Appendix C** for specific calibration procedures and a Calibration Log. Copies of the operating instruction manuals and calibration procedures shall be kept onsite with the equipment as well as in the contractor/HWRB files. All instrument readings shall be recorded in the sampler's calibration log and field notebook/worksheet.

Each SAP shall contain the following tables**:**

1. A table listing equipment, calibration frequency, calibration standards, calibration acceptance criteria and corrective action.
2. A table listing equipment, maintenance and frequency.

See examples on the following pages.

[14] http://www.epa.gov/superfund/policy/remedy/pdfs/93-45303fs-s.pdf,

Example: Field Equipment - Calibration and Corrective Action Table

Parameter	Calibration Standards	Acceptance Criteria For The Daily Calibration Checks [1]	Calibration Frequency	Corrective Action
Multi-parameter Meters: YSI models 600XL/XLM or 6820				
Dissolved Oxygen (DO) & Temperature	Calibrated to 100% Water Saturated Air Use 0 mg/L DO solution to check	0-0.5 mg/L for the Zero (0) mg/L solution	Daily Calibration at the beginning of the day. Calibration Check at the beginning of the day, after calibration. Calibration Check at the end of the day.	**Daily Calibration** Recalibrate with the appropriate standards. If it is still outside the acceptance criteria then replace with a different unit. **Calibration Checks:** If outside the criteria at the beginning of the day, recalibrate the instrument with new standards. If recalibration is unsuccessful, replace the unit. If outside the criteria at the end of the day, the data will be qualified by the contractor.
Oxidation Reduction Potential (ORP)	Zobell Solution Is used to calibrate and check	+/- 5%		
Specific Conductance	718 µS/cm to Calibrate 1413 µS/cm as a check [2]	+/- 5%		
pH	7, 4, 10 units Use pH 7 to check	+/- 5%		
Hach 2100 P or 2100Q Turbidity Meter	Calibrate to <0.1, 10, 20, 100, and 800 NTUs as appropriate for each meter. Use 20 NTUs to check 2100P and the 10 NTU to check the 2100Q.	+/- 5% for 2100P +/- 10% for 2100Q		
MiniRae 2000/3000 PID	Zero air Isobutylene-in-air standard.	+/- 5 %		

Table Notes:

[1] The calibration checks are a check of the instrument against the calibration standards and are performed in the "measurement or run" mode. This is not recalibration, but rather a check.

[2] It is permissible to calibrate with either of the specific conductivity standards and use the other standard to check the calibration.

[3] Use StablCal® Formazin Primary Turbidity Standards.

Example: Field Equipment - Preventive Maintenance Table

Instrument	Activity	Frequency
Electronic Water Level Indicator	Battery Check	Daily
QED Bladder Pump Controller Model MP-10	Battery Check	Daily

Instrument	Activity	Frequency
Multi-Parameter Water Quality Meters: YSI models 600XL/XLM or 6820	Calibration and Calibration Check – pre-sampling event	Once Prior to Sampling Event
	Battery check Calibration – beginning of day Calibration check – beginning of the day Possible mid-day calibration check Calibration check – end of day	Daily
Hach 2100 P or 2100Q Turbidity Meter	Calibration and Calibration Check – pre-sampling event	Once Prior to Sampling Event
	Battery check Calibration – beginning of day Calibration check – beginning of the day Possible mid-day calibration check Calibration check – end of day	Daily
Photoionization Detector (PID) MiniRae 2000/3000	Calibration and Calibration Check – pre-sampling event	Once Prior to Sampling Event
	Battery check Calibration – beginning of day Calibration check – beginning of the day Possible mid-day calibration check Calibration check – end of day	Daily

2.5 Field Screening Instruments

At some sites sampling personnel may be required to use field instruments such as an organic vapor photoionization detector (PID) meter or a combustible gas and oxygen detector (CGI) to evaluate the safety of the site or sampling areas prior to initiating sampling. These instruments shall be calibrated, and have the calibration checked, according to the SOP in the SAP prior to the sampling event and at the beginning of each sampling day at the Site to ensure they are working properly. The calibration is checked after each calibration to ensure the instrument was calibrated properly. The calibration shall be checked again at the end of the day of use to ensure that the instruments have remained in calibration throughout the day. In addition, should any erratic or illogical readings occur between calibrations, the instrument shall be recalibrated in order to ensure that representative measurements are obtained. All calibration, check and maintenance activities shall be documented on a calibration log in a manner that is traceable to the equipment. Copies of the operating instruction manuals and calibration procedures shall be kept onsite with the equipment as well as in the contractor/HWRB files. All instrument readings shall be recorded in the sampler's calibration log and field notebook/worksheet.

2.6 Laboratory Services

Analytical services shall be provided by laboratories which are currently certified by the EPA[15] or accredited by the New Hampshire Environmental Laboratory Accreditation Program, Env-C 300[16], (the National Environmental Laboratory Accreditation Conference [NELAC] standards). NHDES also accepts analytical results from the Region 1 EPA Laboratory in Chelmsford, Massachusetts. The laboratories providing the services should, wherever possible, be accredited for the specific matrix / method / analyte for which testing is required. In some cases, this may not be practical; then a laboratory that is accredited for the equivalent technology (e.g., GC-MS, ICP-MS) shall be used, subject to Project Manager approval. Additional information on accredited laboratories and the NH Environmental Laboratory Accreditation Program may be found on the NHDES Website[17].

Each laboratory shall have their own quality assurance manual and standard operating procedures (SOPs) which are not covered in this QAPP. For projects which use a field laboratory, the Project Manager and QA Coordinator will work with the specific laboratory to assure that quality control measures meet the DQOs of the particular project or event. Additionally, confirmatory samples may be submitted to an accredited lab for analysis.

Each SAP shall contain a summary table of analytes, analytical test methods, regulatory action limits and the laboratory reporting limits (detection limits as needed) for all compounds tested on site. See **Appendix G** Site Analytes, Associated Regulatory Standards & Lab Criteria for an example table.

The NHDES Waste Management Division has established specific analytical requirements for VOCs, including a "Full List of Analytes for Volatile Organics" (Full List). For more information, refer to the NHDES website[18]. The NHDPHS Laboratory's 8260B list is the same as the Full List; however the limits for the compounds with the asterisk are not as low as on the list. If you need to reach those limits, different methods are required. Other laboratory's 8260B method may not include the Full List.

In addition, the WMD now requires a lower reporting limit for 1,4-dioxane (from 3 µg/L to 0.25 µg/L). Specific information for 1,4-dioxane is available on the NHDES website[19]. The NHDPHS laboratory analyzes 1,4-dioxane by EPA Method 522 with a reporting limit of 0.20 µg/L. A list of other accredited laboratories for low level 1,4-dioxane is also located on the NHDES Website[20].

[15] http://water.epa.gov/scitech/drinkingwater/labcert/index.cfm
[16] http://des.nh.gov/organization/divisions/water/dwgb/nhelap/categories/rules.htm
[17] http://des.nh.gov/organization/divisions/water/dwgb/nhelap/index.htm
[18] http://des.nh.gov/organization/divisions/waste/hwrb/documents/voc_changes.pdf
[19] http://des.nh.gov/organization/divisions/waste/hwrb/sss/hwrp/documents/report-limits14dioxane.pdf
[20] http://des.nh.gov/organization/divisions/water/dwgb/nhelap/documents/low-level-dioxane-lab-list.pdf

2.7 Sample Volume, Containers and Labeling

Containers used for collecting samples shall be compatible with the media being sampled and analysis to be performed. Containers shall be obtained from the analytical lab and shall be clean, free of contamination, and, if required, contain the proper preservative. Care shall be taken during sampling to ensure that material is not spilled onto the outer surface of containers and that lids are secured tightly after sampling. The volume sampled shall be in accordance with the analytical lab's requirements. Containers shall be labeled with the date and time sampled, sample location, collectors initials, sample number, project name or number, preservative and any other pertinent information. Information shall be documented in field notebooks/worksheets and chain of custody forms, where applicable.

2.8 Sampling Preservation and Holding Times

Holding times and sample preservation shall be in accordance with the analytical method and/or the analytical lab's requirements, whichever are more stringent. When sampling containers include preservatives, care shall be taken during the sampling process to ensure the preservative is not spilled or diluted by overfilling. Preservation, storage conditions and sampling time shall be recorded in field notebooks/worksheets and chain of custody forms, where applicable.

Each SAP shall contain a summary table of the media, analysis, test methods, containers, sample volumes, preservation and hold times. See **Appendix H** for an example summary table of Media and Laboratory Requirements.

2.9 Chain of Custody and Sample Delivery Procedures

See **Appendix C** for the Chain of Custody Sample Handling & Shipping SOP. Samples and unused sample containers shall remain in the sample collector's view at all times, unless locked in a vehicle or other secure place. It is the sampler's responsibility to ensure that the samples are not tampered with prior to their delivery to the analytical lab. The Chain of Custody (COC) form shall be completed to provide documentation tracing sample possession and handling from the time of collection through delivery to the analytical lab, and shall accompany the samples at all times. The COC is a legal document that may become instrumental in a litigation purposes.

Analytical laboratories often require the use of a specific COC form. The current NHDPHS Laboratory COC form is attached as **Appendix D**. If other COC forms are required, they shall be specified in the SAP. Labeling of samples on the COC shall be consistent with the sample container labeling described in Section 2.7 (above).

The completed original COC shall be attached to the analytical report which is submitted to the HWRB, and becomes part of the permanent project record. The original COC forms and associated analytical results for State Lead Superfund Sites shall be sent to the QA Coordinator for review.

Samples shall be properly packaged in a cooler for shipment to maintain sample integrity and delivered to the analytical laboratory along with a separate signed COC form enclosed in each sample cooler. Samples must be delivered in a manner consistent with the requirements of the analytical laboratory with respect for preservation, temperature and holding times for the particular analytes to be tested. Custody seals shall be used when the cooler is sent to the laboratory by independent courier, unless otherwise specified in the Site SAP.

2.10 Laboratory Sample Management

Lab personnel shall log the samples into their laboratory information management system in accordance with their standard operating procedure. The samples shall be inspected by the Laboratory Sample Controller or other qualified laboratory personnel. A Sample Receipt Checklist shall be used to document the receipt of the samples and shall include checks for breakage, correct container and preservative, sample temperature, holding times, and for other factors that may affect quality. The samples shall be compared to their description on the COC form, and discrepancies in the number or the designations of the samples shall be noted on the form and shall be brought to the attention of the person who relinquished the samples to the lab. If necessary, the contact person on the chain of custody may be contacted for further instruction. Because samples may be held in the lab untouched until discrepancies are resolved, there could be an impact on sample holding times.

The COC form shall be signed and the date and time shall be recorded to formally accept the samples into laboratory custody. The analytical laboratory shall assign laboratory numbers to the samples, and these numbers shall be recorded on the chain of custody forms.

2.11 Sample Quality Control

The following are routine field quality control samples.

- Trip Blanks

  Trip blanks for VOC samples shall be prepared by the laboratory prior to the sampling event using analyte-free water. One trip blank typically consists of two volatile organic analysis (VOA) vials. The trip blanks shall accompany the sample containers to the field, during collection and transportation and shall be submitted with the other samples for analysis. **There shall be only one set of trip blanks per chain of custody per VOC sample cooler,** except when trip blanks require different preservatives for different methods***.** The analysis of this blank will provide a baseline measurement of VOC contamination to which the samples may have been exposed to in the field and during transport.

  > ***Note: Consult with the specific laboratory for their requirements. Separate trip blanks may be required for VOCs and 1,4-dioxane.** (e.g., VOCs typically require hydrochloric acid and 4 ºC +/- 2 ºC; whereas some 1,4-dioxane methods only require 4 ºC +/- 2 ºC).

- Duplicate samples

  Field duplicates are collected to determine precision of samplers and the sampling procedure. They are typically no longer used to determine the precision of the laboratory, except in the cases of a blind duplicate, where the duplicate may serve a dual purpose. Each laboratory has their own quality assurance program which includes quality control samples such as duplicates, matrix spike samples and matrix spike duplicates.
  At a minimum, duplicate samples shall be collected for each batch of 20 samples per matrix, per analysis, or one duplicate per sampling trip for each media sampled if fewer than 20 samples are taken on that particular trip. The duplicates shall be collected at the same time, in the same manner as their corresponding routine samples. In other words, duplicate samples shall be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC sample, VOC duplicate sample; SVOC sample, SVOC duplicate sample). Field duplicates shall be identified in the field notes and logged on the chain of custody forms.

- Matrix Spike/Matrix Spike Duplicate (MS/MSD) Samples

  A Matrix Spike (MS) is a separate aliquot of the sample spiked by the laboratory with known concentrations of the analytes of interest. It is routinely performed in duplicate as the Matrix Spike Duplicate **(**MSD). The primary purpose of these MS/MSD analyses is to establish the applicability of the overall analytical approach (e.g., preparative, cleanup, and determinative methods) to the specific sample matrix from the site of interest. MS and MSD samples shall be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., SVOC sample, SVOC MS sample, SVOC MSD sample). If duplicates are also collected, the order is typically as follows: 1,4-dioxane sample, 1,4-dioxane duplicate sample, 1,4-dioxane MS sample, 1,4-dioxane MSD sample. MS/MSD samples shall be identified in the field notes and logged on the chain of custody forms.

  There are generally two types of MS/MSD samples:

  a) <u>Lab QC MS/MSD Samples</u>:

     A laboratory may require the collection of extra sample bottles as part of their quality assurance program**.** If so, indicate that in the comments section on the COC (e.g., "Lab MS/MSD QC or "Lab MS/MSD-SVOCs" specifying the analysis). The lab typically does not report these results. The number of sample containers on the COC will also change to indicate the extra bottles. These lab QC samples should not be on a separate line on the COC. The NHDPHS lab typically requires extra sample bottles for their internal QC for both SVOC and 1,4-dioxane analysis. One set of MS/MSD samples are generally collected for each batch of 10 or 20 samples. Refer to the specific lab and the site-specific SAP for MS/MSD requirements.

  b) <u>Site MS/MSD Samples</u>:

     A SAP may require MS/MSD samples to be collected at a specific location, and require the lab to report those results, as part of a site-specific sampling program

if matrix interference is suspected. If so, indicate that in the comment section on the COC (e.g., "MS/MSD Report Results" or "MS/MSD-SVOCs Report Results," specifying the analysis if it is not required for each analysis). The number of sample containers will also change to indicate the extra bottles for the MS/MSD sample. These MS/MSD samples may be on a separate line on the COC. Refer to the specific lab and the SAP for MS/MSD requirements.

- Equipment Blanks

  Equipment blanks consists of a sample of deionized (analyte-free) water which has been poured around and through sample collection equipment to determine if contamination has occurred due to improper cleaning and/or contamination of equipment. They shall be handled like any other sample (e.g., preserved) and submitted with the other samples for analysis. The frequency shall be determined based on the type of sampling that occurs and additional equipment blanks shall be required for changes in sample matrix or equipment type as specified in the SAP. If dedicated equipment is used, an initial equipment blank is required; no additional equipment blanks are required. Equipment blanks shall not be required where disposable sampling equipment is used.

- Background Samples

  Upgradient samples may be taken to determine the local naturally occurring conditions. The background samples shall be used as control samples and taken outside the area of contamination. These results shall be compared against actual contaminated sample results. The use of background samples shall be specified in the SAP.

- Split Samples

  Split samples may be collected to compare the analytical results from one laboratory to another using the same techniques or methods, or to compare the analytical results of different laboratory techniques or methods to determine whether they are generally equivalent. Split samples are identical samples that are collected from the same location at a given time, and divided into two or more portions. Split samples may be collected for one analyte, for a group of analytes, or for all analytes that are being quantified. The number of split samples to be collected shall be determined by the Project Manager and documented in the SAP.

  Split samples cannot always be placed in identical sample containers due to the differing quantity or container requirements of various analytical laboratories. It is difficult to accurately split a heterogeneous sample, such as a soil sample, and the sampling team should distribute the sample as uniformly as possible and fill split containers for one analyte at a time. If the sample collection device contains insufficient sample, an equal portion of the sample should be placed in each of the split sample containers and additional sample should be collected and split to fill the containers.

All SAPs shall include the following quality assurance tables:

- A table of the summary of quality assurance samples for that sampling event. See **Appendix I** for an example of a Table of Summary of Quality Assurance Samples.
- A summary Table of Field Quality Control Requirements in the text of the SAP, such as the example below.

Example: Field Quality Control Requirements Table

QC Sample	Frequency	Acceptance Criteria	Corrective Action
Trip Blanks	1 per cooler containing VOC samples (1 trip blank = 2 VOA vials)	No contaminants are detected	Flag in project report (or as specified in SAP)
Equipment Blanks	• If dedicated equipment used, an initial equipment blank is required. No additional equipment blanks are required. • If non-dedicated equipment is used, one equipment blank per sampling event, per equipment type is required.	No contaminants are detected	Flag in project report (or as specified in SAP)
Duplicate	• A minimum of 1 duplicate per batch of 20 samples, or one duplicate per sampling trip for each media sampled if fewer samples are taken on that particular trip; per matrix; per parameter. ▪ A minimum of one duplicate for each sampling method (e.g.. low flow sampling, purging 3 volumes, Barcad, sediment, surface water, pore water) shall be collected per matrix, per analysis.	Duplicate concentrations are within +/- 30% for aqueous samples and 50% for solid samples	Flag in project report (or as specified in SAP)
MS/MSD (Matrix spike / matrix spike duplicate) samples	These will be separate and in addition to the duplicate sample collected above. Refer to the specific lab and the SAP for MS/MSD requirements. Examples: • The NHDPHS Lab requires: Four 1-liter amber bottles for one sample for SVOCs instead of the usual 2 bottles; (4 bottles total: 2 sample & 2 QC); and Two 1-liter amber bottles for one sample for 1,4-dioxane instead of the usual one bottle for MS samples (2 total bottles: 1 sample & 1 QC). • The EPA Lab typically requires additional volume for all samples to accommodate MS/MSD and other lab QC samples.	Method Specific	Flag in project report (or as specified in SAP)

Notes:

1) Sample duplicates are typically identified by adding "DUP" to the end of the station ID (e.g., GIL_T-8-3 DUP).

2) Trip blanks will be prepared by the appropriate laboratory and maintained at all times with the sample containers. The trip blank will be designated "TRIP BLANK".
3) Equipment blank samples will be designated as "EQUIP BLANK". Note that a comment is required on the chain of custody indicating what the equipment blank is for (e.g., water level meter).
4) Refer to the Summary of Quality Assurance Samples Table in the SAP for the analysis required for each QC sample collected. sampling event (see **Appendix I** for an example of that table.)

3.0 REFERENCES

Refer to the most recent editions of the following:

U.S.EPA. 1999. The Region 1, EPA-NE Compendium of QAPP Requirements and Guidance, Final October 1999 with Attachments

___. 2006. EPA Requirements for Quality Assurance Project Plans. EPA QA/R-5

___. 2010. Region 1, Calibration of Field Instruments, EPA SOP. (Draft-June 1998) January

___. 1996. Region 1, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells. EPA SOP #GW-0001. July. Revised January 2010

___. * 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. EPA/625/R-96/010b Second Edition, January

___. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual, Athens, GA. November[21]

___. * 2007. SW 846 Test Methods for Evaluation Solid Waste, Physical/Chemical Methods. US EPA, February

___. * 1992. RCRA Ground-Water Monitoring: Draft Technical Guidance, PB87107751, US EPA, November

___. 1987. A Compendium of Superfund Field Operation Methods. EPA 540/P-87/001, August.

___. 1986. Test Methods for Evaluations Solid Waste, Third Edition. EPA SW 84

___. * 1985. Practical Guide for Ground-Water Sampling. EPA 600/2-85/104, September

___. 1982. Handbook for Sampling and Sample Preservation of Water and Waste Water. EPA 600/4-82/029

* American Society for Testing Materials (ASTM) International, Standards Related to Environmental Sampling. 2014. Fifth edition ASTM SAMP14

___. * 2009. Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds. ASTM D4547-09.

___. * 2013. Standard Practice for Environmental Site Assessments: Phase 1 Environmental Site Assessment Process (ASTM E 1527-13),

[21] http://www2.epa.gov/aboutepa/about-region-4s-science-and-ecosystem-support-division-sesd

___. * 2010 Standard Guide for Risk Based Corrective Action (ASTM E 2081-00(2010)e1)

___. * 2010. Standards on Environmental Site Characterization, Fourth Edition (SITECD-10)

___. 2008. Standard Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites. ASTM D5088-02(2008)

___. 2013. Standard Guide for Sampling Groundwater Monitoring Wells. ASTM D4448-01(2013).

State of New Hampshire. New Hampshire Department of Environmental Services Quality Management Plan.[22]

___. New Hampshire Department of Health & Human Services, Division of Public Health Services Laboratory (NHDPHS Lab) Quality Systems Manual

* These documents are listed in the current New Hampshire Code of Certified Administrative Rules, Env-Or 600 Contaminated Site Management[23], Env-Or Appendix B - Incorporated References, and contain environmental sampling methods not found in **Appendix C**, Standard Operating Procedures of this QAPP.

[22] http://des.nh.gov/organization/commissioner/pip/publications/co/documents/r-co-06-3.pdf

[23] http://des.nh.gov/organization/commissioner/legal/rules/documents/env-or600.pdf

APPENDICES

APPENDIX A

PROGRAM ORGANIZATION AND RESPONSIBILITIES

ORGANIZATIONAL CHART

PROGRAM ORGANIZATION AND RESPONSIBILITIES

In accordance with the Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP), and the New Hampshire Department of Environmental Services (NHDES) Quality Management Plan (QMP), the following individuals will be responsible for major activities performed in the project plans. Class specifications and supplemental job descriptions covering education and experience requirements for specific positions under state law are available through the NHDES Division of Personnel.

The program manager shall be responsible for ensuring that staff have and maintain appropriate training. NHDES provides in-house training and provides for staff participation in other training, such as local and regional workshops. All HWRB personnel and contractors shall be certified by the Unites States Environmental Protection Agency (EPA) training course Personnel Protection and Safety (165.2) or Hazardous Materials Incident Response Operations (165.5). Annual refresher courses are required. The QA Manager and the QA Coordinator shall receive specific QA/QC training as needed to ensure that both are qualified to perform the tasks relating to the QAPP. This training may include conferences and training classes provided by private industry, the NHDES or EPA. Additional training shall be provided for all personnel as it is deemed necessary.

Quality Assurance (QA) Manager

- Oversees the implementation of the NHDES quality systems.
- Maintains independence and impartiality of the data quality review.
- Has no data gathering or reviewing responsibilities that would lead to a possible conflict with the QA Manager role.
- Serves as the liaison between the NHDES and the QA staff at EPA Region I on Quality Assurance/Quality Control (QA/QC) matters.
- Provides interpretations of NHDES QA/QC policies and coordinates the development of policies and procedures that are consistent with the EPA requirements and NHDES goals.
- Performs the reviews, assessments, and audits.
- Provides technical assistance to support the overall mission of NHDES.
- With program managers, develops guidance on QA/QC issues for use within NHDES.
- Resolves any disputes that may arise regarding quality assurance issues within or between various NHDES units.
- Ensures that all program managers and staff understand and implement applicable quality assurance procedures.
- Ensures proper procedures are being followed through system and performance audits.

Quality Assurance (QA) Coordinator

- Responsible for the preparation of this QAPP, an annual review of the QAPP, any necessary revisions, and notifying all appropriate personnel of such.

- Responsible for adhering to the QAPP and assuring that the QAPP is adhered to by the Bureau.
- Works with the QA Manager to develop an acceptable quality assurance program for all environmental data generated or processed relating to the HWRB.
- Identifies and responds to QA needs and answers requests for guidance or assistance.
- Maintains lines of communication with the New Hampshire Department of Health & Human Services, Division of Public Health Services Laboratory (NHDPHS Lab) to ensure that all information for staff is received, problems are resolved and corrective actions are implemented.
- Receives and reviews the Superfund analytical reports from the NHDPHS Lab for quality control.
- Reviews site-specific SAPs to ensure that they adhere to the QAPP.
- Assists Project Managers in reviewing site sampling reports to ensure that they adhere to the QAPP and the site-specific SAPs.
- Assists QA Manager in ensuring that proper procedures are being followed.
- Serves as the primary contact between the HWRB and the current NHDES Contract Lab.

Program Manager

- Responsible for ensuring that staff and State contractors follow the approved QAPP.
- Administers state and federal hazardous waste site programs and policies, ensuring that they are properly implemented.
- Supervises and provides technical assistance to engineers, hydrogeologists, environmentalists, and waste management specialists involved in activities associated with the study and remediation of hazardous waste sites to ensure that all projects are completed in a timely and appropriate manner.
- Responsible for selecting the appropriate contractor for specific sites, with input from the Project Manager.
- Reviews work performed by staff and others to ensure that all projects are conducted in accordance with the best professional practices.
- Assists the Division Director in establishing and implementing Division policies and procedures.
- Provides technical support to the Attorney General’s Office as required in order to properly negotiate settlements with potentially responsible parties.
- Coordinates Department activities to secure permits and clearances from state and federal agencies to ensure that the remedial activities are in compliance with applicable environmental regulations.
- Coordinates with the EPA.
- Responsible for ensuring that personnel have appropriate training and follow appropriate safety procedures.

Project Managers

- Responsible for ensuring that all site work is consistent with the QAPP.
- Responsible for the development and approval of Work-Scopes and site specific SAPs.

- Develops and administers multidisciplinary investigations and remedial actions at hazardous waste sites.
- Coordinates with the EPA Remedial Project Managers (RPMs).
- Ensures that approved procedures meet the project objectives.
- Responsible for implementation of recommendations made by QA Manager and/or QA Coordinator.
- Responsible for initiating corrective actions.
- Reviews and approves all site procedures.
- Reviews all site related documentation.
- Ensures that appropriate sampling and analytical procedures are followed.
- Monitors schedules for field, analytical, and data validation activities.
- Coordinates and oversees all sampling and analytical data assessment activities.
- Coordinates with the appropriate lab for analytical support services.
- Coordinates with the Environmental Health Program for risk assessment evaluations.
- Ensures that the analytical method detection limit is reasonable for the analytical parameters selected and the media sampled.
- Monitors grant money and budget and reports financial activities to EPA.
- Authorizes spending for equipment, samples and sampling supplies.

Permitting & Environmental Health Bureau

- The Environmental Health Program (EHP) in the Permitting & Environmental Health Bureau (PEHB) provides services related to health risk assessments.

New Hampshire Department of Health & Human Services, Division of Public Health Services Laboratory (NHDPHS Lab)

- Coordinates with the QA Coordinator, the appropriate project managers, and the contractors for analytical support services.
- Ensures that sufficient quality assurance activities are conducted to demonstrate that all data generated by the lab is scientifically valid, defensible, and of known precision and accuracy.
- For further detail on QA/QC activities of the NHDPHS Lab, contact the lab for their QA/QC Program Plan.

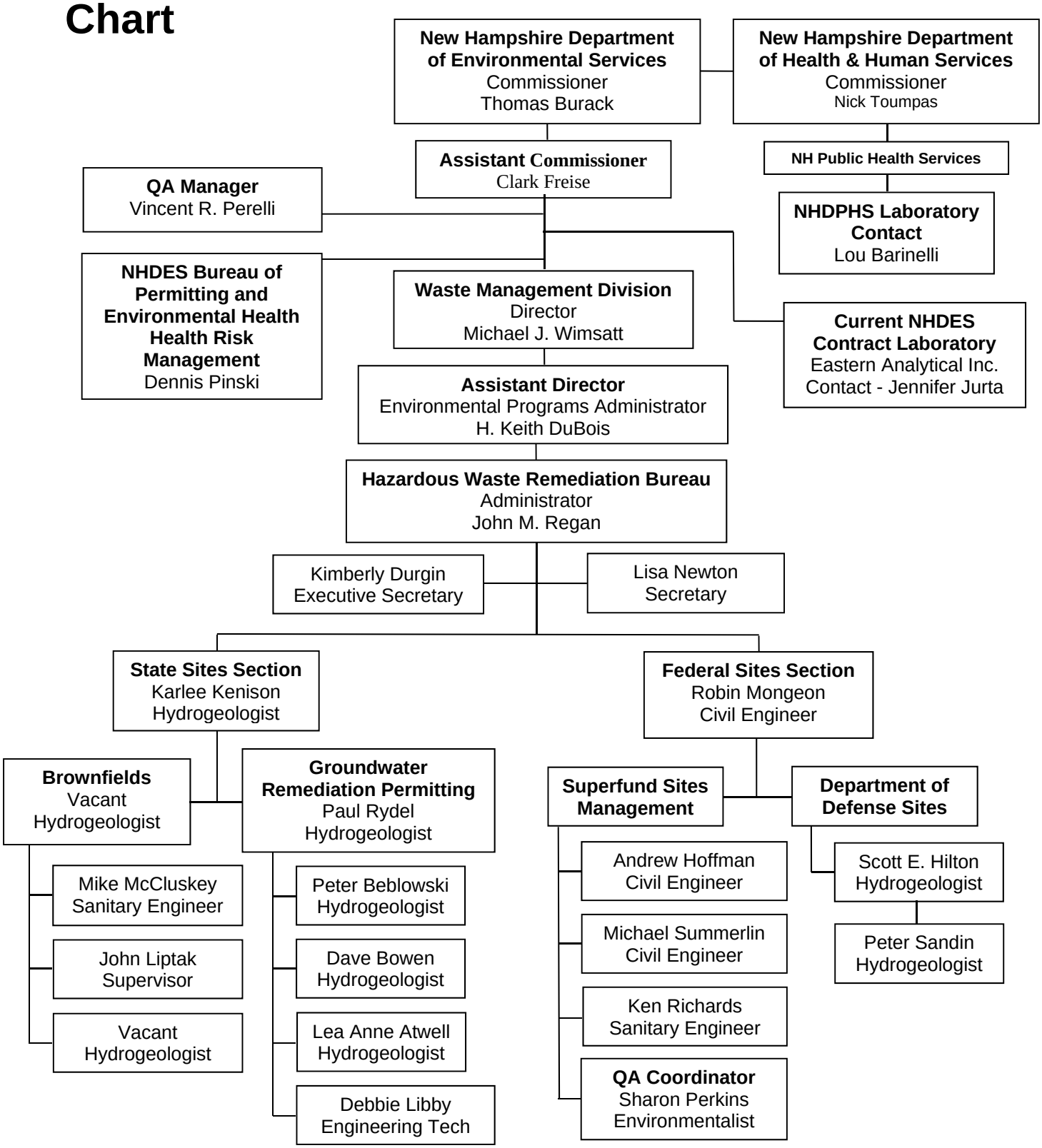
Current NHDES Contract Laboratory

- Contracted by NHDES for a two year period to deliver analytical support services.
- Coordinates with the QA Coordinator, the appropriate project managers, and the contractors for analytical support services that the NHDPHS lab does not provide.
- Ensures that sufficient quality assurance activities are conducted to demonstrate that all data generated by the lab is scientifically valid, defensible, and of known precision and accuracy.
- For further detail on QA/QC activities of the Contract Lab, contact the lab for their QA/QC Program Plan.

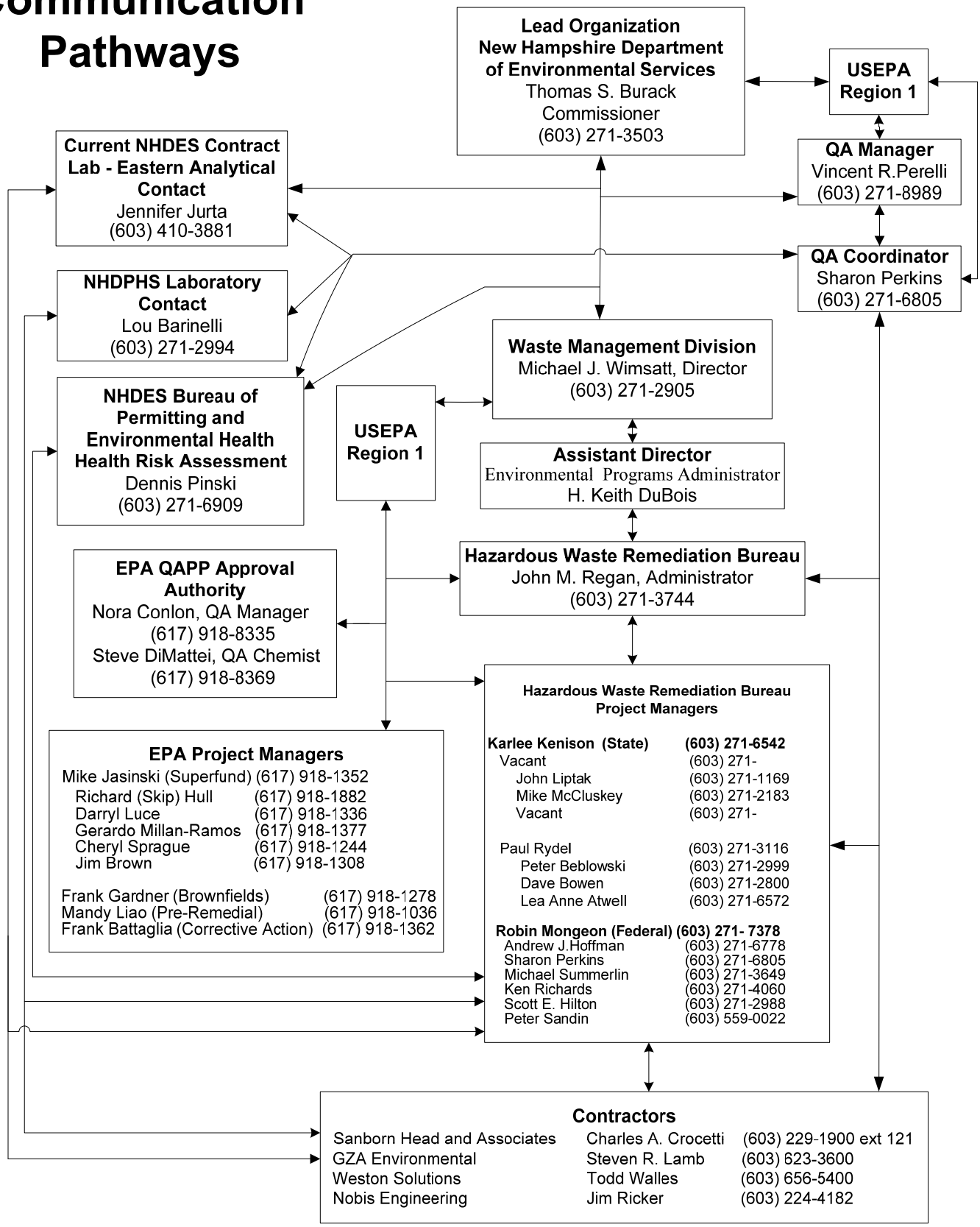
Contractor

- Responsible for following the approved QAPP and any approved site specific SAPs.
- Responsible for training their personnel in the proper sampling techniques, operation of field instruments, including calibration and troubleshooting techniques, and procedures as required, ensuring compliance with this QAPP and any site-specific SAPs. Training records shall be maintained by the employer of the staff and be available upon request.
- Overall contract management ensuring that established protocols and approved procedures are used.
- Coordinates with the Project Manager in the development of Work-Scopes.
- Coordinates with the Project Manager and QA Coordinator in the development of the site specific SAP.
- Performs QA aspects of the project including:
  - Data review, including an in-house examination to ensure data has been recorded, transmitted, and processed correctly.
  - Development of the Health and Safety Plan (HASP).
  - Any data validation reports required to ensure that the data has met the objectives and requirements of this QAPP and that the results are technically valid, reliable and usable.
  - QA Field audits conducted by the contractor QA Officer during monitoring events observing all sampling related activities including equipment calibration, multi-media sampling, QC sampling, and decontamination activities to ensure that all procedures and techniques are conducted in accordance with the site-specific SAP and the current HWRB QAPP.
  - The contractor Project Manager and QA Officer shall be present during NHDES / EPA field audits (unless the audits are unannounced).
- Prepare periodic project technical reports documenting the findings of site sampling work. The reports will include all field notes and worksheets, equipment calibration logs, analytical laboratory reports, QC data and recommendations for the future, as specified in the SAP.
- Coordinates sampling and field activities with the NHDES Project Manager and the appropriate lab.
  - Responsible for on-site coordination of field monitoring and sampling activities. Ensures that samples are collected in accordance with the QAPP, SAP and approved QA procedures.
  - Responsible for the equipment for field activities.
  - Responsible for sample chain-of-custody protocols and sample delivery to the lab.
  - Responsible for the collection of representative field samples.
  - Responsible for delivering the samples to the appropriate lab.
  - Responsible for periodic auditing of field monitoring and sampling activities as outlined in the SAP
- The site-specific SAPs shall contain more detailed descriptions of Contractor responsibilities and the role of specific personnel (e.g., Project Manager and QA Officer).

Organizational Chart



Communication Pathways



APPENDIX B

SAMPLING EQUIPMENT / FIELD EQUIPMENT

SAMPLING EQUIPMENT / FIELD EQUIPMENT

This is a list of equipment most commonly used; additional equipment may also be used as needed.

Calibration of the field instruments will be conducted daily, prior to the use in the field. The field equipment will be maintained, calibrated and operated in a manner consistent with approved standard operating procedures (SOPs), manufacturer's guidelines and United States Environmental Protection Agency (USEPA) standard methods.

Manufacturer instructions and other instructional documentation will be kept with the field staff. Additionally, all field equipment will be operated according to the Hazardous Waste Remediation Bureau's (HWRB) SOPs, found in **Appendix C**, when applicable.

Global Positioning System (GPS) Unit

The Navigation Satellite Time and Ranging (NAVSTAR) Global Positioning System (GPS) is a worldwide radio-navigation system created by the U. S. Department of Defense (DOD) to provide navigation, location, and timing information for military operations. The system was declared available for civilian uses and has seen burgeoning civilian application for navigation and mapping. A GPS unit is an instrument used to receive the GPS information. The unit is typically used to obtain the geophysical coordinates of sampling locations and/or measurements during field investigation. The expected accuracy for Global Positioning System (GPS) data collection activities shall be recorded in the site-specific SAPs and in accordance with site needs.

Electronic Water Level Meter

It is used to measure water levels in wells to 1/100 of a foot, which can then be used to calculate purge volumes, develop groundwater potentiometric maps, etc.

Interface Probe

Similar to a water level meter but is able to differentiate between water and non-aqueous phase liquid (NAPL) contact. It is used to determine the thickness of NAPL layers in monitoring wells.

Peristaltic Pump (Geotech Series II or similar model)

A low volume suction pump used for both purging and sampling; which utilizes a deep cycle battery, battery pack or generator for power. The maximum effective depth is approximately 29 feet.

Submersible Pump (Grundfos Redi-Flo 2 or similar model)

A submersible centrifugal impeller pump used in conjunction with a generator, or direct source of electricity, for both purging and sampling.

Bladder Pump

A bladder pump is a pneumatic pump that incorporates both gravity and compression. It is recommended for purge volumes ranging from 0.5 gallons per minute (gpm) - 3.3 gpm. It can be used for purging and sampling.

Wattera Hand Pump

This pump is not generally recommended for sampling. This pump can be used for purging wells and sampling if it fits the projects data quality objectives. It fits into a well with an inner diameter of an inch, can operate at a maximum depth of 250 feet and has a maximum flow of 2 gpm.

Centrifugal Pump (Honda Pump or similar model)

A centrifugal pump, used as a suction pump to generate the positive displacement of water, has a maximum suction head lift of 26 feet and a maximum pumping rate of 53 gpm. It may be used for purging large volumes of water efficiently. This pump is not used for sampling.

Barcad Samplers

A groundwater sampling instrument designed for permanent installation at a fixed depth. Typically a number of these instruments are installed at various depths in a cluster within a single borehole (monitoring well). The sampler contains a check valve through which water can be extracted from the formation and conducted to the surface via a small-diameter riser tube concentric within a larger gas-drive tube.

Bailers

Bailers shall be made of the appropriate material (e.g., stainless steel, polyethylene or Teflon). Bottom filling and bottom emptying type (bucket) bailers are used to purge wells and collect samples. Bottom-dispensing bailers are required for sampling volatile organic compounds (VOCs).

Kemmerer Samplers

Kemmerer samples are useful for general purpose sampling at specified depths. In operation, the open sampler is lowered on a graduated rope/wire to the desired depth which assures complete flushing of the bottle as it is lowered. Both ends of the bottle are closed by means of a messenger and the undisturbed grab sample within the bottle is brought to the surface.

Passive Diffusion Bag (PDB) Samplers

Passive diffusion bag (PDB) samplers are a simple and inexpensive way to sample ground water monitoring wells for a variety of VOCs. A typical PDB sampler consists of low-density polyethylene lay-flat tubing that is filled with distilled, deionized water and heat-sealed at both ends. The bags are suspended in the monitoring well at the target horizon by a weighted line and allowed to equilibrate with the surrounding water (typically 2-weeks). The PDB samplers are retrieved from the well after the equilibration

period and the enclosed water is immediately transferred to appropriate sample containers for analysis (e.g., 40 ml VOC vials).

Pore Water Samplers

A pore water sampler comes in two parts, a strengthening rod and the pore water sampler itself, both made of stainless steel. The pore water sampler is basically a hollow tube with small holes in its tip that allow groundwater to percolate through. The strengthening rod slides into the pore water sampler, and while in place, blocks water and soil particles from entering the pore water sampler. Both pieces are stored in a PVC sheath for protection. Although the pore water sampler is fairly sturdy, exercise caution during use, as once either piece becomes bent, the equipment is useless.

Gas Cylinders

Portable tanks of compressed inert gas used in the operation of the Barcad sampling instrument and bladder pump controllers.

Tubing

See site-specific SAPs for specific tubing requirements. In general: Dedicated polyethylene tubing (1/4" ID x 3/8" OD) will be used in all monitoring wells whenever possible; silicone tubing will be used in the pump heads of the peristaltic pumps; bladder pump tubing will be sized according to manufactures requirements. Teflon or Teflon-lined tubing will be used as specified in site specific SAPs.

Multiparameter Meter (YSI Models 600Xl or 6820, QED MP-20 or similar approved models)

This is a multiparameter meter with a flow through cell that measures temperature, specific conductivity, dissolved oxygen, pH, and oxidation reduction potential (ORP). These measurements are generally taken for the purpose of determining well stabilization and may also be used as part of the evaluation process of natural attenuation. The meter is calibrated daily before use following the Calibration SOP found in **Appendix C**. Note: turbidity measurements must be obtained from a separate instrument as measurements through a flow-through cell are not acceptable. Refer to the Low Flow SOP in **Appendix C** for specific requirements for the flow through cell (transparency and size) and meter.

pH, Dissolved Oxygen, and Conductivity Meters (Separate meters)

These separate meters may be used when a multiparameter meter is not required. Calibrate daily before sampling following the Calibration SOP found in **Appendix C**.

Turbidity Meter (Hach 2100P, Hach 2100Q or similar model)

Measures the turbidity of water for the purpose of determining well stabilization or other purposes, as needed. It determines the turbidity by viewing light through the sample and determining how much light is obstructed. The meter is calibrated daily following the Calibration SOP found in **Appendix C**.

Barometer

A barometer is used in calibrating dissolved oxygen meters. A separate barometer may be used if the instrument doesn't already have a temperature-compensated barometer. All barometers (either separate or part of a multi-parameter meter) must be checked, and adjusted if necessary, at least yearly against a known calibrated barometer such as one used by the National Weather Service.

Thermometer

A separate thermometer may be used when a multiparameter meter is not required. All thermometers (either separate or within a multiparameter unit) must be checked no less than yearly against a National Institute of Standards & Technology (NIST) Thermometer.

Test Kits (Hach or similar)

Analysis for various parameters may be determined in the field through the use of Hach kits following the manufacture instructions. Some of the parameters that may be tested using this method include alkalinity, ferrous iron, nitrate, sulfate, pH, and dissolved oxygen.

Auger

The system consists of an auger bit, a series of drill rods, a "T" handle and a thin-wall tube corer. The auger bit is stainless steel and is used to sample hard or packed solid media, soil or sediment.

Shovel

A regular lawn or garden shovel used to remove top cover of soil to desired depth for sampling. Not used to collect samples unless it is made of stainless steel.

Scoops/Spoons

Made of stainless steel and used to collect soil samples.

Dredges

Dredges provide a means of collecting sediment from surface water bodies that are too deep to access with a scoop and conduit. They are most useful when collecting softer, finer-grained substrates that include primarily silts and clays but can also be used to collect sediments that are sandy and/or gravely, although sample recovery in these materials may be less than complete.

Eckman Dredge

The Eckman dredge is designed for sampling in soft, finely divided bottoms that are free from vegetation and other coarse debris. The sampler features machined jaws and hinged overlapping lids that open easily during descent to let water pass through and close during retrieval to reduce sample washout. Trigger the jaw release mechanism by lowering a messenger down the line, or by depressing the button on the upper end of the extended handle.

Ponar Dredge Sampler

The Ponar dredge is widely used for quantitative samplings of benthic macro organisms in sand, gravel and clays. The self-tripping sampler features centre hinged jaws and a spring loaded pin that releases when the sampler makes impact with the bottom. Features include an underlip attachment that cleans gravel from the jaws that would normally prevent closing and removable side plates that prevent lateral loss of sample. The top is covered with a stainless steel screen with neoprene rubber flaps that allow water to flow through for a controlled descent and less interference with the sample.

Soil Sampling Device (EnCore™ or similar NHDES approved device)

A syringe type device used to collect soil samples (primarily VOC samples) in the field.

Air Sampling Devices

Air sampling devices may be used in personnel protection and safety as a screening tool to decide whether a respirator or a self-contained breathing apparatus should be worn, or whether the area should be evacuated. They are used primarily at locations where the air quality is unknown and may also be used for sampling, such as for soil gas surveys.

MSA Combustible Gas and Oxygen Meter

The MSA Combustible Gas and Oxygen Meter model 261 is used to determine oxygen content and explosive limits for confined spaces such as well cap, truck bins, drums and closed and open store tanks. It is calibrated using calibration gas cylinders, following manufacture's manual.

Portable PID/FID Instruments (such as the MiniRae 2000 or 3000)

Portable PID/FID instruments have traditionally been used as general survey instruments for headspace analysis of soil and groundwater samples and to determine safe breathing zones. These hand–held instruments employ either a photoionization detector (PID) or flame-ionization detector (FID) for detection of vapors/gases. They are calibrated using calibration check gas cylinders following manufacturer's manual.

Dust Meter

A dust meter is used to monitor dust during excavation in potentially hazardous work zones. It requires calibration according to the manufacture's guidelines.

Gas/Air Collection Containers

Stainless Steel Canisters (such as a SUMMA® Canister)

Pre-evacuated passivated stainless steel canisters, typically used for sampling volatile organic compounds (VOCs) in ambient air.

Sampling Bags (such as Tedlar® Bags)

A convenient container for air samples. The bag is evacuated prior to use and a sample is collected by opening an inlet and using a pump for positive pressure.

APPENDIX C

STANDARD OPERATING PROCEDURES (SOPs)

SOP TABLE OF CONTENTS

This is a list of standard operating procedures (SOPs) commonly used by the Hazardous Waste Remediation Bureau (HWRB). Any additional SOPs needed for a specific site shall be approved by the project manager in consultation with the quality assurance coordinator. Any deviations from these SOPs shall be approved by the project manager in consultation with the quality assurance coordinator.

HWRB-1 Water Level Measurement, Revision 5
Water level Worksheet

HWRB-2 Calculation of Purge Volume, Revision 4
Calculation of Purge Volume for Tubing
Calculation of Purge Volume for Wells

HWRB-3 SOP Intentionally Left Blank

HWRB-4 Sampling With a Bucket Type Bailer, Revision 6
Bailer Sampling Worksheet

HWRB-5 Purging Wells with a Centrifugal Pump, Revision 4

HWRB-6 Sampling with a Grundfos Redi-Flo 2 Submersible Pump, Revision 5

HWRB-7 Purging and Sampling with the WaTerra Hand Pump, Revision 3

HWRB-8 Purging and Sampling with a Bladder Pump, Revision 7
Bladder Pump Setup Diagram
Bladder Pump Sampling Worksheet

HWRB-9 Low Flow Groundwater Purging and Sampling, Revision 8
Modified Sampling Procedure
General Decontamination Procedures
Low Flow Setup Diagram
Well Sampling Worksheet for Bladder Pumps
Well Sampling Worksheet for Peristaltic Pumps

HWRB-10 Surface Water Sampling, Revision 5
Surface Water Worksheet

HWRB-11 Soil Sampling, Revision 4
Soil Sampling Worksheet

HWRB-12 Jar Headspace Technique - Field Screening Soil Samples, Revision 4

HWRB-13 Sediment Sampling, Revision 5
Sediment Sampling Worksheet

HWRB-14 Drinking Water Sampling, Revision 5
Setup Diagram for Collecting Water Quality Parameters at Drinking Water Wells
Drinking Water Quality Parameter Worksheet

HWRB-15 Decontamination, Revision 6

HWRB-16 Pore Water Sampling, Revision 7
Figures 2-6
Field Surface Water and Pore Water Field Screening Summary Worksheet
Handheld Thermometer User Manual

HWRB-17 Calibration of Field Instruments, Revision 7
Instrument Calibration/Maintenance Log

HWRB-18 Chain-of-Custody, Sample Handling & Shipping, Revision 5
NHDPHS Laboratory Services Login and Custody Sheet

HWRB-19 Passive Diffusion Bag VOC Sampling, Revision 4
Figures 1-3
Passive Diffusion Bag Equipment Setup Diagram
EON Products, Inc., Equilibrator™ Diffusion Sampler Instructions

HWRB-20 Bladder Pump Interval Sampling, Revision 3
Equipment Setup Diagram for Interval Sampling Using a Bladder Pump

NHDES Preservation of VOCs in Soil Samples, March 2000

NHDES Vapor Intrusion Guidance, (July 2006) updated February 2013

NHDES Draft Evaluation of Sediment Quality Guidance Document, April 2005

WATER LEVEL MEASUREMENT

PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to set guidelines for the manual determination of the depth to water in an open borehole, cased borehole, monitoring well, temporary well points, or piezometer, as required.

In general, water-level measurements are used to construct water table or potentiometric surface maps and to determine flow direction as well as other aquifer characteristics. It is preferable that all water level measurements at a site are collected in the shortest possible time within a 24-hour period.

EQUIPMENT AND MATERIALS

- Personal protective clothing and equipment as outlined in a site-specific Health and Safety Plan (HASP).
- Site specific Sampling and Analysis Plan (SAP) or Quality Assurance Project Plan (QAPP).
- Boring logs, if available.
- Electronic water level indicator or chemical/water interface probe of an appropriate length (e.g., 100 foot, 200 foot, 300 foot) capable of measuring to 0.01 feet (e.g., Solinst Models 101 or 122, or similar instrument).

  Note: In some cases, such as use with the FLUTe™ Multilevel System, a very small diameter water level probe may be required (e.g., Solinst Coaxial Water Level, Model #102 with a 1/4" diameter P-1 Probe; Heron "Skinny Dipper").
- Photoionization detector (PID), if required.
- Site and well keys, along with any other equipment that may be necessary to open wells.
- Field log book or water level worksheet.
- Miscellaneous items such as black-ink pens, markers (Sharpies), paper towels, clipboard, etc.
- Decontamination equipment and supplies in accordance with the Decontamination SOP in the SAP.

PRELIMINARY PROCEDURES

All monitoring wells should be locked at all times, or within a secure locked area, to ensure the integrity of the well.

Refer to the site-specific SAP for correct reference points. If water level measurements are being completed for the first time following well installation (or if it does not already exist), a survey mark/physical notch should be placed on the top of the riser or casing as a reference point for future groundwater level measurements. If the top of the riser or casing is not flat, the highest point should be the reference point. The measurement reference point must be documented in the site logbook and on the site-specific Water Level Worksheet.

All field personnel must be made aware of the measurement reference point (e.g., top of casing [TOC] or top of PVC pipe [TOPVC]) being used in order to ensure the collection of comparable data.

Water levels in piezometers and monitoring wells should be allowed to stabilize for a minimum of 24 hours after well construction and development before collecting measurements. Equilibrium may take longer in low yield situations. All measurements should be made to an accuracy of 0.01 feet.

The water level meters or interface probes shall be decontaminated in accordance with the approved site-specific decontamination SOP and checked (e.g., batteries) prior to use to ensure that they are in proper working condition.

Water levels should be collected from the least contaminated to the most contaminated wells if possible and where it's applicable.

SURFACE WATER LEVEL MEASUREMENTS

As part of the synoptic water level round, surface water measurements may be required at one or more permanent locations on certain surface water bodies (e.g. lakes, ponds, streams, rivers). Permanent staff gages are typically used at these locations. Refer to the site-specific SAP. These surface water locations and staff gages shall be permanently located using a global positioning system (GPS) unit and included on site maps for future reference. The expected accuracy of the GPS unit shall be determined in advance and specified in the SAP.

The distance from the bottom to the top of the surface water shall be measured and the data shall be recorded in the field log/worksheet.

WATER LEVEL MEASUREMENT PROCEDURES:

Care should be taken to minimize water column disturbance. Use the following procedures to collect water level measurements:

1. Open the well and monitor the headspace with the appropriate air monitoring instrument to determine the presence of volatile organic compounds (if applicable). Record results in field log/worksheet.
2. Turn the meter on.

3. Adjust sensitivity control.
4. Lower the electronic water level meter probe and measuring tape into the well from the reference point until the water surface is reached as indicated by a tone and/or the light display. If non-aqueous phase liquid (NAPL) is known or suspected in a monitoring well, use an interface probe to check, measure and record the presence of a NAPL layer.
5. Read and record measurement (to 0.01 feet) along with the date, time and reference point in field log/worksheet. Note any changes in the conditions of the well and surroundings, including missing locks.
6. Remove all downhole equipment used for the water level measurement, and secure the well cap and lock.
7. Thoroughly decontaminate the tape and probe following approved decontamination procedures. The decontamination procedure for water level meters and oil/interface probes shall include the probes and, at a minimum, the length of tape used in that well.

QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

Equipment blanks may be required to ensure that the equipment has been properly decontaminated and the decontamination procedures are adequate. See the SAP for specific QA/QC requirements.

ATTACHMENT

Water Level Worksheet

Water Level Worksheet

Site Name and Location:

Name of data collector:

Well ID	Well Diameter (inches)	Measuring Reference Point*	Reported Well Depth (feet)	Measured Well Depth (feet)	Measured Depth to Water (feet)	Date	Comments

* Measuring Reference Point: Top of PVC or Top of Casing
The measuring reference point is permanently marked on the PVC or inner casing of the monitoring well. In the event there is no inner casing, the water level is measured from the outer steel casing at the location of the hasp, or the metal label on the rim of the flush mounted wells.

Additional Comments/Observations:

CALCULATION OF PURGE VOLUME

1. Determine the water level in the well.
2. If well depth (or the depth of the tubing intake point) is not already known from well history, measure the depth from the same reference point used to collect the water level data.
3. Measure the well (or tubing) inside diameter in inches.
4. Calculate one purge volume using the following equation, multiplying by number of purge volumes needed (typically 3-5) or use conversion charts shown below and on the next page.

CALCULATION OF PURGE VOLUME FOR WELL

One Purge Volume (Gallons) = $h \times 3.14(r/12)^2 \times 7.48$ gal/ft^3

Per: Volume = $h \times \pi \times r^2$,

Where: $\pi = 3.14$ (a constant),

r = radius = diameter/2 (inches),

(r/12 converts radius to feet)

h = length of water column in well (feet),

7.48 = gallons in 1 cubic foot (ft.) of water.

CALCULATION OF PURGE VOLUME FOR TUBING

The purge volume is equal to $h \times 3.14(r/12)^2 \times 7.48$ gal/ft^3.

Or, using the table below, one purge volume is equal to (h) x (f) where:

h = length of tubing,

f = the volume in gal/foot.

Then convert gallons to milliliters (1 gallon = 3,785 ml) so that the purge volume can be accurately measured using a graduated cylinder.

Below are the factors for some typical tubing sizes.

Tubing ID (Inside Diameter) In inches	1/8 (0.125)	11/64 (0.17)	1/4 (0.25)	3/8 (0.375)	1/2 (0.50)	5/8 (0.625)
Volume (gal/foot)	0.00064	0.00118	0.00255	0.00573	0.01019	0.01593
Volume (ml/foot)	2.42	4.47	9.65	21.69	38.57	60.30

CALCULATION OF PURGE VOLUME FOR WELLS

Purge Volume = h x $3.14(r/12)^2$ x 7.48 gal/ft^3,

One Purge Volume = (length of water column) x (gallons/foot),

h = length of water column in well (feet).

Casing Diameter (Inches)	Gallons Per Foot	Gallons Per Foot X 3 Volumes	Gallons Per Foot X 4 Volumes	Gallons Per Foot X 5 Volumes	Length of Water Column (Feet)	Purge Volume (Gallons)
1.00	**0.04**	**0.12**	**0.16**	**0.20**		
1.25	**0.06**	**0.18**	**0.24**	**0.30**		
1.50	**0.09**	**0.27**	**0.36**	**0.45**		
1.75	**0.12**	**0.36**	**0.48**	**0.60**		
2.00	**0.16**	**0.48**	**0.64**	**0.80**		
2.25	**0.21**	**0.63**	**0.84**	**1.05**		
2.50	**0.25**	**0.75**	**1.00**	**1.25**		
3.00	**0.37**	**1.11**	**1.48**	**1.85**		
3.50	**0.50**	**1.50**	**2.00**	**2.50**		
4.00	**0.65**	**1.95**	**2.60**	**3.25**		
6.00	**1.47**	**4.41**	**5.88**	**7.35**		

SOP Intentionally Left Blank

SAMPLING WITH A BUCKET TYPE BAILER

PURPOSE

This Standard Operating Procedure (SOP) is designed to provide general reference information on purging and sampling of groundwater wells using a bucket type bailer. Every effort must be made to ensure that the sample is representative of the particular zone of groundwater being sampled.

Bottom dispensing bailers are required for collecting volatile organic compound (VOC) samples. This procedure is designed for use with a bottom dispensing bailer.

Bucket type bailers are tall narrow buckets equipped with a check valve on the bottom. This valve allows water to enter from the bottom as the bailer is lowered, then prevents its release as the bailer is raised. Bailers are typically made of stainless steel, polyethylene or Teflon.

This device is particularly useful when samples must be recovered from depths greater than the range (or capability) of suction lift pumps, or when well casing diameters are too narrow to accept submersible pumps. Samples can be recovered with a minimum of aeration if care is taken to gradually lower the bailer until it contacts the water surface and is then allowed to sink as it fills.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as bailer construction material, sample points, analytes and quality assurance (QA) requirements.

EQUIPMENT AND MATERIALS

The following is a list of equipment and material commonly used for the collection of groundwater samples:

- Appropriate health and safety gear and an approved site-specific Health and Safety Plan.
- Site specific SAP and Bailer Sampling Worksheet.
- Electronic water level meter of appropriate length (e.g., 100 ft., 200 ft., and 300 ft.) that measures in increments of 0.01 feet.
- Clean, portable or dedicated, bottom filling/bottom dispensing bailer of appropriate size and construction material (e.g., stainless steel, polyethylene, Teflon) with a sample dispensing device (e.g., slow dispensing VOC tip).
- Bailing twine made of appropriate material (e.g., nylon).
- Gate keys / well keys and other applicable field equipment to open wells.
- Toolbox, which typically includes such items as: sharp knife (locking blade), bolt cutters, spare well locks, screwdrivers, pliers, hacksaw, hammer, flashlight, adjustable wrench, socket set, and duct tape.

- Plastic sheeting.
- Graduated five gallon bucket for collecting purge water.
- Logbook, pencil/pen/sharpies, and calculator.
- Sample labels, chain-of-custody records and custody seals.
- Sample containers, including spare containers, preserved as necessary and re-sealable plastic bags.
- Loose ice and a sample cooler.
- Trash bags to containerize solid waste.
- Decontamination equipment and supplies in accordance with the Decontamination SOP in the SAP.

PROCEDURE FOR USING A BOTTOM DISPENSING BAILER:

1. Decontaminate bailer before use in accordance with the Decontamination SOP in the SAP.
2. If possible, and when applicable, using non-dedicated equipment (e.g., bailer and water level meter), sample the least contaminated wells first and proceed to those wells that are most contaminated, to prevent cross contamination. If the degree of contamination is unknown, sample the upgradient wells first and the downgradient wells last.
3. Note any missing locks and physical changes to the well condition, such as erosion or cracks in protective concrete pad, road box, standpipe, variation in total depth of well, etc. on the Bailer Sampling Worksheet.
4. Determine the water level in the well as follows:
   a) Lower water level meter and graduated measuring tape/cable into the well to the water surface. Care should be taken to minimize water column disturbance.
   b) Measure the distance from the water surface (to 0.01 feet) to the reference measuring point (e.g., top of PVC riser or casing), as determined by the audio signal or tone, and record on the worksheet. In addition, note the reference point used (top of PVC riser or casing).
5. Measure and record the distance to the bottom of the well (to 0.01 feet) a minimum of once every 5 years, during the sampling event just prior to the 5-year review, or as specified in the SAP.
6. Using the water level and well construction information included in the SAP, determine the midpoint of the saturated screen (sample location) and record on the worksheet.
7. Measure the diameter of the inner casing in inches and record on the worksheet.
8. Record the number of well volumes to be purged as specified in the SAP; typically 3 to 5 well volumes.

9. Calculate the minimum purge volume required and record on the worksheet. Refer to the Calculating Purge Volume section below and the worksheet for calculations.

10. Attach a pre-cleaned bailer to a dedicated unused line for lowering.

11. Slowly lower the bailer to the sampling location, being careful not to drop the bailer into the water, causing turbulence and possible loss of VOCs. Allow the bailer to fill and then slowly and gently retrieve the bailer from the well avoiding contact with the casing, so as not to knock flakes of rust or other foreign materials into the bailer. When pulling the bailer out, ensure that the line either falls onto a clean area of plastic sheeting or never touches the ground.

12. Discharge the water from the top of the bailer into a graduated five gallon bucket.

13. Repeat filling and discharging until the appropriate volume has been purged from the well. Be sure that the minimum amount required has been purged; more is better than not enough.

14. Record final volume purged on the worksheet.

15. Discharge the final purge water to the ground or into an appropriate container as specified in the SAP.

16. To collect a groundwater sample:

    a) Remove the cap from the appropriate sample container and place it on the plastic sheet or in a location where it won't become contaminated.

    b) Slowly lower and retrieve the bailer as described above.

    c) Attach the sample dispensing device to the bottom of the bailer.

    d) Begin slowly discharging the groundwater from the bottom of the bailer, using the dispensing device, into the appropriate sample containers.

       All sample containers should be filled by allowing the discharge to flow gently down the inside of the container with minimal turbulence.

       The priority order in which samples should be collected from each well shall be specified in the SAP. VOCs are typically collected first.

    e) Cap sample containers securely after filling each bottle. Sample containers should be wiped dry. Place samples in re-sealable plastic bags and then in loose ice within the cooler.

    f) Continue to remove water from the well until sufficient volume has been obtained to fill all sample containers according to the priority order identified in the SAP.

    g) If a field duplicate sample and/or field matrix spike/matrix spike duplicate (MS/MSD) samples are required, the samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC sample, VOC duplicate sample; 1,4-dioxane sample, 1,4-dioxane duplicate sample and/or 1,4-dioxane MS/MSD sample; etc.). In general, duplicate samples are not intended to be blind duplicate samples. They should be

designated with a "DUP" after the well designation (e.g., TRY_MW-2 DUP). Refer to the SAP for specifics such as: sampling nomenclature, quality control sampling requirements and the appropriate chain-of-custody (COC) notations required for MS/MSD samples.

17. If the bailer is dedicated and will remain in the well, it should be suspended as close to the top of the well as possible and above the water column, if possible.
18. Replace the well cap and secure the well.
19. Log all samples in the field book and ensure all samples are appropriately labeled.
20. Package samples and complete necessary paperwork.
21. Decontaminate the non-dedicated equipment in accordance with the Decontamination SOP in the SAP.

CALCULATING PURGE VOLUME

Calculate one purge volume using the following equation, multiplying by number of purge volumes needed (3-5) or use conversion chart shown below.

One Purge Volume (Gallons) = $h \times 3.14(r/12)^2 \times 7.48$ gal/ft^3

Per: Volume = $h \times \pi \times r^2$, Where: $\pi = 3.14$ (a constant),

r = radius = diameter/2 (inches) (r/12 converts radius to feet),

h = length of water column in well (feet),

7.48 = gallons in 1 cubic foot (ft.) of water.

Conversion Chart

One Purge Volume = (length of water column), x (gallons/foot)

Casing Diameter (Inches)	Gallons Per Foot	Gallons Per Foot X 3 Volumes	Gallons Per Foot X 4 Volumes	Gallons Per Foot X 5 Volumes	Length of Water Column (Feet)	Purge Volume (Gallons)
1.00	0.04	0.12	0.16	0.20		
1.25	0.06	0.18	0.24	0.30		
1.50	0.09	0.27	0.36	0.45		
1.75	0.12	0.36	0.48	0.60		
2.00	0.16	0.48	0.64	0.80		
2.25	0.21	0.63	0.84	1.05		
2.50	0.25	0.75	1.00	1.25		
3.00	0.37	1.11	1.48	1.85		
3.50	0.50	1.50	2.00	2.50		
4.00	0.65	1.95	2.60	3.25		
6.00	1.47	4.41	5.88	7.35		

DECONTAMINATION

Decontaminate all non-dedicated equipment (e.g., bailer and water level meter) following the Decontamination SOP included in the SAP before reuse. Disposable sampling equipment (bailing twine) shall be discarded and not reused after sampling is complete.

EQUIPMENT BLANK

Collect an equipment blank to ensure that the decontamination procedure is adequate. Decontaminate the bailer in accordance with the procedures included in the SAP, then fill the bailer with laboratory-grade deionized (DI) water and rinse the bailer once. Once rinsed, collect an equipment blank sample by filling the bailer with DI water and then slowly discharging the rinsate from the bottom of the bailer using the sample dispensing devise. Refill the bailer with DI water as needed to fill all of the appropriate containers. Refer to the SAP for specific quality control sampling requirements and appropriate COC notations required for samples.

ATTACHMENT

Bailer Sampling Worksheet

Bailer Sampling Worksheet

Site:

Sampler Name **Date:**

Well ID	
Measuring Point (Top of PVC/Inner Casing, Top of Casing)	
PVC/Inner Well Casing Inside Diameter (inches)	
Well Depth (from top of measuring point, feet, to 0.01')	
Static Water Level (from top of measuring point, feet, to 0.01')	
Water Column Length = Well Depth Minus Depth to Water Level (feet to 0.01')	
Midpoint of Saturated Screen =Sample Location (feet to 0.01')	
Number of Purge Volumes Required (e.g., 3, 4 or 5)	
Minimum Purge Volume (gallons)	
Minimum Purge Volume = Water Column Length_____ x _____Factor (Insert Water Column Length from above and Factor from chart below)	
Actual Purge Volume (gallons)	
Sample Collection Time (24 hour time)	
Lab Analyses Collected:	
Quality Control Samples:	

Calculation of Purge Volumes

Purge Volume = h x 3.14(r/12)^2 x 7.48 gal/ft^3

One Purge Volume = (length of water column) x (gallons/foot)

Length of Water Column (in feet) = depth of well - depth to water level.

Conversion Chart Factors

Inner Casing Diameter (Inches)	Gallons Per Foot	Gallons Per Foot X 3 Volumes	Gallons Per Foot X 4 Volumes	Gallons Per Foot X 5 Volumes
1.00	0.04	0.12	0.16	0.20
1.25	0.06	0.18	0.24	0.30
1.50	0.09	0.27	0.36	0.45
1.75	0.12	0.36	0.48	0.60
2.00	0.16	0.48	0.64	0.80
2.25	0.21	0.63	0.84	1.05
2.50	0.25	0.75	1.00	1.25
3.00	0.37	1.11	1.48	1.85
3.50	0.50	1.50	2.00	2.50
4.00	0.65	1.95	2.60	3.25
6.00	1.47	4.41	5.88	7.35

Notes: _____

_____

_____

_____

_____

Sampler Signature

PURGING WELLS WITH A CENTRIFUGAL PUMP

This is a general standard operating procedure (SOP) on the use of a centrifugal pump (e.g., Honda pump, Model WB15). These suction pumps are not used for sampling because they may cause degassing with loss of volatile organic compounds and pH modification. They are typically only used for purging large volumes of water efficiently. A separate device is used for collecting the samples.

A centrifugal pump, used as a suction pump to generate the positive displacement of water, has a maximum suction head lift of approximately 26 feet. A typical centrifugal pump has a combustion engine that drives an impeller, a pull string start, a discharge port, a suction port and pumps approximately 1-5 gallons per minute. The discharge port has an intake, which has an optional strainer to prevent the entry of rocks, pebbles and cobbles.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as the type of tubing to be used, depth the tubing is set for purging, correct device which to collect samples after purging wells and the depth where samples are to be collected. Purging is generally carried out from the least contaminated to the most contaminated wells where possible and applicable.

GENERAL PROCEDURE FOR USE:

1. Determine the screen interval in feet: depth of screen from top of the measuring point of the well (usually the inside casing).
2. Measure water level in well, in feet.
3. Measure well diameter, in inches.
4. Measure well depth or note it from site history. *(Note: the well depth should be checked periodically for accuracy.)*
5. Calculate purge volumes, typically 3 to5 well volumes. Refer to Calculating Purge Volume section below.
6. Set up the pump downwind from the well with the muffler turned away from the direction of the well, so it does not emit exhaust fumes in the direction of the well.
7. Check to see if the pump has been primed. Do not operate the pump unless there is water in the priming chamber. Operating the pump without sufficient water can cause the motor to overheat and burn out.
8. Attach dedicated (or disposable) tubing to inlet on pump, lowering other end of tubing into well at a pre-determined depth (typically within the screen interval).
9. Position a 5 gallon bucket, marked in 1/2 or 1 gallon intervals, to catch the discharge from the discharge port.
10. Start the pump.

11. Count the number of buckets filled until pre-determined purge volume has been reached. Note: If the flow rate (gallons/minute) is consistent, a stopwatch may be used to time the outflow from the discharge port into the 5-gallon bucket until purge volumes have been reached.
12. Move the tubing up and down the water column while purging to assist in removing stagnant water in the casing, if appropriate.
13. Periodically check the water level. **Do not let the water level in the well fall below the top of the screen.**

    If the water level reaches the top of the screen, either:

    a. Stop purging and allow the well to recover sufficiently before resuming. This step may have to be repeated until the appropriate volumes have been reached; or

    b. Stop purging and proceed to the next step.

    Refer to the SAP for site-specific details.
14. Turn off the pump and remove tubing.
15. Collect samples with a pre-approved sampling device (e.g. bailer, peristaltic pump) at the appropriate depth.
16. Decontaminate equipment following approved decontamination procedures.
17. Properly dispose of non-dedicated tubing.

CALCULATING PURGE VOLUME

Calculate one purge volume using the following equation, multiplying by number of purge volumes needed (3-5) or use conversion chart shown below.

One Purge Volume (Gallons) = $h \times 3.14(r/12)^2 \times 7.48$ gal/ft^3

Per: Volume = $h \times \pi \times r^2$,

Where: $\pi = 3.14$ (a constant),

r = radius = diameter/2 (inches),

(r/12 converts radius to feet)

h = length of water column in well (feet),

7.48 = gallons in 1 cubic foot (ft.) of water.

See the Conversion Chart on the next page.

Conversion Chart

One Purge Volume = (length of water column) x (gallons/foot),

h = length of water column in well (feet).

Casing Diameter (Inches)	Gallons Per Foot	Gallons Per Foot X 3 Volumes	Gallons Per Foot X 4 Volumes	Gallons Per Foot X 5 Volumes	Height of Water (Feet)	Purge Volume (Gallons)
1.00	0.04	0.12	0.16	0.20		
1.25	0.06	0.18	0.24	0.30		
1.50	0.09	0.27	0.36	0.45		
1.75	0.12	0.36	0.48	0.60		
2.00	0.16	0.48	0.64	0.80		
2.25	0.21	0.63	0.84	1.05		
2.50	0.25	0.75	1.00	1.25		
3.00	0.37	1.11	1.48	1.85		
3.50	0.50	1.50	2.00	2.50		
4.00	0.65	1.95	2.60	3.25		
6.00	1.47	4.41	5.88	7.35		

SAMPLING WITH A GRUNDFOS REDI-FLO 2 SUBMERSIBLE PUMP

The Grundfos Redi-Flow 2 Submersible Pump is a submersible impeller pump that will fit inside a two inch or greater diameter well, operates at depths equal to the length of the motor lead and is powered by a gasoline powered generator or other power supply. Larger pumps are also available.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as sample points, analytes and quality assurance (QA) requirements.

PROCEDURE FOR USE:

1. Determine water level in well and record.
2. Determine depth to, and length of, screened interval in well.
3. Screw safety cable bracket into pump.
4. Attach safety cable to bracket (Teflon coated/stainless steel cable) or an unused line (polyethylene bailing twine) for lowering.
5. Cut tubing length to reach the middle of the screened area (or to a depth as required in a site-specific sampling and analysis plan [SAP]), adding an additional few feet to remain outside the well for discharging.
6. Attach tubing to safety cable bracket on pump with a small hose clamp. A check valve may be added to prevent backflow.
7. Slowly lower the pump and accompanying motor lead into the well by safety cable (not by the tubing).
8. If using the low flow procedure, refer to the site-specific SAP for the equipment setup diagram and set up the equipment accordingly.
9. Take another water level now and record.
10. Fit the motor lead plug from pump into the converter.
11. Start the generator. If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.

    MAKE SURE THE GENERATOR IS RUNNING <u>BEFORE</u> YOU PLUG THE CONVERTER INTO IT.
12. Plug the converter into the generator.
13. Set the converter's speed dial near the middle of the dial (12 o'clock position).
14. Start the pump by pressing the start switch.
15. Adjust the pump flow by turning the speed dial.

16. At this point you can purge a minimum of three tubing or well volumes, or follow the low flow procedure and purge until selected parameters stabilize. Refer to the site-specific SAP for details.
17. Collect samples. Samples must be collected directly from the well tubing.
18. Turn off the pump.
19. Turn off the generator BEFORE removing the motor lead from the converter.
20. Remove pump from well by safety cable.
21. Disconnect tubing from pump. Dedicated tubing will be secured in the well. Non-dedicated tubing shall be properly discarded.
22. Decontaminate the water level meter, pump, safety cable and motor lead.

DECONTAMINATION

Dedicated equipment must be decontaminated prior to use and will not need further decontamination. However, non-dedicated equipment shall be decontaminated prior to fieldwork and after each sampling location.

The pump motor is filled with approximately 25 milliliters of contaminant free water. During operation, it is possible that a very small portion of this water could be replaced by the fluid being pumped. Therefore, there is a potential risk for cross contamination. A syringe is provided with each pump to replace the water with laboratory-grade deionized water before each use. See operating manual for instructions.

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump, or the pump can be disassembled and flushed with the decontaminating solutions. The manufacturer discourages the use of chemicals/solvents in the decontamination process and recommends that if used, they should be used sparingly and that water-flushing steps should be extended.

The electrical wires and safety cable must be rinsed with the decontaminating solutions as well. The decontamination procedure for water level meters shall include the probes and, at a minimum, the length of tape used in that well.

The general decontamination procedure is as follows:

1. Flush the equipment with tap water. Be sure to flush out any sediment trapped in the pump.
2. Wash with a non-phosphate detergent, if required in the SAP.
3. Rinse with tap water.
4. Flush sparingly with an appropriate solvent (e.g., isopropyl alcohol), if required in the SAP.

5. Flush one final time with deionized water. If solvents are used, extend the rinse time appropriately.
6. Replace the water in the pump motor with deionized water.

EQUIPMENT BLANK

Collect equipment blanks to ensure that the decontamination procedure is adequate.

PURGING AND SAMPLING WITH THE WATERRA HAND PUMP

The WaTerra hand pump can operate at a maximum depth of 250 feet and can have a maximum flow of 2 gallons per minute. It can fit into a well with a one-inch inner diameter. The WaTerra hand pump is mainly used for purging wells and may be used for collecting inorganic samples. **It is recommended that once the well is purged, a bottom dispensing bailer or other method be used to procure samples for volatile organic compounds (VOCs).** The WaTerra pump may be used for the collection of VOCs or semi-VOCs under certain circumstances if it meets the quality assurance objectives for the project, the method is noted, it is approved by the project manager and the results are flagged.

The WaTerra Model 404 hand pump is an inertial pump which consists of a levered stainless steel pump handle, a 5-/8" inside diameter (ID) high-density polyethylene (HDPE) riser tube and a delrin acetal thermoplastic standard foot valve. The standard foot valves typically come in two sizes: Model D-25, a check valve 3” in length with a 1" outside diameter (OD); or Model D-16, a check valve 1” in length with a 0.625" OD. The tubing with the one-way check valve is lowered into the well and gradually raised. As the valve is pushed down water enters the tube. The water rises and discharges out of the tube.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as tubing and valve sizes, sample points, analytes and quality assurance requirements.

PROCEDURE FOR OPERATION:

1. Position the pump so that tubing does not hit the well cap or hasp of the well casing.

2. Then mount the WaTerra pump handle to the well casing by adjusting the clamps, which are located by the hold rings.

3. Sever the edge of the HPDE polyethylene tubing to create a groove for the foot valve with threading to attach.

4. Screw on the foot valve to the bottom of the tubing by turning the foot valve in a clockwise direction. The threading of the foot valve should mesh with the tubing.

5. Check that the foot valve is secure by pulling on the foot valve. If the foot valve loosens, rethread it on to the tubing.

6. Securely hold the tubing and lower the end with the foot valve to the middle of the screened interval or other predetermined approved depth. The tubing should be positioned vertically through the well and not coil.

7. Loop the tubing through the "holder" (clamps) in the handle.

8. Continue to loop the tubing below the handle and place it in the "hold ring". The discharge end of the tubing should not move freely. If it moves freely, it may splatter water.

9. The tubing should be horizontal after it passes through the loop and then positioned to dip down into a bucket for purge water.

10. Purge the well: Gradually lift the pump handle in a stroking motion. Do not jerk the pump.

11. Measure the flow into a bucket marked with gallon intervals. Purge the well until the required volume is reached.

12. Collect the non-volatile samples: Reduce flow and hold tube, so that it discharges into the sample container.

13. Dismount the WaTerra hand pump.

14. Pull out the tubing and detach foot valve. The foot valve may be decontaminated. The tubing should be properly discarded. Note: The foot valve and/or tubing may be dedicated to the well after sampling.

15. Rinse a stainless steel or Teflon bailer at least three times in the well and collect sample for VOCs or semi-VOCs at the same depth to which the tubing was inserted.

16. Decontaminate equipment according to the approved decontamination procedure in the SAP. Non-dedicated sampling equipment shall be properly discarded after completing the sampling task.

17. Collect equipment blanks as required.

PURGING AND SAMPLING WITH A BLADDER PUMP

PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to give general instructions on sampling with a bladder pump. This procedure may be used in conjunction with the Low Flow Groundwater Purging and Sampling SOP (#HWRB-9) in the Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP). A diagram has been provided to show the equipment setup for low flow sampling using a bladder pump with a nitrogen tank and gas regulator (preferred method); however, the diagram may be modified to use the bladder pump with an air compressor and a marine battery, with or without the multi-parameter and turbidity meters.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as sample points, analytes and quality assurance (QA) requirements.

BLADDER PUMP CONSTRUCTION

The pump consists of four basic parts: 1) upper check valve assembly, 2) bladder assembly, 3) pump casing and 4) lower check valve assembly. It is connected to a controller, which allows the operator to adjust the pumping rate.

A flexible bladder with a check valve at either end is suspended inside a rigid chamber. During sampling the rigid chamber is pressurized with gas, typically compressed air. This hydrostatic pressure squeezes the bladder, causes the closure of the lower check valve, and forces the water in the bladder out through the upper check valve and into the discharge tubing. This cycle is then repeated until the sample is recovered.

EQUIPMENT AND MATERIALS:

The following equipment and materials are generally used with a bladder pump, including equipment typically used with the low flow sampling method:

- Appropriate health and safety gear and an approved site-specific Health & Safety Plan.
- Site-specific SAP which includes well construction data, location map, field data from last sampling event, if available, and other project-specific information.
- A diagram to show how the equipment should be set up.
- The manufacture's instruction manuals for all equipment.
- Bladder pumps (preferably dedicated bladder pumps).
    1. The size, capacity and placement of the pump in the well shall be selected to maximize the filling of the pump's bladder. For proper operation, the bladder pump will need a

minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence value should be determined during the planning stage because it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

2. For the collection of VOCs and dissolved gases:

   a) The bladder's capacity shall be large enough (over 70 milliliters [ml], preferably 100 ml) to ensure filling a volatile organic analysis (VOA) vial in one pulse.

   b) The pump settings (refill and discharge rates) shall be set so that one pulse will deliver a water volume that is sufficient to fill a 40 ml VOA vial.

- Controller (e.g., QED Bladder Pump Controller Model MP-10 or Model 400).

  The controller shall have a manual control button and be capable of adjusting the flow rates as low as 50 ml/minute.

- Compressed gas power source (non-gasoline powered): Either a compressed nitrogen tank (preferred) with a gas regulator for 150/200 pounds per square inch (psi) to a maximum of 400 psi (See "Special Notes" section at end of this SOP) or a marine battery operated air compressor (e.g., QED Model 3020 Electric Compressors); depending upon data quality objectives.

- Appropriate tubing:

  Use the size tubing recommended by the manufacturer.

  Teflon, Teflon-lined polyethylene or polyethylene, as required in the site-specific SAP. Both the air and sample lines should be made of the same material.

  Pharmaceutical or surgical grade silicon tubing: size #15 (3/16" inside diameter [ID] x 3/8" outside diameter [OD] x 3/32" wall) may be used from the well cap to the three-way stopcock and from the stopcock to the input of the multiparameter meter, if parameters are required.

- Electronic water level meter measured to the nearest one one-hundredth of a foot (0.01').

- An appropriate sized graduated cylinder, (e.g., 250 ml, measured in 10 ml increments) to accurately measure the flow in ml/minute.

- A stopwatch to accurately measure the flow in ml/minute.

- Multi-Parameter Water Quality Meters (e.g., YSI 600XL/XLM or 6820) with a 250 ml or less internal volume transparent flow through cell that measures the following parameters to use with the low flow sampling technique:

  Temperature, ˚C
  Specific Conductivity, microsiemens per centimeter (µS/cm)
  Dissolved Oxygen (DO), mg/l
  pH that calibrates using 3 standards (pH 4, 7 and 10)
  Oxidation Reduction Potential (ORP), millivolts (mV)

When the pump is turned off or cycling on/off, water in the cell must not drain out. Turbidity must be taken at a point before the flow-through-cell and from an instrument separate from the flow-through-cell apparatus.

- Hach 2100P or 2100Q Portable Turbidity Meter.
- Calibration standards for the multiparameter and turbidity meters, including: 100% water-saturated air chamber (small wet sponge or paper towel for DO 100% saturation calibration) and zero (0) mg/l DO solution for DO; Zobell solution for ORP; two different specific conductance standards, one to calibrate and one to check the calibration (e.g., 1,413 µS/cm and 718 µS/cm); pH 4, 7 and 10; <0.1, 10, 20, 100 and 800 NTUs turbidity standards, as appropriate for the selected meter; and extra DO membranes in case of breakage.
- A three way stopcock to divert sample flow for turbidity reading (e.g., Nalgene three-way stopcock with a plug bore of 4 mm (or 0.157 in.): NNI No. 6470-0004; VWR catalog No. 59097-080).
- Graduated bucket for purge water.
- Plastic sheeting, table or bucket to keep monitoring and sampling equipment off the ground.
- Paraphernalia to adequately shade and protect personnel, equipment, tubing and sample containers from the elements, and to prevent temperature variations in the readings, bubbles forming in the tubing and the acid preservative in the sample containers from volatilizing.
- Laboratory-grade deionized (DI) water.
- Decontamination equipment and supplies as specified in the SAP.
- Logbook, pencil/pen/sharpies and calculator.
- Field-data sheets, worksheets, sample labels, chain-of-custody records and seals. Sample containers, preserved as necessary, cooler and loose ice (not bagged).
- Re-sealable plastic bags and bubble wrap to protect and store samples.
- Appropriate keys for gates and wells.
- Trash bags to containerize solid waste.
- Toolbox to include typical items such as wrenches, pliers, screw drivers, a 25’ measuring tape, a sharp knife with a locking blade, wire strippers, hose connectors, Teflon tape and duct tape.

GENERAL OPERATING PROCEDURE

Manufacturer’s instruction manuals should be followed.

1. Set up the equipment according to the attached diagram.
2. Measure and record the water level (to 0.01 feet) before any disturbance to the well. Care should be taken to minimize suspension of any particulates attached to the sides.

3. Lower pump to desired depth in well after making all connections according to the assembly instructions. Note: Some pumps may be dedicated to the well and be installed permanently.

4. Measure and record the water level again with the equipment in the well before starting the pump.

5. If parameter readings are to be collected, the equipment shall be calibrated according to the Calibration of Field Equipment SOP in the SAP or the HWRB Master QAPP.

6. Activate the gas source, which activates the pneumatic controller.

7. If available, check flow rates, drawdown and pump setting information from previous sampling events for each well. Duplicate, to the extent practicable, the PSI, refill and discharge settings (use final pump dial setting information) and flow rates from previous events.

   Adjust pressure regulator for the appropriate pump depth. The psi setting should be close to the psi needed to lift water the depth of the pump intake, plus approximately 10 feet, to maximize the discharge volume from the bladder. However, be careful not to set the psi setting too high, which may result in a sample stream that shoots out of the tubing during sampling and/or damage to the bladder. Refer to the manufacturer's instruction manual for the specific recommendations. Once final psi selection is made, lock flow throttle in place. Record the pressure on the attached worksheet.

   The water flow out of the bladder pump during sampling must be a laminar flow without air bubbles. If air bubbles are observed, they can usually be removed by elevating the discharge tube to allow the air to continue rising until discharged with the water. In the event that it is difficult to remove the captured air bubbles in the sample tubing, use the "pause-hold-sample" mode to flush the air bubbles out of the sample tubing.

8. Vent the moisture from the controller filter regulator before starting, periodically during pumping and at the end, if it is not done automatically.

9. Use a cycle setting of one cycle per minute. Adjust the "refill" and "discharge" controls (cycles) according to well depth and pressure to optimize purging and sampling rates. Start with a discharge setting of 20 seconds and a refill setting to 40 seconds unless otherwise specified in the SAP. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. **Purging rates shall not be below 50 milliliters per minute.** Record the settings and adjustments.

   The refill and discharge rates shall be adjusted to collect a VOC vial in one pulse.

10. Purge the well according to the low flow sampling procedure, if appropriate, or as required in the site-specific SAP. Record all readings, adjustments and comments. The attached worksheet is set up to be used with the low flow sampling procedure.

11. Collect the samples as required in the SAP. Record the time of collection.

    If the flow rate is such that you cannot fill a 40 milliliter VOC vial in one pulse of the pump, the manual sample button on the controller shall be used to collect a VOC vial in one pulse.

Follow the manufacturer's instructions on using the manual control button. Allow the bladder to refill completely before discharging into the sample containers.

Samples must be collected before the flow cell and the three way stopcock. This will be done by disconnecting the flow cell and the three way stopcock so that the sample is collected directly from the pump tubing.

VOCs samples are typically collected first and directly into pre-preserved sample containers. For VOC collection, do not collect the initial 10 ml (approximate) or the last 10 ml (approximate) of the sample pulse volume. The beginning and end of the sample pulse volume has been in contact with air.

All sample containers should be filled by allowing the discharge to flow gently down the inside of the container with minimal turbulence.

Sample containers should be wiped dry and placed in re-sealable plastic bags. Samples requiring cooling will be placed into a cooler in loose ice for delivery to the laboratory. Metal samples, after acidification to a pH less than 2, do not need to be cooled.

12. Record final water level reading, when finished sampling
13. When finished sampling, deactivate the gas source.
14. Disconnect equipment, as needed.
15. If the pump is not dedicated to the well, it must be removed and decontaminated.

DECONTAMINATION

Decontaminate equipment (e.g., pump and water level) following the approved decontamination procedure in the SAP. Non-dedicated equipment shall be cleaned prior to fieldwork and decontaminated after each sampling location. If dedicated pumps are used, only the initial sampling event will require decontamination of the pump before use.

NOTE: If you must disassemble the pump, please see the operating manuals on each specific pump for instructions on disassembling. Some models are not designed to be disassembled in the field.

Disposable sampling equipment (e.g., non-dedicated tubing) shall be discarded after completing the sampling task.

EQUIPMENT BLANK

An equipment blank should be collected on non-dedicated equipment to ensure that the decontamination procedure is adequate.

SPECIAL NOTES

Special Considerations When Using Compressed Gas

When using compressed gas as the compressed air source, be sure to transport tanks upright and properly secured. Always remove regulator when transporting tanks or moving tank to a new sampling location. When using a tank for the first time, connect the regulator valve and shut the regulator valve off, then open the tank valve all the way and then close the tank valve (this seats the valve seal properly). The regulator valve shall use a pressure gauge that is 150 psi (minimum) to 400 psi (maximum).

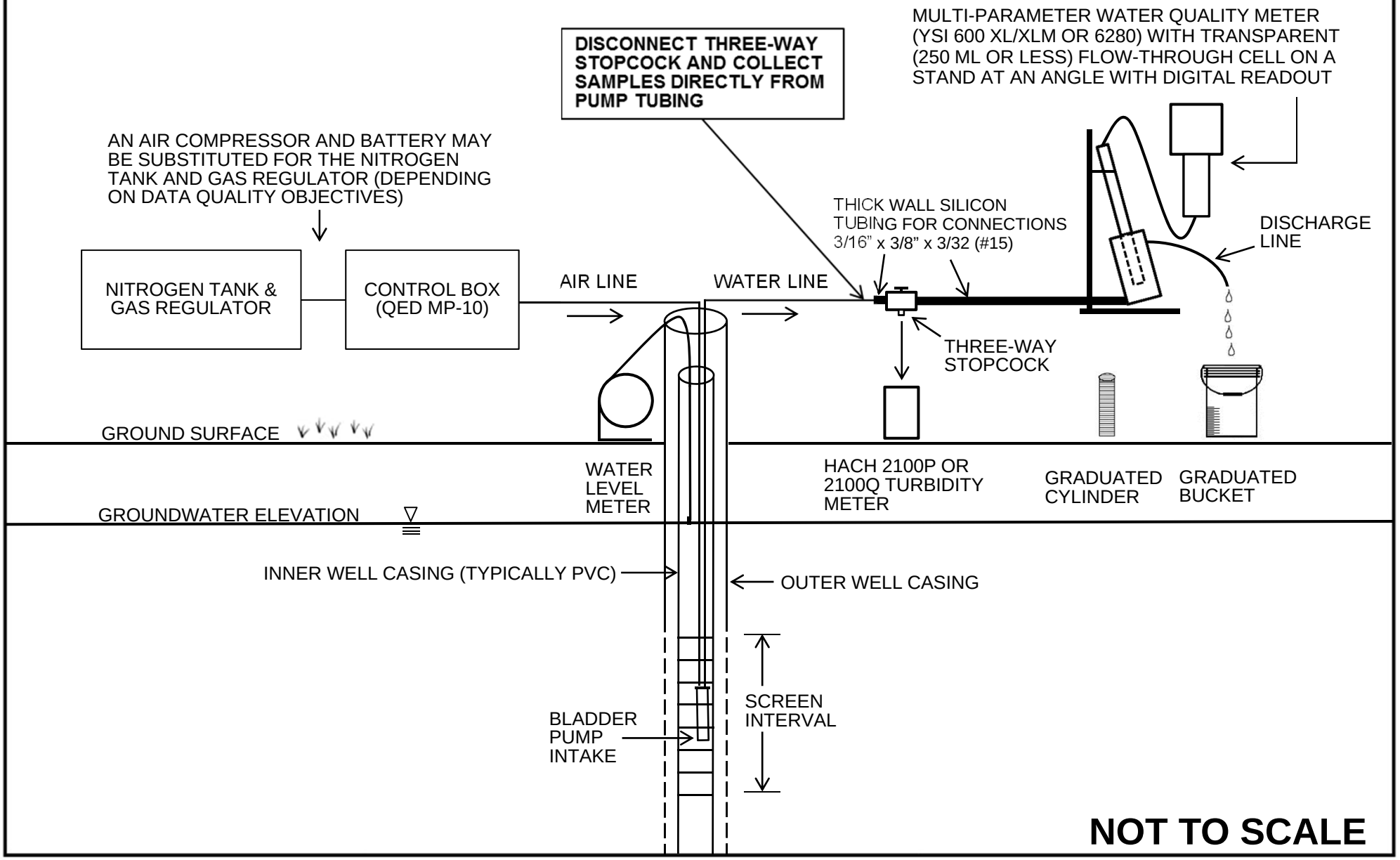
ATTACHMENTS

Bladder Pump Setup Diagram

Bladder Pump Sampling Worksheet

BLADDER PUMP SETUP DIAGRAM

THIS DIAGRAM SHOWS THE BLADDER PUMP SETUP FOR LOW FLOW SAMPLING



NOT TO SCALE

BLADDER PUMP SAMPLING WORKSHEET

Site Name

Page _____of_____

Date : _____ **Well ID :** _____

Weather Conditions : _____

Sampler's Name (Print) _____

Purging Device & Serial # (pump type): _____

Reference Measuring Point (Top of PVC/Top of Casing): _____

Screen Interval (ft., ref. to measuring point): _____

Well Depth (ft., ref. to measuring point): _____

Inner Casing Diameter (inches): _____ Tubing ID (inches): _____

Purging Start Time : _____ (24 hour cycle) Sample Time: _____ (24 hour cycle)

Initial Water Level (ft., ref. to measuring point): _____

Pump Intake (ft., ref. to measuring point): _____

Head Above Pump Intake (ft., ref. measuring point): _____

Total Purge Volume (gallons or ml/liters): _____

Indicator Parameter Stabilization: **yes** OR **no** (circle one)

Two Hour Time Limit Reached ? yes OR no (circle one)

Bladder Pump Control Box Cycle Setting should be set to "1"

Samples Collected: _____

Time at Sample Completion: _____ (24 hour cycle)

Clock Time	Water Level	Drawdown	Cumulative Drawdown	Bladder Refill Time	Bladder Discharge Time	Pressure	Purge Rate	Temp. +/- 1 ºC	Spec. Cond. +/- 3%	DO +/- 10% if > 0.5	pH +/- 0.1	ORP +/-10	Turbidity +/- 10% if > 5	Comments/Adjustments
(24 HR.)	(ft.)	(ft.)	(ft.)	setting	setting	(psi)	(ml/min)	(ºC)	(µS/cm)	(mg/l)	units	(mV)	(NTU)	
FPV =	Calculations:													

Notes: 1. All depths in feet below the referenced measuring point, unless specified. 2. "NR" indicates no reading taken. 3. ID = Inner Diameter

4. When recording pH and dissolved oxygen data, only use one decimal place. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers.
When DO data is less than 0.5 mg/l, data should be recorded as "<0.5" or "less than 0.5". DO values between 0.5 and 1.0 are typically considered stable within +/- 0.1 mg/l.
When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". Turbidity values between 5 and 10 are typically considered stable within +/- 1 NTU.

5. Tubing Factors - Milliliters to purge standing water in tubing: 1/2" ID: length in ft. x 38.6 = ml needed; 3/8" ID: length in ft. x 21.7 = ml needed; 1/4" ID: length in ft. x 9.7 = ml needed; 0.17" ID: length in ft. x 4.5 = ml needed.

6. Final Purge Volume (FPV) = (Total Tubing Length x Tubing Capacity) + (Total Drawdown x Well Capacity) Record N/A in box if not applicable. Note: Include the length of tubing that is outside the well in the Total Tubing Length.

_____

Sampler's Signature

LOW FLOW GROUNDWATER PURGING AND SAMPLING

This Standard Operating Procedure (SOP) provides a general framework for collecting groundwater samples that are indicative of total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions with minimal physical and chemical alterations from sampling operations.

This procedure does not address the collection of water or free product samples from wells containing light or dense non-aqueous phase liquids (LNAPLS and DNAPLS). For this type of situation, the reader may wish to check: Cohen and Mercer (1993) or other pertinent documents.

The controlled version of this document is the electronic version viewed on-line on the NHDES website only[1]. If this is a printed copy of the document, it is an uncontrolled version and may or may not be the version currently in use.

This SOP is considered generally consistent with the United States Environmental Protection Agency (EPA), Region 1 SOP, "Low Stress (low flow) Purging and Sampling Procedure For the Collection of Ground Water Samples From Monitoring Wells," Revision 3, January 19, 2010.

[1] http://des.nh.gov/organization/divisions/waste/hwrb/documents/hwrb_master_qapp.pdf

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USE OF TERMS

Drawdown rate: The rate at which the water level in the well riser drops as the well is purged and sampled.

Equipment blank: is a sample of deionized (analyte-free) water which has been poured around and through sample collection equipment to evaluate the equipment decontamination procedures and the potential for cross-contamination between sample locations. Refer to the SAP for equipment blank requirements.

For bladder pumps, the equipment blank typically includes the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank need only include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after decontamination following sampling from contaminated wells and not following sampling from background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect a duplicate for each analyte group in consecutive order (volatile organic compound [VOC] original, VOC duplicate, metal original, metal duplicate, et cetera [etc.]).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen (DO), specific conductance, temperature, pH, and oxidation reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates (MS/MSD): Primarily used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Potentiometric Surface: The level to which water rises in a tightly cased well, constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan (site-specific)

SOP: Standard Operating Procedure

Stabilization: A condition that is achieved when the drawdown rate and all indicator field parameter measurements are sufficiently stable (as described in the “Well Purging and Sampling Procedure” section), thereby allowing sample collection to begin (as long as the minimum purge volume requirement is met).

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): A trip blank is a sample of analyte-free water taken to the sampling site along with the sample bottles, and returned to the laboratory for analysis (e.g., treated as a sample), to measure possible cross contamination of samples during shipping to and from the site. Trip blanks must not contain any analytes at or above the quantitation limit of the test. One trip blank consists of two full volatile organic analysis (VOA) vials and is added to each sample cooler that contains VOC samples.

SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides a general framework for collecting groundwater samples that are indicative of total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions with minimal physical and chemical alterations from sampling operations. This method involves pumping the well at a rate approaching ambient groundwater flow in order to minimize disturbance of the sampling zone and mixing with the riser water. Field parameters are monitored during purging until readings have stabilized; at this point (theoretically), groundwater entering the pump intake represents formation water and the sample is collected.

This SOP will help ensure that the project's data quality objectives (DQOs) are met when low flow sampling conditions are required. The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer. This is accomplished by low pumping rates, negligible water level draw down and stabilization of water quality parameters.

In low permeability formations or poorly installed monitoring wells, it may not be possible to collect groundwater samples using the standard low flow procedure. Under such conditions the "Modified Sampling Procedure" in **Appendix A** should be evaluated and approved by the project manager. The conditions that will require moving from the standard low-flow procedure to the modified procedure are:

a. The water level is at, or falls below, the top of the screen.

b. The well is under artesian conditions.

b. The specified drawdown rate is exceeded.

c. The pump flow rate needed to achieve a stabilized groundwater level is below 50 ml per minute.

In long term monitoring programs, if the low flow procedure has been attempted unsuccessfully at a well for two consecutive rounds, it may be possible (with the project manager's approval) to proceed to the "Modified Sampling Procedure" without further attempt to use the standard low flow procedure.

This procedure is primarily designed for monitoring wells with an inside diameter that can accommodate a positive lift pump (1.5-inches or greater) with a screen length or open interval of ten feet or less and with a water level above the top of the screen or open interval. (Hereafter, the "screen or open interval" will be referred to only as "screen interval.")

A goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help minimize sampling variability.

This SOP is to be used when collecting ground-water samples from monitoring wells at all Superfund, Federal Facility and Resource Conservation and Recovery Act (RCRA) sites in New Hampshire under the conditions described herein. This Low Flow sampling SOP may be modified to meet the DQOs for the sampling event. In long-term monitoring events, it may be possible to reduce the indicator field parameter list after baseline information is obtained over the first year or two. Careful consideration should be given to the purpose of each parameter used in the procedure. Each parameter may have some importance that extends beyond the measurement for stabilization. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. All changes and modifications must be approved and included in the site-specific Sampling and Analysis Plan (SAP) before implementation in field. The personnel responsible for approval of all changes shall be designated in the site-specific SAP. Typically, this is the NHDES Project Manager and may require consultation with the quality assurance (QA) coordinator and EPA.

Low flow indicator field parameters include: pH, turbidity, specific conductance, temperature, dissolved oxygen (DO) and oxidation reduction potential (ORP). All measurements must be obtained using a “flow-through cell”, except for turbidity. Turbidity must be collected at a point before the flow-through cell and measured with an instrument that is separate from the flow-through cell apparatus. A three-way stop cock (or “T” connection with a clamp) attached to the tubing before the flow-through cell will be used to collect the turbidity sample. Transparent flow-through cells are required. The transparency allows field personnel to watch for air bubbles and particulate build-up within the cell, which may affect indicator field parameter values measured within the cell. The flow-through cell must be designed, and used, in a way that prevents air bubble entrapment in the cell. Placing the flow-through cell at a 45 degree angle with the outlet port facing upward can help remove bubbles from the flow-through cell. All during the measurement process, the flow-through cell must remain free of any air bubbles. Otherwise, the monitoring probes may act erratically. When the pump is turned off or cycling on/off, water in the cell must not drain out. Monitoring probes must be submerged in water at all times. Refer to the Low Flow Setup Diagram in **Appendix C**.

A small volume cell (250 ml or less) facilitates more-rapid turnover of water in the cell between measurements of the indicator field parameters. The pump’s flow rate must be able to “turn over” at least one flow-through cell volume between measurements.

BACKGROUND FOR IMPLEMENTATION

Prior to conducting a low flow sampling event, information regarding well construction, development, screen length and water level records for each well to be sampled should be obtained and reviewed to determine the appropriate pump to be used, the location of the intake, and the potential groundwater recharge rate of the well. If this information is not available, a reconnaissance should be made prior to the actual sampling event to determine well depth, water

level, etc., and possibly perform a pump test to determine the recharge rate of the well. Additionally, wells that have not been sampled in years should be redeveloped prior to conducting the actual sampling event, if possible.

It is expected that the monitoring well screen, or open interval, has been properly located (both laterally and vertically) to intercept existing contaminant plumes, or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable for all wells to be sampled, then efforts to build a sampling history should commence with the next sampling event.

The pump intake shall be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate at a given well remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake.

Significant chemical or permeability differences within the screen or open interval may require additional field work (e.g., interval sampling, borehole geophysics) to determine the optimum vertical location for the pump/tubing intake and appropriate pumping rate for purging and sampling more localized target zones. Primary flow zones (e.g., higher permeability and/or higher chemical concentrations) shall be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help ensure that the low stress procedure will not underestimate contaminant concentrations.

For new wells, or for wells without pump intake information, the site-specific SAP must provide clear instructions on how the pump intake depth will be selected and require that the rationale be documented in the sampling report. If the depths to top and bottom of the well screen are not known, the SAP will need to describe how the sampling depth will be determined and how the data can be used.

Total purge volume, stabilization of indicator field parameters and drawdown rate are used to indicate when conditions are suitable for sample collection. Achievement of turbidity levels of less than 5 NTU and stable drawdown less than 0.3 feet, while desirable, are not mandatory.

Note: The project manager may set a limit on the amount of time allowed at each well due to financial, manpower and/or other constraints. In that case, sample collection would occur after the specified time has elapsed and it would be noted on the worksheet that the time limit had been reached before stabilization occurred.

In general, there is a two hour time limit for each well unless specified differently in the site-specific SAP.

If, after 2 hours of purging, indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved; b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization); or c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization. Note: there is a risk that the analytical data obtained in the case of this last course of action, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias, and therefore, the data may not meet the data quality objectives of the sampling event.

Cold weather considerations must be factored into a low flow sampling plan. It is recommended that low flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the DQOs, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be implemented. Ice formation in the flow-through cell will cause the monitoring probes to act erratically. A transparent flow-through cell is required to observe whether ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

The use of dedicated sampling equipment is recommended, as it promotes consistency in the sampling, may reduce sampling bias by having the pump's intake at a constant depth, avoids cross contamination and can streamline sampling activities that significantly reduce the time needed to complete each sampling event, thereby reducing the overall field costs.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All appropriate personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples shall be handled with suitable protection for skin, eyes, etc.

CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the conditions listed below are expected to occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethane, ethene, dissolved oxygen) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing (e.g., constricting the flow) which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem.

The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data. If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable. If minor differences in the groundwater concentrations could affect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device may not be the best pump to use for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

Direct sunlight and hot ambient air temperatures may cause the groundwater in the tubing and flow-through cell to heat up. This may cause the groundwater to degas, which will result in loss of VOCs and dissolved gases. When sampling under these conditions, shade the equipment from the sunlight (e.g., umbrella, tent). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid sunlight or ambient air heating up the groundwater.

<u>Condensation (fogging) of Turbidity Vial</u>: Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly by standing at ambient temperature or immersing in a container of ambient temperature water for a short period. After warming, gently invert the sample cell to thoroughly mix the contents before measurement.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water, which is denser than warm water, sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convection cell. "During low flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Interferences may result from using contaminated equipment, cleaning materials and sample containers, or from uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems caused by ambient air interferences can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely inspected to ensure that it is free from contaminants and equipment blanks also need to be collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected, then a more rigorous or alternative cleaning procedure will be required.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. Federal regulations may require the sampler to take the 40 hour OSHA health and safety training course and be current with refresher courses prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team must read, and be familiar with, the site Health and Safety Plan, the SAP, all relevant SOPs, and the current Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP)[2] (including the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest and document that they and their field team have read and understand these site documents.

EQUIPMENT AND MATERIALS

A. Appropriate health and safety gear.

B. Informational materials for sampling event

A copy of the current approved site-specific Health and Safety Plan, site-specific SAP, monitoring well construction data (e.g., well depth, inner casing diameter, screen interval), location maps, field data from prior sampling events, manuals for sampling, diagrams to show how the equipment is to be set up, and the monitoring instrument's operation and maintenance manuals, shall be brought to the site. The site-specific SAP shall specify the equipment that will be used and include a separate calibration SOP.

C. Well/site keys and spare locks.

[2] http://des.nh.gov/organization/divisions/waste/hwrb/documents/hwrb_master_qapp.pdf

D. Pumps:

Adjustable rate, submersible pumps (e.g., centrifugal, bladder) that are constructed of stainless steel or Teflon™ are preferred. Peristaltic (suction) pumps may be used (see project manager for restrictions). Note: if pumps constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used and will support DQOs. Acceptance of these materials must be obtained before the sampling event. Pumps capable of pumping at a low flow rate of 50 milliliters per minute (ml/minute) may be required in wells with low recharge. See the site-specific SAP for pump requirements.

Peristaltic Pumps:

1. A thin walled tubing pump head is necessary in order to achieve a 50 ml/min flow rate during purging and the use of a thin walled tubing pump head is a requirement for sampling. This may require the purchase/rental of a different peristaltic pump head than the one that comes standard with the pump.
2. Adjustable rate, peristaltic pumps are to be used with caution when collecting VOCs and dissolved gases (e.g., methane, carbon dioxide) analyses. Additional information on the use of peristaltic pumps can be found in the section on cautions above.
3. The use of piggybacked peristaltic pump heads is unacceptable as the arrangement may produce an uneven flow with potential to aerate the water and cause the loss of VOCs and dissolved gases. "Piggybacked" pump heads are defined as multiple heads stacked on a common drive axel (i.e., when the pump's standard rotor head is too large for a small tubing size, and a smaller rotor head is piggy-backed onto the standard rotor head).

Bladder Pumps:

1. The size and capacity of the pump, and it's placement in the well, shall be selected to maximize the filling of the pump's bladder. For proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's submergence requirements must be determined during the well drilling planning stage, because it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.
2. The control box shall have a manual control option.
3. For the collection of VOCs and dissolved gases:
   a. The bladder's capacity shall be large enough (greater than 70 milliliters) to fill a VOA vial in one pulse.
   b. The pump settings (refill and discharge rates) shall be set so that one pulse will deliver a water volume that is sufficient to fill a 40 ml VOA vial while allowing the discharge to flow gently down the inside of the container with minimal turbulence.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This

can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

E. Appropriate tubing:

The HWRB requires that a fiberglass measuring tape or other accurate measuring device be used when measuring and installing down-well tubing.

See the site-specific SAP for down-well tubing requirements that meet the site's DQOs. Adequate information must be provided to show that the tubing materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

Polyethylene, Teflon-lined polyethylene or Teflon tubing is typically used in the well. Teflon or Teflon-lined polyethylene tubing is preferred when sampling for SVOCs, pesticides, and PCBs. If these samples are collected with a bladder pump, both the down-well air and sampling lines shall be made of Teflon (or Teflon-lined polyethylene).

The use of one-quarter inch (1/4") inside diameter (ID) tubing is recommended. This will help ensure that the tubing remains liquid-filled when operating at very low pumping rates with centrifugal and peristaltic pumps. Three-eighths (3/8) inch ID tubing may also be used with project manager approval. Smaller diameter tubing (less than 1/4" ID) is not generally recommended. If sampling with a bladder pump, use the size tubing recommended by the manufacturer.

Dedicated pharmaceutical or surgical grade silicon (Silastic™) tubing shall be used in the rotor head of peristaltic pumps (sized according to ID x outside diameter (OD) x wall thickness). <u>For sampling</u>: Thin walled tubing #16 (1/8" x ¼" x 1/16") and/or thin walled tubing #14 (1/16" x 3/16" x 1/16") if necessary to reduce flow to 50 ml/min. <u>For connections</u>: thick walled tubing #15 (3/16" x 3/8" x 3/32") and possibly #17 (1/4 x 3/8 x 1/16). Either a tubing connector will be used to connect the pump rotor head tubing to the well tubing or two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing.

F. The water level measuring device

An electronic tape, pressure transducer, water level sounder/level indicator, etc., capable of measuring to one one-hundredth of a foot (0.01 ft.) accuracy shall be used. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include measurement checks with a water level tape at the start and end of each sampling event.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL or DNAPL) before purging begins (as needed).

H. Flow measurement supplies

A graduated cylinder sized according to the flow rate (e.g., 100 ml or 250 ml graduated cylinder, measured in 10 ml increments) to accurately measure the flow in ml/minute.

A stopwatch to accurately measure the flow in ml/minute.

Large graduated bucket (e.g., five-gallon size) used to record the total volume of water purged from the well, marked in gallons and/or liters (milliliters where appropriate).

I. Power source

Portable power pack, twelve (12) volt, deep cycle marine battery, or other battery; nitrogen tank or air compressor; etc.; depending upon data quality objectives.

The HWRB prefers the use of non-gasoline powered equipment. If a gasoline-powered source (e.g., generator) is used, it must be located downwind and at a safe distance from the well (at least 30 feet) so that there is reduced potential for the exhaust fumes to contaminate the samples.

J. Indicator field parameter monitoring instruments

The use of multi-parameter water quality meters with a transparent 250 ml or less internal volume flow-through cell capable of measuring pH, ORP, DO, specific conductance and temperature are required (e.g., YSI 600 XL/XLM or 6820). Record the equipment/instrument identification information (including manufacturer serial and model number) on the Calibration Log or appropriate form.

The transparent cell allows easy detection of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes.

A small volume cell (250 ml or less) facilitates rapid turnover of water in the cell between measurements of the indicator field parameters. The pump's flow rate must be able to "turn over" at least one flow-through cell volume between measurements (for a 250 mL flow-through cell with a flow rate of 50 ml/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through cell at the same flow rate, it would be every ten minutes). If the cell volume cannot be replaced in the proper interval (e.g., five minute for a 250 mL flow-through cell), then the time between measurements must be increased accordingly.

The flow-through cell must be designed and used in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times.

It is recommended to use a flow-through cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through cell.

The meter shall measure the following parameters to use with the low flow sampling technique:

Temperature, degrees Celsius (˚C)
Specific Conductivity, micro Siemens per centimeter (µS/cm)
DO, milligrams per liter (mg/l) with 100% saturation for calibration
pH that calibrates using 3 standards (pH 4, 7 and 10)
ORP, millivolts (mV)

Turbidity samples are collected before the flow-through cell. A portable turbidity meter with a calibration range from 0.00 to 800 (or 1000) Nephelometric Turbidity Units (NTUs) is required (e.g., Hach 2100P or 2100Q Portable Turbidity Meter).

A three-way stopcock (recommended) or a "T" connector coupled with a clamp is connected between the pump's tubing and flow-through cell (e.g., Nalgene three-way stopcock with a plug bore of 4 mm [or 0.157 inch]: NNI No. 6470-0004, VWR catalog No. 59097-080). If using an

in-line "T" connector, attach a short piece of tubing to the center branch of the "T" connector to serve as a sampling port for the turbidity samples. When a turbidity measurement is required, the valve/clamp is opened to allow the ground water flow to be diverted into a container. The valve/clamp is closed and the sample container is capped and then placed into the turbidity meter.

Appropriate calibration standards are required for the multi-parameter and turbidity meters, including: 100% water-saturated air chamber (small wet sponge or paper towel for DO 100% saturation calibration) and zero (0) mg/l solution for DO; Zobell solution for ORP; two different specific conductance standards, one high and one low, where one standard is used to calibrate and the other standard is used to check the calibration (e.g., 1,413 µS/cm and 718 µS/cm); 4, 7, & 10 units pH buffering solution; and <0.1, 10, 20, 100, 800 NTUs standards, as appropriate for the selected meter, for turbidity. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP, which uses a Zobell solution as a standard. Extra DO membranes, in case of breakage are also required.

A barometer (used in the calibration of the DO probe) and the conversion formula (to convert the barometric pressure into the units of measure used by the DO probe) are needed unless the instrument already has a built-in temperature-compensated barometer.

K. Equipment protection paraphernalia to:

1. Adequately shade equipment and tubing to prevent temperature variations in the readings, bubbles forming in the tubing, and the acid preservative in the sample containers from volatilizing.
2. Protect both personnel and equipment from other elements including rain, wind, etc.
3. Keep the sampling equipment from freezing in the winter.
4. Keep monitoring and sampling equipment off the ground (e.g., table, bucket or polyethylene sheeting). **Note:** When using peristaltic pumps, it is highly recommended that the pump be placed on a table, or other surface, as close to the height of the well casing as possible to eliminate or reduce the buildup of air bubbles in the sample line between the peristaltic pump and the top of the casing.

L. Decontamination supplies

Decontamination supplies, as appropriate: (e.g., non-phosphate detergent, laboratory-grade deionized (DI) water, appropriate solvent such as isopropyl alcohol, plastic sheeting, buckets, brushes and spray bottles). Note: Some non-phosphate detergents may contain 1,4-dioxane, which may be a concern.

Trash bags to containerize solid waste.

M. Sample containers, etc.

Sample containers preserved as necessary, sample labels, cooler and <u>loose</u> ice (not bagged). Re-sealable plastic bags and bubble wrap to protect and store samples.

N. PID or FID instrument

Used if appropriate, to detect VOCs for health and safety purposes and provide qualitative field evaluations.

O. Toolbox

To include such items as: wrenches, pliers, screw drivers, tubing cutter, 25-ft. measuring tape, a sharp knife with a locking blade, wire strippers, bolt cutters, hacksaw, hammer, flashlight, hose connectors, a socket set, Teflon tape, and duct tape.

P. Record keeping supplies

Logbook(s) and other forms (e.g., field-data sheets, sample labels, chain-of-custody forms and seals, field worksheets, well purging forms, calibration logs), pens, sharpies, calculator, camera, etc. Note: Use only ball point pens (preferably with black ink) to record field data (e.g., calibration logs, worksheets, log books). Do not use Sharpies® to record field data as they can bleed through pages and smudge.

Q. In-line filters

If filtered samples (e.g., dissolved metals) are required, use an in-line filter (transparent housing preferred). The filter size (0.45 micron is commonly used) is based on the sampling objective.

EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field. The manufacturer's instruction manuals for field equipment shall be on site during each sampling event.

All instruments shall be successfully calibrated (including a calibration check) and the calibration/calibration check documented once by the sampling team in the office prior to the sampling event (within one week) to ensure that the equipment is working properly. Refer to the HWRB-17 Calibration of Field Instruments SOP in the current HWRB Master QAPP for specific calibration and calibration check procedures and a calibration log.

The instruments shall be calibrated at the beginning of each sampling day at the Site using the appropriate solutions. The calibration will be checked in the run mode after the morning (initial) calibration has been completed to ensure that the calibration was successful. If the field measurement falls outside the calibration range, the instrument must be re-calibrated and checked again so that all measurements fall within the calibration range.

The calibration will be checked at the end of the day in the run mode to verify the accuracy of the instrument readings throughout the day. If a calibration check at the end of the day is not within the acceptable range for that parameter, the data collected that day for that parameter shall be qualified in its use. All calibration data shall be recorded on the calibration log. In addition,

should any erratic or suspect readings occur between calibrations, the instrument shall be recalibrated in order to ensure that representative measurements are obtained.

If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is recommended to ensure that the instruments did not drift out of calibration.

Note: during the day, if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), then this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs, the data from this instrument will need to be qualified or rejected and the instrument must be recalibrated before use.

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., multi-parameter meter) can result in faulty data being collected.

PRELIMINARY SITE ACTIVITIES

Inspect the well for security (e.g., damage, evidence of tampering, missing lock) and record pertinent observations (include photographs as warranted). Note any physical changes to well condition, such as erosion or cracks in protective concrete pad, road box or standpipe. If a lock is found to be damaged, then replace it with a new lock. Wells shall be locked at all times when not being sampled.

Remove well cap. Immediately measure VOCs at the rim of the well with a PID or FID instrument if required in the SAP or Health and Safety Plan; record the reading in the field logbook/worksheet.

If the well casing does not have an established reference point (usually a V-cut or indelible mark on the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the elevation of this point should be determined using techniques that are appropriate to the site's DQOs).

A synoptic water level measurement round is performed (in the shortest possible time, i.e., all in one day) before any purging and sampling activities begin, unless otherwise specified in the SAP. A synoptic water level measurement round will be necessary if potentiometric surface maps are to be constructed for the sampling event. It is recommended that water levels (to 0.01 feet) be measured at least one day prior to well sampling activities, if possible, in order to allow for re-settlement of any particulates that were mixed into the water column by the measuring activity. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made at least 24 hours in advance, it shall not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care shall be taken to minimize water column disturbance.

Note: Unless otherwise specified, annual measurement of total depth is usually sufficient after the initial low flow sampling event. However, a greater frequency may be needed if the well has a "silting" problem or if confirmation of well identity is needed, and a lesser frequency may be adequate for long term site monitoring.

Well depths shall be measured at least once every five years in the sampling event just prior to the Five Year Review at all Superfund Sites. It may not be possible to measure the depth of the well if dedicated bladder pumps are used. If that is the case, the depth of the well should be measured when the pump is removed for maintenance, if there is evidence of high turbidity, or as otherwise required in the SAP.

Install sampling pump or tubing, if necessary. Lower equipment (e.g., pump, safety cable, tubing and electrical lines) slowly into the well so that the pump or tubing intake is located at the center of the saturated screened interval at a depth that will remain under water at all times. The lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. The SAP shall specify the sampling depth, or provide criteria for selection of intake depth for each well. Great care must be taken to minimize the disturbance of particulates that can greatly extend the purge time by increasing turbidity. If possible, keep the pump or tubing intake at least two feet above the bottom of the well to minimize mobilization of particulates present in the bottom of the well. The suction-pump down-well tubing or the submersible pump's safety cable shall be secured to the well casing (or PVC stick-up) to minimize movement.

Pump tubing lengths extending beyond the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

Lay out a sheet of clean polyethylene to place the monitoring and sampling equipment on, unless equipment is elevated above the ground (e.g., on a table or a bucket). **Note**: When using peristaltic pumps, it is highly recommended that the pump be placed on a table, or other surface, as close to the height of the well casing as possible to eliminate or reduce the buildup of air bubbles in the sample line between the peristaltic pump and the top of the casing.

Set up equipment according to the attached Low Flow Setup Diagram. This diagram shows the low flow setup using a bladder pump; however, the diagram may be modified in the site-specific SAP to show the appropriate pump and power source.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent measurement checks with an interface probe may not be necessary, unless analytical data or field analyses signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternative sampling method. All project modifications must be approved and documented prior to implementation.

If available, check intake depth and drawdown information from previous sampling events for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous events. If changes are made to the intake depth or extraction rate used during previous sampling events, for either portable or dedicated pumps, record new values, and explain reasons for the changes in the field log/sampling worksheet.

WELL PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

In general, the well is considered ready for sample collection once the appropriate drawdown rate requirement has been achieved, the indicator parameters have stabilized and the purge volume requirement has been met, or two hours of purge time has elapsed.

1. Carefully lower a water level indicator to the top of groundwater. Measure and record the water level (to 0.01 feet) before any disturbance to the well. Care shall be taken to minimize suspension of any particulates attached to the sides.
2. If the well is under the following conditions, refer to the "Modified Sampling Procedure" section for instruction for sampling the well (with the project manager's approval): the well is under artesian conditions, the water level is at, or below, the top of the screen, or if the well is flagged as having insufficient recharge for two consecutive rounds. If the well is not under any of these conditions, then proceed to the next step.
3. Start the pump
    a. Try to match the final pumping rate used during previous sampling events. If no previous information is available, start the pump at its lowest speed setting and slowly increase the speed until discharge occurs.
    b. From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged.
    c. The water flow during sampling needs to be a laminar flow without air bubbles.

       If air bubbles are observed, they can usually be removed by elevating the discharge tubing to allow the air to continue rising until discharged with the purge water. When using a peristaltic pump, any air captured in the tubing can usually be removed by elevating the discharge tube and the pump.

       Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.
    d. When using the bladder pump for VOC or dissolved gas samples, the pump settings (refill and discharge rates) shall be set so that one pulse will deliver a water volume that is sufficient to fill a 40 ml VOA vial.

e. If excessive turbidity or floc is anticipated or encountered with the pump startup, divert the water through the three-way stopcock, as if you were taking a turbidity sample, until it clears in order to minimize particulate buildup in the cell (this is a judgment call made by the sampler). Make sure that the discharge water is going into the graduated bucket so that it will be included in the determination of the final purge volume. If possible, install the pump the day before purging to allow particulates that were disturbed during pump insertion to settle.

4. Measure and record the water level in the well after 5 minutes of pumping. Record the drawdown and assess the water level drawdown rate.

5. Adjust pump rates until there is little or no water level drawdown.

Pumping rates shall, if needed, be reduced to the minimum capabilities of the pump and tubing size to avoid drawdown and to ensure stabilization of monitoring parameters. **Pumping rates shall not be less than 50 ml/minute.**

Concentrate on the flow rate and drawdown rate stabilization for the first 15 minutes, or so, of the well purging effort (e.g., first 3 to 4 water level readings at 5 minute intervals). In general, the drawdown rate is expected to be stabilized within 15 to 20 minutes after the purge water first exits the flow-through cell and enters the bucket.

The following drawdown limits are acceptable with a flow rate of between 50 to 60 ml/min:

Maximum Allowable Drawdown Over One 5-Minute Period	
Inside Diameter of Inner Casing (in.)	**Drawdown Rate (feet / 5 min.)**
3 or less	0.02
3.5 - 5	0.01
6	No drawdown allowed

These maximum allowable drawdown rates provide at least 90% (and greater for smaller diameter wells within the range) fresh aquifer water and no more than 10% stagnant well water in the flow-through cell and samples.

When using a peristaltic pump, if a flow rate of 50 ml/minute cannot be achieved or maintained using the #16 silicon tubing, the #14 tubing must be used through the pump head. Once the tubing is changed, re-adjust pump rate and continue to assess drawdown rate (e.g., by collecting 3 to 4 water level readings at 5 minute intervals).

Recording of the indicator parameters, although useful, is not mandatory during this initial 15 to 20 minute time period when attempts are being made to adjust the flow rate and stabilize the drawdown rate; however, make sure the purge water is still being collected in the graduated bucket as part of the total purge volume.

Make a notation on the field worksheet “NR” for “no reading” at times when only partial data is being collected (e.g., water level only) during this initial stage of adjusting pump speed and stabilizing the drawdown rate. Note that if you observe minimum fluctuation of the indicator parameters during this initial period, then go ahead and begin recording

data, as it may help reduce the time spent purging. Measure the purge volume of a cycle with a 250 ml, or smaller size, graduated cylinder.

6. The well will be considered to have insufficient recharge for low flow sampling under the following conditions:

   a. The initial water level was above the top of the screen prior to starting the pump but the water level falls below the top of the well screen during purging, or

   b. After the first 4 water level readings at 5 minute intervals (or when using the peristaltic pump, the subsequent 4 water level readings using the size #14 tubing), the water level continues to drop at a rate that is greater than the maximum allowable drawdown in the chart above, with the pump setting at the lowest level, or

   c. The flow rate to achieve a stabilized groundwater level is below 50 ml per minute (with the size #14 silicon tubing if using a peristaltic pump).

   Under an "insufficient recharge" condition, sampling may occur immediately if the total purge volume is greater than one tubing volume, and enough water remains above the tubing intake to collect the samples, as follows:

   a. If one tubing volume has not yet been purged, continue purging until it has been reached.

   b. Collect at least one set of field parameters before disconnecting the three-way stopcock and collecting the samples, unless the site-specific SAP states otherwise.

   c. To collect the samples, refer to the sample collection steps below.

   If this type of problematic situation persists in a well (e.g., for a minimum of two consecutive sampling rounds), then the modified sampling procedure in **Appendix A** should be evaluated and approved for future sampling events at the well by the project manager if it's consistent with the site's DQOs or a new well should be installed.

   If the well is not considered to have insufficient recharge for low flow sampling, then continue to the next step.

7. In addition to the water level, drawdown rate, pumping rate and any adjustments, now begin recording the indicator field parameters (pH, turbidity, specific conductance, temperature, DO and ORP) at a frequency of five minute intervals or greater (e.g., every ten minutes until the indicator field parameters start to stabilize is an acceptable interval initially, but then every five minutes until stabilization) or until the two hour time limit is up. **Readings shall NOT be taken less than five minutes apart.**

   a. The pump's flow rate must be able to "turn over" at least one flow-through cell volume between measurements (i.e., for a 250 ml flow-through cell with a flow rate of 50 ml/minute, the monitoring frequency would be every five minutes; for a 500 ml flow-through cell at the same flow rate, it would be every ten minutes). If the cell volume cannot be replaced in the proper interval (e.g., five minute for a 250 ml flow-through cell), then the time between measurements must be increased accordingly.

b. Periodically check the probes and the top of the flow-through cell for air bubbles and eliminate any that are found. Be sure to tilt the flow-through cell with the outflow connection facing upward to eliminate and prevent air bubbles.

c. Rinse the turbidity vial with DI water before collecting the first sample. Rinse the vial with fresh purge water or DI water between readings to eliminate any sediment that may have collected on the bottom.

d. Condensation may occur on the outside of the turbidity sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly by standing at ambient temperature or immersing in a container of ambient temperature water for a short period. After warming, wipe the sample cell dry and gently invert the sample cell to thoroughly mix the contents before measurement.

e. If the flow-through cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities. Record begin and end times for cleaning and document with a brief description of cleaning activities.

f. The flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples. It may be necessary to reduce the flow rate to collect volatile samples (e.g., VOCs, methane, ethane, ethene, carbon dioxide, volatile fatty acids, etc.) in order to fill the sample containers by allowing the discharge to flow gently down the inside of the container with minimal turbulence.

8. Stabilization of indicator parameters is considered to be achieved when three consecutive readings at five-minute (or longer) intervals are within the following limits:

- **Temperature: +/- 1º C**
  Values are typically rounded to the nearest whole number (e.g., 10.4 is rounded to 10, whereas 10.5 is rounded to 11).

- **Specific Conductivity (µS/cm): +/-3%**
  Values are typically rounded to the nearest whole number.

- **DO: +/-10% for values greater than 0.5 mg/l**
  Values are typically rounded to one decimal place.
  Values between 0.5 and 1.0 are typically considered stable within +/- 0.1 mg/l.
  Values less than zero point five (0.5) are typically reported as <0.5.
  If three consecutive DO values are less than 0.5 mg/l, consider the DO stabilized.

- **pH: +/- 0.1 unit**
  Values are typically rounded to one decimal place.

- **ORP: +/- 10 millivolts**
  Values are typically rounded to the nearest whole number.

- **Turbidity: +/-10% for values greater than 5 NTU**
  Values are typically rounded to the nearest whole number.
  Values between 5 and 10 are typically considered stable within +/- 1 NTU.
  Values less than five (5) are typically reported as <5.
  If three consecutive turbidity values are less than 5 NTU, consider the values stabilized.

9. If all the indicator field parameters have not stabilized within 2 hours of commencing purging, collect the samples (with project manager approval) and record the following information on the field worksheet: indicate that two-hour purge limit was reached, note the specific conditions that were not achieved, which parameters were not stabilized, the final set of readings, and the total purge volume.

10. **Purge Volume Requirement**

Now that the drawdown rate and parameters have stabilized, the purge volume requirement (PVR) must be calculated to ensure that a minimum volume of water has been removed from the well before sampling begins.

a) **If the total drawdown in the well is less than 0.3 feet**, then the purge volume requirement is one tubing volume. In other words:

PVR = (Total Tubing Length [ft.] x Unit Tubing Capacity [gal/ft. or ml/ft.])

b) **If the total drawdown in the well is greater than 0.3 feet**, then the purge volume requirement is the combination of one tubing volume and the volume of water in the well between the initial water level and the current water level.

PVR = (Total Tubing Length [ft.] x Unit Tubing Capacity [gal/ft. or ml/ft.]) + (Total Drawdown [ft.] x Unit Well Capacity [gal/ft. or ml/ft.])

The tables below can be used to determine the appropriate volumes.

Unit Tubing Capacity Values

Tubing Diameter (Inches)	1/4 (0.25) OD **(0.17 ID)***	3/8 (0.375) OD **(0.25 ID)***	1/2 (0.50) OD **(0.375 ID)***	5/8 (0.625) OD **(0.50 ID)***
Volume (gal/foot)	0.0012	0.0026	0.0057	0.0102
Converted to Volume (ml/foot)	4.5	9.7	21.7	38.6

Unit Well Capacity Values

PVC/Inner Well Casing ID* (inches)	**1.25**	**1.5**	**1.75**	**2**	**2.25**	**3**	**3.5**	**4**	**6**
Volume (gal/ft.)	0.06	0.09	0.12	0.16	0.21	0.37	0.5	0.65	1.47
Converted to Volume (ml/foot)	227.1	340.7	454.2	605.6	794.9	1400.5	1892.5	2460.3	5564.0
Converted to Volume (liter/foot)	0.227	0.341	0.454	0.606	0.795	1.401	1.893	2.460	5.564

* Calculations are based on the ID, not the OD.

11. Sample Collection.

a) Samples for laboratory analyses must be collected before the flow cell and the three-way stopcock. This will be done by disconnecting the three-way stopcock from the pump discharge tubing so that the samples are collected directly from the pump tubing.

b) Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.

c) VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling projects; the SAP shall list the order in which the samples are to be collected based on the project's objectives.

For collecting VOC samples, including 1,4-dioxane (using Methods 8260 SIM or EPA EIASOP-VOADIOX4), carbon dioxide, methane, ethane and ethene, refer to the Special Considerations for VOC Sampling section at the end of this SOP.

d) If dissolved (i.e., filtered) metals samples or other samples collected for dissolved analytes, such as dissolved organic carbon (DOC), are required, attach a onetime-use-only in-line filter (transparent housing preferred) to the end of the tubing. The filter size (0.45 micron is commonly used) is based on the sampling objective. Make sure the filter is free of air bubbles before samples are collected. Hold the filter upright until the purge water exits the top to allow the water to completely fill the filter. Allow a volume of purge water, roughly equivalent to the volume of the filter, to discharge into the bucket to rinse the filter before collecting the sample. Discard the filter after use. When collecting a duplicate sample, a new filter must be used**.**

Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

e) Make sure that all sample containers are properly labeled. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry.

1) If the pump's flow rate is too high to collect the VOC/dissolved gases samples, follow this procedure unless otherwise specified in the SAP: collect the other samples first, lower the pump's flow rate to a reasonable rate, collect the VOC/dissolved gases samples and record the new flow rate.

2) For bladder pumps that will be used to collect VOC or dissolved gas samples, the pump must be set to deliver long pulses of water so that one pulse will fill a 40 ml VOA vial.

f) Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples shall be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC original, VOC duplicate, VOC MS/MSD, SVOC original, SVOC duplicate, SVOC MS/MSD).

g) Place samples in re-sealable plastic bags. Samples requiring cooling shall be placed **<u>into loose ice</u>** within a cooler for delivery to the laboratory. Metals samples, after acidification to a pH less than 2, do not need to be cooled.

h) If the water level in the well drops to, or below, the tubing intake during sample collection, then discontinue sampling at that location and return to collect the remaining samples once the well has sufficiently recharged.

If the well has to recharge overnight, refer to the "Modified Sampling Procedure" section for instruction on sampling the well. One tubing volume of water must be removed immediately before collecting the samples.

12. Post Sampling Activities

a) Just prior to turning off the pump, measure and record the water level on the worksheet, then turn off the pump.

b) Record the total purged volume (contained in the graduated bucket) on the worksheet.

c) If a recording pressure transducer is used, re-measure water level with tape.

d) Disconnect equipment as needed.

e) Remove the pump and tubing from the well, unless dedicated. Secure dedicated pump and tubing to the inside of the well. Non-dedicated tubing should be discarded.

f) If not previously measured, measure and record the depth of the well (to 0.1 ft.), as required in the SAP. More information on measuring well depths is located under Preliminary Procedures.

g) Secure the well with the locking cap.

h) Decontaminate any non-dedicated equipment according to the Decontamination SOP in the SAP.

i) Collect an equipment blank if required. Refer to the site-specific SAP for details and analysis.

SPECIAL CONSIDERATIONS FOR VOLATILE ORGANICS SAMPLING

This consideration for VOC sample collection includes 1,4-dioxane samples analyzed by Methods 8260 SIM and EPA EIASOP-VOADIOX4.

The proper collection of a sample for volatile organic compound analysis requires minimal disturbance of the sample to limit volatilization and therefore achieve a minimal loss of volatiles from the sample.

The proper VOC collection procedure is as follows:

1. Open the vial, set cap in a protected place, and collect the sample by allowing the water to flow gently down the inside wall of the container with minimal turbulence. When collecting quality control samples (duplicates and MS/MSD samples), collect them

immediately following the original sample (e.g., VOC sample, VOC duplicate sample, then VOC MS/MSD sample).

2. Do not rinse the vial or excessively overflow it because it likely contains a specific volume of preservative that must not be diluted.

3. Do not collect the initial 10 ml (approximate) of sample in the discharge tubing, as the beginning of the sample has been in contact with air.

4. Be sure the sample flow is laminar and there are no air bubbles in the sample flow.

5. There should be a convex meniscus on the top of the vial prior to capping the vial. The cap may be used to create the convex meniscus for VOC samples, if needed.

   For methane/ethane/ethene and carbon dioxide, the laboratory typically requests that the sample bottle cap is not used to top off the sample vials. Fill these vials in the shortest time possible and cap immediately. Do not uncap these vials and add more water. Small bubbles are considered normal for these pre-preserved containers; however, every effort shall be made to collect the highest quality (e.g., bubble free) sample possible.

6. Check that the cap has not been contaminated (splashed) and carefully cap the vial.

7. Place the cap directly over the top and screw down firmly. Do not over-tighten and break the cap.

8. Invert the vial and tap gently. If an air bubble appears, uncap and attempt to add a small volume of sample to achieve the convex meniscus without excessively overfilling the vial. If this has to be repeated more than twice, discard the sample and begin again with a new container and preservative. It is imperative that no entrapped air is in the sample vial.

9. Wipe the vial dry and immediately place the vial in a re-sealable plastic bag and then in loose ice in the cooler.

FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same way as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, MS/MSD, trip blanks (VOCs) and temperature blanks. Refer to the site SAP for specific quality control requirements. Collecting equipment blanks on non-dedicated equipment will ensure that the decontamination procedure is adequate.

DECONTAMINATION

All non-dedicated sampling equipment, including water level probes/tape, pumps, support cable and electrical wires that were in contact with the well shall be decontaminated following approved decontamination procedures, as specified in the site-specific SAP. General decontamination procedures may be found in **Appendix B** and in the HWRB-15 Decontamination SOP in the current version of the HWRB Master QAPP.

Decontaminate sampling equipment prior to use in the first well and then following sampling of each well. Non-dedicated tubing should be discarded.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps are used, only the initial sampling event will require decontamination of the pump before use.

Note: if the previous equipment blank showed that contaminants were present after using one of the described procedures in **Appendix B** or in the SAP, a more rigorous or alternative procedure may be required.

DOCUMENTATION

A field log and field worksheets (well sampling worksheets, equipment calibration logs, etc.) shall be kept to document all groundwater field monitoring activities (see **Appendix D** for an example worksheet). Record the following for each well, at a minimum:

- Date.
- Site name and location.
- Well identification.
- The sampler's name.
- Description of all sampling/monitoring equipment used, including type of pump used, trade names, model number, instrument identification (serial) number, diameters, material composition, etc. (Some of this information may be located on the Calibration Log, see HWRB-17 Calibration of Field Instruments SOP).
- Reference measuring point description (e.g., top of PVC, top of casing).
- Well depth in reference to measuring point.
- Well screen interval from measuring point.
- Pump or tubing intake depth from measuring point.
- Head above pump intake in reference to the measuring point for bladder pumps.
- Static water level from measuring point.
- Inside diameter of the tubing for purge volume requirement.

- The volume required for removing one tubing volume of water, as applicable, including the calculations used.
- The inside diameter of the PVC (or inside well casing), in inches, for purge volume calculation or determination.
- Calculated purge volume required, as appropriate. Document the actual calculations on the worksheet to show how the total volume was determined.
- Purge rate in milliliters per minute.
- Any adjustments, water level at the specified purging rate, and clock time for each set of measurements.
- Pump speed, if applicable.
- Pump refill and discharge settings and pressure (psi) for bladder pumps.
- All measurement readings of indicator parameters and water levels.
- Time of all measurements.
- Drawdown and cumulative drawdown, in feet.
- Total purge volume, in gallons.
- Notation of reaching time limit, if applicable.
- Notation of parameter stabilization (or not) and which parameters did not stabilize after time limit was reached (if any).
- Time of sample collection (start and end).
- Samples collected and preservatives.
- Comments or field observations during sampling event (e.g., condition of well, missing locks).
- Weather conditions, including approximate ambient air temperature.
- Quality assurance/quality control (QA/QC) data for field instruments. This information is located on the Calibration Log. Refer to the HWRB-17 Calibration of Field Instruments SOP.
- If the calibration check at the end of the day is not within the acceptable range for any of the indicator parameter(s), make a notation on the worksheet that the data collected for that parameter needs to be qualified as used for stabilization purposes only and not as representative of the water being sampled. Refer to the HWRB-17 Calibration of Field Instruments SOP for more information on the calibration check.
- Presence and thickness of immiscible liquid (NAPL) layers and detection method as applicable.
- Latitude-longitude or state grid coordinates, if available.

- Highlight any problems encountered.
- Sampler's signature

DATA REPORT

Data reports are to include all laboratory analytical results with chain-of-custody forms, QA/QC information, field indicator parameters measured during purging, field instrument calibration information (e.g., Calibration Log), a copy of all field logbooks and worksheets and whatever other information is needed to allow for a full evaluation of data usability. See the site-specific SAP for report requirements.

REFERENCES

Cohen, R. M. and J. W. Mercer, 1993, DNAPL Site Evaluation: C. K. Smoley (CRC Press), Boca Raton, Florida

USEPA Region I, 1996; Low-Stress (Low-flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, Revision 2, July 30, 1996, revised January 19, 2010.

Vroblesky, Don A., Clifton C. Casey, and Mark A. Lowery, Summer 2007, Influence of Dissolved Oxygen Convection on Well Sampling, *Ground Water Monitoring and Remediation* 27, no. 3: 49-58.

APPENDIX A

LOW FLOW PROCEDURE EVALUATION AND MODIFICATIONS

Due to site conditions, sample variability, manpower, financial and/or other constraints, the HWRB project manager may generate modifications to this procedure such as time limitations, equipment used, alternative sampling techniques, etc.

The purpose of the low-flow sampling procedure is to sample the groundwater from the surrounding aquifer at a rate approaching ambient groundwater flow in order to minimize disturbance of the sampling zone and mixing with the riser water.

In low permeability formations or poorly installed monitoring wells it may not be possible to collect groundwater samples using the standard low flow procedure. Under such conditions the modified sampling procedure presented here should be evaluated and approved by the project manager.

MODIFIED SAMPLING PROCEDURE

This modified procedure is to be used (with the project manager's approval) if the well has insufficient recharge and minimal drawdown cannot be achieved according to the criteria listed in the standard procedure above, if the well is under artesian conditions, or if the water level is at, or below, the top of the screen. Refer to site-specific SAP to determine if field parameters are required. Wells where this occurs will be considered for replacement in the future.

This modified procedure has a purge volume requirement (PVR) of one tubing volume of water that must be purged before sample collection; with or without the collection of field parameters.

A. Modified Sampling Procedure with No Field Parameters

1. Set up equipment according to the attached Low Flow Setup Diagram. If field parameters are not required, it is not necessary to set up the equipment associated with the field parameters as indicated on the Low Flow Setup Diagram.
2. Carefully lower a water level indicator to the top of groundwater. Measure and record the water level (to 0.01 feet) before any disturbance to the well. Care shall be taken to minimize suspension of any particulates attached to the sides.
3. Start the pump at its lowest speed setting and slowly increase the speed until a flow rate of 50 ml/minute is reached. If a 50 ml/minute flow rate cannot be achieved, then set the pump at the lowest flow rate that the pump is cable of attaining. **Pumping rates shall not be less than 50 ml/minute.**

   If using a peristaltic pump, make sure the correct pump head (thin wall tubing pump head) and the silicon tubing (smallest size silicon tubing, #14) is being used and that the pump head is set at 300 RPM not 600 RPM.

4. Purge one tubing volume of water at 50 ml/min, or lowest flow rate possible above that, prior to sample collection.

   One purge volume (in gallons) is equal to h * 3.14 * $(r/12)^2$ * 7.48 gal/ft^3, where

   h = length of tubing (feet)
   r = internal radius of tubing (inches) = inside diameter/2

   Or, in other words, one purge volume is equal to (h) * (f) where:
   h = length of tubing (feet)
   f = the unit volume per foot of water column (gal/ft.)

   For convenience, the table below is provided in order to quickly determine the "f" factor. In order to more accurately measure the purge volume, the table can also be used to determine the purge volume in units of milliliters. It accounts for the gallons-to-milliliters conversion (1 gallon = 3,785 mL).

   One unit purge volume (gal/ft. or ml/ft.) = one foot of tubing (ft.) x volume (gal or ml).

Tubing Diameter (inches)	1/4 (0.25) OD **(0.17 ID)***	3/8 (0.375) OD **(0.25 ID)***	1/2 (0.50) OD **(0.375 ID)***	5/8 (0.625) OD **(0.50 ID)***
Volume (gal/foot)	0.0012	0.0026	0.0057	0.0102
Volume (ml/foot)	4.5	9.7	21.7	38.6

   Record the PVR and the calculations used to determine the purge volume required on the well sampling worksheet.

5. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.

6. Begin collecting groundwater samples in the order listed in the site-specific SAP. VOCs are typically collected first.

   For collection of VOC samples, including 1,4-dioxane (using Methods 8260 SIM or EPA EIASOP-VOADIOX4), carbon dioxide, methane, ethane and ethene, refer to the Special Considerations for VOC Sampling section in the standard low flow procedure above.

7. If dissolved metals or other dissolved samples are required, attach a onetime use only 0.45 micron in-line filter to the end of the tubing. Hold the filter upright until the purge water exits the top to allow the water to completely fill the filter. Allow a volume of purge water, roughly equivalent to the volume of the filter, to discharge into the bucket to rinse the filter before collecting the sample. Discard the filter after use. When collecting a duplicate sample, a new filter must be used.

8. All sample containers shall be filled by allowing the discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry.

9. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples shall be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC sample, VOC duplicate sample, 1,4-dioxane

sample, 1,4-dioxane duplicate sample and/or 1,4-dioxane MS/MSD sample). Refer to the site-specific SAP for specific QA sampling requirements.

10. Place samples in re-sealable plastic bags and then in loose ice within the cooler. Metals samples, after acidification to a pH less than 2, do not need to be cooled.
11. Just prior to turning off the pump, measure and record the water level on the worksheet, then turn off the pump.
12. Record total volume purged on the well sampling worksheet.
13. Disconnect equipment as needed. Secure tubing to the inside of the well.
14. Secure the well with the locking cap.
15. All non-dedicated equipment (e.g., water level meter) must be decontaminated following the Decontamination SOP in the site-specific SAP.

B. Modified Sampling Procedure with Field Parameters

1. Set up equipment according to the attached Low Flow Setup Diagram. Be sure to tilt the low flow cell with the outflow connection facing upward to eliminate and prevent air bubbles.
2. Carefully lower a water level indicator to the top of groundwater. Measure and record the water level (to 0.01 feet) before any disturbance to the well. Care shall be taken to minimize suspension of any particulates attached to the sides.
3. Start the pump at its lowest speed setting and slowly increase the speed until a flow rate of 50 ml/minute is reached. If a 50 ml/minute flow rate cannot be achieved, then set the pump at the lowest flow rate that the pump is cable of attaining. **Pumping rates shall not be less than 50 ml/minute.**

   If using a peristaltic pump, make sure the correct pump head (thin wall tubing pump head) and the silicon tubing (smallest size silicon tubing, #14) is being used and that the pump head is set at 300 RPM not 600 RPM.
4. Pump the well at 50 ml/min, or lowest flow rate possible above that, until a minimum of one tubing volume of water is discharged from the flow-through cell. Do not include the volume of water (approximately 250 ml) in the flow-through cell as part of the minimum volume required; instead add the flow cell volume (e.g., 250 ml) to the total purged volume at the end. All purged water is to be discharged into a graduated beaker/cylinder/bucket to determine the total volume of groundwater purged.

   One purge volume (in gallons) is equal to $h * 3.14 * (r/12)^2 * 7.48$ gal/ft^3, where

   h = length of tubing (feet)
   r = internal radius of tubing (inches) = inside diameter/2

   Or, in other words, one purge volume is equal to (h) * (f) where:
   h = length of tubing (feet)
   f = the unit volume per foot of water column (gal/ft.)

For convenience, the table below is provided in order to quickly determine the "f" factor. In order to more accurately measure the purge volume, the table can also be used to determine the purge volume in units of milliliters. It accounts for the gallons-to-milliliters conversion (1 gallon = 3,785 mL).

One unit purge volume (gal/ft. or ml/ft.) = one foot of tubing (ft.) x volume (gal or ml).

Tubing Diameter (inches)	1/4 (0.25) OD **(0.17 ID)***	3/8 (0.375) OD **(0.25 ID)***	1/2 (0.50) OD **(0.375 ID)***	5/8 (0.625) OD **(0.50 ID)***
Volume (gal/foot)	0.0012	0.0026	0.0057	0.0102
Volume (ml/foot)	4.5	9.7	21.7	38.6

Record the PVR and the calculations used to determine the purge volume required on the well sampling worksheet.

5. Collect one set of parameter readings from the YSI instrument, and an aliquot of water through the three-way stop cock to analyze for turbidity using the Hach Turbidity meter. Record the readings on the sampling worksheet.

6. Samples for laboratory analyses must be collected before the flow cell and three-way stop cock. This will be done by disconnecting the flow cell and three-way stopcock. The sample will be collected directly through the pump tubing.

7. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.

8. Begin collecting groundwater samples in the order found in the site-specific SAP. VOCs are typically collected first.

   For collection of VOC samples, including 1,4-dioxane (using Methods 8260 SIM or EPA EIASOP-VOADIOX4), carbon dioxide, methane, ethane and ethene, refer to the Special Considerations for VOC Sampling section in the standard low flow procedure above.

9. If dissolved metals or other dissolved samples are required, attach a onetime use only 0.45 micron in-line filter to the end of the tubing. Hold the filter upright until the purge water exits the top to allow the water to completely fill the filter. Allow a volume of purge water, roughly equivalent to the volume of the filter, to discharge into the bucket to rinse the filter before collecting the sample. Discard the filter after use. When collecting a duplicate sample, a new filter must be used.

10. All sample containers shall be filled by allowing the discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry.

11. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples shall be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC sample, VOC duplicate sample, 1,4-dioxane sample, 1,4-dioxane duplicate sample and/or 1,4-dioxane MS/MSD sample). Refer to the SAP for specific QA sampling requirements.

12. Place samples in re-sealable plastic bags and then in loose ice within the cooler. Metals samples, after acidification to a pH less than 2, do not need to be cooled.
13. Just prior to turning off the pump, measure and record the water level on the worksheet, then turn off the pump.
14. Record total volume purged on the well sampling worksheet.
15. Disconnect equipment as needed. Secure tubing to the inside of the well.
16. Secure the well with the locking cap.
17. All non-dedicated equipment (e.g., water level meter) must be decontaminated following the Decontamination SOP in the SAP.

APPENDIX B - GENERAL DECONTAMINATION PROCEDURES

General decontamination procedures may be found below and in HWRB-15 Decontamination SOP in the current HWRB Master QAPP.

Decontaminate sampling equipment prior to use in the first well and then following sampling of each well. Non-dedicated sampling equipment, including water level meters, the pump, tubing, support cable and electrical wires that were in contact with the well shall be decontaminated following the approved decontamination procedures as specified in the site-specific SAP. **The decontamination procedure for water level meters and oil/interface probes shall include the probes and, at a minimum, the length of tape used in the well.**

All sampling equipment shall be inspected and maintained according to the manufacturer's recommendations. Refer to the manufacturer's manual for specific information. The use of dedicated equipment will reduce the amount of time spent on decontamination of the equipment. Non-dedicated tubing should be discarded.

In general, equipment blanks are collected to ensure that the decontamination procedure used is adequate. If the previous equipment blank showed that contaminant(s) were present, a more rigorous or alternative procedure may be needed. Refer to the site-specific SAP for details.

General Procedure

1. Disassemble equipment, as appropriate.
2. Remove gross contamination by brushing and then rinsing with tap water.
3. Wash, or steam clean, the equipment with a non-phosphate detergent*, as required, and tap water.
4. Rinse with tap water.
5. Rinse with the appropriate solvents, as required.
6. Rinse the equipment with laboratory-grade DI water between solvent rinses, with a final rinse of DI water.
7. Air dry and secure clean equipment.

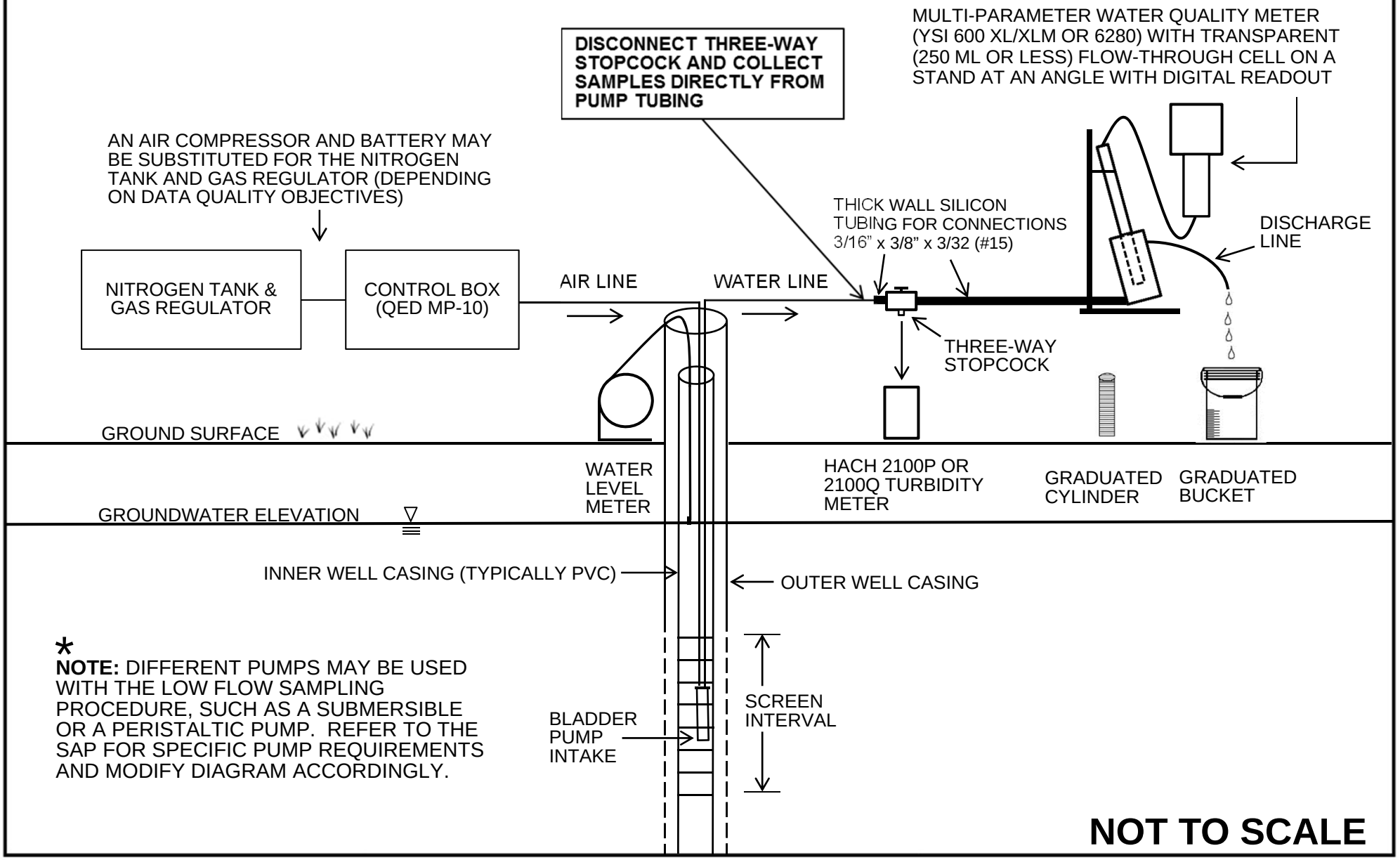
Pump Decontamination: The decontamination solutions may be pumped through the pump and tubing from either buckets or short PVC casing sections with an end cap, or the pump can be disassembled and flushed with the decontamination solutions.

***Note: Some non-phosphate detergents may contain 1,4-dioxane. If 1,4-dioxane is a concern at the site, it may be appropriate to seek a non-phosphate detergent that does not contain 1,4-dioxane. At the very least, an equipment blank shall be collected and analyzed for 1,4-dioxane to ensure that the decontamination procedure is adequate and that there is no 1,4-dioxane residue. If 1,4-dioxane is found in the equipment blank, the sampling data must be qualified.**

APPENDIX C

LOW FLOW SETUP DIAGRAM

THIS DIAGRAM SHOWS THE BLADDER PUMP SETUP FOR LOW FLOW SAMPLING*



*
NOTE: DIFFERENT PUMPS MAY BE USED WITH THE LOW FLOW SAMPLING PROCEDURE, SUCH AS A SUBMERSIBLE OR A PERISTALTIC PUMP. REFER TO THE SAP FOR SPECIFIC PUMP REQUIREMENTS AND MODIFY DIAGRAM ACCORDINGLY.

APPENDIX D: WELL SAMPLING WORKSHEET

For use with Bladder Pumps

Site Name

Page _____of_____

Date : _____ **Well ID :** _____

Weather Conditions : _____

Sampler's Name (Print) _____

Purging Device & Serial # (pump type): _____

Reference Measuring Point (Top of PVC/Top of Casing): _____

Well Depth (ft., ref. to measuring point): _____

Screen Interval (ft., ref. to measuring point): _____

PVC/Inner Well Casing ID (inches): _____ Tubing ID (inches): _____

Purging Start Time : _____ (24 hour cycle) Sample Time: _____ (24 hour cycle)

Initial Water Level (ft., ref. to measuring point): _____

Pump Intake (ft., ref. to measuring point): _____

Head Above Pump Intake (ft., ref. measuring point): _____

Total Purge Volume (gallons, ml or liters): _____

Indicator Parameter Stabilization: **yes** OR **no** (circle one)

For PVR: Total Drawdown <0.3 ft. OR > 0.3 ft. at Parameter Stabilization (circle one)

Two Hour Time Limit Reached ? yes OR no (circle one)

Samples Collected: _____

Time at Sample Completion: _____ (24 hour cycle)

Bladder Pump Control Box Cycle Setting should be set to "1"

Clock Time	**Water Level**	**Drawdown**	**Cumulative Drawdown**	**Bladder Refill Time**	**Bladder Discharge Time**	**Pressure**	**Purge Rate**	**Temp. +/- 1 ºC**	**Spec. Cond. +/- 3%**	**DO +/- 10% if > 0.5**	**pH +/- 0.1**	**ORP +/-10**	**Turbidity +/- 10% if > 5**	**Comments/Adjustments**
(24 HR.)	**(ft.)**	**(ft.)**	**(ft.)**	**setting**	**setting**	**(psi)**	**(ml/min)**	**(ºC)**	**(µS/cm)**	**(mg/l)**	**units**	**(mV)**	**(NTU)**	
PVR =	Calculations:													

Notes: 1. All depths in feet below the referenced measuring point, unless specified. 2. "NR" indicates no reading taken. 3. ID = Inside Diameter

4. When recording pH and dissolved oxygen data, only use one decimal place. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers.
When DO data is less than 0.5 mg/l, data should be recorded as "<0.5" or "less than 0.5". DO values between 0.5 and 1.0 are typically considered stable within +/- 0.1 mg/l.
When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". Turbidity values between 5 and 10 are typically considered stable within +/- 1 NTU.

5. Tubing Factors - Milliliters to purge standing water in tubing: 1/2" ID: length in ft. x 38.6 = ml needed; 3/8" ID: length in ft. x 21.7 = ml needed; 1/4" ID: length in ft. x 9.7 = ml needed; 0.17" ID: length in ft. x 4.5 = ml needed.

6. Purge volume requirement (PVR) . If the total drawdown is <0.3 ft., the PVR = one tubing volume of water, so the PVR = Total Tubing Length x Unit Tubing Capacity. Note: Include the length of tubing that is outside the well in the Total Tubing Length.
If the total drawdown is >0.3 ft., the PVR = one tubing volume of water & the volume of water in the well between the initial water level and the current water level, so the PVR = (Total Tubing Length x Unit Tubing Capacity) + (Total Drawdown x Unit Well Capacity).

_____
Sampler's Signature

APPENDIX E: WELL SAMPLING WORKSHEET

For use with Peristaltic Pumps

Site Name

Page _____of_____

Date : _____ **Well ID :** _____

Weather Conditions : _____

Sampler's Name (Print) _____

Purging Device & Serial # (pump type): _____

Reference Measuring Point (Top of PVC/Top of Casing): _____

Well Depth (ft., ref. to measuring point): _____

Screen Interval (ft., ref. to measuring point): _____

Samples Collected: _____

Purging Start Time : _____ (24 hour cycle) Sample Time: _____ (24 hour cycle)

Initial Water Level (ft., ref. to measuring point): _____

Tubing Intake (ft., ref. to measuring point): _____

Total Purge Volume (gallons, ml or liters): _____

PVC/Inner Well Casing ID (inches): _____

Tubing ID (inches): _____

Two Hour Time Limit Reached ? yes OR no (circle one)

Indicator Parameter Stabilization (all): **yes** OR **no** (circle one)

For PVR: Total Drawdown <0.3 ft. OR > 0.3 ft. at Parameter Stabilization (circle one)

Time at Sample Completion: _____ (24 hour cycle)

Clock Time	**Water Level (ft.)**	**Drawdown (ft.)**	**Cumulative Drawdown (ft.)**	**Pump Speed**	**Purge Rate (ml/min)**	**Temp +/- 1 ºC (ºC)**	**Spec. Cond. +/- 3% (µS/cm)**	**DO +/- 10% if > 0.5 (mg/l)**	**pH +/- 0.1 units**	**ORP +/-10 (mV)**	**Turbidity +/- 10% if > 5 (NTU)**	**Comments/Adjustments**
PVR =	Calculations:											

Notes: 1. All depths in feet below the referenced measuring point, unless specified. 2. "NR" indicates no reading taken. 3. ID = Inside Diameter

4. When recording pH and dissolved oxygen data, only use one decimal place. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers.
When DO data is less than 0.5 mg/l, data should be recorded as "<0.5" or "less than 0.5". DO values between 0.5 and 1.0 are typically considered stable within +/- 0.1 mg/l.
When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". Turbidity values between 5 and 10 are typically considered stable within +/- 1 NTU.

_____
Sampler's Signature

5. Tubing Factors - Milliliters to purge standing water in tubing: 1/2" ID: length in ft. x 38.6 = ml needed; 3/8" ID: length in ft. x 21.7 = ml needed; 1/4" ID: length in ft. x 9.7 = ml needed; 0.17" ID: length in ft. x 4.5 = ml needed.

6. Purge volume requirement (PVR) . If the total drawdown is <0.3 ft., the PVR = one tubing volume of water, so the PVR = Total Tubing Length x Unit Tubing Capacity. Note: Include the length of tubing that is outside the well in the Total Tubing Length.
If the total drawdown is >0.3 ft., the PVR = one tubing volume of water & the volume of water in the well between the initial water level and the current water level, so the PVR = (Total Tubing Length x Unit Tubing Capacity) + (Total Drawdown x Unit Well Capacity).

SURFACE WATER SAMPLING

PURPOSE

The purpose of the Standard Operating Procedure (SOP) is to obtain surface water samples for analysis that are representative of environmental conditions at the location sampled.

PREPARATION

If a sample cannot be obtained safely, the sample should not be collected at all and the circumstances shall be documented in the sampler's field book. In general this procedure requires a minimum of two sample personnel in consideration of safety.

When collecting surface water, pore water, and sediment samples in the same location, sampling should occur in that order: surface water samples first, then pore water samples and finally sediment samples.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as sample points, analytes and quality assurance (QA) requirements. Weather conditions and data quality objectives should be considered and documented in the SAP when planning a surface water sampling event. Determine what conditions the sampling event should occur in: “dry” or “wet” and define those terms prior to the sampling event.

Sampling locations shall be permanently located using a global positioning system (GPS) unit for future reference. The expected accuracy of the GPS unit shall be determined in advance and specified in the SAP.

EQUIPMENT

The following equipment is typically used in collecting surface water samples:

- Appropriate health and safety gear and an approved site-specific Health & Safety Plan.
- Site-Specific SAP which includes a map and other project-specific information including field data from last sampling event, if available.
- Waders.
- Pre-decontaminated glass jar or stainless steel container to use as an intermediary container to fill pre-preserved sample containers. Include a minimum of one spare if using glass.
- Pole and strapping, as necessary, to collect samples from locations with limited access.
- Fifty (50) cubic centimeter (cc) syringes (plus spares) if collecting dissolved metals.

- 0.45 micron filters to fit over the end of the syringes if collecting dissolved metals. Have enough filters on hand to collect the volume required by the lab. Keep in mind that the turbidity of the water may clog the filters at an unknown rate. Use separate filters when collecting duplicate samples.
- Sample containers, preserved as necessary, cooler and loose ice.
- Re-sealable plastic bags to protect and store samples.
- Field worksheets, sample labels and chain of custody forms.
- Logbook, pencil/pen/sharpies and calculator.
- Camera to take digital pictures.
- The manufactures instruction manuals for all equipment.
- Stream staff/gage or similar measuring device.
- GPS unit or similar device.
- Decontamination supplies/equipment; including laboratory-grade deionized water.
- Paper towels.
- A multiparameter meter (e.g. YSI 600XL/XLM) with a built in barometer, capable of measuring pH (units); ORP, mV; DO, milligrams per liter (mg/l), 100% saturation for calibration; specific conductance, µS/cm; and temperature, degrees Celsius (˚C); the same make and model as used for groundwater sampling, if applicable.
- Appropriate calibration solutions for the YSI meter, if water quality parameters are collected, including: 0 mg/l DO for DO; Zobell solution for ORP; two different specific conductance standards, one standard is used to calibrate and the other standard is used to check the calibration (e.g., 718 and 1,413 µS/cm); and 4, 7, & 10 units pH buffering solution. A small wet sponge or paper towel for DO 100% saturation calibration. Extra DO membranes in case of breakage.
- A probe guard for the multiparameter meter to take in-situ parameter readings.
- A Turbidity Meter (e.g., Hach 2100P or 2100Q); the same make and model as used for groundwater sampling, if applicable.
- Calibration solutions for the Hach Turbidity meter: <0.1, 10, 20, 100, 800 Nephelometric Turbidity Units (NTUs) standards as appropriate for the selected meter.
- Peristaltic pump and tubing, if required for subsurface sampling.
- Toolbox to include general items such as large and small wrenches, pliers, screw drivers, 25’ measuring tape, hose connectors, sharp knife (locking blade) and duct tape, at a minimum.

GENERAL PROCEDURE

In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested, and inspected according to the manufacturer's instructions. The manufacturer’s instruction manuals for field equipment shall be kept on-site with the equipment.

If water quality parameters such as pH, Specific Conductivity, Temperature, ORP and DO are required, they shall be collected in-situ. If turbidity is required, an aliquot of water shall be collected in a turbidity vial and analyzed using a separate Turbidity meter.

All instruments will be successfully calibrated once by the sampling team prior to the sampling event according to the Calibration of Field Instruments SOP in the Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP) or site-specific SAP.

Instruments will be calibrated at the beginning of each sampling day at the site and will be checked (in the run mode) in the morning and again at the end of the day. Instrument calibration will be performed at additional times during the sampling day if instrument readings appear to be significantly different than previously observed.

Analytical samples shall be collected prior to collecting parameter readings unless otherwise specified in the site-specific SAP.

Digital photographs are usually taken at each sampling location, upstream and downstream from the same position so that consistency can be maintained between sampling rounds.

If not previously done, use a GPS unit to permanently mark the sample location for future reference.

Surface water samples should be collected from the bank if possible for safety and ease of sampling. If the stream/creek/water body must be entered to collect samples, the water should not exceed three feet in depth. If no safe access is available, attach the sample collection container to a pole with strapping or tape and collect the samples.

Using a stream staff gage or similar measuring device, measure the depth of water from the bottom of the streambed/lakebed to the surface of the water, in feet, directly downstream of each sampling location and record on the Surface Water Worksheet. Some sites may have a permanently-installed staff gage at one location to monitor water levels instead of, or in addition to, collecting measurements at each separate location.

Surface water samples to be collected from the same water body should be collected sequentially from downstream to upstream sample locations. Sample locations will be approached from the downstream side to minimize bottom sediment disturbance, and the sample should be collected up stream of the sampler. Water samples collected from a boat shall be collected from the bow

or upstream side of the boat, away from the motor, with extreme care taken to avoid contamination of the sample.

Samples may be collected directly into the sample containers if the sample calls for un-preserved sample containers. If the sample containers are pre-preserved, the sample must be collected using an appropriate intermediate container, such as a glass jar or stainless steel beaker. Dissolved metals samples shall be collected using a syringe and an appropriate filter.

Collection of floating debris and surface skim shall be avoided. The mouth of the container shall be facing upstream and the container will be slowly submerged just beneath the surface of the water, unless specified otherwise in the SAP. If surface water is collected with an intermediate container, the container shall be rinsed once downstream of the sampling location before the sample is collected. Once the sample is collected, it shall be immediately transferred to the appropriate sample containers. The intermediate container will then be decontaminated before reuse unless new or dedicated containers are used for each sampling location.

Samples are collected from most to least volatile (e.g., VOCs, SVOCs, total manganese/hardness, and dissolved manganese), unless otherwise specified in the site-specific SAP. Collect duplicates and other quality control samples as required in the SAP. If collecting samples for dissolved metals, use a new 0.45 micron in-line filter for the duplicate and at each new sample location.

Once sampling containers are filled with the appropriate amount, they are capped and cleaned to remove any potential residue. Place samples in re-sealable plastic bags and store the samples in accordance with appropriate protocols. If samples require cooling, the samples shall be placed in a cooler of **loose** ice.

If field parameters are required, the following procedure shall be used:

1. With the probe guard on the YSI instrument, rinse the probes in the brook downstream of the sampling location.
2. Immerse the probes into the water immediately upstream of any disturbance caused by accessing the sample location, making sure it is deep enough to cover the probes and probe guard. It is important that there are no air bubbles on/in the electrode. To dislodge any bubbles, gently move the electrode through the water before recording the measurement. If the sample location is not accessible, a pole and strapping may be used to hold the probes in place for stabilization and readings.
3. Allow a minimum of two minutes for the readings to stabilize.
4. Once the readings have stabilized, record the pH, Specific Conductivity (µS/cm), Temperature (°C), ORP (millivolts) and DO (mg/l) on the Surface Water Worksheet.
5. Rinse out a turbidity vial downstream of the sampling location.
6. Collect an aliquot of water for the Hach Turbidity Meter and analyze the sample for turbidity. Record the NTU value on the Surface Water Worksheet.

Subsurface water samples may be collected using an appropriate pump and tubing, extending the tubing to the sampling depth; or with a device made of the appropriate materials designed for depth-specific sampling. This information shall be specified in the site-specific SAP.

QUALITY ASSURANCE SAMPLES

Collect appropriate quality assurance samples as specified in the site-specific SAP.

At least one duplicate sample should be collected per analysis. If collecting samples for dissolved metals, use a new 0.45 micron in-line filter for the duplicate and at each new sample location.

Duplicate samples are collected by filling a separate container for each analysis immediately following the actual field sample collection of the same parameter and should be in the same priority order as indicated in the site-specific SAP. Duplicate samples are typically not intended to be blind duplicate samples.

Equipment blanks should be collected on non-disposable equipment to ensure that the equipment is clean and the decontamination procedure is adequate (e.g., syringes, glass or stainless steel containers).

If using an in-line filter for dissolved metals, collect an equipment blank prior to sampling by running deionized water through the filter and collecting a sample for dissolved metals to ensure the integrity of the filter.

DECONTAMINATION

Decontaminate equipment according to the Decontamination SOP in the HWRB Master QAPP or site-specific SAP. Disposable sampling equipment shall be discarded after completing the sampling task and not reused.

DOCUMENTATION

In general all data and sampling information will be documented as recorded, as specified in the site-specific SAP. Specific reporting of these sampling events may include, but is not limited to, the following information:

1. Samples collected.
2. Date and time of sample collection.
3. Past 7 days of local meteorological data showing a minimum of daily precipitation totals and barometric pressure.
4. Water depths at the sampling locations.
5. Any water quality parameter readings taken.
6. General physical description of the samples and sampling locations.

7. Digital photographs of sampling locations including one or more of the larger surrounding area, along with any notes on the photos.

ATTACHMENT

Surface Water Worksheet

SURFACE WATER WORKSHEET

Site name

Date: Field Personnel:

WEATHER CONDITIONS									
CURRENT (Sampling Day)		**PAST 7 DAYS**							
Barometric Pressure (in mm/hg)		Dates:							
Storm (heavy rain): circle one	Yes or No	Barometric Pressure (in mm/hg)							
Rain (Steady Rain): circle one	Yes or No	Estimated Rainfall (in)							
Intermittent Showers: circle one	Yes or No	Comments:							
Cloud Cover (%)									
Clear/Sunny: circle one	Yes or No								
Comments:									

STREAM / SAMPLING LOCATION CHARACTERIZATION		
Provide Physical Description of Sampling Locations At The Time of Sampling	SW-1	
	Photograph #, date & time	
	SW-2	
	Photograph #, date & time	
	SW-3	
	Photograph #, date & time	
	SW-4	
	Photograph #, date & time	
	SW-5	
	Photograph #, date & time	

IN SITU SURFACE WATER QUALITY

Minimum 2 minute parameter stabilization period met (Y/N)?

Sample Location ID	Temperature (ºC)	Specific Conductivity (µS/cm)	DO (mg/l)	pH units	ORP (mV)	Turbidity (NTU)	Sample Time	Comments
SW-1								
SW-2								
SW-3								
SW-4								
SW-5								

DEPTH-OF-WATER INFORMATION FROM PERMANENT STAFF GAGE			
Initial Synoptic Round (From Water Level Measurement Form):	**Date:**	**Depth of Water (nearest 0.01 ft.):**	**Comments:**
Pre-Sampling Round:	**Date:**	**Depth of Water (nearest 0.01 ft.):**	**Comments:**

Notes: 1. Surface Water Quality Parameters are collected using the YSI 600 XL/XLM and Hach 2100 P or 2100Q units. Both units are calibrated in accordance with the calibration SOP in the HWRB Master QAPP.

SOIL SAMPLING

This Standard Operating Procedure (SOP) applies to the collection of surface and subsurface soil samples for contaminant analysis.

All non-dedicated sampling equipment shall be decontaminated prior to use and between samples. Sample collection activities shall generally proceed progressively from the suspected least contaminated area to the suspected most contaminated area when possible. Stage all equipment and supplies on plastic sheeting, or equivalent, to prevent contact with potentially contaminated surfaces.

NOTE: The collection of samples for volatile organic compound (VOC) analysis shall follow the guidelines written for soils in the New Hampshire Department of Environmental Services (NHDES) "Final Policy Preservation of VOCs in Soil Samples" dated March 2000 included in the current NHDES Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP).

A variety of soil sampling tools, typically made of stainless steel, are available for collection of soil samples (e.g., hand augers, split spoons, coring devices, scoops, spoons, etc.). Boreholes for subsurface soil samples may be advanced by hand boring devices (hand augers), portable powered augers, drilling rig, or hammering equipment. This procedure primarily references hand augers but is applicable to other soil sampling equipment.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as the type of equipment to be used, sample points, analytes and quality assurance (QA) requirements.

Sampling locations shall be permanently located using a global positioning system (GPS) unit for future reference. The expected accuracy of the GPS unit shall be determined in advance and specified in the SAP. Flagging should also be used to visually mark the location. Digital photographs should be taken at each sampling location from the same position so that consistency can be maintained between sampling rounds.

EQUIPMENT

The following equipment is typically used in collecting soil samples:

- Appropriate health and safety gear and an approved site-specific Health & Safety Plan.
- Site-Specific SAP, which includes map and other project-specific information.
- EnCore™ samplers or disposable syringes with the tips cut off for collecting VOC samples directly from the sampling device. These are to be used once and then disposed of. Be sure to have one for each VOC sample and duplicate, plus extras.
- Stainless steel scoops, bowls, spoons.

- Hand augers, as appropriate.
- Coring tubes/devices, as appropriate.
- Sample containers, preserved as necessary, cooler and loose ice.
- Re-sealable plastic bags to protect and store samples;
- Field data from last sampling event if available;
- Field worksheets, sample labels, chain of custody forms;
- Logbook, pencil/pen/sharpies, calculator;
- The manufactures instruction manuals for all equipment, if applicable;
- Decontamination supplies/equipment, including laboratory-grade deionized water.
- Paper towels.
- Toolbox to include general items such as large and small wrenches, pliers, screw drivers, 25' measuring tape, hose connectors, sharp knife (locking blade) and duct tape, at a minimum.
- Camera to take digital pictures.
- GPS unit and flagging to mark locations.

GENERAL PROCEDURE FOR COLLECTION OF SOIL SAMPLES

Carefully clear away all surface debris (leaves, twigs, etc.) for a 1-foot radius around the sampling location. Collection of plant or foreign material that is not part of the sample should be avoided.

VOCs must be collected directly from the sampling device according to the **NHDES "Final Policy Preservation of VOCs in Soil Samples" dated March 2000**. Using the disposable syringe, the proper volume of soil is added to the methanol preserved volatile organic analysis (VOA) vial until the volume in the VOA vial reaches the pre-marked line established by the laboratory. An additional unpreserved sample must be collected to allow for a determination of moisture.

For surface soil samples (e.g., 0-6", 0-12", etc.): using a decontaminated stainless steel hand auger or other soil sampling device, auger or core into the material which is being sampled to the specified depth, retrieve the sample, collect VOC samples directly from the sampling device, and place remaining sample in a stainless steel or glass pan. Continue to collect additional soil from areas adjacent to the original sample location to ensure staying within the required depth until the appropriate volume of soil is obtained. When collecting duplicates, collect enough sample material in the stainless steel mixing bowl for both the sample and the duplicate.

For subsurface soil samples: using a decontaminated hand auger or other boring or drilling device, advance the borehole to the appropriate sampling depth. Prior to collecting the sample, remove and/or minimize cuttings/cavings from the borehole to avoid collection of material that is

not from the target sampling interval. Then use a decontaminated hand auger or sampling device, such as a thin walled tube or split spoon sampler, to collect the sample. After retrieving the sampler, trim the upper portion of the sample to remove any cuttings or cavings that may be present with the sample, collect VOC samples directly from the sampling device, and place remaining sample in a stainless steel or glass pan. Continue to collect additional soil from areas adjacent to the original sample location to ensure staying within the required depth until the appropriate volume of soil is obtained. When collecting duplicates, collect enough sample material in the stainless steel mixing bowl for both the sample and the duplicate.

<u>If using a backhoe, shovel or other equipment to remove soil from the excavation</u>: use a stainless steel trowel to collect soil that has not come into contact with the tool used for excavation, collect VOC samples directly from the sampling device, and place remaining sample in a stainless steel or glass pan. Continue to collect additional soil from areas adjacent to the original sample location to ensure staying within the required depth until the appropriate volume of soil is obtained. When collecting duplicates, collect enough sample material in the stainless steel mixing bowl for both the sample and the duplicate.

Following VOC sample collection, mix and homogenize the remaining soil as described below. Fill and cap the remaining sample containers in the order specified in the SAP. Clean the exteriors of the containers to remove any potential residue. Place samples in re-sealable bags. VOC and other samples requiring cooling shall be placed within **loose** ice in a cooler.

With the exception of VOC samples, it is extremely important that the sample be mixed and homogenized as thoroughly as possible to ensure that the sample is representative of the sampled material. A common method of mixing is referred to as quartering. Using a decontaminated stainless steel trowel, the sample in the sample pan is divided into quarters. Each quarter is mixed, and then all quarters are mixed into the center of the pan. This procedure is followed several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material. **Note**: If samples are predominantly moist and clayey, extra effort may be necessary to produce a homogenous mixture.

Record a general physical description of the sample such as color; basic makeup (sand, silt or clay); and whether or not there is a high degree of organic material, on the Soil Sampling Worksheet. Note grain size unless a separate sample is collected for that purpose. Document the system of soil classification used.

Take digital photographs at each sampling location, from at least two different positions, so that consistency can be maintained between sampling rounds. Record appropriate information on the Soil Sampling Worksheet.

If not previously done, use a GPS unit to permanently mark the sample location for future reference. In addition, use flagging to visually mark the location if possible.

Decontaminate equipment according to the Decontamination SOP in the site-specific SAP or the HWRB Master QAPP. Disposable sampling equipment shall be discarded after completing the sampling task and not reused.

QUALITY ASSURANCE

Collect appropriate quality assurance samples as specified in the site-specific SAP.

At least one duplicate sample should be collected. Collect enough sample material in the stainless steel mixing bowl for both the sample and the duplicate; thoroughly mix the soil to obtain a homogeneous sample; remove any leaves, twigs, rocks or other gross debris that may have been collected; fill a separate container for each analysis immediately following the actual field sample collection and cap the containers for both the sample and duplicate sample. Note that the VOC sample and duplicate shall be collected directly from the sampling device, prior to sample mixing.

Equipment blanks are collected to ensure that the equipment is clean and the decontamination procedure is adequate.

To collect an equipment blank after decontamination: gently pour deionized water over all the equipment used to collect the soil sample. Collect the rinsate that flows off the equipment into the appropriate sample containers. Refer to the site-specific SAP for detailed information.

DOCUMENTATION SUMMARY

In general all data and sampling information will be documented as specified in the SAP. Specific reporting of these sampling events may include, but is not limited to, the following information as recorded on the Soil Sampling Worksheet:

1. Samples collected.
2. Date and time of sample collection.
3. A general physical description of the sample such as color; basic makeup (sand, silt or clay); and whether or not there is a high degree of organic material. Note grain size unless a separate sample is collected for that purpose. Document the system of soil classification used.
4. GPS coordinates of the sampling location.
5. A general physical description of the sampling locations, as well as digital photographs of sampling locations including one or more of the larger surrounding area.

ATTACHMENT

Soil Sampling Worksheet

SOIL SAMPLING WORKSHEET

Site Name

Date: Field Personnel:

A GENERAL PHYSICAL DESCRIPTION OF THE SAMPLE AND SAMPLE TIME		
Sample Location ID	**Provide a general physical description of the sample such as color; basic makeup (sand, silt or clay) and whether or not there is a high degree of organic material. Note grain size unless a separate sample is collected for that purpose.**	**Sample Time**
SS-1		
SS-2		
SS-3		
SS-4		
SS-5		

SOIL SAMPLING LOCATION CHARACTERIZATION		
Provide Physical Descriptions of the Sampling Locations at the Time of Sampling	SS-1	
	Photograph #, Date & Time	
	SS-2	
	Photograph #, Date & Time	
	SS-3	
	Photograph #, Date & Time	
	SS-4	
	Photograph #, Date & Time	
	SS-5	
	Photograph #, Date & Time	

JAR HEADSPACE TECHNIQUE - FIELD SCREENING SOIL SAMPLES

The purpose of this Standard Operating Procedure (SOP) is to describe the procedure for field screening volatile organic content of soils using a "Jar Headspace Technique" (JHT) with a photoionization detector (PID) or a flame ionization detector (FID). This methodology is not to replace actual laboratory analysis; it is to provide a screening tool in the field for determining "hot spots" and other areas of high or low concentrations of volatile organic compounds (VOCs) presence in soil, or for when choosing samples from a site for laboratory analysis.

In conducting this procedure, a soil sample is placed in a sealed jar or polyethylene bag and the volatile constituents are allowed to come to equilibrium with the jar headspace. The headspace is then measured with a calibrated PID or FID, with a result expressed in parts per million (ppm). Due to the different ionization potentials of various compounds, actual levels of contamination cannot be determined. However, this technique provides an effective means of screening.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as sample points, analytes and quality assurance (QA) requirements.

Sampling locations shall be permanently located using a global positioning system (GPS) unit for future reference. The expected accuracy of the GPS unit shall be determined in advance and specified in the site-specific SAP. Flagging should also be used to visually mark the location. Digital photographs of the sampling locations should be taken.

EQUIPMENT

The following equipment is required for conducting the JHT:

- Soil sampling equipment (shovel, bucket auger, soil borer, etc.).
- 16 oz. wide mouthed, metal screw top jars and roll of heavy duty aluminum foil.
- Or, one quart, re-sealable, polyethylene bags.
- PID or FID.
- GPS unit and flagging.
- Digital camera.

PROCEDURE

1. Warm up and calibrate the PID and FID instrument to be used according to the manufacturers recommended procedure (See additional considerations with use of PID/FID below). The PID and/or FID should be ready for use prior to collection of the first sample.

2. Collect the soil sample with appropriate soil sampling equipment. See Soil Sampling Procedure and the "Final Policy Preservation of VOCs in Soil Samples" SOP dated March 2000 located in the current Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan.

3. Place approximately 250 grams of the soil sample into a wide mouth jar or polyethylene bag. One or the other should be consistently used at the site for comparison purposes, do not mix headspace containers. In so far as possible, samples should be mineral soil, free of vegetation and stones larger than ½ inches in diameter. If soil samples are of different type (loam, sand, silt), this should be identified in the field logbook. If a duplicate sample is to be submitted to the laboratory for analysis, this sample should be containerized and preserved as appropriate. Soil that has been screened with JHT should not be submitted for laboratory analysis, unless so documented. If using jars, the jars should be sealed by placing a square of foil over the mouth and screwing on the lid. If using a bag, the bag should be sealed closed leaving sufficient air in the bag so that the instrument can withdraw an adequate headspace sample.

4. Shake the jars for 30 seconds to thoroughly mix the contents. If bags are used, they may be kneaded until the contents are uniform.

5. Allow at least fifteen minutes but not more than two hours for VOCs to reach headspace equilibrium with the headspace. An attempt should be made to allow the same amount of equilibration time for each sample.

   During winter conditions, samples should be placed inside a heated vehicle while they achieve equilibrium (but not on a heating vent) so that VOCs will more-readily volatilize into the headspace.

6. Shake jars/knead bags again for thirty seconds.

7. Measure the samples headspace concentration with the instrument. If the jar is used, unscrew and slightly lift cap allowing insertion of the probe tip, puncture the foil and insert the probe approximately ½ inch into jar. If using a bag, open the seal just enough to insert the probe (this is easiest using two people). Record the highest reading on the instrument after allowing the probe to "sniff" the container for 10 – 15 seconds. It is important to insert the probe as quickly as possible after the seal to the container has been broken. Once a container has been used, it may not be used again for JHT screening.

ADDITIONAL CONSIDERATIONS WITH USE OF A PID/FID

There are limitations of PIDs and FIDs. A PID and FID cannot detect all VOCs, nor do they detect all VOCs equally. Factors that influence the response of the particular compound include ionization potential of compound, particular energy rating of lamp, calibration standard used, response factor, response curve, etc. In some instances, such as when the contaminant of concern is a single known compound, it is possible to calibrate the instrument so that a relatively accurate measurement, when compared to laboratory analysis, can be obtained. Because of this,

it is recommended that the operator who will be conducting JHT take the time before the sampling event to become familiar with the particular instrument that will be used. This includes reviewing the specific user manual, calibrating and practicing with the instrument prior to the sampling event.

DOCUMENTATION

When documenting such a sampling event, one should include enough information so that in the future, another person can easily conduct the same sampling in a manner consistent with the previous event.

In general all data and sampling information will be documented as specified in the SAP. Specific reporting of these sampling events may include, but is not limited to, the following information:

1. The specific lamp energy rating, calibration standard, and special response factors or curves that may be employed for the particular sampling event.
2. A general physical description of the sample with the classification system used, if appropriate.
3. GPS coordinates of the sampling location; and
4. A general physical description of the sampling locations, as well as digital photographs of sampling locations, including one or more of the larger surrounding area.

SEDIMENT SAMPLING

PURPOSE

This Standard Operating Procedure (SOP) applies to the collection of sediment samples from rivers, lakes, streams, and other water bodies, for contaminant analysis. Sediments are typically defined as fine-grained, natural materials; transported and deposited by water; and are not unduly affected by processes that are localized. In general this procedure requires a minimum of two sampling personnel for safety concerns.

The methods described here are for collection of surface sediments, generally to a depth of about six to eight inches, and for collecting sediment cores, which can extend several feet into sediment (subsurface sediment).

GENERAL

Proper safety precautions must be observed when collecting sediment samples. Refer to the site-specific Health and Safety Plan (HASP) for guidance.

NOTE: The collection of samples for volatile organic compound (VOC) analysis shall follow the guidelines written for soils in the New Hampshire Department of Environmental Services (NHDES) "Final Policy Preservation of VOCs in Soil Samples" dated March 2000 included in the current NHDES Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP).

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as sample points, analytes and quality assurance (QA) requirements. Weather conditions and data quality objectives should be considered and documented in the site-specific SAP when planning a sediment sampling event. Determine what conditions the sampling event should occur in: "dry" or "wet", and define those terms prior to the sampling event.

Sampling locations shall be permanently located using a global positioning system (GPS) unit for future reference. The expected accuracy of the GPS unit shall be determined in advance and specified in the SAP. Flagging should also be used to visually mark the location if possible. Digital photographs should be taken at each sampling location, upstream and downstream from the same position, so that consistency can be maintained between sampling rounds.

When collecting surface water, pore water, and sediment samples in the same location, sampling should occur in that order: surface water samples first, then pore water samples and finally sediment samples.

Sediment samples collected from the same water body should be collected from downstream to upstream locations. Shallow sediment sample locations shall be approached from downstream to upstream locations to minimize bottom disturbance. If the bottom sediment is disturbed, the

sample will be collected from progressively upstream locations as required. Samples collected from a boat shall be collected from the bow or upstream side of the boat, away from the motor, with extreme care taken to avoid contamination of the sample.

EQUIPMENT

The following equipment is typically used in collecting sediment samples:

- Appropriate health and safety gear and an approved site-specific Health & Safety Plan.
- Site Specific SAP which includes map and other project-specific information.
- Waders.
- EnCore™ samplers or disposable syringes with the tips cut off for collecting VOC samples directly from the sampling device. These are to be used once and then disposed of. Be sure to have one for each VOC sample and duplicate, plus extras.
- Stainless steel scoops, bowls, spoons.
- Hand augers, as appropriate.
- Coring tubes, as appropriate.
- Eckman or Ponar dredges, as appropriate.
- A tripod or stand, to hold the Ponar dredge while excess water is being removed.
- Stream staff gage or similar measuring device.
- Sample containers, pre-preserved as necessary, cooler and loose ice.
- Re-sealable plastic bags to protect and store samples.
- Field data from last sampling event if available.
- Field worksheets, sample labels, chain of custody forms.
- Logbook, pencil/pen/sharpies, calculator.
- The manufacturer instruction manuals for all equipment, if applicable.
- Decontamination supplies/equipment, including laboratory-grade deionized water.
- Paper towels.
- Toolbox to include general items such as large and small wrenches, pliers, screw drivers, 25’ measuring tape, hose connectors, sharp knife (locking blade), duct tape, at a minimum.
- Camera to take digital pictures.
- GPS unit and flagging to mark locations.

GENERAL PROCEDURE FOR COLLECTION OF SURFACE SEDIMENT

Surface sediment samples, in shallow water, may be collected with stainless steel scoops, bowls, spoons, hand augers, or coring tubes that are hand held or attached to a coring tool. In deeper waters dredge samplers, such as Eckman or Ponar dredges, should be used unless otherwise specified. All non-dedicated sampling equipment shall be decontaminated prior to use and between samples. The following procedure is applicable for surface sediment sample collection.

1. Using a stream staff/gage or similar measuring device, measure the depth of water from the bottom of the streambed to the surface of the water in feet, directly downstream of the sampling location in order not to disturb the sediment where the sample is collected. Record the measurement on the Sediment Sampling Worksheet.

2. If possible, carefully clear away all surface debris (leaves, twigs, etc.) for a 1-foot radius around the sampling location, taking care not to greatly disturb fine sediments.

3. Using a stainless steel scoop, dredge, or other sampling device, slowly scoop or otherwise collect and retrieve the surface sediment from the bottom of the upstream location.

4. Remove any leaves, twigs, rocks or other gross debris that may have been collected.

5. Collect VOC samples directly from the sampling device according to the **NHDES "Final Policy Preservation of VOCs in Soil Samples" dated March 2000.** Using the disposable syringe, the proper volume of sediment is added to the methanol preserved volatile organic analysis (VOA) vial until the volume in the VOA vial reaches the pre-marked line established by the laboratory. An additional unpreserved sample must be collected to allow for a determination of moisture.

   Using the syringe method to extract the VOC sample assumes that the water content does not prevent sample collection. If the water content and/or sediment characteristics are such that a sample can't be obtained using a syringe, a stainless steel spoon will be used to transfer sediment from the sampling device to the VOC sample vial.

6. Transfer the remaining sediment to a pre-decontaminated stainless steel mixing bowl. Continue to collect additional sediment from areas adjacent to the original sample location to ensure staying within the required depth. Continue this procedure until the appropriate volume of sediment is obtained, and carefully decant excess liquid from the bowl.

7. When collecting duplicates, collect enough sample material in the stainless steel mixing bowl for both the sample and the duplicate.

8. Thoroughly mix sediment to obtain a homogeneous sample by quartering the sample, mixing each quarter and mixing all quarters together as described under sample mixing at the end of this document.

9. Record a general physical description of the sample such as color; basic makeup (sand, silt or clay); whether or not there is a high degree of organic material or high water content, etc. on the Sediment Sampling Worksheet. Note grain size unless a separate sample is collected for that purpose.

10. Following VOC sample collection, the sample containers should be filled in the order specified in the SAP.
11. Fill and cap the sampling containers and clean the exteriors of the containers to remove any potential residue. Place samples in re-sealable bags. VOC and other samples requiring cooling shall be placed within **loose** ice in a cooler.
12. If not previously done, use a GPS unit to permanently mark the sample location for future reference. In addition, use flagging to visually mark the location if possible.
13. Take digital photographs at each sampling location, upstream and downstream from the same position so that consistency can be maintained between sampling rounds.
14. Decontaminate the equipment. Refer to the Decontamination section below.
15. Collect an equipment blank as required. Refer to the Quality Assurance section below.

PONAR DREDGE PROCEDURE FOR COLLECTING SURFACE SEDIMENT

1. Pre-decontaminate the Ponar dredge according to the Decontamination SOP in the SAP or the HWRB Master QAPP.
2. Set up the tripod to hold the dredge once it's full.
3. Attach a dedicated nylon rope to the hook provided on top of the dredge.
4. Arrange the Ponar dredge sampler in the open position, setting the trip bar so the sampler remains open when lifted from the top.
5. Using a stream staff/gage or similar measuring device, measure the depth of water from the bottom of the streambed to the surface of the water, in feet, directly downstream of the sampling location in order not to disturb the sediment where the sample is collected. Record the measurement on the Sediment Sampling Worksheet.
6. If possible, carefully clear away all surface debris (leaves, twigs, etc.) for a 1-foot radius around the sampling location, taking care not to greatly disturb fine sediments.
7. Slowly lower the sampler to a point just above the sediment (about 2 inches).
8. Drop the sampler sharply into the sediment, then pull sharply up on the line, thus releasing the trip bar and closing the dredge.
9. Raise the sampler to the surface and slowly decant any free liquid through the screens on top of the dredge. Be careful to retain fine sediments.
10. Suspend the dredge on the tripod.
11. Open the dredge and using a syringe, siphon off, to the extent possible while minimizing the disturbance of any fines, any existing standing water in the Ponar dredge.
12. Remove any leaves, twigs, rocks or other gross debris that may have been collected.
13. Collect VOC samples directly from the sampling device according to the **NHDES "Final Policy Preservation of VOCs in Soil Samples" dated March 2000**. Using the disposable syringe, the proper volume of sediment is added to the methanol preserved

volatile organic analysis (VOA) vial until the volume in the VOA vial reaches the pre-marked line established by the laboratory. An additional unpreserved sample must be collected to allow for a determination of moisture.

Using the syringe method to extract the VOC sample assumes that the water content does not prevent sample collection. If the water content and/or sediment characteristics are such that a sample can't be obtained using a syringe, a stainless steel spoon will be used to transfer sediment from the sampling device to the VOA sample vial.

14. Transfer the remaining sediment to a pre-decontaminated stainless steel mixing bowl. Continue to collect additional sediment from areas adjacent to the original sample location until sufficient material has been gained to fill the remaining sample containers in the priority listed in the SAP.
15. When collecting duplicates, collect enough sample material in the stainless steel mixing bowl for both the sample and the duplicate.
16. Thoroughly mix sediment to obtain a homogeneous sample by quartering the sample, mixing each quarter and mixing all quarters together as described under sample mixing at the end of this document.
17. Record a general physical description of the sample such as color; basic makeup (sand, silt or clay); whether or not there is a high degree of organic material or high water content, etc. on the Sediment Sampling Worksheet. Note grain size unless a separate sample is collected for that purpose.
18. Following VOC sample collection, the sample containers should be filled in the order specified in the SAP.
19. Fill and cap the sampling containers and clean the exteriors of the containers to remove any potential residue. Place samples in re-sealable bags. VOC and other samples requiring cooling shall be placed within **loose** ice in a cooler.
20. If not previously done, use a GPS unit to permanently mark the sample location for future reference. In addition, use flagging to visually mark the location if possible.
21. Take digital photographs at each sampling location, upstream and downstream from the same position, so that consistency can be maintained between sampling rounds.
22. Decontaminate the equipment. Refer to the Decontamination section below.
23. Collect an equipment blank as required. Refer to the Quality Assurance section below.

SUBSURFACE SEDIMENT SAMPLE COLLECTION

Subsurface sediment samples greater than 8 inches in depth may be collected using coring devices that are pushed, driven, dropped, or vibrated into the sediment, and retrieved. The coring devices include split spoon type samplers, and tubes made of metal or plastic material, from which samples are extruded (with or without the aid of a tube liner). During retrieval, the core is typically retained in the tube by one or more of the following: capping the top of the tube to provide a vacuum, use of a core catcher, or by driving the tube into a clay layer to form a plug.

The following procedures are applicable to subsurface sediment sample collection.

1. Pre-decontaminate the coring device according to the Decontamination SOP in the SAP or the HWRB Master QAPP.
2. If possible, carefully clear away all surface debris (leaves, twigs, etc.) for a 1-foot radius around the sampling location, taking care not to greatly disturb fine sediments.
3. Advance the coring device into the sediment. A gentle rotation of the coring tube may aid penetration.
4. Cap the top of the tube (if applicable) to provide a vacuum for sample retention during retrieval.
5. Pull the sampler from the sediment and decant excess liquid from the surface of the sample. If the sample is to be stored or transported for processing, cap both ends of the core barrel (or the insert after removal) and store upright in a re-sealable plastic bag (the top of the barrel or insert shall be marked or identified).
6. If required, cut or divide the sample into the desired sample intervals.
7. Collect VOC samples directly from the sampling device according to the **NHDES "Final Policy Preservation of VOCs in Soil Samples" dated March 2000**. Using the disposable syringe, the proper volume of sediment is added to the methanol preserved volatile organic analysis (VOA) vial until the volume in the VOA vial reaches the pre-marked line established by the laboratory. An additional unpreserved sample must be collected to allow for a determination of moisture.

   Using the syringe method to extract the VOC sample assumes that the water content does not prevent sample collection. If the water content and/or sediment characteristics are such that a sample can't be obtained using a syringe, a stainless steel spoon will be used to transfer sediment from the sampling device to the VOA sample vial.
8. Place the remaining sample in an appropriate size pre-decontaminated stainless steel bowl or pan. If more sediment is needed, collect additional sediment next to the original sampling location to ensure staying within the required depth. Continue this procedure until the appropriate volume of sediment is obtained.
9. When collecting duplicates, collect enough sample material in the stainless steel mixing bowl for both the sample and the duplicate.
10. Thoroughly mix sediment to obtain a homogeneous sample by quartering the sample, mixing each quarter and mixing all quarters together as described under sample mixing at the end of this document.
11. Record a general physical description of the sample such as color; basic makeup (sand, silt or clay); whether or not there is a high degree of organic material or high water content, etc. on the Sediment Sampling Worksheet. Note grain size unless a separate sample is collected for that purpose.
12. Following VOC sample collection, the sample containers should be filled in the order specified in the SAP.

13. Fill and cap the sampling containers and clean the exteriors of the containers to remove any potential residue. Place samples in re-sealable bags. VOC and other samples requiring cooling shall be placed within **loose** ice in a cooler.
14. If not previously done, use a GPS unit to permanently mark the sample location for future reference. In addition, use flagging to visually mark the location, if possible.
15. Take digital photographs at each sampling location, upstream and downstream from the same position, so that consistency can be maintained between sampling rounds.
16. Decontaminate the equipment. Refer to the Decontamination section below.
17. Collect an equipment blank as required. Refer to the Quality Assurance section below.

SAMPLE MIXING

With the exception of VOC samples, it is important that the sediment samples be mixed as thoroughly as possible to ensure that the sample is representative of the sample interval. A common method of mixing is referred to as quartering. The sediment in the pre-decontaminated sample pan is divided into quarters. Each quarter is mixed, and then all quarters are mixed into the center of the pan. This procedure is followed several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material.

Note: If samples are predominantly moist and clayey, extra effort may be necessary to produce a homogeneous mixture.

QUALITY ASSURANCE

Collect appropriate quality assurance samples as specified in the site-specific SAP.

At least one duplicate sample should be collected. Collect enough sample material in the stainless steel mixing bowl for both the sample and the duplicate; thoroughly mix the sediment to obtain a homogeneous sample; remove any leaves, twigs, rocks or other gross debris that may have been collected; fill a separate container for each analysis immediately following the actual field sample collection and cap the containers for both the sample and duplicate sample. Note that the VOC sample and duplicate shall be collected directly from the sampling device, prior to sample mixing.

Equipment blanks are collected to ensure that the equipment is clean and the decontamination procedure is adequate.

To collect an equipment blank after decontamination: Gently pour deionized water over the equipment (e.g., Ponar dredge or other sampling device, stainless steel bowl, and mixing spoon) used to collect the sediment sample. Collect the rinsate that flows off the equipment into the appropriate sample containers. Refer to the site-specific SAP for detailed information.

DECONTAMINATION

Decontaminate equipment according to the Decontamination SOP in the site-specific SAP or the HWRB Master QAPP. All non-dedicated sampling equipment shall be decontaminated prior to use and between samples. Disposable sampling equipment shall be discarded after completing the sampling task and not reused.

DOCUMENTATION

In general all data and sampling information will be documented as specified in the SAP. Specific reporting of these sampling events may include, but is not limited to, the following information as recorded on the Sediment Sampling Worksheet:

1. Samples collected.
2. Date and time of sample collection.
3. Past 7 days of local meteorological data showing a minimum of daily precipitation totals and barometric pressure.
4. Water depths at various points along the streambed/lakebed.
5. A general physical description of the samples such as color; basic makeup (sand, silt or clay); whether or not there is a high degree of organic material or high water content, etc. Note grain size unless a separate sample is collected for that purpose. Document the system of classification used for the description.
6. A general physical description of the sampling locations.
7. GPS coordinates of the sampling location.
8. Digital photographs of sampling locations, including one or more of the larger surrounding area.

ATTACHMENT

Sediment Sampling Worksheet

SEDIMENT SAMPLING WORKSHEET

Site Name

Date: Field Personnel:

WEATHER CONDITIONS										
CURRENT		**PAST 7 DAYS**								
Barometric Pressure (in mm/hg)		Dates:								
Storm (Heavy Rain), circle one	Yes or No	Barometric Pressure (in mm/hg)								
Rain (Steady Rain), circle one	Yes or No	Estimated Rainfall (in)								
Intermittent Showers: circle one	Yes or No	Comments:								
Cloud Cover (%)										
Clear/Sunny, circle one	Yes or No									
Comments:										

SEDIMENT SAMPLING LOCATION CHARACTERIZATION		
Provide Physical Descriptions of the Sampling Locations at the Time of Sampling	SED-1	
	Photograph #, Date & Time	
	SED-2	
	Photograph #, Date & Time	
	SED-3	
	Photograph #, Date & Time	
	SED-4	
	Photograph #, Date & Time	
	SED-5	
	Photograph #, Date & Time	

A GENERAL PHYSICAL DESCRIPTION OF THE SAMPLE, DEPTH OF WATER INFORMATION AND SAMPLE TIME			
Sample Location ID	**Provide a general physical description of the sample such as color; basic makeup (sand, silt or clay); whether or not there is a high degree of organic material or high water content, etc. Note grain size unless a separate sample is collected for that purpose.**	**Depth of Water (nearest 0.01 ft)**	**Sample Time**
SED-1			
SED-2			
SED-3			
SED-4			
SED-5			

DRINKING WATER SAMPLING

The purpose of this Standard Operating Procedure (SOP) is to describe the procedure for collecting water samples from drinking water supply wells at or near contaminated sites.

Sampling drinking water supply wells can be an essential part to a proper investigation of groundwater contamination at a potential or actual contaminated site for the protection of human health. Each drinking water supply well represents an exposure point concentration that can be used to assess actual or potential risk to receptors and should be factored into the groundwater investigation program. At times it may also be useful to collect water quality parameters, in addition to chemicals of concern, from the drinking water supply wells as part of an on-going hydrogeological investigation. This SOP includes a procedure to collect water quality parameters in the field.

Sampling personnel must use common sense prior to and during sampling activities. For instance, samplers should try to avoid gassing up a vehicle on the day of the sampling event. Sampling personnel should also remember that they are at someone's home and so should not do anything to adversely impact the residence or unnecessarily inconvenience the resident. Notification to homeowners will be made prior to the sampling event.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as sample points, analytes and quality assurance (QA) requirements.

EQUIPMENT AND MATERIALS

- Appropriate health and safety gear (e.g., gloves) and an approved site-specific Health & Safety Plan.
- Site-specific SAP which includes sampling location maps, well information, all quality assurance samples and other project-specific information.
- Trip blanks and sample containers preserved as necessary.
- Cooler and loose ice.
- Re-sealable plastic bags to protect and store samples.
- Labels, chain-of-custody forms; field log books.
- An appropriate container to collect purge water from a tap at the tank in the basement if necessary. This may require a low profile container to collect purge water from a low-lying tap (e.g., the top of a small cooler works well).
- A brass tap apparatus with a permanently attached length of polyethylene or Teflon tubing is recommended in order to obtain a laminar flow when collecting volatile organic compounds (VOCs) from an outside or basement tap. This apparatus is not to be used on kitchen or bathroom faucets.

- Flashlight (to enter dark basements/cellars).
- Paper towels
- Decontamination supplies: laboratory-grade deionized (DI) water may be sufficient to rinse brass tap apparatus between sampling locations. Refer to the Decontamination SOP in the SAP for specifics.
- Trash bags to containerize solid waste.
- Bleach, if sampling for bacteria.
- Arsenic (As) speciation kits, if appropriate. The New Hampshire Division of Public Health Services (NHDPHS) Laboratory requires the following: a 500 milliliter (ml) unpreserved plastic bottle for Total As, a 250 ml unpreserved plastic bottle for As (III), a 60 ml syringe and a special Meng filter tip. Other labs may have different requirements. Refer to the SAP for detailed information.
- The following additional equipment is required if collecting water quality parameters:
    - An equipment setup diagram.
    - A multiparameter meter (e.g., YSI 600XL/XLM) with a built in barometer, a transparent 250 ml or less flow through cell and a ring stand, capable of measuring pH (units); oxidation reduction potential (ORP), mV; dissolved oxygen (DO), milligrams per liter (mg/l), 100% saturation for calibration; specific conductance, µS/cm; and temperature, degrees Celsius (˚C).; the same make and model as used for the site groundwater sampling.
    - Appropriate calibration solutions for the YSI meter: a small wet sponge or paper towel for DO 100% saturation calibration, “Zero” (0) mg/L DO check standard; Zobell Solution for ORP; two different specific conductance standards, one standard is used to calibrate and the other standard is used to check the calibration (e.g., 718 µS/cm and 1,413 µS/cm); 4, 7, & 10 units pH buffering solution; and extra DO membranes in case of breakage.
    - A Turbidity Meter (e.g., Hach 2100P or 2100Q), if turbidity is required; the same make and model as used for the site groundwater sampling.
    - Calibration solutions for the Hach Turbidity meter: <0.1, 10, 20, 100, 800 Nephelometric Turbidity Units (NTUs) standards as appropriate for the selected meter.
    - Various sizes of silicone tubing to connect the brass tap connector to the multi-parameter meter such as the following in ID x OD x Wall: #15 (3/16” x 3/8” x 3/32) and size 5/16 x 1/2 x 3/32.
    - A three way stopcock to divert sample flow (before the multi-parameter meter) to collect turbidity samples.
    - Plastic five gallon bucket to collect purge water from flow through cell.
    - Water quality parameter worksheet.

PRELIMINARY PROCEDURES

1. The sampler should inquire as to the type of piping used in the residence and record all available information in the field log book.
2. The residential water distribution system must be inspected to determine whether a water treatment system is in place, such as: a cartridge filter, a water softener, pH adjuster, point of entry (POE) treatment system, radon system, carbon system or an ultra violet system. The sample must be collected prior to any type of water treatment system or the system must be bypassed.
3. The sample may be collected from an indoor faucet (kitchen, bathroom, tap at the holding tank, etc.) or an outside spigot, preferably from the closest spigot to the well holding tank in the plumbing system. An outside spigot is preferable to an inside faucet, for convenience and to reduce loading of the septic system due to well purging. Do not collect water quality parameters with the flow through cell from the kitchen or bathroom faucets for sanitary reasons.
4. If sampling from a kitchen faucet, remove the aerator. If the aerator cannot be removed, the sample should be collected at a different location. Refer to the SAP for specific instructions.
5. If the sample is collected from an outside spigot, or if the outside spigot is used to purge water, the water may be purged through the homeowner's garden hose (with their permission), with the hose outlet directed away from the building foundation and positioned so as not to cause erosion.
6. Remove any hoses or attachments prior to sample collection. It may not be possible to remove all attachments; however, if there is an attachment made of plastic or other material that cannot be removed and could potentially contaminant the sample, the sample should be collected at a different location. Refer to the SAP for specific instructions.
7. If the sample is collected from the tap at the tank in the basement, first purge the well using the outside faucet, then purge water from the tap at the tank itself into an appropriately sized container (use a low profile container, should the tap be located near the floor) to flush the faucet, piping and connections back to the tank, of any debris.
8. Make sure that the sample point is clean (e.g., no grease, lead soldering, or other possible contaminants) and that no possible sources of cross-contamination (gas cans, solvents, etc.) are nearby.
9. Always wear new personal protection gloves at each location when collecting samples.
10. **Please note:** A dwelling may have numerous sampling locations. The New Hampshire Department of Environmental Services (NHDES) environmental monitoring database (EMD) requires that each specific sampling location have its own unique identification known as a Station ID. For example: the kitchen faucet at a particular residence may be called MOT_DW-1, whereas the outside tap at the same residence may be called MOT_DW-1A and the tap at the tank in the basement may be called MOT_DW-1B, etc. In this case the "MOT_" prefix identifies the Site associated with the sample. Refer to the SAP for specific sample identification nomenclature. Be sure to correctly identify the sample on

the chain-of-custody form.

SAMPLING PROCEDURE

The following steps should be followed once the preliminary steps have been completed:

1. If sampling for bacteria, wipe the faucet rim/threads (inside and out) with a bleach soaked paper towel prior to purging and sampling; otherwise skip this step.
2. Turn on the cold water at a high rate of flow for 10-15 minutes (a minimum of 10 minutes) to purge the system.

   Running the water will accomplish two goals. First, it will purge the pipes of any stagnant water; second, it will flush the pressure tank and cause the pump to turn on and start pumping the well. This should assure the collection of a fresh and representative sample from the well.
3. While the water is running, record any observations and/or comments about matters pertinent to the sample and/or site in a field logbook.
4. Once the water has been running for a minimum of ten minutes:

   a) If collecting a bacteria sample, reduce the flow to a very slow flow rate and collect the sample by allowing the water to flow gently down the inside wall of the container with minimal turbulence. **Bacteria samples are always collected first and without the use of the brass tap apparatus.** If using a brass tap apparatus to collect additional samples, continue to Step 4B, if not, continue to Step 5.

   b) If using the brass tap to collect additional samples, shut the water off. Attach the brass tap apparatus to the tap. Turn water back on at a very slow flow rate. Purge a small amount of water through the apparatus to rinse it with the water being sampled. **Do not use the brass tap on kitchen or bathroom faucets or when collecting bacteria samples.** Fill appropriate sample containers by allowing the water to flow gently down the inside wall of the container with minimal turbulence.
5. Collect the samples in the appropriate containers in the order specified in the SAP. Volatile samples are usually collected first (after any bacteria samples).

   All sample containers should be filled by allowing the discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers should be wiped dry.

   a. **For collection of VOC samples, including carbon dioxide, methane, ethane, ethene and 1,4-dioxane using Methods 8260 SIM or EPA EIASOP-VOADIOX4, refer to the Special Notes section at the end of this SOP.**

   b. If collecting samples for arsenic speciation, refer to the specific procedure outlined in a separate section below.

c. For households with a POE treatment system, it may be necessary to collect multiple samples. If so, sample in order from the potentially least contaminated sample point to the most contaminated sample point to minimize the potential for cross-contamination (e.g., fully treated, partially treated and untreated sampling points). When sampling any of these devices, trace the route of the plumbing (pipes) to make sure the sample is being taken from the correct sampling port. Purge water from each sample point into an appropriate container to flush the faucet, piping and connections of stagnant water and debris before collecting the samples. Gloves must be worn and changed between sample ports.

6. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC sample, VOC duplicate sample, VOC MS/MSD sample). Refer to the SAP for specific quality control (QC) sampling requirements and appropriate chain-of-custody notations required for MS/MSD samples.

   If collecting samples for arsenic speciation, use a new kit, including a new filter, for the duplicate sample.

7. Cap sample containers securely after filling each bottle. Sample containers should be wiped dry and placed in re-sealable plastic bags. Place samples in loose ice within the cooler, or store in accordance with appropriate protocols. Metal samples, after acidification to a pH less than 2, do not need to be cooled.

8. Once all the samples have been collected, collect the quality parameters, if appropriate. Refer to the procedure outlined in a separate section below.

9. Once all the samples have been collected, remove the brass tap apparatus, if it was used, and return all plumbing to its original position (aerator on faucet, all sample ports closed, replace hoses and attachments, etc.).

10. Decontaminate the brass apparatus before each sample location. Refer to the section on decontamination below.

Special Considerations for Volatile Organic Compound Sampling

Including 1,4-dioxane samples analyzed by Methods 8260 SIM or EPA EIASOP-VOADIOX4.

The proper collection of a sample for volatile-organic compounds requires minimal disturbance of the sample to limit volatilization and therefore a minimal loss of volatiles from the sample. The following VOC procedures should be followed:

1. Open the labeled vial, set cap in a protected place, and collect the sample by allowing the water to flow gently down the inside wall of the container with minimal turbulence. When collecting quality control samples, collect them immediately following the original sample (e.g., VOC sample, VOC duplicate sample, VOC MS/MSD sample).

2. Do not rinse the vial or overflow it (e.g., it likely contains a preservative that must not be diluted).

3. Be sure the sample flow is laminar and there are no air bubbles in the sample flow.

4. There should be a convex meniscus on the top of the vial before capping. The cap of the vial may be used to create the convex meniscus for VOC samples, if needed.

   For methane/ethane/ethene and carbon dioxide, the laboratory typically requests that the sample bottle cap is not used to top off the sample vials. These vials should be filled in the shortest time possible and capped immediately. Do not uncap these vials and add more water. Small bubbles are considered normal for these pre-preserved containers; however, every effort should be made to collect the best sample possible.

5. Check that the cap has not been contaminated (splashed) and carefully cap the vial.

6. Place the cap directly over the top and screw down firmly. Do not over-tighten and break the cap.

7. Invert the vial and tap gently. If an air bubble appears, uncap and attempt to add a small volume of sample to achieve the convex meniscus without excessively overfilling the vial. If this has to be repeated more than twice, discard the sample and begin again with a new container and preservative. It is imperative that no entrapped air is in the sample vial.

8. The vial should be wiped dry and immediately placed in a re-sealable plastic bag and then placed into loose ice within the cooler.

PROCEDURE FOR COLLECTING SAMPLES FOR ARSENIC SPECIATION

The following is a specific procedure for collecting arsenic speciation samples to be analyzed by the NHDPHS Laboratory in Concord, New Hampshire. Other laboratories may have different requirements.

The arsenic speciation kit includes the following**:** a 500 ml unpreserved plastic bottle for Total As (and possibly other total metals), 250 ml unpreserved plastic bottle for As (III), a 60 ml syringe and a special Meng filter tip to remove As (V).

1. Fill the 500 ml total arsenic bottle.

2. Draw up 60 ml of water from the total arsenic bottle with the syringe.

3. Attach the special filter tip.

4. **Discard the first five ml of water** (to rinse the filter before collecting the sample).

5. **SLOWLY*** dispense the remaining 55 ml of water through the filter into the 250 ml arsenic (III) bottle.

   ***It must take a minimum of ONE MINUTE to dispense the remaining volume of water in the syringe through the filter into the arsenic (III) bottle in order for the filter to work properly.**

6. Remove the filter tip, fill the syringe from the total arsenic bottle for the second time, attach the filter tip again and **SLOWLY** dispense the entire syringe contents through the filter into the same 250 ml arsenic (III) bottle. A minimum of 100 ml of water is needed

in the 250 ml arsenic (III) bottle. It is not necessary to discard an additional 5 ml of water the second time the filter tip is used.

7. DO NOT add more water to the total arsenic bottle.
8. Collect a duplicate sample at the appropriate locations using a new kit for each sample, including a new filter tip.
9. These sample bottles DO NOT need to be put on ice if the samples are brought back to the NHDPHS lab daily. The lab will acidify the samples once they are received.

PROCEDURE FOR COLLECTING WATER QUALITY PARAMETERS

This procedure was developed for use on the tap at the tank in the basement or on outside taps only. Do not use this procedure on kitchen or bathroom faucets for sanitary reasons.

Instruments will be calibrated at the beginning of each sampling day and will be checked (in the run mode) in the morning and again at the end of the day. **IMPORTANT:** ***Refer to the Calibration SOP (SOP No. HWRB-17) in the current Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP) for specific calibration information and procedures.***

1. Turn on the meters so they can warm up according to the manufacture manuals.
2. Review the attached equipment setup diagram.
3. After the water has run for a minimum of ten minutes and all samples have been collected, shut off the water and attach the brass tap apparatus to the tap if it is not already attached.
4. Connect the other end of the brass tap apparatus to the three way stopcock and the three way stopcock to the multi-parameter meter flow through cell bottom inlet port using silicone tubing, typically size #15 (3/16” x 3/8” x 3/32). Other sizes of silicone tubing, such as 5/16 x 1/2 x 3/32, may be necessary. If turbidity readings are not required connect the other end of the brass tap apparatus to the multi-parameter meter flow through cell bottom inlet port.
5. Attach the multi-parameter meter to the ring stand next to the five gallon bucket. The flow cell should be tilted with the outflow connection facing upward to eliminate and prevent air bubbles from building up.
6. Connect a piece of silicone tubing to the flow cell upper discharge port and direct that tubing into the five gallon bucket to collect the purge water.
7. Turn on the tap to the slow flow rate used for collecting the samples, allowing the water to slowly fill the flow cell and exit into the bucket. Check to make sure there are no bubbles forming at the top of the cell. Tilt the cell again or lightly tap the cell, as necessary, to remove any bubbles.
8. Allow the parameter values to stabilize for a minimum of two minutes. Record the values on the sampling worksheet.

9. Collect an aliquot of water from the 3-way stopcock for analysis in the Hach turbidity meter, if required. Record the value on the sampling worksheet.
10. Turn off the meters once you have recorded all the readings.
11. Shut off the tap.
12. Disconnect silicone tubing from brass apparatus taking care to empty the contents into the bucket.
13. Allow the water to drain from the hoses (silicone tubing) and the flow cell into the bucket.
14. Leave all hoses connected to the flow through cell.
15. Dispose the bucket of purge water as appropriate and dry the bucket.
16. Place the ring stand with unit still attached into the bucket along with the hoses and meter to bring to the next sampling location.
17. Remove the brass tap apparatus and return all plumbing to its original position (all sample ports closed, replace hoses and attachments, etc.).
11. Decontaminate the brass apparatus before each sample location. Refer to the section on decontamination below.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Refer to the SAP for specific quality assurance requirements.

A minimum of one duplicate should be collected per sampling event unless otherwise specified in the SAP. MS/MSD samples should be collected as specified in the SAP.

If collecting samples for arsenic speciation, one equipment blank should be collected on a syringe and filter tip before sampling by filling one of the 500 ml total arsenic bottles with distilled water from the lab and proceed with the steps outlined above under **Procedure for Collecting Samples for Arsenic Speciation** so there is a total arsenic sample and an arsenic (III) sample.

If the brass tap apparatus is used, an equipment blank should be collected after decontamination to ensure that the decontamination procedure is adequate.

DECONTAMINATION

Decontamination of the brass apparatus shall be performed before each sample location. Laboratory-grade deionized (DI) water may be sufficient to rinse brass tap apparatus between sampling locations. Refer to the Decontamination SOP in the SAP for the appropriate decontamination procedure.

DOCUMENTATION

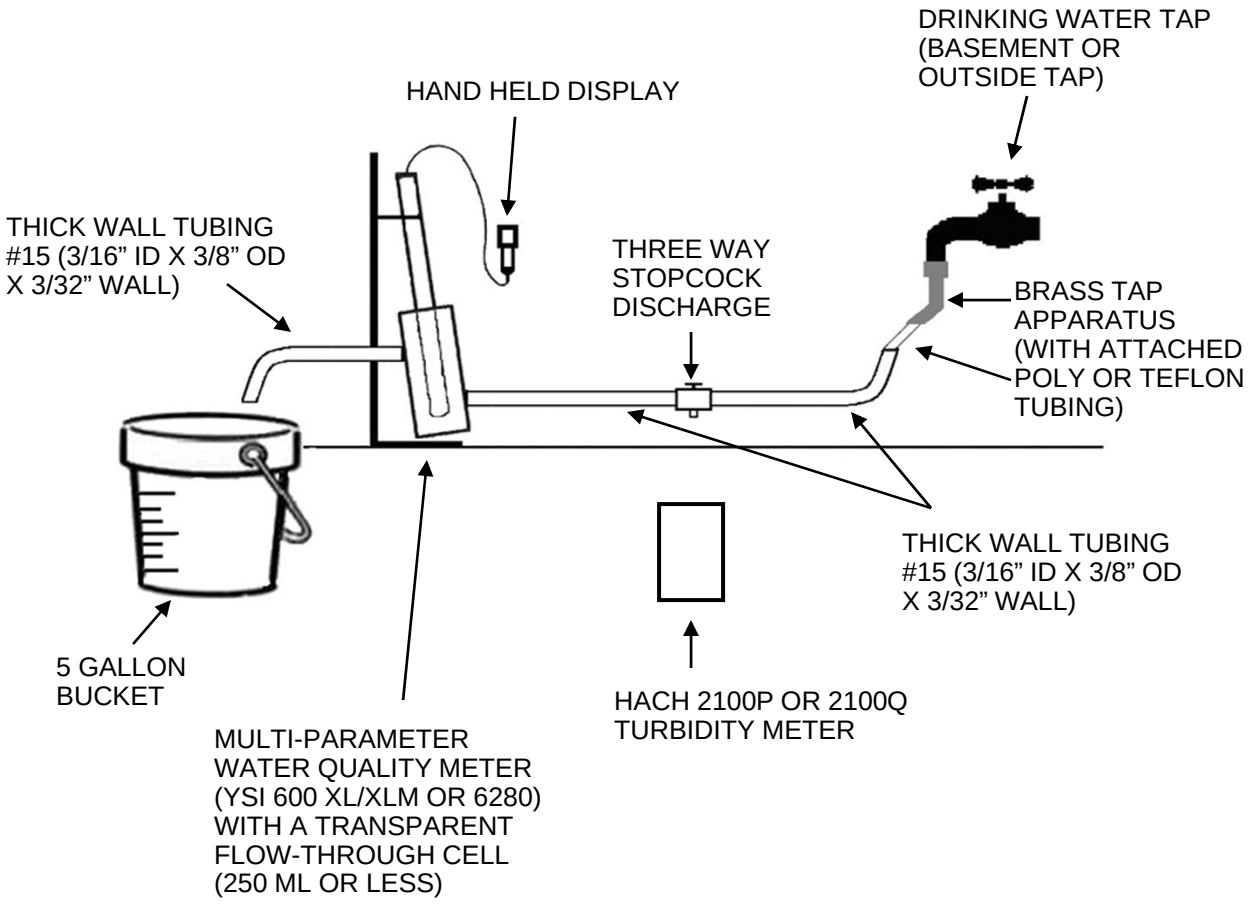
Document observations and/or comments in the field log book or on the sampling worksheet. See the Chain of Custody SOP in the current HWRB Master QAPP for the minimum information to include on the labels and chain-of-custody forms.

ATTACHMENTS

Setup Diagram for Collecting Water Quality Parameters at Drinking Water Wells

Drinking Water Quality Parameter Worksheet

SET UP DIAGRAM FOR COLLECTING WATER QUALITY PARAMETERS AT DRINKING WATER WELLS



NOT TO SCALE

Drinking Water Quality Parameter Worksheet
Site Name

Personnel:

Station ID	Date	Time	Temp ^0C	Specific Conductance µS/cm	DO mg/l	pH Unit	ORP mv	Turbidity NTU

Notes:

When recording pH and dissolved oxygen data, only use one decimal place.
When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers.
When turbidity data is less than 5 NTU, data should be recorded as “< 5” or “less than 5”.
When DO data is less than 0.5 mg/L, data should be recorded as "<0.5" or "less than 0.5".
"NR" indicates no reading taken.
YSI Multiparameter Meter 600XL/XLM or 6820; Hach 2100P or 2100Q Turbidity Meter

Comments/Observations:

DECONTAMINATION

PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide a procedure for preventing, minimizing, or limiting cross-contamination of environmental samples. This procedure is intended to ensure that field equipment is properly and adequately decontaminated in order to preserve the integrity of data collected with that equipment in the field, as well as to protect staff working with the equipment from exposure to contaminants.

This SOP focuses on small equipment decontamination (e.g., pumps, water level meters, hand augers, stainless steel spoons and mixing bowls for sediments).

For site work involving large equipment, such as backhoes, bulldozers, drill rigs, etc., a specific decontamination procedure will be required in the site-specific Sampling and Analysis Plan (SAP). As a guideline, a thorough brushing, scraping, washing and/or steam cleaning should be completed. Such maximum contact points as tires, treads, buckets, blades, and drill pipe/bits, should be thoroughly decontaminated in an effort to prevent migration of contaminants off the site. At sites where equipment becomes highly contaminated, provisions to collect rinsate water/solutions may have to be made.

Decontamination consists of physically removing contaminants or changing their chemical nature to innocuous substances. How extensive decontamination must be depends on a number of factors, the most important being the type of contaminants involved. The more harmful the contaminant, the more extensive and thorough decontamination must be. Less harmful contaminants may require less decontamination. Decontamination procedures shall be determined on a site by site basis and documented in the site-specific SAP.

Decontamination is an essential part of a successful field operation as it: prolongs the usable life of the equipment; lessens the potential for cross-contamination of samples; prevents the mixing of incompatible substances; and reduces the likelihood of contamination leaving the site and threatening other areas with contamination.

In addition to this guideline, personnel should also review the manufacturer's user manual for any equipment specific recommended decontamination procedures.

EQUIPMENT AND MATERIALS

The following is a list of equipment and material commonly used for decontamination:

- An approved site-specific Health and Safety Plan.
- Appropriate personal protective equipment (e.g. safety glasses, appropriate chemically resistant gloves, boots);
- Site-specific SAP.
- Non-phosphate detergent.

Note: Some non-phosphate detergents may contain 1,4-Dioxane. See section below on quality assurance samples.

- Selected solvent rinses (e.g., pesticide-grade isopropanol, hexane).
- Tap water.
- Laboratory-grade deionized (DI) water.
- Long and short handled brushes and bottle brushes.
- Drop cloth/plastic/polyethylene sheeting.
- Paper towels.
- Plastic, galvanized or stainless steel tubs or buckets, as appropriate.
- Spray bottles and/or pressurized sprayers.
- Aluminum foil and/or re-sealable plastic bags.
- Appropriate containers for decontamination waste products.

GUIDELINES

All field activities must be carried out in accordance with a site-specific Health and Safety Plan. All decontamination procedures should be completed with an appropriate level of personnel protection: at a minimum equal to the level the fieldwork was completed in; no less than level D which includes safety glasses, chemically resistant gloves, boots, etc. Some solvents used in decontamination may require more stringent protection levels than used for fieldwork.

Safety Data Sheets (SDS) are required to be on site when using decontamination acid and/or solvent solutions.

Each item used for the decontamination of equipment may also become contaminated and must be appropriately handled, stored, and either decontaminated itself or disposed of. Certain items that become grossly contaminated and cannot be practically decontaminated (e.g., small tools and tools with wooden handles) should be disposed of properly. In some instances it is more practical and sensible to dispose of these items properly than to attempt decontamination. Such decisions will be made by the project manager and specified in the site-specific SAP.

In addition, decontamination of equipment generates investigation-derived waste (IDW) such as contaminated rinse liquids and sludges that may need to be containerized onsite until proper disposal arrangements are made. The project manager will use professional judgment and guidance documents such as Guide to Management of Investigation-Derived Wastes, EPA 93-45303fs-s, January 1992[i] on a site by site basis to determine if the levels of contamination are sufficiently low so that disposal at a hazardous waste facility is not necessary. This information shall be documented in the site-specific SAP.

GENERAL PROCEDURE FOR SMALL EQUIPMENT DECONTAMINATION

This procedure refers to both the inside and outside of equipment where appropriate.

The decontamination procedure is summarized as follows:

1. Set up a decontamination line on polyethylene sheeting. The decontamination line should progress from "dirty" to "clean", with an area for drying decontaminated equipment.
2. Disassemble any items that might trap contaminants internally before washing. Do not reassemble until decontamination is complete.
3. Remove gross contamination from the equipment by brushing and then rinsing with tap water.
4. Wash the equipment with a non-phosphate detergent* and tap water, as required.
5. Rinse with tap water.
6. Rinse with the appropriate solvents**, as required.
7. An additional step of wiping the equipment with appropriate solvent (e.g., hexane) saturated paper towels may be necessary if the equipment made contact with a light non-aqueous phase liquid (LNAPL) to assist in its removal.
8. Rinse the equipment with DI water between solvent rinses, with a final rinse of DI water.
9. Air dry and secure clean equipment.

***Non-Phosphate Detergent**

In some cases, it may not be necessary to wash the equipment with a non-phosphate detergent if it can be demonstrated that washing the equipment with tap water alone (then rinsing with DI water) is sufficient.

**** Solvents**

In some instances, an additional wash with a solvent, such as isopropyl alcohol or hexane may be required depending upon the contaminant. In other cases, it also may be necessary to carefully wipe the equipment down (inside/outside, as appropriate) with a paper towel saturated with the solvent. A solvent wash/wipe may be necessary in the case of sampling in high levels of contamination, or when sampling particularly difficult to clean contamination such as LNAPL or coal tar. The need for a solvent wash/wipe will be determined on a site by site basis by project manager prior to the sampling event and be documented in the site-specific SAPs. Lab personnel can assist in determining an appropriate solvent.

<u>Decontaminating Pumps</u>

The decontaminating solutions may be pumped through the pump and tubing from either buckets or short PVC casing sections with an end cap, or the pump can be disassembled and flushed with the decontaminating solutions.

SPECIAL NOTES

The decontamination procedure for water level meters and oil/interface probes shall include the probes and, at a minimum, the length of tape used in that well.

With instruments such as multiparameter meters and turbidity meters, the probes, flow through cells and turbidity vials shall be thoroughly rinsed with DI water. If appropriate, some of these items may be washed with non-phosphate detergent and tap water, rinsed with tap water and finally rinsed with DI water. Sensitive equipment that is not water proof should be wiped down with a damp cloth. Great care shall be taken not to damage the instrument. Refer to the manufacture manuals for specific guidance.

IDW Disposal, if appropriate
Solid Waste – Place all solid waste materials generated from the decontamination area (e.g., gloves and plastic sheeting, etc.) in an approved container.

Liquid Waste – Place used soap water and solvent liquid wastes into 5-gallon plastic containers and store with lid on. Contact the appropriate personnel to arrange for disposal. Refer to site-specific SAPs for detailed information on handling liquid waste.

ALTERNATIVES

Decontamination is, by its nature, an arduous and painstaking task which is often better to avoid. Avoid decontamination procedures whenever feasible by implementing alternative plans of action such as:

- Dedicating specific equipment to a well (e.g., bladder pumps or bailers) when economically feasible;
- Using disposable equipment when applicable; and
- Wrapping monitoring equipment in plastic bags (or other materials) to protect from contamination. It is important to keep monitoring equipment such as a photoionization detectors (PID) from contacting soil or liquids at hazardous substance sites. By eliminating contact with contamination and/or using disposable equipment, decontamination of equipment may be avoided. Develop a method of wrapping/bagging these instruments in polyethylene sheeting/bags so that contact with contamination is minimized but the performance of the instrument is not adversely effected (e.g., the knobs made inaccessible, the meter covered).

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Equipment blanks should be collected on non-disposable equipment to insure that equipment is clean and the decontamination procedure is adequate. Equipment blank samples shall be collected and analyzed according to the site-specific SAP.

If 1,4-Dioxane is a concern at the site it may be appropriate to seek a non-phosphate detergent that does not contain 1.4-Dioxane. At the very least, an equipment blank should be collected and analyzed for 1,4-Dioxane to ensure that the decontamination procedure is adequate and that there is no 1,4-Dioxane residue. If 1,4-Dioxane is found in the equipment blank the sampling data must be qualified.

If an equipment blank is analyzed and found to contain a contaminant, possible sources of error will have to be investigated to determine whether or not the decontamination procedures were properly followed. Possible sources of error include: inadequate scrubbing/ washing/ rinsing/ wiping of equipment; use of incorrect decontamination solvent/solutions; use of contaminated detergents or rinse waters; contact with contaminants after decontamination but prior to sampling, and/or, lab error.

REFERENCES

ASTM D 5088 – 02, 2008. Standard Practice for Decontamination of Field Equipment Used at Waste Sites. American Society for Testing and Materials (ASTM), Pennsylvania
http://www.astm.org

US DHHS, 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. U.S. Department of Health and Human Services, Washington, D.C.
https://www.osha.gov/Publications/complinks/OSHG-HazWaste/4agency.html

US EPA, 1984. Standard Operating Safety Guides. Office of Emergency and Remedial Response, Washington, D.C.

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http://nepis.epa.gov/Exe/ZyNET.exe/P100L3QK.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1991+Thru+1994&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C91thru94%5CTxt%5C00000030%5CP100L3QK.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

PORE WATER SAMPLING
(GROUNDWATER/SURFACE WATER INTERFACE SAMPLING)

PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to describe the procedure for collecting groundwater samples using a pore water (PushPoint) sampler. All personnel who collect these types of samples must be appropriately trained in this methodology.

It is often difficult to determine the extent and origin of contamination using surface water sampling techniques. In some cases, a surface water body may be clean but the groundwater beneath it may be contaminated. Thus, sampling the groundwater prior to its discharge to a surface water body may lead to a better understanding of the extent and origin of contamination. This can be accomplished by using a pore water sampler. Underlying the procedure is the assumption that surface water bodies are common discharge points for groundwater. Thus, a sample of the water beneath a stream or riverbed would be characteristic of the groundwater in the area.

Refer to the site-specific Sampling and Analysis Plan (SAP) for specific details such as sample points, sampling depths, means of accessing the sample points, analytes and quality assurance (QA) requirements.

INTRODUCTION AND SAMPLING CONSIDERATIONS

A pore water sampler comes in two parts, a strengthening rod and the pore water sampler itself, both made of stainless steel. The pore water sampler is basically a hollow tube with small holes or a screen in its tip that allow groundwater to enter the tube. See F**igure 1** below and the attached **Figures 2 through 5**. The screened zone consists of a series of interlaced machined slots which form a short screened zone with approximately 20% open area. Additional filters ("Screen Soks", **Figure 6**) can be placed over the screened zone if additional screening is needed. The strengthening rod slides into the pore water sampler (**Figure 2**), and while in place, gives structural support to the PushPoint and prevents plugging and deformation of the screened zone during insertion into sediments. Both pieces are placed in a PVC sheath for protection. Although the pore water sampler is fairly sturdy, exercise caution during use, as once either piece becomes bent, the equipment is useless.

Onsite decontamination is difficult and should be avoided. There should be at least as many pore water samplers as there are sampling locations.

It is critical in the collection of pore water to avoid surface water intrusion. Water will flow in a path of least resistance. If space is created around the sides of the PushPoint during deployment surface water may flow down the outside of the tube to the screened area and into the intended sample. Therefore, the pore water sampler should be inserted to the desired depth using a twisting motion without shifting the axis of the sampler. Care must be taken not to rock or

wiggle the sampler back and forth, which would create a cone within the sediment around the sampler that could act as a potential path for surface water to mix with pore water. A sampling platform or flange (**Figure 3**) may be useful to aid in assuring linear insertion into the sediment.

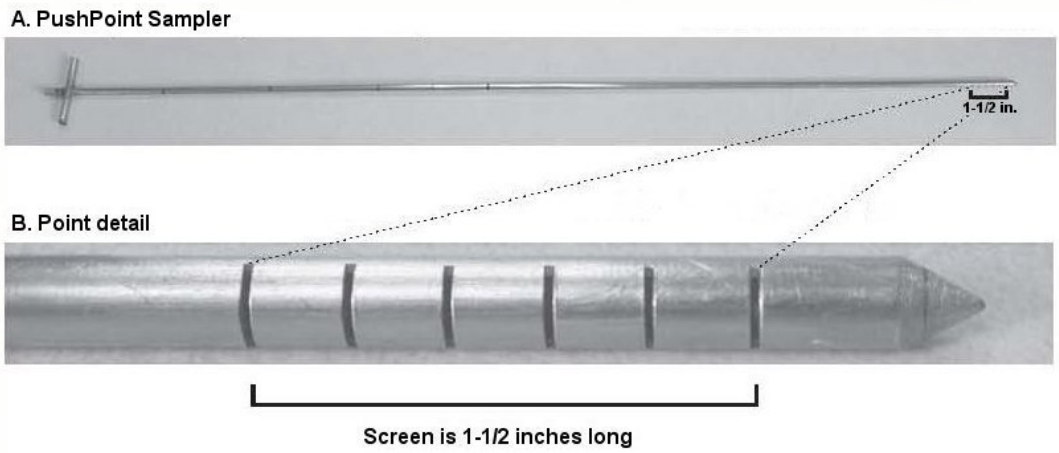


Figure 1. *A*, 36 Inch long PushPoint (PPX36) 1/4 inch diameter Field Investigation Sampler, and *B*, Closeup of the slotted screen at the tip.

The flange would be especially useful when collecting pore water in shallow sediments near the sediment-surface water interface. The flange should fit securely around the pore water sampler to eliminate surface water intrusion from around the sampler body during sample collection, but must allow smooth operation of the sampler along the axis of penetration. The flange could be made of any material which will not cross contaminate the intended sample, such as stainless steel or Teflon.

The pore water sampler should be inserted deep enough to ensure the sample collected will contain only groundwater and no surface water. The depth of the surface water at the sampling point must be shallow enough to allow sufficient insertion into the sediment and to ensure that the total depth of the water & sediment combined does not exceed the length of the sampler (**Figure 4**).

Finding the ideal sampling depth is a matter of experience and trial and error. Coarse sediment and sediments with a high percentage of organic matter are the most permeable, and with experience samplers can actually “feel” the type of sediment as the pore water sampler is advanced. If the sediment layer intercepted by the screen is not permeable enough for collection of sample, gently advance and/or pull back the sampler in an attempt to find a more permeable zone.

Sampling locations should be located and staked at least one day before sampling occurs, whenever possible. Sampling locations shall be permanently located using a global positioning system (GPS) unit for future reference. The expected accuracy of the GPS unit shall be determined in advance and specified in the SAP. Digital photographs should be taken at each

sampling location, upstream and downstream from the same position to further document the locations.

Pore water sample locations and depths are pre-determined based on pore water temperature screening. A hand-held thermometer with a 4 foot (or other appropriate length) probe is used to determine the location and the ideal depth based on the nature of the sediment layer and the maximum temperature differential between surface and pore water. If a suitable sediment layer is not found it may be necessary to change the sampling location. Unless stated otherwise in the SAP, this change is made at the discretion of the sampler and is documented in the field notes. It should be noted that streams are dynamic, and a location that is suitable during one sampling round may not be on subsequent rounds.

Dissolved oxygen (DO) and temperature readings will be collected from both the surface water and the pore water at each sampling location to ensure that the sampler has actually penetrated into the pore water. DO and temperature readings will be collected from the surface water in-situ prior to pore water sampling, and then they will then be collected from the pore water (**Figure 5**) for comparison. Although actual results may vary, pore water DO is expected to be less than 2 milligrams per liter (mg/L) and most surface water DO is expected to be above 8 mg/L. Pore water temperatures also tend to be cooler than surface water during summer and warmer during winter. Pore water temperatures should be compared to those determined during the sample location phase.

Turbidity should also be measured if sampling for metals. In general, if pore water turbidity is above 30 NTUs, it is recommended that an additional sample be collected that has been filtered through a 0.2-0.45 micron in-line particulate filter.

Pore water will be collected from sediments using a peristaltic pump and placed directly into the sampling containers (**Figure 5)**.

Wading is the preferred method for reaching the sampling location. Pore water samples shall be collected from downstream to upstream and facing upstream to avoid disrupting bottom sediments causing biased results.

If sampling for other media at the same location, the samples should be collected in this order:

1. Pore Water Samples
2. Surface Water Samples
3. Sediment Samples

Low flow purging and sampling protocol is not required, but if desired, refer to the current Low Flow Groundwater Purging and Sampling SOP in the current Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP).

Weather conditions and data quality objectives should be considered when planning a pore water sampling event and should be defined and documented in the SAP.

HEALTH AND SAFETY

All personnel must understand that if a sample cannot be obtained safely, the sample should not be taken at all. If a sample cannot be obtained due to safety considerations it should be documented in the sampler's field logbook.

All personnel should be aware of the potential dangers associated with this particular sampling method. These dangers include, but are not limited to, strong water currents, slippery substrate, roots or sharp objects beneath the water's surface that may cause a fall or other personal injury. All necessary precautionary measures should be heeded when performing this sampling technique. See site-specific Health & Safety Plan for specific details.

EQUIPMENT

The following is a list of typical equipment used for collecting groundwater samples using the pore water sampler method.

- Appropriate health and safety gear and an approved site-specific Health & Safety Plan.
- Site-specific SAP which includes well logs, map and other project-specific information.
- Waders.
- A hand-held thermometer with a 4 foot (or other appropriate length) probe and user's guide to determine pore water sampling depths (e.g. HH201A Omega Hand-held Thermometer).
- Separate containers of ambient temperature water and ice water to check the temperature probe in the hand-held thermometer and in the multi-parameter meter.
- Pore Water Samplers (e.g. 36" PushPoint [PPX36] 1/4" diameter Field Investigation Samplers). There should be at least as many pore water samplers as there are sampling locations, as onsite decontamination is difficult and should be avoided.
- #54 polypropylene "Screen-Sok", which acts as a pre-filter if working in soft or highly organic sediments. They are not normally needed for sandy sediments.
- Peristaltic pump with a sampling head capable of using thin wall tubing and pumping low speeds (40-50 milliliters per minute) with a battery or other power supply.
- Pharmaceutical or surgical grade silicon/silastic tubing for pump. (e.g. For sampling: Thin walled tubing #16 [1/8" ID x ¼" OD x 1/16" Wall]. For connections, if needed: thick walled tubing #15 [3/16" ID x 3/8" OD x 3/32" Wall]) Enough tubing should be supplied to reach from the pore water sampler to the shore.
- Polyethylene or Teflon tubing, as appropriate, with an inside diameter (ID) of 1/4 inch to fit around the top opening of the pore water sampler. Depending upon the site specific circumstances it may be appropriate to use enough tubing to reach from the pore water sampler to the shore for safety reasons.
- A toolbox which includes a knife or other tool to cut tubing to desired lengths.

- Measuring stick or similar measuring device with 5 millimeter or 1/4 inch divisions or smaller to measure depth of water at the sampling location and to verify depth the sampler has been inserted into sediment.
- A multi-parameter meter for measuring Temperature (˚C) and DO (mg/L) with a 250 ml maximum volume clear flow through cell; the same make and model as used for the site groundwater sampling (e.g. YSI 600XL/XLM or 6820) with a probe guard to collect in-situ parameter readings of the surface water. The sonde must be waterproof to collect in-situ parameter readings. Refer to the SAP as other parameters, such as pH, specific conductivity and oxidation reduction potential (ORP), may also be required.
- Appropriate calibration solutions for the multi-parameter meter, including a small wet sponge or paper towel for the 100% DO saturation and a zero (0) mg/L solution for the DO check; additional standards, as necessary, depending upon required parameters. Refer to the Calibration of Field Instruments SOP in the current HWRB Master QAPP for specific standards.
- A turbidity meter and standards: the same make and model and standards as used for the site groundwater sampling, as required (e.g. Hach 2100P or 2100Q Turbidity Meter with <0.1, 10, 20, 100, and 800 NTU standards, as appropriate for each meter).
- A three-way stopcock to divert sample flow for turbidity reading:
  (e.g. Nalgene three-way stopcock with a plug bore of 4 mm [or 0.157 in] NNI No. 6470-0004 VWR catalog No. 59097-080).
- A clear 100 ml graduated cylinder and stop watch.
- Plastic sheeting, bucket or table to set peristaltic pump on.
- Large clear plastic bags to separately store the tubing from each sampling location.
- Large clear plastic bags to store pore water sampler and strengthening rod after use and prior to decontamination.
- Flange or sampling platform, if required.
- Appropriate sample containers, preserved as necessary, cooler (with loose ice if cooling is required).
- 0.2-0.45 micron in-line particulate filters for dissolved metals (one for each sample and a few extras), as required in SAP (the filters are not to be re-used). Typically, 0.45 micron filters are used.
- Re-sealable plastic bags to protect and store samples.
- Field data from last sampling event, if available.
- Field worksheets (see attached example), sample labels, chain of custody forms.
- Logbook, pencil/pen/sharpies, calculator.
- The manufactures instruction manuals for all equipment.
- Decontamination supplies/equipment, as required in the field.

- Laboratory-grade deionized (DI) water.
- Paper towels.
- Stakes and flagging, as needed to temporarily mark sample locations.
- A camera to take digital pictures of the conditions during the sampling event.
- A GPS unit to locate the pore water sampling locations so that the area may be mapped.

PRELIMINARY PROCEDURES

Instrument Calibration/Check and Maintenance

1. In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested, and inspected according to the manufacturer's instructions. The manufacturer's instruction manuals for field equipment shall be kept on site with the equipment.
2. All instruments shall be successfully calibrated once, off-site, by the sampling team immediately prior to the sampling event to make sure the instruments are working properly and meets the quality assurance criteria prior to mobilizing.
3. Instruments shall be calibrated at the beginning of each sampling day at the site and shall be checked in the run mode (on a run/measurement screen) in the morning and again at the end of the day. Instrument calibration will be performed additional times during the sampling day if instrument readings appear to be significantly different than previously observed.

   IMPORTANT – All field equipment shall be calibrated according to the Calibration SOP in the site-specific SAP or the Calibration of Field Instruments SOP in the current HWRB Master QAPP.
4. Conduct a hand-held temperature probe check to ensure probe is functioning properly.
   a. Place the probe in a container of ambient temperature water, allow the temperature to equilibrate and record the temperature on the attached worksheet.
   b. Place the probe in a container of ice water, allow the temperature to equilibrate and record the temperature on the attached worksheet.
   c. Place the probe in a container of ambient temperature water once more, allow the temperature to equilibrate and record the temperature on the attached worksheet.
   d. Compare the three readings to ensure probe is functioning properly. Record result on the attached worksheet.
5. Compare the hand-held temperature probe readings to the multi-parameter temperature probe readings: Put both the multi-parameter and hand-held temperature probes in ambient temperature water and record readings and the relative difference on the attached worksheet. **The key in this comparison is to document the relative difference between the two probes.**

Weather Conditions

Based on weather reports, the sampling team will select the driest period during the Site sampling events to collect the samples, unless otherwise directed by the project manager.

Local meteorological data showing a minimum of daily precipitation totals and barometric pressure should be obtained for a seven day period prior to sampling unless otherwise specified in the SAP.

Reconnaissance Phase - General Procedure to Determine Sample Locations and Depths

The same attached worksheet may also be used for this phase.

1. Locate the boundaries of the general sampling area.
2. Select a representative location within the sampling area.
3. Insert the hand-held temperature probe into the surface water and collect and record the reading.
4. Insert the same probe into the soft sediment until you reach the maximum differential between the surface temperature and the pore water temperature and you are deep enough to support the sampler (e.g. minimum of six inches). Collect and record the temperature reading (under the "Pore Water Temp" column) and the shallowest depth where the maximum temperature differential is obtained. There should be at least a 2 degree differential with the pore water being colder during the summer and warmer during the winter. At some point during the spring and fall the temperature differential will approach zero, and the temperature will not provide useful information.
5. During the insertion of the temperature probe, an effort should be made to identify sediment layers that are relatively course grained with voids (less resistant to insertion). Record the depths of such layers as they may provide the best permeability.
6. Repeat steps 2-4 until the proper sampling location has been established.
7. Place a stake to identify sampling location which will be located by GPS once the sampler is in place.
8. Repeat the procedure until all sampling locations have been determined.

Equipment Blanks

If using an in-line filter for dissolved metals, collect an equipment blank prior to sampling. See Quality Assurance Section below for details and additional quality assurance samples.

Equipment Setup

Set up the equipment, on shore if possible, on plastic sheeting, a bucket or table (**Figure 5**).

PORE WATER SAMPLING PROCEDURE

1. Prepare sampling equipment and bottles on shore. The order of data and sample collection includes:
   a. Surface water field screening;
   b. Pore water field screening; and
   c. Laboratory sample collection.
2. If sampler is wading in the water body, the sampler should lean out and insert the PushPoint as far as possible away from where the sampler is standing to reduce potential effects of the sampler on the integrity of the pore water sample. Pore water samples shall be collected from downstream to upstream and facing upstream to avoid disrupting bottom sediments causing biased results.
3. **Surface water field screening**:
   a. Using a probe guard, insert the probes of the multi-parameter meter into the water to collect in-situ readings of DO and temperature (and additional parameters, if required).
   b. Let readings stabilize for a minimum of two minutes and record results on the attached worksheet.
   c. Collect separate aliquot of surface water for turbidity, as required, and record the results on the attached worksheet.
4. **Installation of Pore Water Sampler:**

   The pore water sampler must be inserted deep enough as to ensure the sample collected will contain only groundwater and no surface water. Hold the device in a manner that squeezes the two handles towards each other to maintain the guard-rod fully inserted in the PushPoint body during the insertion process. Carefully insert a pore water sampler into the soft sediments of the streambed to the desired depth (typically 6-12-inches as determined by prior temperature probe screening and estimated depths of potentially permeable sediment layers, or as specified in the SAP) **using a gentle twisting motion without shifting the axis of the sampler**.

   Care must be taken **not to rock or wiggle the sampler** back and forth, which would create a cone within the sediment around the sampler that could act as a potential path for surface water to mix with pore water. A sampling platform of flange may be helpful (**Figures 3 and 4)**.

   Do not remove strengthening rod until sampler has been securely placed in sediment. Once this has been accomplished, remove the strengthening rod from the pore water sampler.

   Using a measuring stick or similar measuring device, measure the depth of water from the bottom of the streambed to the surface of the water and from the stream bed to the top of the sampler. Record the water depth, and the depth of the screen in the sediment (equals the distance from the center of screen to the top of sampler less the distance from

the stream bed to the top of the sampler) to verify that the sampler has been inserted into sediment to the proper depth.

Connect pore water sampler to peristaltic pump using appropriate tubing (**Figure 5A)**. Connect the tubing to the three-way stopcock and then to the multi-parameter meter.

5. **Pore Water Field Screening:**

   a. Turn pump on and start to purge at a rate of approximately 40-50 ml/minute. Determine the flow rate using the graduated cylinder and stop watch. Pumping rate should be low enough to ensure that surface water is not being drawn in.

      If the sediment layer at the screen has insufficient permeability it may be necessary to adjust the depth. Under normal circumstances, the depth will not be less than the point where the maximum temperature differential was first observed during the reconnaissance phase.

   b. Collect and record the pore water DO, temperature and turbidity results on the attached worksheet every 1-2 minutes until readings stabilize, with a minimum of three readings. If sample is not visually free of sediment, it should be documented on the worksheet. Record any observations about the sampling location or other pertinent information.

   c. Compare temperature and DO readings with the in-situ surface water readings to ensure that you are in fact sampling pore water. The sampler is typically considered to be sampling pore water if there is a difference in DO of at least 2 mg/L (pore water is less than surface water), and the temperatures are in the range indicated during the reconnaissance phase. Temperature and DO should not fluctuate more than one degree or mg/L, respectively. Refer to the SAP for site-specific details.

6. **Pore Water Laboratory Sample Collection (Figure 5B):**

   a. Turn off the pump and disconnect the multi-parameter meter and three-way stopcock.

   b. Turn the pump back on at the same flow rate.

   c. Remove the cap from the (pre-preserved, as required) sample container and place it on the plastic sheet or in a location where it won't become contaminated.

   d. Collect the sample directly from the peristaltic pump's silastic tubing into the sample container. Samples should be collected in the priority order designated in the SAP, for example:

      1) Total Metals and Hardness; and

      2) Dissolved Metals.

         * When collecting samples for dissolved metals:

            1) First collect all non-metals samples.

            2) Collect the total metals.

3) Turn off the pump.

4) Attach a new 0.45 micron in-line particulate filter for each sample.

5) Turn the pump back on at the same flow rate.

6) Allow enough pore water to flow through the filter to adequately rinse the filter.

7) Collect the dissolved metals sample.

8) Use a new in-line filter for the duplicate and at each new sample location.

e. Replace the sample cap, wipe off the exterior of the containers with clean paper towels, place in a re-sealable plastic bag and store the sample in accordance with appropriate protocol. Samples requiring cooling shall be placed in a cooler within **loose** ice.

f. Collect duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples as required, see Quality Assurance section below. For quality assurance samples, fill a separate container for each analysis immediately following the actual field sample collection (e.g., arsenic sample, arsenic duplicate sample, arsenic MS/MSD sample). Duplicate samples should be designated with a "DUP" after the sample designation, or as indicated in the SAP. Record sample time on the attached worksheet.

g. Record sample time on the attached worksheet.

7. Turn off the pump, and disconnect the tubing from the pore water sampler.

8. Use a GPS device to accurately document the sample location.

9. Remove the pore water sampler from the sediment.

Do not put strengthening rod back in pore water sampler once sample has been collected.

The sediment in the sampler must be flushed out first. Rather, place the sampler in the PVC sheath for protection, and put it and the strengthening rod separately into a large plastic bag for decontamination.

Note: The pore water sampler shall be carefully decontaminated according to approved decontamination procedures before further use. It is highly recommended that sufficient samplers are available so that this decontamination does not occur in the field. In the course of sampling, sediment will build up in the sampler and must be carefully flushed out. For this reason, it is best if decontamination is conducted with a large amount of water available for continuous flushing.

10. The tubing and in-line filters, if used, shall be properly discarded.

11. Repeat the above process at all sampling locations.

QUALITY ASSURANCE SAMPLES

Refer to the SAP for specific QC sampling requirements. In general:

1. Trip Blanks: Include a trip blank if collecting volatile organic compounds (VOCs).
2. Duplicates: A minimum of one duplicate should be collected per matrix, per analysis, per sampling event. Fill a separate container for each analysis immediately following the actual field sample collection (e.g., arsenic sample, arsenic duplicate sample).
3. MS/MSD samples: As required. Fill a separate container for each analysis immediately following the actual field sample collection (e.g., arsenic sample, arsenic duplicate sample, arsenic MS/MSD sample).
4. Equipment Blanks:

   Equipment blanks are collected to insure that the sampling equipment is contaminant free and that decontamination procedures are adequate.

   a. If using an in-line filter for dissolved metals, collect an equipment blank prior to sampling by running DI water through the filter and collecting a sample for dissolved metals to ensure the integrity of the filter.
   b. Collect an equipment blank for the pore water sampling equipment, at the sampling location with the highest known, or suspected, contamination following sample collection and after equipment decontamination. Gently pour DI water over and through the pore water sampler used to collect the pore water sample. Collect the rinsate that flows off the equipment into the appropriate sample containers. Refer to the SAP for the specific analysis required.

DOCUMENTATION

In general all data and sampling information will be documented as specified in the SAP.
Specific reporting of these sampling events include, but is not limited to, the following information:

1. Past 7 days of local meteorological data showing a minimum of daily precipitation totals and barometric pressure.
2. Depth of water at the sampling location.
3. Any water quality parameter readings taken.
4. General physical description of the samples and sampling locations.
5. Observational data concerning the pore water, such as the approximate depth of the screen when the sample was collected, any detection of odor or contamination, color and turbidity.
6. GPS coordinates of the sampling location; and
7. Digital photographs of sampling locations including one or more of the larger sampling area.

REFERENCES

Protocol for Groundwater/Surface Water Interface Sampling using a Pore Water Sampler, DR#023, Revision: 2, 2004, Maine Department of Environmental Protection, Division of Site Remediation

Henry, M.E., 2001, PushPoint Sampler Operators Manual and Applications Guide, Version 2.00, at http://mheproducts.com/

United States Environmental Protection Agency, Region 4, Science and Ecosystem Support Division, SESD Operating Procedure Pore Water Sampling SESDPROC-513-RO, Pore Water Sampling_AF.RO.doc, February 5, 2007

Pushpoint Sampling for Defining Spatial and Temporal Variations in Contaminant Concentrations in Sediment Pore Water near the Ground-Water/ Surface-Water Interface By Marc J. Zimmerman, Andrew J. Massey, and Kimberly W. Campo, U.S. Department of the Interior, U.S. Geological Survey, 2005 In cooperation with the U.S. Environmental Protection Agency Measurement and Monitoring for the 21st Century Initiative Scientific Investigations Report 2005-5036 U.S

ATTACHMENTS

Figures 2 through 6

Field Surface Water and Pore Water Field Screening Summary Worksheet

HH201 Handheld Thermometer User Manual

Figure 2. Pore Water PushPoint (PPX36) 36 inch long, 1/4 inch diameter Field Investigation Sampler

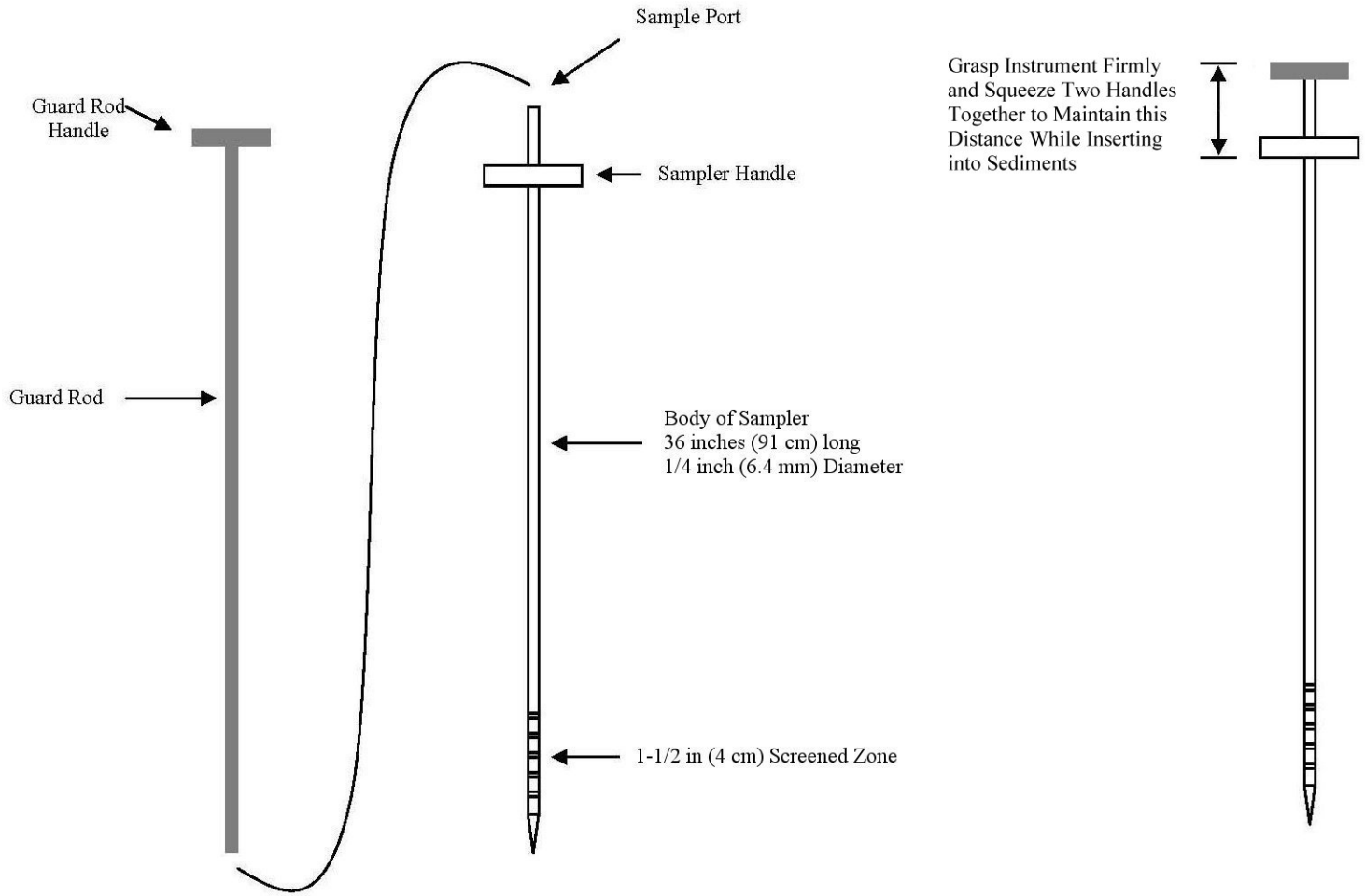
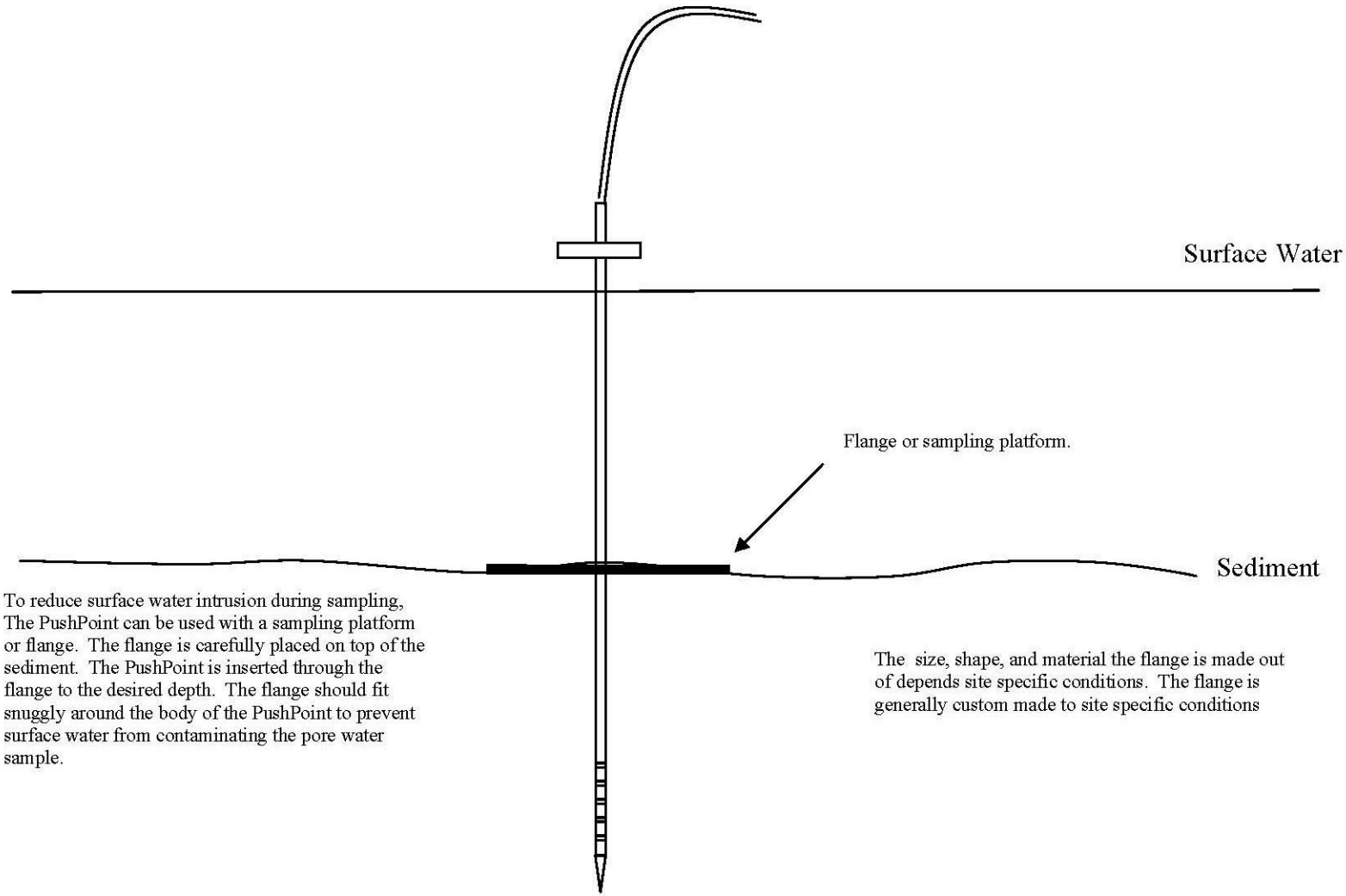


Figure 2A. Disassembled PushPoint

Figure 2B. Assembled PushPoint

Actual length and width of PushPoints will vary, depending on sampling needs and site conditions.

Figure 3. PushPoint deployed with a Sampling Platform



To reduce surface water intrusion during sampling, The PushPoint can be used with a sampling platform or flange. The flange is carefully placed on top of the sediment. The PushPoint is inserted through the flange to the desired depth. The flange should fit snuggly around the body of the PushPoint to prevent surface water from contaminating the pore water sample.

The size, shape, and material the flange is made out of depends site specific conditions. The flange is generally custom made to site specific conditions

Figure 4. PushPoint Being Deployed into the Sediment

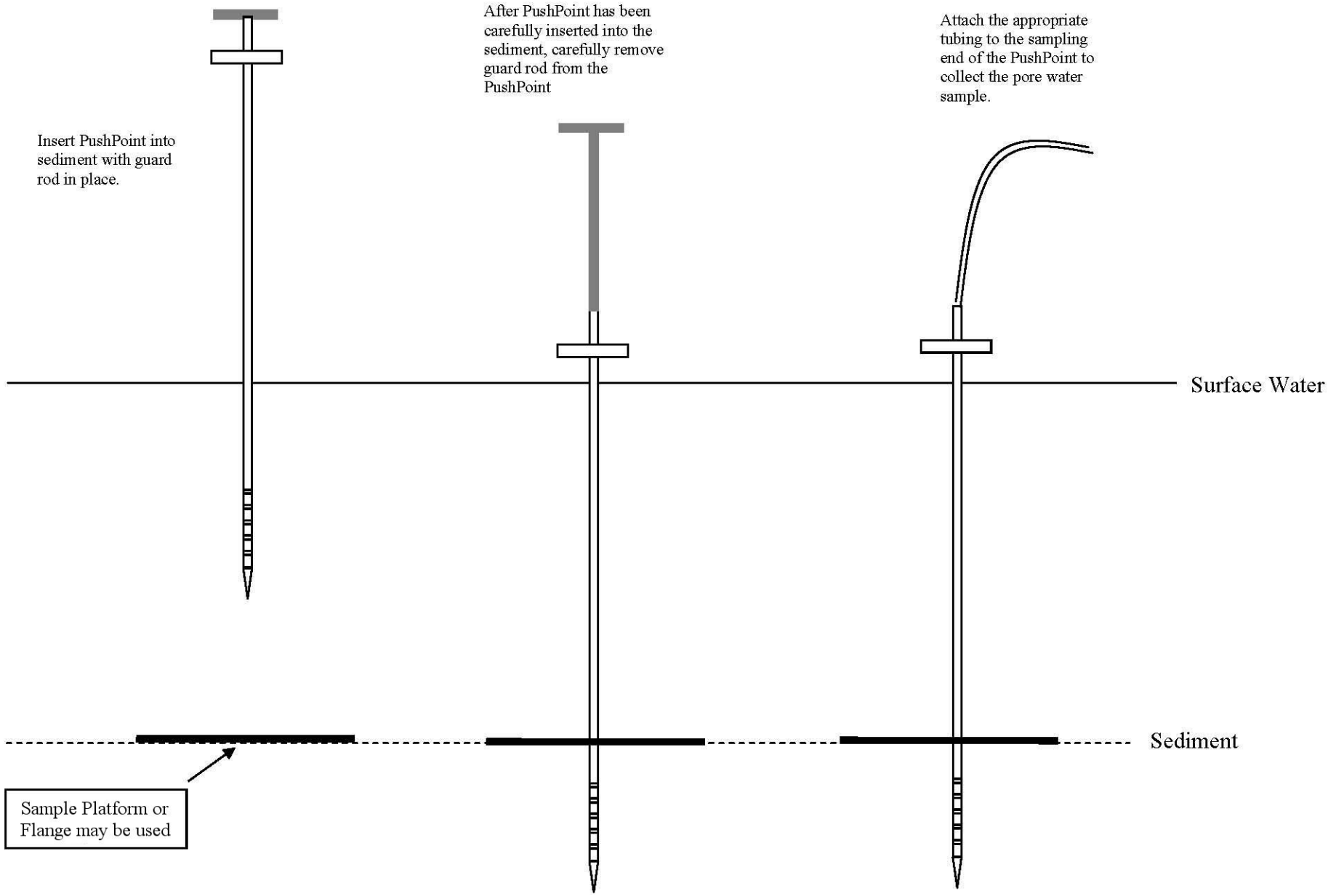


Figure 5. PushPoint Setup Diagram using a Peristaltic Pump

NOT TO SCALE

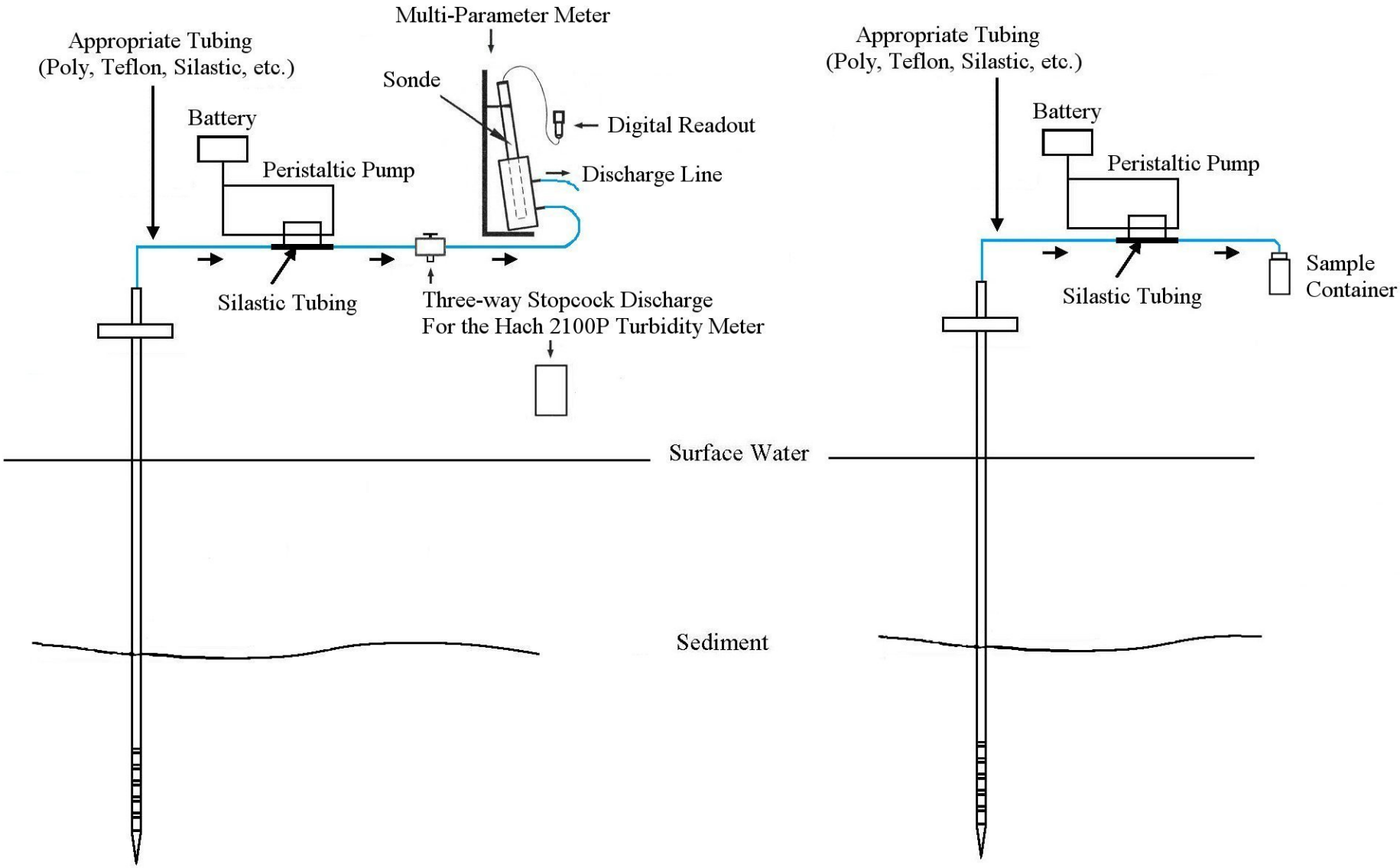


Figure 5A. Setup Diagram for Parameter Readings

Figure 5B. Setup Diagram for Sampling

Figure 6. Pore Water "Screen Soks"

Field Surface Water and Pore Water Field Screening Summary Worksheet

Date: Time: Site: Field Personnel:

WEATHER CONDITIONS										TEMPERATURE PROBE CHECKS	
CURRENT		**PAST 7 DAYS**								**Hand Held Temperature Probe Check (°C)**	
Barometric Pressure (in mm/hg)		Barometric Pressure (mm/hg)								Pre-ambient temp water:	°C
Storm (heavy rain)		Est. Rainfall (in)								Ice water:	°C
Rain (Steady Rain)		Comments:								Post- ambient temp water	°C
Showers (Intermittent)										Is temperature probe functioning properly? (Yes or No)	
Cloud Cover (%)										**Hand Held Temperature Probe Compared to Multi-parameter Temperature Probe Check in Ambient Temperature Water (°C)**	
Clear/Sunny										Hand Held Temperature Probe:	°C
Comments:										Multi-Parameter Meter Temperature Probe :	°C
										Relative Difference:	°C

IN SITU SURFACE WATER QUALITY /PORE WATER FIELD SCREENING DATA

Sample Location ID	Sample Time (24 HR Clock Time)	Water Depth (feet/inches)	Screen Depth Below Sediment Surface [5] (inches)	Purge Rate (ml/minute)	Hand Held Temperature Probe Reading	In-Situ Surface Water Readings			Pore Water Readings			Comments
						Temp +/- 1 ºC	DO +/- 10% if > 0.5 mg/l	Turbidity +/- 10% if > 5 NTU	Temp +/- 1 ºC	DO +/- 10% if > 0.5 mg/l	Turbidity +/- 10% if > 5 NTU	

Notes:

1. When recording DO data, only use one decimal place. When recording temperature and turbidity record only whole numbers.
   When DO data is less than 0.5 mg/l, data should be recorded as "<0.5" or "less than 0.5". DO values between 0.5 and 1.0 are typically considered stable within +/- 0.1 mg/l.
   When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". Turbidity values between 5 and 10 are typically considered stable within +/- 1 NTU.
2. "NR" indicates no reading taken. "N/A" indicates not applicable.
3. The sampler is considered to be sampling pore water if there is a difference in temperature between pore water and surface water of at least 2 ºC and/or DO of at least 2 mg/l, and these parameters do not fluctuate more than one degree or mg/l, respectively.
4. The depth of the screen in the sediment equals the distance from the center of the screen to the top of the sampler (XX") less the water depth.

Sampler's Signature

1 YEAR WARRANTY

CE

User's Guide

Shop online at

omega.com®

OMEGA®

www.omega.com

e-mail: info@omega.com

ISO 9001 CERTIFIED CORPORATE QUALITY — STAMFORD, CT

ISO 9002 CERTIFIED CORPORATE QUALITY — MANCHESTER, UK

HH201A
Handheld Thermometer

Introduction

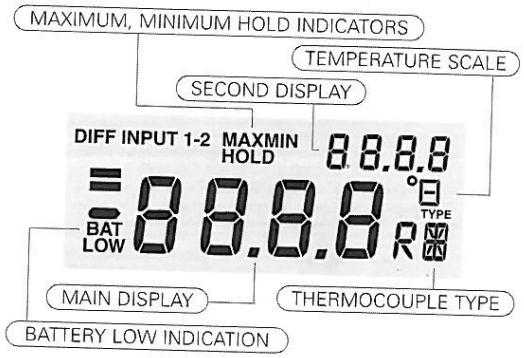
Your high accuracy microprocessor driven thermometer is suitable for use with thermocouple types K,J,T,R,N,E,S or Infra-Red sensors.

The thermocouple calibrations are in accordance with national and international standards (NBS and IEC) tables.

Features

- °C / °F/ °A TEMPERATURE SCALES
- MAXIMUM AND MINIMUM FUNCTIONS
- HOLD FUNCTION
- OVERRANGE / OPENCIRCUIT PROBE INDICATION
- LOW BATTERY INDICATION
- K,J,T,R,N,E,S THERMOCOUPLE TYPES
- COMPATIBLE WITH INFRA-RED SENSORS.
- RETENTION OF THERMOCOUPLE TYPE AND SCALE

fig 1



OPERATING INSTRUCTIONS

To Measure Temperature

1. Fit the battery to the instrument (refer to battery replacement details)
2. Switch thermometer ON.
3. Plug thermocouple into input socket.
4. Check temperature scale is correct.(°C / °F / °A)
5. Check thermocouple is correct
6. Take measurement by contacting object with probe and reading from the display.

Changing Temperature Scale (°C / °F / °A)

To change the temperature scale simply press the button marked 'SCL'

The temperature scale will alter as shown on the right hand side of the display.

Changing Thermocouple Type

To change thermocouple type, follow the sequence below:

1. Switch the unit OFF.
2. Press and hold the 'SCL' button.
3. Switch the unit ON.
4. Release buttons.

The new thermocouple type will appear in the bottom right hand corner of the display (see fig 1). Repeat steps above until desired thermocouple type is shown.

Replacing The Battery

The instrument will indicate 'BAT LOW' when the battery needs changing.

To change the battery, firstly remove the unit from the outer case. The battery compartment is on the rear of the instrument. Using a small screwdriver ease back the tab of the battery compartment. The compartment will then lift away.

Open Circuit Thermocouple Detection

An error in the probe is shown on the display by a series of bars '- - - - -' coupled with the word 'INPUT' at the top of the display. This indicates either that the probe has an error or the temperature is out of range.

Using The MAX / MIN Features

The MAX/MIN features are used to record the highest or lowest temperatures. The MAX/MIN features are activated by pressing the MAX/MIN key. When the key is pressed the MIN annunciator is activated and the minimum temperature is displayed on the secondary display. This is updated whenever the minimum value is exceeded. The MAX feature functions in the same manner and is activated by pressing the MAX/MIN key again. The main display continues to show the real time measurement. To cancel the feature simply press the key again.

Using The Hold Feature

The hold feature is used to store the current value. When you press the key the current value will transfer to the top right of the display, while the main display continues to be updated. To cancel press the hold key again.

SPECIFICATIONS

Environmental

Ambient operating range	-30°C to 50°C (-21 to 122°F)
Storage temperature range	-40°C to 60°C (-40 to 140°F)
Humidity	0 to 70% R.H.

ELECTRICAL

Measurement Ranges

	CENTIGRADE	FAHRENHEIT	KELVIN
K	-200°C to 1372°C	-328°F to 2501°F	-73°F to 1645°F
T	-200°C to 400°C	-328°F to 752°F	-73°F to 673°F
R	-50°C to 1767°C	-58°F to 3212°F	-223°F to 2040°F
N	-200°C to 1300°C	-328°F to 2372°F	-73°F to 1573°F
J	-200°C to 1200°C	-328°F to 2192°F	-73°F to 1473°F
E	-200°C to 1000°C	-328°F to 1832°F	-223°F to 1273°F
S	-50°C to 1767°C	-58°F to 3212°F	-223°F to 2040°F
I/R	-50°C to 200°C	-58°F to 392°F	-223°F to 473°F

Accuracy@23°C	±0.15% of reading ±0.2°C
Characterising error	less than 0.05°C
Temperature coefficient	0.01% of reading/°C
Cold junction compensation	0.0075°C/°C
Resolution	0.1°autoranging to 1° 1000°

Note

Strong RF fields may adversely affect measurement accuracy.

General

WEIGHT	155 gms (5.47 oz)
DIMENSIONS	130 x 70 x 33 mm
BATTERY	PP3
BATTERY LIFE	200 Hours

CALIBRATION OF FIELD INSTRUMENTS

PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide a framework for calibrating field instruments used to measure water quality parameters for ground water, surface water and pore water. Water quality parameters include temperature, pH, dissolved oxygen (DO), specific conductance, oxidation reduction potential (ORP) and turbidity.

This SOP is written for instruments where the probe readings for pH, dissolved oxygen, and specific conductance are automatically corrected for temperature; such as the YSI Models 600XL/XLM or 6820 or the QED Model MP20. The YSI models have a built in barometer and probe guards so that in-situ readings can be taken where appropriate. pH meters must be calibrated using three pH standards (4, 7 and 10 pH units). Turbidity must be taken with a separate meter (such as the Hach 2100P or 2100Q Turbidity meters).

For ground water monitoring, the instrument must be equipped with a clear flow-through-cell with a maximum capacity of 250 milliliters and the display/logger or computer display screen needs to be large enough to simultaneously contain the readouts of each probe in the instrument. Turbidity must be taken at a point before the flow-through cell and from a meter separate from the flow through cell apparatus. A three way stopcock is recommended to divert sample flow for the turbidity reading. Turbidity cannot be measured in or after a flow-through-cell because the flow-through-cell acts as a sediment trap. This procedure is applicable for use with the current Low Flow Groundwater Purging and Sampling SOP in the Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP).

Refer to the site-specific Sampling and Analysis Plan (SAP) for details concerning specific makes and models of instruments, calibration solutions, and other pertinent information.

HEALTH AND SAFETY WARNINGS

Read all labels on the standards and note any warnings on the labels. Wear appropriate personal protection equipment (e.g., gloves, eye shields) when handling the standards. If necessary, consult the Safety Data Sheets (SDS) for additional safety information on the chemicals in the standards.

CALIBRATION ACCEPTANCE CRITERIA

All field instruments must be calibrated, and have a calibration check, once in the office prior to the sampling event to ensure that the units are working properly.

The instruments shall be calibrated at the beginning of each sampling day at the Site prior to sample collection. The calibration shall then be checked immediately following the calibration to ensure the instrument was calibrated properly. If the morning calibration check is not within the acceptable range for that parameter, the instrument shall be recalibrated using all the standards for that parameter and the calibration shall be checked again. See individual parameters for specific instructions. If the calibration or calibration check is not successful, replace the appropriate calibration solutions, recalibrate and check the new calibration. If the calibration or calibration check is still unsuccessful, replace the unit. Backup instruments shall be calibrated and used in place of the inoperable unit.

The calibration shall be checked again at the end of the day of use to ensure that the instruments have remained in calibration throughout the day. In addition, should any erratic or illogical readings occur between calibrations, the instrument shall be recalibrated in order to ensure that representative measurements are obtained. All calibration and check values shall be documented on the calibration log maintained by each user (see attached log).

If a calibration check at the end of the day is not within the acceptable range for that parameter, the data collected that day for that parameter shall be qualified in its use. This qualification shall be documented on the calibration log and the field sheets/logs for the appropriate sampling locations. For example: pH measurements are collected as part of the low flow sampling procedure. If the afternoon pH calibration check was not within the acceptable range that day, the pH data collected by that instrument on that day would be qualified as useful only for determining stabilization and not as representative pH measurements of the water being sampled. That qualification would then be documented on the calibration log and the sampling worksheets or log book for each of the locations where the instrument was used.

COLD WEATHER CONDITIONS

Given the temperature sensitivity of the calibration solutions in very cold weather conditions, the New Hampshire Department of Environmental Services (NHDES) project manager may approve performing the morning calibration and calibration check in the office just prior to going into the field and the end of the day calibration check upon returning to the office. Careful thought must be given before approval. On the one hand, this may avoid delays and budget increases due to cold weather calibration issues in the field. On the other hand, not being able to check the calibration or re-calibrate in the field may result in the qualification or loss of data if there are problems with the equipment that day. In each case, this deviation to the normal procedure must be approved by the NHDES project manager in advance. If approved, it must be documented on each Calibration Log and in all Site sampling and annual reports that the calibration and checks for that day were performed off-site due to very cold weather conditions, including where the calibration and checks were performed and that it was approved in advance by the NHDES project manager. See page two of the attached Calibration Log.

EQUIPMENT AND MATERIALS

The following is a list of equipment and materials commonly used during calibration:

- Site-specific SAP
- Manufacturer's instruction manuals (including the instrument specifications) to accompany the instruments into the field
- Multi-meter sonde and handheld meter (such as the YSI Models 600XL/XLM or 6820 or the QED model MP20), preferably with a built in barometer
- Calibration solutions:

  Note: It is advisable to have a sufficient number of extra bottles of each standard on hand in case of complications (especially the conductivity standards). Be sure that the standards are not near their expiration dates.

  - Small wet sponge or paper towel for DO 100% saturation calibration
  - "Zero" (0) milligrams per liter (mg/l) DO check standard
  - pH buffers 4, 7 and 10
  - Two standards for specific conductance: one for calibration and one for checking the calibration: 718 microsiemens per centimeter (µS/cm) and 1,413 µS/cm
  - Zobell Solution for ORP
- Separate Turbidimeter (Hach 2100P or 2100Q Turbidity meter) w/calibration standards: <0.1, 10, 20, 100, 800 Nephelometric Turbidity Units (NTUs) as appropriate for each meter
- Calibration cup with cap
- Cooler (for storage of calibration solutions)
- Laboratory-grade deionized (DI) water
- Paper towels
- Kimwipes
- Barometer for instruments that require a separate barometer for the dissolved oxygen calibration (such as the QED MP-20)
- NIST certified thermometer, degrees Celsius (if the vendor has not verified the accuracy of the instrument temperature sensor)
- Ring stand with clamp
- Calibration log

GENERAL INFORMATION

In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested and inspected according to the manufacturer's instructions. It is assumed that most of this equipment will be rented and is not owned by the contractor. Any reference made to a vendor applies to the owner/renter of the equipment.

Prior to calibration, all instrument probes must be cleaned in accordance with the manufacturer's instructions, preferably by the vendor if the unit is rented. Failure to perform this proper maintenance step can lead to erratic measurements. The vendor is required to provide written documentation (which will be included in sampling reports) that indicates the equipment was cleaned, by who and dated.

Calibration standard values, check results, temperature and barometer checks, and maintenance for each piece of equipment shall be documented on the calibration logs and included in reports as requested by the NHDES project manager. This information includes dates, personnel, calibration standards expiration dates, etc. A calibration log is provided at the end of this SOP.

This SOP requires that the manufacturer's instruction manuals (including the instrument specifications) accompany the instruments into the field.

Turn on the instrument and allow it to warm up according to the manufactures instructions. Program the multi-probe instrument so that the following parameters to be measured will be displayed: temperature in ˚C; pH in units; DO in % for calibration and mg/l for measurements; specific conductance in µS/cm; and ORP in millivolt (mV).

> **Note:** It may not be possible to program the meter to read the specific conductance in µS/cm. Some instruments are pre-programmed in millisiemens per centimeter (mS/cm) (e.g. QED Model MP20). In that case, the results must be converted so that the results are recorded in µS/cm on the worksheets.

All calibration solutions shall be placed into the calibration cup to calibrate the instrument and to check the calibration. The calibration cup shall be rinsed with DI water and dried with paper towels or Kimwipes between each standard. The probes shall not be put directly into the bottles of calibration solutions from the vendor. The volume of the calibration solutions must be sufficient to cover both the probe and temperature sensor. See manufacturer's instructions for additional information.

While calibrating or measuring, make sure there are no air bubbles lodged on or between the probes.

Mark the "date opened" on each new bottle of calibration solution. Record the lot number and expiration date on the calibration log.

All calibration solutions shall be stored at room temperature or at cool/stable temperatures in the field. Storage of calibration solutions in an insulated cooler kept in the shade will help to maintain calibration solution integrity.

CALIBRATION PROCEDURES

TEMPERATURE

This procedure is not to be done in the field.

For instrument probes that rely on the temperature sensor, each temperature sensor must be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST) prior to the sampling event. A temperature check is required once a year for each instrument at a minimum.

The temperature check shall be performed prior to the field event, preferably via the vendor if the unit is rented. If the check is not performed by the vendor, then it must be performed by field personal prior to using the unit. Verification and documentation, including accuracy, dates and personnel, of this procedure are required. The documentation shall be recorded on the calibration log and included in any sampling reports.

Temperature Sensory Accuracy Procedure

1. Allow a container filled with water to come to room temperature.
2. Place a NIST thermometer and the instrument's temperature sensor into the water and wait for both temperature readings to stabilize.
3. Compare the two measurements and record the results on the calibration log. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (typically ±0.15 °C or ±0.2 °C). Check the manual that came with the instrument. If the measurements do not agree, the instrument may not be working properly and the vendor/manufacturer needs to be consulted and the unit replaced.

DISSOLVED OXYGEN

Dissolved oxygen (DO) content in water is measured using a membrane electrode.

The DO probe's membrane and electrolyte solution shall be replaced prior to the sampling event and replaced as needed thereafter. Failure to perform this step may lead to erratic measurements. If the vendor changes the membrane and electrolyte solution they must send the appropriate documentation with each unit. If there is no documentation with the unit, the field personnel will have to replace the membrane and electrolyte solution before the sampling event begins. Documentation shall be noted on the calibration log.

Barometer

For instruments that require a separate barometer for the dissolved oxygen calibration, each barometer shall be checked against a National Weather Service (NWS) Station calibrated barometer and adjusted accordingly at least once a year either by the vendor or field personnel. **The barometer must be brought to a National Weather Service Station to be checked and adjusted.** Verification and documentation of this procedure in required on the calibration log; including accuracy (results before and after adjustments), dates and personnel. There is a NWS Station at the Concord Airport. Check with the NWS for other stations that may be closer to the site or other applicable office.

DO Calibration/Calibration Check Procedure

1. Gently dry the temperature sensor and remove any droplets of water from the Do probe's sensor membrane according to manufacturer's instructions. Inspect the DO membrane for air bubbles and nicks.
2. Place a wet sponge or a wet paper towel on the bottom of the DO calibration container to create a 100 percent water-saturated air environment.
3. Loosely fit the DO probe into the calibration container to prevent the escape of moisture evaporating from the sponge or paper towel while maintaining ambient pressure (see manufacturer's instructions on attaching the calibration container to the instrument). Do not allow the probe to come in contact with the wet sponge or paper towel.
4. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 10 to 15 minutes). Make sure that the instrument is turned on during this time to allow the DO probe to warm-up according the manufactures directions. Make sure that both the DO reading and the temperature have stabilized before starting the calibration sequence.
5. Select calibration mode; then select "DO %".
6. Enter the local barometric pressure (usually in mm of mercury) for the sampling location into the instrument using an on-site hand held barometer, unless the instrument already has a temperature-compensated barometer built in.
7. Record the barometric pressure on the calibration log.
8. The instrument should indicate that the calibration is in progress. Observe the readings for percent dissolved oxygen and temperature. When they show no significant change for approximately 30 seconds press enter. After calibration, the instrument should automatically display dissolved oxygen in mg/l (% DO is only used for calibration).
9. Record the initial DO reading in mg/l and temperature reading in ˚C on the calibration log immediately after calibration.
10. To check the calibration, select monitoring/run mode (on a run/measurement screen), remove the probe from the container and place it into a 0.0 (zero) mg/l DO standard.

11. Wait until the "mg/l DO" and temperature readings have stabilized. Record the zero mg/l DO reading on the calibration log. The instrument must read 0 to 0.5 mg/l DO. If the instrument reads above 0.5 mg/l or reads a negative value, it will be necessary to clean the probe, and change the membrane and electrolyte solution. If this is unsuccessful, use a new 0.0 mg/l DO standard. If these measures are still unsuccessful, consult the manufacturer/vendor or replace the unit.
12. Remove probe from the zero DO standard, rinse with DI water, and gently blot dry. Rinse the calibration cup with DI water and dry it with paper towels or Kimwipes.

pH (electrometric)

The pH of a sample is determined electrometrically using a glass electrode. Three standards are needed for the calibration: 4, 7 and 10. Rinse the calibration cup with DI water and dry it with paper towels or Kimwipes between standards.

NOTE: Although an instrument that takes a three point calibration is preferred, if the instrument only accepts two pH standards for calibration (e.g., QED model MP20), then follow the procedure below with the following changes: select the two point calibration, calibrate with an initial pH 4 solution, use a pH 10 solution for the second standard, then check the calibration with pH 7.

<u>pH Calibration/Calibration Check Procedure</u>

1. Allow the buffered standards to equilibrate to the ambient temperature.
2. Fill calibration containers with the buffered standards so each standard will cover the pH probe and temperature sensor.
3. Remove probe from its storage container, rinse with DI water, and gently blot dry with a Kimwipe. Use caution during drying, such that the dissolved oxygen probe membrane is not disturbed.
4. Select the calibration mode for a three point pH calibration.
5. Immerse probe into the initial standard, pH 7.
6. Enter the buffered standard value (e.g., pH 7) into the instrument. Wait until temperature and pH readings stabilize. If the readings do not change within 30 seconds, press enter to accept the calibration.
7. Remove probe from the initial standard, rinse with DI water, and gently blot dry.
8. Immerse probe into the second standard (pH 4). Repeat step 6.
9. Remove probe from the second standard, rinse with DI water, and gently blot dry.
10. Immerse probe in third buffered standard (pH-10) and repeat step 6.
11. Remove probe from the third standard, rinse with DI water, and gently blot dry.

12. To check the calibration, select monitoring/run mode (on a run/measurement screen) and immerse the probe into the pH 7 buffer solution. Wait for the temperature and pH readings to stabilize. Record the pH value on the calibration log. The value must be pH 7 +/-5% (pH 6.65-7.35). If the calibration check failed re-calibrate the instrument using fresh standards for all three values and check it again. If re-calibration fails, clean the pH probe, re-calibrate and check the calibration. If the calibration check fails again, consult the manufacture/vendor or replace the unit.
13. Remove probe from the pH 7 check standard, rinse with DI water, and gently blot dry. Rinse the calibration cup with DI water and dry it with paper towels or Kimwipes.

SPECIFIC CONDUCTANCE

Conductivity is used to measure the ability of an aqueous solution to carry an electrical current. Specific conductance is the conductivity value corrected to 25 °C. When monitoring groundwater, surface water or pore water, use the specific conductance readings and record in µS/cm.

Most instruments are calibrated against a single standard which is near, (above or below) the specific conductance of the environmental samples. A second standard is used to check the linearity of the instrument in the range of measurements. Specific conductivity standards concentrations are generally dependent on expected field conditions and availability. However, there have been some issues with the stability of some of the standards in the field. Unless specified in a site specific SAP, the NHDES and the Environmental Protection Agency (EPA), Region 1, have agreed that specific conductivity is, in general, a non-critical measurement and it is more important to use standards that are stable in the field even though they may be above or below the actual field conditions.

Therefore, the HWRB recommends using the following standards as they have been field tested, are readily available from most vendors, and are acceptable for use by EPA: a 1413 µS/cm standard and a 718 µS/cm standard. It is acceptable to use either one of the standards to calibrate and the other to check the calibration. **The use of only ONE standard to both calibrate and check the calibration is NOT ACCEPTABLE,** as the second standard is used to check the linearity of the instrument in the range of measurements. For the purpose of explaining the calibration procedure in this document, the 1413 µS/cm standard will be used to calibrate and a 718 µS/cm standard to check the calibration.

Note: It may not be possible to program the meter to calibrate or read the specific conductance in µS/cm. Some instruments (e.g., QED Model MP20) are pre-programmed in mS/cm. In that case, the field measurements must be converted to so that the results are recorded in µS/cm on the worksheets. To convert from mS/cm to µS/cm you multiply by 1000 (Example: 1.413 mS/cm = 1,413 µS/cm). The HWRB does not recommend using a meter that cannot be programmed for µS/cm to avoid confusion in the field.

Specific Conductance Calibration/Calibration Check Procedure

1. Allow the calibration standards to equilibrate to the ambient temperature.
2. Remove the probe from its storage container, rinse the probe with a small amount of the first (1413 µS/cm) specific conductance standard, discard the rinsate and place the probe into the standard. Be sure that the temperature sensor and the probe's vent hole are fully immersed in the standard. Gently move the sonde up and down to dislodge any air bubbles from the conductivity cell.
3. Allow at least one minute for temperature equilibrium before proceeding.
4. Select the calibration mode for specific conductance. Enter the calibration value of the standard being used (1413 µS/cm). Allow the temperature and specific conductance to stabilize. If the reading does not change within 30 seconds, press enter to accept the calibration.
5. To check the calibration, select monitoring/run mode (on a run/measurement screen). Remove the probe from the first standard, rinse the probe with DI water and then a small amount of the second standard, discard the rinsate and place the probe into the second (718 µS/cm) standard. The second standard will serve to verify the linearity of the instrument. Wait until the specific conductance and temperature readings have stabilized. Read the specific conductance value from the instrument and record the value on the calibration log. Compare the value to the standard. The value must be +/-5% (682-754 µS/cm for the 718 µS/cm standard). Note, if the 718 µS/cm standard was used to calibrate, 5% of the 1413 µS/cm check standard must be 1342-1484 µS/cm. If this range is not met, check the calibration with a fresh check standard. If this range is still not met, recalibrate using new standards and check again. If the re-calibration does not correct the problem, clean the probe, re-calibrate (this may require new standards) and check the calibration again. If that does not solve the problem, consult the manufacturer/vendor or replace the unit.
6. Remove probe from the specific conductance check standard, rinse with DI water, and gently blot dry. Rinse the calibration cup with DI water and dry it with paper towels.

OXIDATION/REDUCTION POTENTIAL (ORP)

The oxidation reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent. A Zobell solution is required to calibrate ORP. Read the warning on the label before use.

ORP Calibration/Calibration Check Procedure

1. Allow the Zobell solution calibration standard to equilibrate to ambient temperature.
2. Remove the probe from its storage container, rinse the probe with DI water, gently blot dry with a Kimwipe and place it into the standard.
3. Select monitoring/run mode.

4. Wait for the probe temperature to stabilize, and then read the temperature. Record the temperature reading on the calibration log.

5. Look up the mV value at this temperature from the temperature / mV chart found below and on the calibration log. These values have been rounded to the nearest whole number. Record this value on the calibration log.

Zobell Solution mV Values Based on Temperature for ORP Calibration
Calibration Check Range Values (+/- 5%)
(Round off temperature to whole number, e.g. 23.5 ºC rounds up to 24 ºC)

Temp. ºC	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. ºC	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. ºC	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%
-3	**267**	254-280	10	**251**	238-264	23	**234**	222-246
-2	**266**	253-279	11	**249**	237-261	24	**232**	220-244
-1	**265**	252-278	12	**248**	236-260	25	**231**	219-243
0	**264**	251-277	13	**247**	235-259	26	**230**	219-242
1	**262**	249-275	14	**245**	233-257	27	**228**	217-239
2	**261**	248-274	15	**244**	232-256	28	**227**	216-238
3	**260**	247-273	16	**243**	231-255	29	**226**	215-237
4	**258**	245-271	17	**241**	229-253	30	**225**	214-236
5	**257**	244-270	18	**240**	228-252	31	**223**	212-234
6	**256**	243-269	19	**239**	227-251	32	**222**	211-233
7	**254**	241-267	20	**238**	226-250	33	**221**	210-232
8	**253**	240-266	21	**236**	224-248	34	**219**	208-230
9	**252**	239-265	22	**235**	223-247	35	**218**	207-229

6. Select the calibration mode for ORP. Enter the temperature-corrected ORP value into the instrument. Once the temperature and ORP values stabilize, press enter to accept the calibration.

7. To check the calibration, select monitoring/run mode (on a run/measurement screen). Immerse the probe in the Zobell solution. Wait until the ORP and temperature readings have stabilized. Read the ORP on the instrument. Record the check value on the calibration log**,** and compare the value to the ORP value of the standard in Step 5. The instrument value must be +/- 5% of the calibration value. See the chart above for the check range. If it is not within +/- 5%, recalibrate using a new Zobell solution. If the re-calibration is not successful, consult the manufacture/vendor or replace the unit. For the afternoon calibration check, the instrument must be within +/- 5% of the mV value for the current temperature.

8. Remove the probe from the ORP check standard, rinse with DI water, and gently blot dry. Rinse the calibration cup with DI water and dry it with paper towels.

TURBIDITY

The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A turbidimeter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed ninety degrees to the path of the light source.

The HWRB low flow procedure requires that the turbidity meter shall have a calibration range from 0.00 to 800 (1000) NTUs.

Some instruments will only accept one standard. For these instruments, additional standards will serve as check points. Turbidity standards concentrations are dependent on expected field conditions. The standards used to calibrate and serve as check points must be within the range expected during that sampling event.

Condensation (fogging):
Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly by standing at ambient temperature or immersing in a container of ambient temperature water for a short period. After warming, gently invert the sample cell to thoroughly mix the contents before measurement.

This procedure is based on the use of the Hach 2100P or the 2100Q Turbidimeter and the commercially available StablCal® Formazin Primary Turbidity Standards appropriate for each meter, which is preferred; however, an approved equivalent meter may be used, and the standards may be prepared using Formazin according to the EPA analytical Method 180.1.

A - Calibration/Calibration Check Procedures for the Hach 2100P Turbidity Meter

1. Use the commercially available StablCal® Formazin Primary Turbidity Standards: <0.1, 20, 100 and 800 NTUs.
2. Before performing the calibration procedure, make sure the cells are not scratched. If the cell is scratched, the standard must be replaced.
3. Allow the calibration standards to equilibrate at the ambient temperature.
4. Turn on the meter.
5. The meter should be in the Auto Range. “Auto Rng” and 0.00 NTUs should show on the display. If not press the range key until it is in the auto range and reading to two (2) decimal points (e.g., 0.00)
6. Gently invert the standards to thoroughly mix the contents. (**DO NOT SHAKE**)
7. Wipe the standards with a soft, lint free cloth or Kimwipe to make sure the outside surfaces are dry, free from fingerprints and dust.

8. Insert the standard into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment.
9. Insert the first (blank) standard, <0.1 NTU, into the cell compartment and close the lid.
10. Press **CAL.** The "CAL" and "S0**"** icons will be displayed (the "0" will flash).
11. Press **READ.** The instrument will count down from 60 to 0, read the blank and use it to calculate a correction factor for the second, 20 NTU standard. The display will automatically increment to the next standard. The display will now show "S1" (with the 1 flashing) and "20 NTU", the value of the second standard. Remove the <0.1 NTU standard from the compartment.
12. Insert the second, 20 NTU, standard into the cell compartment and close the lid.
13. Press **READ.** The instrument will count down from 60 to 0, measure the turbidity and store the value. The display will automatically increment to the next standard with the display showing "S2" (with the 2 flashing) and "100 NTU", the value of the third standard. Remove the 20 NTU standard from the compartment.
14. Insert the third, 100 NTU, standard into the cell compartment and close the lid.
15. Press **READ.** The instrument will count down from 60 to 0, measure the turbidity and store the value. The display will automatically increment to the next standard. The display will show the "S3" (with the 3 flashing) and the 800 NTU standard, the value of the fourth standard. Remove the 100 NTU standard from the compartment.
16. Insert the fourth and last, 800 NTU, standard into the cell compartment and close the lid.
17. Press **READ.** The instrument will count down from 60 to 0, measure the turbidity and store the value. Then the display will increment back to the S0 display. Remove the 800 NTU standard from the compartment and close the lid.
18. Press **CAL** to accept the calibration. The instrument will return to the measurement mode automatically.
19. To check the calibration (in run mode), insert the 20 NTU standard into the cell compartment and close the lid.
20. Press **READ.** The meter will display a lamp symbol (which looks like a light bulb) indicating that the reading is in progress. The lamp turns off and the measurement value is displayed. Record the turbidity reading on the calibration log. The calibration check must be +/- 5% (19-21 NTUs). If not, recalibrate using all standards. If re-calibration is unsuccessful, use new standards, consult the manufacture/vendor or replace the unit.
21. Remove the 20 NTU check standard from the compartment and close the lid.

B - Calibration/Calibration Check Procedures for the Hach 2100Q Turbidity Meter

1. Use the commercially available StablCal® Formazin Primary Turbidity Standards: 20, 100 and 800 NTUs and the 10 NTU Verification Standard.
2. Before performing the calibration procedure, make sure the cells are not scratched. If the cell is scratched, the standard must be replaced.
3. Allow the calibration standards to equilibrate at the ambient temperature.
4. Turn on the meter.
5. Push the **CALIBRATION** key to enter the Calibration mode.

   The Calibration key is the graph symbol with 2 points in the lower left hand side. The screen shows the three standards (20, 100 & 800 NTUs). The 20 NTU standard is shown bolded with a box around it indicating that is the first standard to be calibrated.
6. Gently invert the standards to thoroughly mix the contents. (**DO NOT SHAKE**)
7. Wipe the standards with a soft, lint free cloth or Kimwipe to make sure the outside surfaces are dry, free from fingerprints and dust.
8. Insert the first standard, 20 NTU, into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment and close the lid firmly. Note: the standard to be inserted is bordered.
9. Press **READ** (right hand key)**.** The display shows Stabilizing and then shows the results accompanied by an audio beep. The display will automatically request the next standard by bordering it and darkening the first standard. Remove the 20 NTU standard from the compartment.
10. Insert the second, 100 NTU, standard into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment and close the lid firmly.
11. Press **READ.** The display shows Stabilizing and then shows the results accompanied by an audio beep. The display will automatically request the next standard by bordering it and darkening the previous standards. Remove the 100 NTU standard from the compartment.
12. Insert the third and last, 800 NTU, standard into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment and close the lid firmly.
13. Press **READ.** The display shows Stabilizing and then shows the results accompanied by an audio beep. Remove the 800 NTU standard from the compartment.
14. Push **DONE** to complete a 3 point calibration and review the calibration details (values of the three standards).
15. Push **STORE** to save the results.
16. After a calibration is complete, the meter automatically goes into the Verify Cal mode.

17. Insert the 10 NTU Verification Standard into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment and close the lid firmly.
18. Push **READ** (right hand key). The display shows Stabilizing and then shows the results and the tolerance range. The calibration check must be +/- 10% (9.0- 11.0 NTUs).
19. Push **DONE** to return to the reading display.
20. If the calibration verification (Cal Check) is not within the +/- 10% range, repeat the calibration verification. If that fails, recalibrate using all standards. If re-calibration is unsuccessful, use new standards, consult the manufacture/vendor or replace the unit.

OVERNIGHT STORAGE OF MULTIPARAMETER INSTRUMENT PROBES

Check with the vendor for the appropriate overnight storage of the probes. Some manufacturers/venders may recommend storing the multiparameter probes overnight in a calibration cup filled with pH 4 solution. If so, fill the calibration cup with pH 4 solution, place the probes into the calibration cup and seal tightly.

DATA MANAGEMENT AND RECORDS MANAGEMENT

All calibration information must be documented on the attached calibration log, including the instrument manufacturer, model number and identification number; standards used to calibrate the instruments (including source, lot numbers and expiration dates); date; personnel; the instrument readings, barometer reading, DO membrane inspection, changed DO membrane and solution, etcetera. Each daily calibration log shall be dated and signed by the user.

REFERENCES

Standard Operating Procedure Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction potential [ORP], and turbidity), U.S. Environmental Protection Agency, Region 1, Revision Number 2, January 10, 2010.

Instruction manuals for each instrument used (e.g., YSI Models 600XL/XLM Multi-parameter Meter & Sonde, Hach Model 2100P/2100Q Portable Turbidity, separate barometer), as appropriate.

ATTACHMENT

Instrument Calibration/Maintenance Log

INSTRUMENT CALIBRATION / MAINTENANCE LOG

Date: **Time:** Field Personnel (print):

Meter: **(circle one)** **YSI:** Models 600XL or XLM, 6820 **QED:** Model MP 20 **Multimeter Serial Numbers (**Sonde & Meter**):**

Beginning of Day Instrument Calibration

Multimeter Calibration	Value of Standard	Check as Completed	Lot #	Expiration Date	Comments
DO (% saturation)	**100%**				**Allow time for stabilization per manufacture**
DO mg/l reading					**Record these values immediately after calibration**
DO Temp. (˚C) reading					
pH 1st Standard	**7**				
2nd Standard	**4**				
3rd Standard	**10**				
Specific Conductance **(µS/cm)**	**1413**				**One standard is used to calibrate, second one to check (1413 µS/cm and 718 µS/cm standards)**
ORP using Zobell Solution					**See Chart on Page 2 for ORP Zobell Solution mV Value Based on Current Temperature**
Zobell Solution _____ ˚C					

Additional Information for Dissolved Oxygen Calibration

Barometric Pressure Check: NWS Barometer Location: _____ Personnel _____Date: _____

NWS Pressure: _____ mm Hg Original Hand-held Barometer Pressure _____ mm Hg Adjusted to NWS Pressure (circle one) YES or NO

Barometric Pressure of Meter or Hand Held Barometer : _____ mm Hg [BP inches _____ x 25.4 + BP _____ mm Hg]

Dissolved Oxygen Charge (YSI Meters): _____ (Acceptable Range: 25 to 75) You MUST change the membrane if charge is out of range.

Inspected DO membrane for nicks or bubbles (check as completed) _____ Personnel:_____

Changed Dissolved Oxygen Membrane and Electrolyte Solution (circle one) **YES or NO**

HACH 2100P or 2100Q * Turbidimeter Calibration	Value of Standard	Check as Completed	Lot #	Expiration Date	Comments
Turbidity 1st Standard (blank)	**<0.1 NTU**				**Calibrate w/ StablCal® Formazin Primary Turbidity Standards**
2nd Standard	**20 NTU**				
3rd Standard	**100 NTU**				
4th Standard	**800 NTU**				

HACH Serial Number: **Rental Company:**

*** Circle appropriate model. NOTE: the 2100Q does not have a <0.1 standard, record N/A (not applicable) in the <0.1 standard boxes as appropriate.**

*** When performing calibration checks, wait for temperature and parameter readings to stabilize before recording the results.***

Post Calibration Check

Date: **Time:** **Personnel:**

Calibration Check	Value of Standard	Check Results	Acceptable Range	Within Range (yes/no)	Lot #	Expiration Date	Comments
Zero DO check (mg/l)	**0**		**0 to 0.5 mg/l**				
pH 7 check	**7**		**+/- 5%**				**Range 6.65 - 7.35 pH**
Specific Conductance **(µS/cm)** Second standard used for check	**718**		**+/- 5%**				**Range 682 - 754 µS/cm (718) or Range 1342 - 1484 µS/cm (1413)**
ORP check - Zobell (mV)			**+/- 5%**				**See Chart on Page 2 for ORP Zobell Solution mV Value Based on Current Temperature**
Zobell Solution _____ ˚C							
Turbidity Standard (NTU) **2100P**	**20**		**+/- 5%**				**Range 19.0 - 21.0 NTU (2100P)**
Turbidity Standard (NTU) **2100Q**	**10**		**+/- 10%**				**Range 9.0 - 11.0 NTU (2100Q)**

Notes: 1) NWS = National Weather Service
2) If the post calibration check is not within the acceptable range the meter must be recalibrated.
3) All calibration checks must be made in the run mode, not the calibration mode.
4) If the lot numbers and expiration dates are the same as the initial calibration place a check mark ✓ in the appropriate box.
5) Either standard (718 or 1413 µS/cm) maybe used to calibrate specific conductance, the second standard is used to check it.
6) Record N/A (Not Applicable) in the boxes for the turbidity meter that was not used.

Calibration & Post Calibration Check Performed by: _____(Print)_____ (Sign)

*** When performing calibration checks, wait for temperature and parameter readings to stabilize before recording the results.***

END OF DAY INSTRUMENT CALIBRATION CHECK

Calibration Check	Value of Standard	Check Results	Acceptable Range	Within Range (yes/no)	Lot #	Expiration Date	Comments
Date: Time:		**Personnel:**					
Zero DO check (mg/l)	**0**		**0 to 0.5 mg/l**				
pH 7 check	**7**		**+/- 5%**				**Range 6.65 - 7.35 pH**
Specific Conductance **(µS/cm)** Second standard used for check	**718**		**+/- 5%**				**Range 682 - 754 µS/cm (718) or Range 1342 - 1484 µS/cm (1413)**
ORP check - Zobell (mV)			**+/- 5%**				**See Chart below for ORP Zobell Solution mV Value Based on Current Temperature**
Zobell Solution _____ ˚C							
Turbidity Standard (NTU) **2100P[5]**	**20**		**+/- 5%**				**Range 19.0 - 21.0 NTU (2100P)**
Turbidity Standard (NTU) **2100Q[5]**	**10**		**+/- 10%**				**Range 9.0 - 11.0 NTU (2100Q)**

Notes:

1) If the end of the day calibration check is not within the acceptable range the data collected that day for that parameter shall be qualified in it's use.
2) All calibration checks must be made in the run mode (on a run/measurement screen), not the calibration mode.
3) If the lot numbers and expiration dates are the same as the initial calibration place a check mark ✓ in the appropriate box.
4) Either standard (718 or 1413 µS/cm) maybe used to calibrate specific conductance, the second standard is used to check it.
5) Record N/A (Not Applicable) in the boxes for the turbidity meter that was not used.

Weather Conditions:
If the calibration/calibration check was performed off-site (e.g. in the office, etc.) due to weather conditions, check (√) here:_____
Was prior approval given by the NHDES Project Manager? (Circle one) Yes or No

Where off-site was the calibration/calibration check performed? _____

Calibration Check by _____ _____
Print Name Signature

List wells sampled using this equipment on this day <u>if data needs to be qualified</u>.

_____ _____
_____ _____
_____ _____

Zobell Solution mV Value Based on Temperature for ORP Calibration
Calibration Check Range Values (+/- 5%)
Round off temperature to whole number (e.g. 23.5 ºC rounds up to 24 ºC)

Temp. ºC	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. ºC	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. ºC	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%
-3	**267**	254-280	10	**251**	238-264	23	**234**	222-246
-2	**266**	253-279	11	**249**	237-261	24	**232**	220-244
-1	**265**	252-278	12	**248**	236-260	25	**231**	219-243
0	**264**	251-277	13	**247**	235-259	26	**230**	219-242
1	**262**	249-275	14	**245**	233-257	27	**228**	217-239
2	**261**	248-274	15	**244**	232-256	28	**227**	216-238
3	**260**	247-273	16	**243**	231-255	29	**226**	215-237
4	**258**	245-271	17	**241**	229-253	30	**225**	214-236
5	**257**	244-270	18	**240**	228-252	31	**223**	212-234
6	**256**	243-269	19	**239**	227-251	32	**222**	211-233
7	**254**	241-267	20	**238**	226-250	33	**221**	210-232
8	**253**	240-266	21	**236**	224-248	34	**219**	208-230
9	**252**	239-265	22	**235**	223-247	35	**218**	207-229

Equipment Rental Company:
Probe Pre-cleaned Certification Provided By: Name **Date:**
Temperature Calibration: Name: **Date:**
Manufactures Accuracy Range of Sensor (e.g. +/- 0.2˚C): **Check results YSI:_____ NIST:_____ Difference:_____**

CHAIN-OF-CUSTODY, SAMPLE HANDLING AND SHIPPING

PURPOSE

This Standard Operating Procedure (SOP) *Chain-of-Custody, Sample Handling and Shipping* has been established to provide for sample integrity including proper sample labeling, completion of chain-of-custody (COC) forms, sample packaging and shipment.

A COC is a legal document designed to track persons who are responsible for the preparation of the sample container, sample collection, delivery, storage, and analysis. The field sampler is personally responsible for the care and custody of the samples, including un-used sample containers, until they are transferred or properly dispatched. As few people as possible should handle the samples.

Never leave samples, including un-used sample containers, unattended. All samples and un-used sample containers must be in the person's possession or placed in a locked location at all times.

All samples submitted to a laboratory shall be accompanied by a properly completed COC form, packaged and shipped, as appropriate. Always check with the Project Manager and the selected laboratory for specific requirements regarding COCs. A copy of the current New Hampshire Department of Health & Human Services, Division of Public Health Services (NHDPHS) Laboratory COC form is attached.

Failure to maintain possession in the ways outlined in this SOP may constitute a break in sample custody and would likely discredit affected samples as use of evidence in court proceedings. The sampler must assume that all samples collected will someday be used as evidence in court and treat the task of sample custody accordingly.

Prior to undertaking any sampling, a site-specific Sampling and Analysis Plan (SAP) or a site-specific Quality Assurance Project Plan (QAPP) must be developed that includes site-specific information.

EQUIPMENT AND MATERIALS

The following is a list of equipment and material commonly used for labeling, packaging and shipping samples:

- COC forms/seals.
- Bubble wrap or air cushions and packing.
- Re-sealable plastic bags.
- Permanent waterproof ink marker.
- Black ink pen.
- Shipping coolers.

- Loose ice.
- Sample labels, and packing tape.

CUSTODY PROCEDURES

1. The field sampler will review the SAP provided by the Project Manager for specific COC record-keeping requirements. Note the following key COC related items:
   a. The specific laboratory to be used along with contact information.
   b. Specific quality assurance/quality control (QA/QC) data validation packages for project-specific data validation needs.
   c. Laboratory reporting options, including preliminary results or electronic deliverables.
   d. Standard or rush turn-around-times required.
   e. Special laboratory requirements including lower detection limits; short hold times; and sample volume issues.
2. The field sampler will label all sample bottles, using waterproof ink, with the following information at a minimum:
   a. Sample ID.
   b. Site name/location.
   c. Sampler name.
   d. Date and time sample was collected.
   e. Laboratory analysis and test method requested.
   f. Preservative used.

   Note: If soil volatile organic compound (VOC) samples are collected, no additional labels or tape shall be applied to the sample container, as these are pre-weighed by the laboratory.
3. The unique laboratory COCs will be prepared by either the field sampler collecting the samples or the onsite QA officer and include the following information at a minimum:
   a. The site/project name.
   b. Town the site is located in.
   c. Appropriate activity/project number (New Hampshire Department of Environmental Services [NHDES] site number).
   d. Unique sample IDs.
   e. Time and date of collection.
   f. Matrix type.
   g. Laboratory analysis and method requested.

h. Number of containers.

i. Preservatives.

j. Name and phone numbers of all samplers and staff involved in filling out the COC forms.

k. Name and phone number of the project contact person.

l. Specific requirements such as specific reporting detection limits (RDLs).

m. Any special notes or requirements such as the lab account number, OneStop Project ID, etc.

n. Typically, the street addresses corresponding to residential samples are included in the comment section for each sample, unless otherwise specified in the SAP.

o. All quality assurance/quality control (QA/QC) samples and associated information such as:

1) **Trip Blanks:**

Trip blanks typically consist of two VOA (volatile organic analysis) vials. Before placing the trip blank in a re-sealable plastic bag, record the date and time on the labels. The trip blank must be placed in the cooler within the loose ice prior to the collection of the first volatile sample.

The trip blank should be designated as "TRIP BLANK" in capital letters on the COC and should be recorded on the first line along with the date and time. Only one trip blank per sample type (e.g., VOCs, low level 1,4-Dioxane, etc.) with different preservatives, per COC, per cooler is acceptable.

2) **Duplicates:**

Sample duplicates are identified by adding "DUP" (in capital letters) to the end of the station ID (example "OKT_MW-14D DUP"). The duplicate samples should appear on the next line of the COC after the regular samples. If blind duplicates are collected, refer to the site-specific SAP for proper identification and labeling.

3) **Matrix Spike (MS) Matrix Spike Duplicate (MSD) samples:**

MS/MSD samples are typically collected together at one sampling location. Refer to the site-specific SAP for specific MS/MSD requirements. There are generally two types of MS/MSD samples:

a) <u>Lab QC MS/MSD Samples</u>:

A laboratory may require the collection of extra sample bottles for their internal lab QC. If so, indicate that in the comments section on the COC (e.g., "Lab MS/MSD QC or "Lab MS/MSD-SVOCs" specifying the analysis). The lab typically does not report these results. The number of samples containers will also change to indicate the extra bottles. These lab QC samples should not be on a separate line on the COC. The

NHDPHS lab typically requires extra sample bottles for their internal QC for both SVOC and 1,4-Dioxane analysis. Refer to the specific lab and the site-specific SAP for MS/MSD requirements.

b) Site MS/MSD Samples:

A site-specific SAP may require MS/MSD samples to be collected at a specific location, and require the lab to report those results, as part of a site-specific sampling program if matrix interference is suspected. If so, indicate that in the comment section on the COC (e.g., "MS/MSD Report Results" or "MS/MSD-SVOCs Report Results" specifying the analysis if it is not required for each analysis). The number of samples containers will also change to indicate the extra bottles for the MS/MSD sample. These MS/MSD samples may be on a separate line on the COC. Refer to the specific lab and the site-specific SAP for MS/MSD requirements.

4) **Equipment Blank Samples:**

Equipment blank samples will be designated as "EQUIP BLANK" in capital letters on the COC without any other designation. Add a note to the comment section of the COC indicating what the equipment blank is for (e.g., water level meter, etc.).

5) **Temperature Blanks:**

A temperature blank will be included with each shipment cooler to verify that samples have been kept at the required temperature during shipping. Check off the box on the COC to indicate that there is a temperature blank in the cooler. If there is no box, indicate the temperature blank's presence in the comment section of the COC.

4. Prior to leaving the site and before the samples are delivered to the lab, the field sampler or Field Operations Lead will check for errors on the sample label and COC form and verify that all pertinent data is present and correct.

5. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage area.

Only one of the field samplers signs the first "relinquished by" line. The person who receives the samples at the laboratory signs the COC last in the "received by" line. In case there are additional steps in the process requiring another person or persons to take custody of the sample, the form has additional lines for signatures. All signatures must be in ballpoint pen and are followed by a date and time that the COC was signed. The last line of the NHDPHS COC is provided for personnel from the laboratory to sign for receiving the sample. The line at the bottom of the page "Data Reviewed By" is for Lab use only. If the samples are taken to the NHDPHS lab via courier the sampler may relinquish the

samples to "NHDPHS Laboratory via courier", as appropriate. Pre-approved NHDES personnel may relinquish the samples to "locked storage" in the NHDPHS Lab.

Note: Any errors must be lined out, initialed, dated and the correction written in.

6. If the samples are shipped by public courier (e.g., Federal Express, UPS, etc.) the airbill generally serves as the COC record for that portion of the trip and will be retained by the field sampler and provided to the Project Manager as part of the permanent documentation.
7. The Field Operations Lead, QA Officer or Project Manager will review the COC to evaluate completeness; holding time or sample volume issues that may impact the validity of the results.

SAMPLE PACKAGING PROCEDURES

After collection, all samples shall be transported to the laboratory in such a manner as to prevent breakage and preserve sample integrity. Sample containers are generally packaged in insulated coolers for shipment or pickup by the laboratory courier. Appropriate packing materials include bubble wrap and air cushions. Sample containers are packed tightly so minimize movement during shipment that may cause breakage.

1. To eliminate the chance of breakage during shipment, approximately one inch of inert material shall be placed in the bottom of the cooler.
2. Include a temperature bank and any necessary trip blanks in loose ice in each cooler prior to sample collection.
3. Place each sample container, or set of sample containers (e.g., 2 to 4 VOCs vials), inside a re-sealable plastic bag as a precaution against cross-contamination due to leakage or breakage.
4. Place all containers in an upright position into the loose ice in the cooler and place all glass containers in such a way that they do not come into contact with each other during shipment.
5. After samples have been packed, loose ice will be added to the cooler to ensure temperature preservative is achieved (temperature 4 +/-2 degrees Celsius).
6. Place a completed COC in a re-sealable plastic bag within each cooler. Only one COC per cooler is acceptable. COCs may contain more than one page.
7. Coolers being shipped (not couriered) will be secured with strapping tape in at least two locations for shipment to the laboratory and include a custody seal.
8. Prior to any cooler being shipped that contains environmental samples, the Field Operations Lead, QA Officer or Project Manager is required to evaluate if the samples/sample containers being shipped are considered hazardous. Consult appropriate trained personnel for proper packaging and labeling requirements.

SAMPLE PICKUP/SHIPPING PROCEDURES

Field personnel will coordinate sample delivery arrangements directly with each lab. Refer to the site-specific SAP or QAPP for all holding time requirements and laboratory contact

information.

Samples shall be properly packaged for shipment to maintain sample integrity and delivered to the analytical laboratory with a separate signed COC form enclosed in each sample cooler. Samples must be delivered in a manner consistent with the requirements of the analytical laboratory with respect for preservation, temperature, holding times for the particular analytes to be tested.

In general and whenever possible, all samples will be checked into the laboratory performing the analyses on the same day the samples are collected, unless other arrangements have been made. If it is impossible to check in samples at the laboratory the same day, the field team will be responsible for proper secure storage of samples following appropriate protocol for sample preservation (such as cooling to 4° +/- 2°C) until the samples are delivered to the laboratory or handed over to a courier.

Sample Pickup/Delivery

Samples are either delivered directly to the laboratory by the field team or the laboratory provides a courier to transport them. Custody seals shall be used when the cooler is sent to the laboratory by independent courier, unless otherwise specified in the site-specific SAP.

Shipping Samples to the Laboratory

When samples need to be shipped, they are typically sent next-day delivery by Federal Express or an equivalent overnight carrier. Field personnel will coordinate directly with the appropriate laboratory in advance for delivery times and requirements and will notify the laboratory (typically, no later than 48 hours) prior to sample shipment. Coolers will be secured with strapping tape in at least two locations for shipment and include a custody seal. If the sample is considered hazardous, consult appropriate trained personnel for proper packaging and labeling.

For shipments by commercial carrier, the appropriate side of the shipping container should be prominently marked with a "This End Up" label with arrows pointing in the correct orientation. The Sampling and Reporting Contractor will affix the shipping company label to the top of the cooler. The label should include the shipper's name, address, and telephone number, and the name, address, and telephone number of the receiving laboratory. Also on the top of the shipping container, the shipper's return address should be written in black ink.

If the samples are shipped by public courier (e.g., Federal Express, UPS, etc.) the airbill generally serves as the chain-of-custody record for that portion of the trip and will be retained by the field sampler and provided to the Project Manager as part of the permanent documentation.

DOCUMENTATION

The original COC record will accompany the cooler and a copy will be retained by the sampler for return to the Project Manager.

ATTACHMENT

NHDPHS Laboratory Services Login and Custody Sheet

NHDPHS LABORATORY SERVICES LOGIN AND CUSTODY SHEET

(Laboratory Policy: Samples not meeting method requirements will be analyzed at the discretion of the NHDPHS Laboratory.)

Samples must be delivered in a cooler with loose ice (no ice packs).

LAB ACCOUNT (Billing) #_____ One Stop Project ID# _____ DES Site Number _____Temp. ^{0}C. _____

Description: _____ Town: _____ NHDES Contact & Phone#: _____

Comments: **Contractor Contact & Phone #_____**

Collected By & Phone#:_____

_____

_____

Sample Location / ID	Date/Time Sampled	# of Containers	Matrix											Other / Notes	Lab Login ID # (For Lab Use Only)

Preservation: _____

Relinquished By_____Date and Time_____Received By_____ ☐ Temperature Blank Included in Cooler

Relinquished By_____Date and Time_____Received By_____

Matrix: A= Air S= Soil SED = Sediments AQ= Aqueous (Ground Water, Surface Water, Drinking Water) Other: _____

Section No.: 22.0
Revision No.: 8 (HWRB)
Date: 1-8-15

Page _____ of _____ Data Reviewed By_____ Date_____

PASSIVE DIFFUSION BAG VOC SAMPLING

PURPOSE

This Standard Operating Procedure (SOP) provides guidelines for deployment, recovery and quality assurance (QA) associated with the use of water-filled passive diffusion bag (PDB) samplers for obtaining volatile organic compound (VOC) data results in groundwater monitoring wells with screen intervals ten feet or greater in length. Where the screened interval (within a well) is greater than ten feet, the potential for contaminant stratification and/or intra-borehole flow within the screened interval is greater than in screened intervals shorter than ten feet.[1] For the purpose of this SOP, screen refers to screen intervals or open borehole.

This SOP allows for multiple deployment of PDB samplers within a well as there may be multiple intervals of the formation contributing to flow or varying concentrations of VOCs vertically within the screened or open interval. The purpose of using multiple PDB samplers is to determine whether contaminant stratification is present and to locate the zone of highest concentration. An assumption is that there is horizontal flow through the well screen and that the quality of the water vertically within a well is representative of the groundwater in the aquifer directly adjacent to the screen at that location.

Prior to undertaking any groundwater sampling using PDBs, a site-specific Sampling and Analysis Plan (SAP) must be developed. The SAP shall include specific information such as the data quality objectives (DQOs), size of the samplers, the number of samplers required at each location, and all quality assurance/quality control (QA/QC) requirements. In general this procedure requires a minimum of two sample personnel, especially when recovering the PDBs. Because of the flexible nature of the PDB samplers and limited amount of water available to sample, it is easier to collect the VOC samples with two sample personnel.

A summary of the general procedure is as follows: The vendor provides pre-filled PDB samplers. The PDB samplers are attached to a weighted tether and suspended from a locking J-plug/well cap while they are deployed. Samplers are evenly positioned along the screen and allowed to equilibrate for two weeks. Recovery of the PDB consists of removing the samplers from the well and immediately transferring the enclosed water to 40-milliliter sampling VOC vials for laboratory analysis.

GENERAL BACKGROUND INFORMATION

A PDB sampler works on the principle of diffusion; chemical compounds dissolved in water move from areas of high concentration outside the sampler to low concentration inside the sampler until equilibrium is reached.

[1] User's Guide For Polyethylene-based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells, Part 1: Deployment, Recovery, Data Interpretation, and Quality Control and Assurance Water-Resources Investigations Report 01-4060, USGS, dated 2001.

The effectiveness of the use of a single PDB sampler in a well is dependent on the assumption that there is horizontal flow through the well screen and that the quality of the water is representative of the groundwater in the aquifer directly adjacent to the screen. If there are vertical components of intra-borehole flow, multiple intervals of the formation contributing to flow, or varying concentrations of VOCs vertically within the screened or open interval, then deployment of multiple PDB samplers within a well may be more appropriate for sampling the well.

A typical PDB sampler consists of low-density polyethylene (LDPE) lay-flat tubing that is filled with laboratory-grade deionized (DI) water and closed at both ends. They are typically 18 to 24 inches long, with a 1.25 to 1.75 inch outside diameter (OD), and hold between 200 and 350 milliliters (ml) of DI water; however they can be custom sized to fit particular needs. The Hazardous Waste Remediation Bureau (HWRB) recommends placing the samplers in a low-density polyethylene mesh for protection against abrasion in open boreholes and as a means of attachment at the prescribed depth. The bags are suspended in the monitoring well at the target horizon by a weighted line and allowed to equilibrate with the surrounding water. A minimum equilibration time of two weeks is recommended. The PDB samplers are retrieved from the well after the equilibration period and the enclosed water is immediately transferred to appropriate sample containers for analysis (40 ml volatile organic analysis [VOA] vials).

The PDB can be attached to the weighted line by a variety of methods, such as wire/cable ties through a knot or ring in non-buoyant non-stretch rope, stainless steel clamp, or direct attachment to the weight. Sufficient weight should be added to counterbalance the buoyancy of the PDB samplers. Non-buoyant non-stretch rope should be dedicated to the well to prevent carryover of contaminants. Stainless steel line could be reused if thoroughly decontaminated. All weights should be made of stainless steel and thoroughly decontaminated after each use.

The PDB method has both advantages and limitations when compared to other sampling methods. Advantages include the following. The potential for PDB samplers to eliminate or substantially reduce the amount of purge water associated with sampling. The samplers are relatively inexpensive and easy to deploy and recover. Because PDB samplers are disposable, there is little to no downhole equipment to be decontaminated between wells. There is a minimum amount of field equipment required. Multiple PDB samplers, distributed vertically along the screened or open interval, may be used in conjunction with borehole flow meter testing to gain insight on the movement of contaminants into and out of the well screen or open interval or to locate the zone of highest concentration in the well. In addition, the samplers are not subject to turbidity interferences because sediment can’t pass through the small pore size membrane.

Water-filled polyethylene PDB samplers are not appropriate for all compounds (e.g., methyl tertiary butyl ether (MtBE), acetone, styrene, most semi-volatiles, most ions). The use of PDB samplers would not be appropriate for collecting a sample at a given point in time. There may be a problem using PDB samplers where there is low permeability, or if the well is not properly developed. If there is a vertical hydraulic gradient in the well, then the concentrations in the

sampler may represent the concentrations in the water flowing vertically past the sampler rather than in the formation directly adjacent to the sampler.

Although, the purpose of using PDB samplers in this SOP is to determine whether contaminant stratification is present and to locate the zone of highest concentration, there are also other applications, such as the use of PDB samplers for long-term monitoring of VOCs in groundwater wells at well characterized sites.

EQUIPMENT AND MATERIALS

- Appropriate health and safety gear and an approved site-specific Health & Safety Plan.
- An approved site-specific SAP which includes boring logs.
- Field log book.
- Well keys and other applicable field equipment to open the wells.
- Electronic water level meter (measures in increments of 0.01 feet).
- Pre-filled (with laboratory-grade DI water) PDBs with protective outer mesh. Order enough bags to have a few spares and at least one extra bag for the deployment equipment blank. Typical sizes include:

  OD = 1.75 inches for 2-inch inside diameter (ID) wells:

  - 18-inch long with a capacity of 350 ml.
  - 24-inch long with a capacity of 500 ml.

  OD = 1.3 inches for 1.5 inch ID wells:

  - 18-inch long with a capacity of 200 ml.
  - 24-inch long with a capacity of 300 ml.
- Disposable discharge “straws” or tubes (provided by the vendor with the PDB) used to puncture the PDB sampler and collect the VOC samples; one for each PDB bag and a few spares.
- Deployment line, typically polyester or stainless steel.

  Non-buoyant braided polyester of sufficient strength to support the weight and samplers and subject to minimal stretch may be used. The line should be dedicated to the well to prevent the high potential for cross contamination.

  Stainless steel line may be reused after decontamination.
- Tether Winding Reel: Used to keep longer tether lines tangle-free and dirt-free during deployment and retrieval. These may be supplied by the vendor.
- A stainless-steel weight (or weights) dedicate to each well.

  Sufficient weight is required to be added to counterbalance the buoyancy of the PDB samplers. The stainless steel weights may be reused after decontamination.

- Stainless steel rings to secure the PDB to the tether and the tether to the well cap. Each bag requires two stainless steel rings, one at either end to properly secure the bag to the tether.

  The stainless steel rings may be reused after decontamination.
- Cable ties to secure the stainless steel rings on the tether to the mesh protecting the PDB sampler.

  Stainless steel clamps may be used to secure the PDB samplers to a stainless steel line.
- Tags (made of an appropriate material) to identify the various interval depths.
- Locking J-plugs/caps for wells to attach and suspend the PDB samplers from while they are deployed.
- Tripod/adjustable ladder to place over the well opening to hold the weight of the PDBs while deploying and retrieving.
- Plastic sheeting.
- Canopy or paraphernalia to protect the equipment from the elements.
- Appropriate preserved sample containers, sample labels, coolers, and loose ice.
- Re-sealable plastic bags, bubble wrap, to protect and store samples.
- Record keeping supplies: Chain-of-custody forms, field worksheets, field logs, indelible black-ink pens, Sharpies®, calculator, etc. Do not use Sharpies to record field data as they can bleed through pages and smudge.
- Paper towels
- Decontamination supplies as required in an approved Decontamination SOP.

PRELIMINARY PROCEDURES

It is preferable to have the vendor pre-fill the PDBs with DI water. The stainless steel rings used to position the sampler at the desired depth on the tether may be attached by the vendor at the time of purchase or attached in the office prior to deployment. This information shall be specified in the SAP.

The size (length, diameter and capacity) of the PDB sampler and the particular depths where the various sized PDBs will be deployed will depend on the size and depth of the well and the DQOs specified in the SAP.

The following pre-deployment PDB assembly procedures are to be used:

1. Before sampler deployment, measure the total well depth and compare it with the reported depth to the bottom of the well from well construction diagrams or tables to evaluate whether sediment has accumulated in the bottom of the well.

2. Check for any obstruction in the well that would prevent PDB deployment.

3. Based on the well depth and the screen interval at each well location, determine the length of screen to be sampled using PDBs and the depths to deploy the samplers. Typically, in wells with a 10 foot screen, three 18-inch samplers are evenly positioned along the screen; and in wells with screen lengths greater than 10 feet, one 24-inch sampler is positioned evenly every 5 to 10 feet of screen length. When using one PDB sampler in a well with a five foot or shorter well screen, the center point of the PDB sampler should be the vertical midpoint of the saturated well screen length unless specified otherwise in the SAP.

4. Measurement for the placement of the samplers on the tether should begin from the bottom of well. The preferred deployment method is to have the weight attached to the end of the tether so that the weight rests on the bottom of the well with the line taut above it suspended from a locked J-plug. Sufficient weight is required to be added to counterbalance the buoyancy of the PDB samplers. Calculate the distance from the bottom of the well up to the desired interval in the well where the sampler will be suspended. The first sampler should be at least two feet from the bottom of the weighted tether unless specified otherwise in the SAP.

   For wells that are screened across the water table, PDB must be placed at least two feet below the top of the water column in the well. Extreme care must be taken to ensure that no part of the sampler bag will be exposed above the water table during the equilibration period.

5. If the vendor is attaching the stainless steel rings to the tether at the desired depths prior to shipment, provide the proper sampler depths to the vendor in advance. Each bag requires two stainless steel rings, one at either end to properly secure the bag to the tether. Once the tethers are received from the vendor they should be carefully checked to ensure the rings are properly placed as it is critical that the PDBs are deployed at the designated depths. Attach a tag to the ring at the top of each PDB sampler identifying the sampling depth. This is especially important when numerous PDB samplers are used in the same well. Be sure the tags are made of an appropriate material and do not have any sharp edges that could puncture the PDB samplers or get caught up in the well.

6. The filled PDB samplers in the protective mesh should be carefully placed in a cooler(s) prior to deployment in the field. A minimum of one PDB sampler will be designated as the deployment equipment blank. Refer to the quality assurance/quality control QA/QC section below and in the SAP.

7. The PDB samplers may be attached to the tether in the office prior to deployment or they may be attached in the field. This must be specified in the SAP.

PDB DEPLOYMENT PROCEDURE

Use the following procedure for PDB deployment:

1. Check well for security damage or evidence of tampering, record observations. Wells shall be locked at all times when not being sampled.

2. Set up equipment according the attached PDB Equipment Setup Diagram and **Figure 1**. Set up the tripod/ladder over the well opening to hold the weight of the PDBs during deployment. Attach the reel holding the tether cable (or the tether cable itself if a reel was not provided) to the tripod.

3. Lay out plastic sheeting on the ground surface at the sampling location to provide a contaminant free surface to assemble and prepare the samplers for deployment.

4. Collect a water level measurement at the well and record the measurement in the log book. Decontaminate the water level after each well.

5. Review the attached vendor PDB instructions. Attach the weight to the bottom of the tether so that the weight will rest on the bottom of the well.

6. Attach the mesh at the top of the PDB sampler and the handle (or mesh if there is no handle) at the bottom of the PDB sampler to the appropriate rings on the tether using a cable ties in a way that prevents slipping of the sampler bag along the tether. Clip off excess cable tie. Care should be taken to eliminate sharp points or ends of clamps, tags, or cable ties to decrease the potential for PDB punctures or tears. Once all samplers are attached to the tether, attach tether to the new j-plug/well cap (**Figure 3**).

   A check on the depth can be done by placing a knot or mark on the line at the correct distance from the top knot/loop of the PDB sampler to the top of the well casing and checking to make sure that the mark aligns with the lip of the casing after deployment.

7. Once all samplers are attached, lower the weight, and weighted line with the attached samplers, down into the well until the weight rests on the bottom of the well and the line above the weight is taut. The PDB samplers should now be positioned at the expected depths as long as the check knot or mark aligns with the lip of the casing.

8. Secure the assembly in this position with the j-plug/well cap and secure the well.

9. Allow the system to remain undisturbed as the PDB samplers equilibrate for a minimum of two weeks.

10. Once the PDB sampler has been deployed in the last well, collect the deployment equipment blank. Refer to the quality assurance/quality control QA/QC section below.

PDB RECOVERY PROCEDURES

Use the following procedure for PDB recovery:

1. Set up equipment according the attached PDB Equipment Setup Diagram and **Figure 1**. Set up the tripod/ladder to hold the tether and samplers as they are being retrieved.

2. Collect and record a water level measurement. Decontaminate the water level after each well. Compare the current water level to the water level recorded during deployment, and the depth of the highest PDB sampler. No part of the sampler bag should be exposed above the water table during the equilibration period.

3. When retrieving the samplers, only one sampler should be removed and processed at a time. The remaining samplers should be suspended in the well until they can be processed, to isolate them from agitation and from exposure to ambient weather conditions and direct sunlight. Check the depth written on the tag attached to the top ring of the PDB sampler to ensure the correct depth is recorded on the chain of custody.

4. Detach and remove the PDB sampler from the tether. Once retrieved, examine the surface of the PDB sampler for evidence of algae, iron or other coatings, and for tears in the membrane. Note the observations in a field log book. If there are tears in the membrane, the sample should be rejected. If there is evidence that the PDB sampler exhibits a coating, then this should be noted and the data results should be qualified.

5. Remove the excess liquid from the exterior of the bag to minimize the potential for cross contamination or dilution of the sample.

6. Collect the VOC sample. The proper collection of VOC samples requires minimal disturbance of the sample to limit the loss of volatiles. Because of the flexible nature of the PDB samplers and limited amount of water available to sample, this is easier to accomplish with two sample personnel, one to hold the PDB sampler and the other to pierce the PDB sampler and collect the VOC sample. The following procedure should be followed:

   a. Open the vial and set cap in a protected place.

   b. Using the disposable discharge tube, pierce the PDB sampler near the bottom. Allow the water to flow gently through the tube and down the inside of the VOC vial with minimal turbulence. (**Figure 2**).

      If needed, the flow rate can be controlled by tilting or manipulating the PDB sampler.

      Be sure the sample flow is laminar and there are no air bubbles in the sample flow.

      There should be a convex meniscus on the top of the vial. The cap may be used to create the convex meniscus if needed.

   c. Once filled, check that the cap has not been contaminated (splashed) and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not over-tighten and break the cap.

d. Invert the vial and tap gently. If an air bubble appears, uncap and attempt to add a small volume of sample to achieve the convex meniscus without excessively overfilling the vial. If this has to be repeated more than twice, discard the sample and begin again with a new preserved container.

e. Fill the required number of VOC vials per sample. Sample containers are then wiped dry.

f. Immediately place the vials in a re-sealable plastic bag and then within loose ice in the cooler.

7. Duplicate samples are collected from the same PDB bag as the original sample. Refer to the SAP for the specific sampling depth requirements.

8. When the samples are retrieved, extreme care must be taken to ensure the depth of each sampler within the well is accurately recorded in the field log book and in the comments section on the chain-of-custody as specified below.

9. Discard any unused water from the PDB sampler according to the instructions in the SAP.

10. Do not reuse the discharge tube.

QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

QA/QC sampling shall be conducted in accordance with the SAP and generally consists of sample duplicates, deployment equipment blanks, and routine temperature and trip blanks. Refer to the SAP for specific requirements.

At least one duplicate should be collected at a specific sampling depth. The actual sample is collected first, and then the duplicate sample is collected from the same PDB sampler. Refer to the SAP for the specific well and depth locations for the collection of all duplicate samples.

The deployment equipment blank is a PDB that has been stored and transported with the field PDB samplers from the time of sampler construction by the vendor to the time of deployment in the last well. An aliquot of the deployment blank DI water should be collected from the PDB sampler in a VOC vial and submitted for analysis at the time of the last sampler deployment. A minimum of one deployment equipment blank is required. Refer to Records and Documentation section below for specific labeling instructions for the equipment blank.

There shall be one temperature blank and one trip blank per chain-of-custody per cooler of VOCs. These are placed within loose ice in the cooler before the samples from the PDBs are collected.

DECONTAMINATION

Decontamination of all non-dedicated equipment (e.g., water levels; stainless steel weights, line, rings) shall be conducted according to the Decontamination SOP in the SAP or the current HWRB Master Quality Assurance Project Plan (HWRB Master QAPP).

RECORDS AND DOCUMENTATION

Refer to the SAP for specific documentation requirements.

If the sampling results are going into the New Hampshire Department of Environmental Services (NHDES) Environmental Monitoring Database (EMD), sample labeling must follow the labeling constraints established for the EMD. In this case, the deployment depths for each sample in each well will have to be identified by the depth in the comment section only. The sample ID of the well itself (e.g., NHP_MW-102S) will remain the same under the sample ID on the chain of custody. The <u>various depths for which the PDB is deployed to will be in the comments section only</u>. The laboratory will record the depths on each analysis page.

In addition, the equipment blank must be labeled as "EQUIP BLANK" on the chain of custody and "Deploy PDB" should appear in the comment section. If more than one deployment equipment blank is required, the locations of the associated PDB samplers must also appear in the comment section of the chain-of-custody. The laboratory will record the comments on each analysis page.

Field data records must be maintained while performing PDB sampling. Water levels must be recorded and, as indicated above, special notations are required relative to the condition the PDB at the time the sampler is retrieved. This is critical to the validity of the data results. All observations shall be recorded in the field log books in permanent pen.

REFERENCES

"User's Guide For Polyethylene-based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells, Part 1: Deployment, Recovery, Data Interpretation, and Quality Control and Assurance," Water-Resources Investigations Report 01-4060, USGS, dated 2001.

"Technical and Regulatory Guidance for Using Polyethylene Diffusion Bag Samplers to Monitor Volatile Organic Compounds in Groundwater," Interstate Technology and Regulatory Council (ITRC), dated 2004 (issued by the ITRC Diffusion Sampler Team).

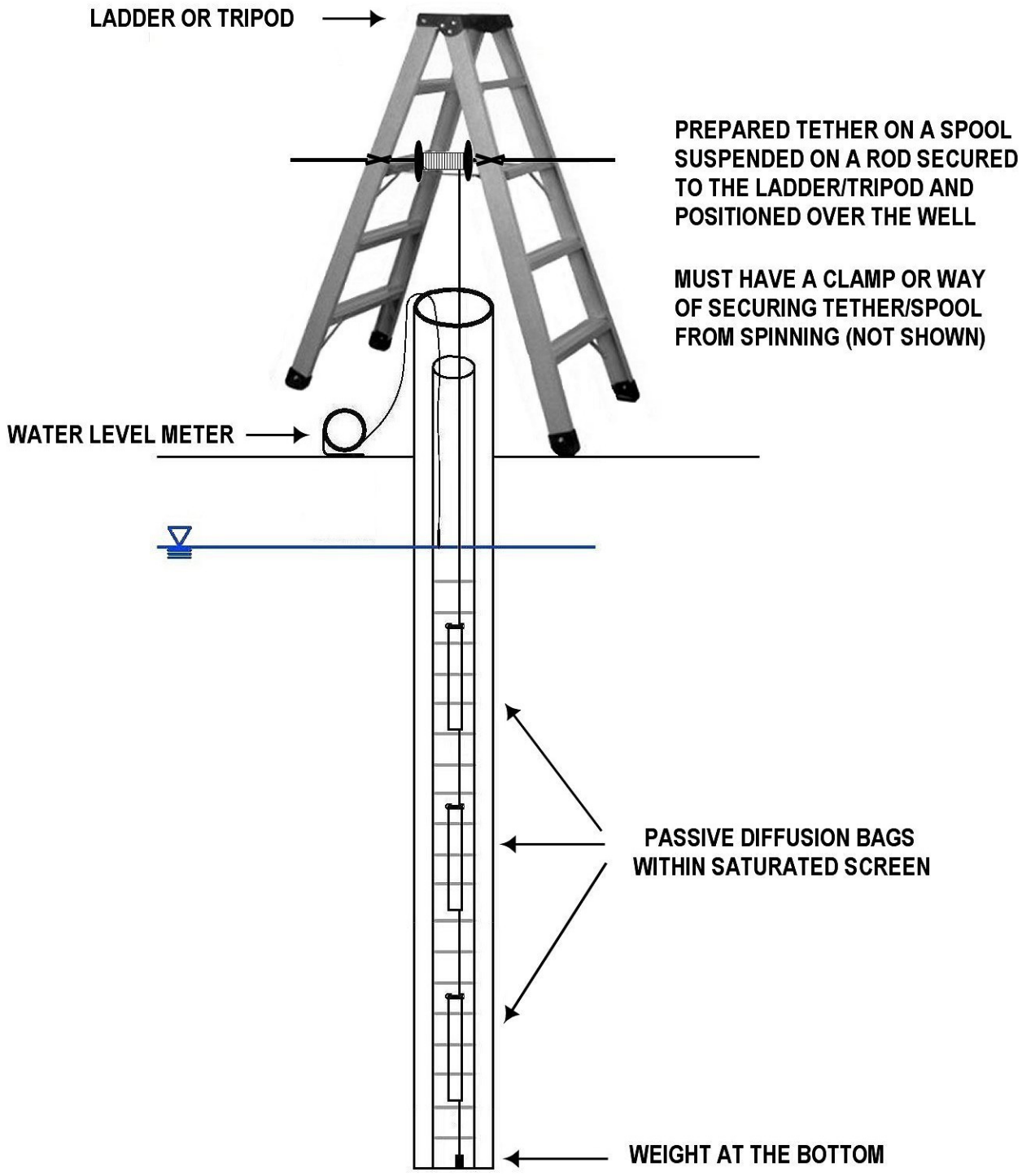
ATTACHMENTS

Passive Diffusion Bag Equipment Setup Diagram

Figures 1-3

EON Products, Inc., Equilibrator™ Diffusion Sampler Instructions

PASSIVE DIFFUSION BAG EQUIPMENT SETUP DIAGRAM



NOT TO SCALE

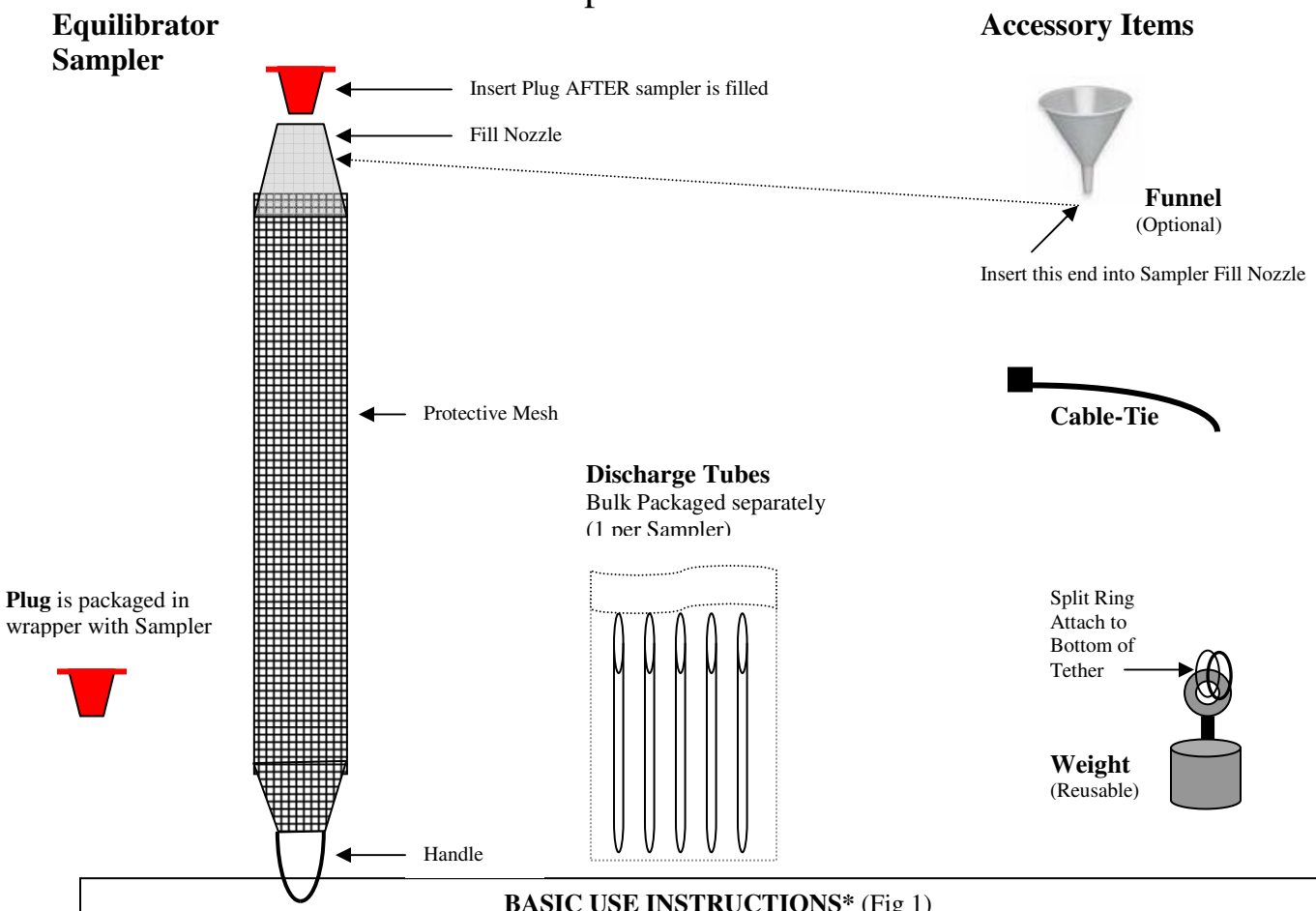
FIGURES

Figure 1.
Sample deployment and/or retrieval using a tether winding reel and an adjustable ladder.

Figure 2.
Filling a VOC Vial

Figure 3.
Locking J-Plug/Well Cap

EQUILIBRATOR ™
Diffusion Sampler Instructions



BASIC USE INSTRUCTIONS* (Fig 1)

1. **Fill the Sampler with deionized water** until the entire assembly is completely full of water. To use the funnel, insert the tip into the Sampler and pour deionized water into the tube. Fill the Sampler until water rises and stands at least two inches up the funnel to expand the Sampler to its maximum capacity. ***Gently squeeze and add more water to expand the membrane and remove air pockets. Repeat as needed until completely full.*** *Disclosure Statement – When filling the Sampler, we recommend that you hold the Sampler firmly at the top as close to nozzle tip as possible to prevent unnecessary stress on inside poly bag which could cause a leak to develop.*
2. **Insert the Plug firmly into the Sampler,** until the rim of the plug is as close to the nozzle as possible.
3. **Attach a Weight to the bottom of the Tether or Hanger.**
4. **Attach the Equilibrator(s) to the Tether line.** If installing on a factory prepared tether, locate the small (1/2" diameter) stainless steel rings that are attached to the Tether line. The rings will be separated by approximately 2/3 the length of the sampler. Use a Cable-Tie through the lower of two adjacent rings and through handle. Use a second Cable-Tie through upper of two adjacent rings and through a section of mesh below the fill nozzle in the softer part of the filled sampler. Tighten the Cable-Ties and snip off excess. Continue with each Sampler. If the factory did not prepare the Tether, then securely attach the Sampler(s) to the tether using cable ties at the intended location(s).
5. **Lower the Tether with Sampler(s) attached into the well.** Locate Sampler(s) below the water surface, in the screen flow zone of the well. Attach the top of the suspension cord to a well cap or other secure location at the top of the well. Leave Sampler in place for a time suitable for equilibration, a minimum of 2 weeks required.
6. **Upon retrieval: Discharge sample immediately** to avoid loss of volatile compounds. Select a point on the Sampler near the handle/bottom of sampler. Press one end of the Discharge Tube firmly into the clear polyethylene membrane at a downward angle until it pierces the membrane. ***Discharge small amount to waste to purge discharge tube.***

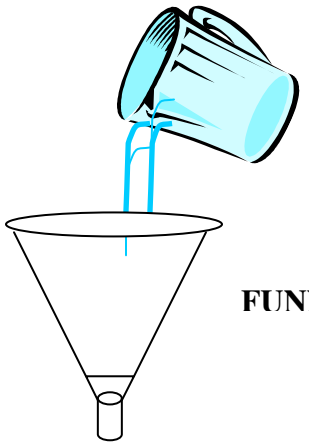
***Contact EON for detailed installation information and for factory prepared Tethers.**

800-474-2490

EQUILIBRATOR ™
Diffusion Sampler Instructions

STEP 1

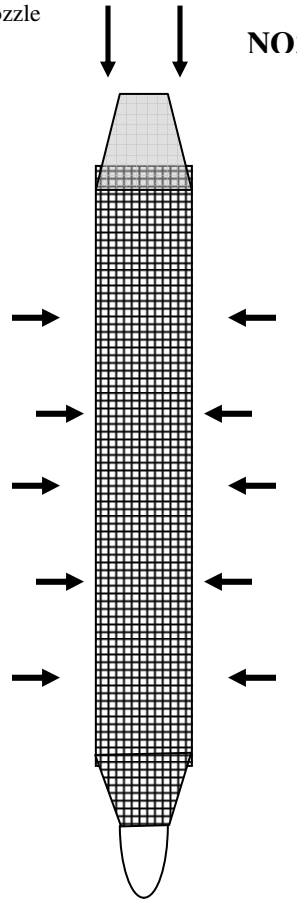
2. Pour DI Water into Sampler



FUNNEL

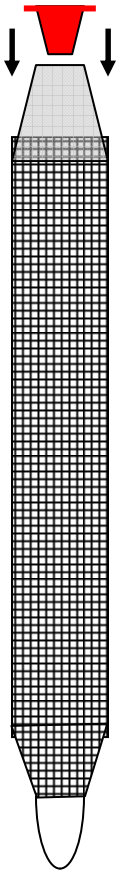
1. Insert Fill Funnel into Sampler Nozzle

NOZZLE

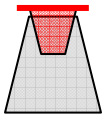


3. Squeeze Sampler & release multiple times to release air and expand volume. Add water & repeat as needed to fill.

STEP 2



1. Press Plug firmly into nozzle



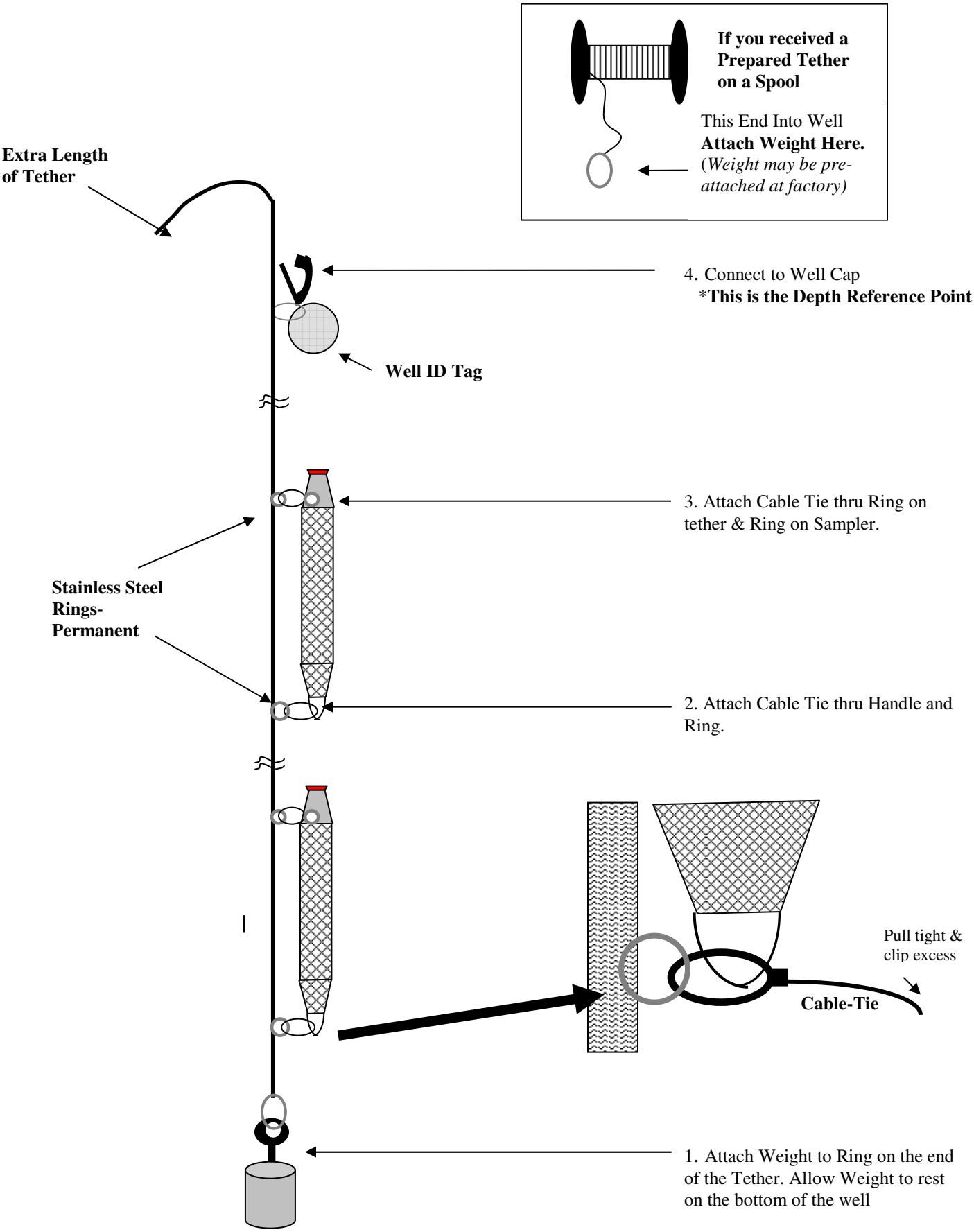
PRESS PLUG INTO NOZZLE UNTIL RED RIM TOUCHES WHITE NOZZLE

1. Fill the Sampler with deionized water until the entire assembly is completely full of water. To use the Funnel, insert the short nozzle into the Sampler and pour deionized water into the tube. Fill the Sampler until water rises and stands at least two inches up the funnel to expand the Sampler to its maximum capacity. **Squeeze the Sampler several times and add more water. Repeat as needed to expand the membrane and remove air pockets.** Fill to top of nozzle, leaving a meniscus.

2. Insert the Plug firmly into the Sampler, **until the rim touches the nozzle.**

3. Fill at least two VOA Vials with the DI water used to fill the samplers to use as a water blank. (Not Shown)

EQUILIBRATOR ™
Diffusion Sampler Instructions



BLADDER PUMP INTERVAL SAMPLING

PURPOSE

This Standard Operating Procedure (SOP) provides a general framework for using a bladder pump to collect groundwater samples at discrete intervals in select groundwater monitoring wells with screen intervals greater than ten feet in length. The purpose of sampling intervals is to evaluate whether contaminant stratification is present and to locate the zone of highest contaminant concentration.

Where the screened interval (within a well) is greater than ten feet, the potential for contaminant stratification and/or intra-borehole flow within the screened interval is greater than in screened intervals shorter than ten feet.

A key assumption in this SOP is that there is horizontal flow through the well screen and that the quality of the water vertically within a well is representative of the groundwater in the aquifer directly adjacent to the screen at that location. To the extent possible this SOP should be used in conjunction with borehole geophysics, or at a minimum a review and consideration of the specific well construction information to ensure the proper application of this procedure. For the purpose of this SOP, screen refers to screen intervals or open borehole.

Prior to sampling, a site and event specific Sampling and Analysis Plan (SAP) must be developed. The SAP should include specific information, such as the data quality objectives (DQOs), the number and type of samples and specific depths required at each monitoring well, and all quality assurance/quality control (QA/QC) requirements.

EQUIPMENT AND MATERIALS

The following is a list of equipment and materials commonly used for the collection of groundwater interval samples using a bladder pump set up:

- Appropriate health and safety gear and an approved site-specific Health & Safety Plan.
- Site Specific SAP which includes well construction data and a map.
- Appropriate keys for gates and wells.
- A diagram to show how the equipment should be set up.
- The manufactures instruction manuals for all equipment.
- Bladder pumps (e.g. QED Bladder Pumps) and repair kits (as applicable).
    1. The length, capacity, and placement of the pump in the well, shall be selected to maximize the filling of the pump's bladder.
    2. The bladder's capacity shall be large enough (over 70 milliliters [ml], preferably 100 ml) to ensure filling a volatile organic analysis (VOA) vial in one pulse.

- Controller (e.g. QED Bladder Pump Controller Model MP-10).

  The controller shall have a manual control button and be capable of adjusting the flow rates as low as 50 ml/minute.

- Compressed gas power source (non-gasoline powered): Either a compressed nitrogen tank (preferred) with a gas regulator for 150/200 pounds per square inch (psi) to a maximum of 400 psi (See "Special Notes" section at end of this SOP) or a marine battery operated air compressor (e.g. QED Model 3020 Electric Compressors); depending upon data quality objectives.
- Appropriate tubing (Teflon, Teflon-lined polyethylene or polyethylene); sized as recommended by the manufacturer or specified in the SAP. Both the air and sample lines should be made of the same material.
- Tags made of an appropriate material to identify the various interval depths.
- Cable ties to attach the tags to the tubing.
- Electronic water level meter measured to the nearest one one-hundredth of a foot (0.01').
- Flow measurement supplies: An appropriate sized graduated cylinder, (e.g. 50 or 100 ml, measured in 10 ml increments) and a stop watch to accurately measure the flow in ml/minute.
- A graduated bucket for purge water.
- Hach 2100P or 2100Q Turbidity Meter. Turbidity samples may be required when collecting semi-volatile organic compounds or metals.
- Calibration solutions the Hach Turbidity meter: <0.1, 10, 20, 100, 800 Nephelometric Turbidity Units (NTUs) standards, as appropriate for the selected meter.
- Laboratory-grade deionized (DI) water and tap water.
- Plastic sheeting, table or bucket to keep monitoring and sampling equipment off the ground.
- Paraphernalia to adequately shade and protect personnel, equipment, tubing and sample containers from the elements; to prevent bubbles forming in the tubing; and acid preservative in the sample containers from volatilizing.
- Decontamination equipment and supplies as specified in the SAP.
- Log book, pencil/pen/sharpies, and a calculator.
- Field-data sheets (as appropriate), worksheets, sample labels, chain-of-custody records (and custody seals if required in the SAP).
- Sample containers, preserved as necessary, cooler and loose ice (not bagged).
- Re-sealable plastic bags, bubble wrap, to protect and store samples.
- Trash bags to containerize solid waste.

- Toolbox to include such items as: adjustable wrenches, pliers, screw drivers, 25' measuring tape, a sharp knife with a locking blade, wire strippers, hose connectors, Teflon tape, a socket set, and duct tape.

PRELIMINARY PROCEDURES

1. If used, the turbidity meter must be calibrated according to an approved Calibration SOP. Refer to the SAP or the Calibration of Field Instruments SOP in the current Hazardous Waste Remediation Bureau Master QAPP (HWRB Master QAPP) for specific calibration and calibration check procedures, and calibration log.
2. Measure the total well depth of the wells and compare it with the reported depth of the well from well construction diagrams to evaluate whether sediment has accumulated in the bottom of the well.
3. Based on the measured well depth and the screen interval at each well location, determine the length of screen and the specific depths to be sampled. The bottom most sample should be collected from at least one foot from the bottom of the well.

   Samples are typically collected at every 5 foot interval of saturated screen. Refer to the SAP for specific interval lengths (e.g., 5, 10 or other foot intervals).

   Note. Unless otherwise specified in the SAP: If the screen is not fully saturated, the upper most sample interval should be at least 2 feet below the top of the water column; the bottom most sample should be collected from at least 2 feet from the bottom of the well.

   Attach tags identifying the specific sampling depth to the sample tubing using cable ties. To limit the purge volume at each depth, sampling should occur vertically, from the bottom to top. As the tubing is raised, the excess tubing is cut off to limit the volume required to be purged.
4. Remove any dedicated equipment from the well and temporarily place on clean poly sheeting.
5. Check well for security damage or evidence of tampering, record observations. Wells shall be locked at all times when not being sampled.
6. Refer to the quality assurance/quality control (QA/QC) section below and the SAP for equipment blanks.
7. Collect a water level measurement and record the measurement in field log book. Decontaminate the water level after each well using an approved Decontamination SOP from the SAP or the current HWRB Master QAPP.

SAMPLING PROCEDURES

1. Set up the equipment on polyethylene sheeting according to the attached diagram. Lower the pump intake to the first sample interval (bottom most sample location) and secure the pump and tubing to the well. Check the depth on the tag at the top of the PVC or well casing to make sure that the pump intake is located at the correct depth for the first sample.

Great care must be taken during pump installation and sampling to minimize the disturbance of particulates. Be sure all sampling equipment is properly protected from the elements.

2. Collect and record a water level measurement.

3. Activate the gas source, which activates the pneumatic controller.

4. Select the appropriate pressure/cycle setting for the MP-10 controller for the select well. The psi setting should be close to the psi needed to lift water the depth of the pump intake. **Note – this is different than typical low flow procedures. The goal is to minimize purging. Do not increase psi any more than necessary.** Be careful not to set the psi setting too high, which may result in a sample stream that shoots out of the tubing during sampling and/or damage to the bladder.

   The water flow out of the bladder pump during sampling must be a laminar flow without air bubbles. If air bubbles are observed they can usually be removed by elevating the discharge tube to allow the air to continue rising until discharged with the water. In the event that it is difficult to remove the captured air bubbles in the sample tubing, use the "pause-hold-sample" mode to flush the air bubbles out of the sample tubing.

5. Use a cycle setting of one cycle per minute. This setting should not change. Adjust the "refill" and "discharge" controls (cycles) according to well depth and pressure to optimize purging and sampling rates. Start with a discharge setting of 20 seconds and a refill setting to 40 seconds unless otherwise specified in the SAP. **Purging rates shall not be below 50 milliliters per minute.** Record the settings and adjustments.

   The refill and discharge rates shall be adjusted to collect a VOA vial in one pulse.

6. The purge rate should be approximately 50 ml/minute to limit draw from within the water column. **Purging rates shall not be below 50 milliliters per minute.** Use the graduated cylinder to measure the flow rate and adjust as needed. Record the settings and adjustments.

7. Purge one tubing and bladder volume prior to sampling. Any volume purged while adjusting the flow rate is considered part of the total required purge volume.

   Calculate the tubing volume based on the following formula:

   One purge volume (in gallons) is equal to $h * 3.14(r/12)^2 * 7.48$ gal/ft^3, where

   h = length of tubing (feet)
   r = internal radius of tubing (inches) = inside diameter/2

   Or, in other words, one purge volume is equal to (h) * (f) where:

   h = length of tubing (feet)
   f = the unit volume per foot of water column (gal/ft.)

   For convenience, the table below is provided in order to quickly determine the "f" factor. In order to more accurately measure the purge volume, the table can also be used to determine the purge volume in units of milliliters. It accounts for the gallons-to-milliliters conversion (1 gallon = 3,785 mL).

One purge volume (gal/ft. or ml/ft.) = one foot of tubing (ft.) x volume (gal or ml).

Tubing Diameter (inches)	1/4 (0.25) OD **(0.17 ID)***	3/8 (0.375) OD **(0.25 ID)***	1/2 (0.50) OD **(0.375 ID)***	5/8 (0.625) OD **(0.50 ID)***
Volume (gal/foot)	0.0012	0.0026	0.0057	0.0102
Volume (ml/foot)	4.5	9.7	21.7	38.6

OD = outside diameter ID = inside diameter

***Volume calculations based on tubing inside diameter (ID)**

Once the tubing volume is calculated, add the volume capacity of the bladder pump to get the total purge volume required. The volume capacity of the bladder pump and the specific tubing should be documented in the SAP.

Examples of various bladder pumps and tubing:

- **QED Sample Pro** – 100 ml capacity bladder with 1/4 (0.25) inch OD and a 0.17 inch ID for both air and water lines.
- **QED T1300** – 220 ml capacity bladder with 0.25 inch OD and 0.17 ID for air line; 3/8 (0.375) inch OD and 0.25 inch ID for water line.
- **QED T1250** – 100 ml capacity bladder with 0.25 inch OD and 0.17 ID for both air and water lines.
- **Geotech Geo.85SS24** – 60 ml capacity bladder with 0.25 inch OD and 0.17 ID for both air and water lines.

Record the calculations on the worksheet.

8. Once the purging has been completed, collect the samples. VOC samples are normally collected first and directly into pre-preserved sample containers.

   If the refill and discharge rates cannot be adjusted to collect a VOC vial in one pulse, then the VOC sampling will need to be performed in the “pause-hold-sample mode” to ensure a pulse volume of approximately 70 ml is available.

   Refer to the SAP for specific analytes and order of sample collection. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Sample containers should be wiped dry and placed in re-sealable plastic bags. Samples requiring cooling shall be placed within loose ice in the cooler.

   When the samples are retrieved, extreme care must be taken to ensure the depth of the pump intake within the well is accurately recorded in the field log book and in the comments section on the chain-of-custody as specified below.

9. After the samples have been collected, collect an aliquot and analyze for turbidity, if required. Record the measurement. Turn the pump off.

10. With the pump off, raise the bladder pump intake to the next sampling depth selected. Check the depth on the tag at the top of the PVC or well casing to make sure that the pump intake is located at the correct depth for the next sample. If the pump is at the

correct depth, cut off the excess tubing to limit the volume required to be purged and secure the tubing to the well.

11. Collect and record a water level measurement if required in the SAP.
12. Purge one tubing and bladder volume and collect the samples by repeating Steps 4-9 above. Continue raising the pump to each pre-determined depth, checking the depth on the tag at each interval, until samples have been collected at all sample depths.
13. Refer to the QA/QC section below and the SAP for information on field duplicate samples.
14. Once all samples have been collected, collect and record a final water level measurement.
15. Remove the pump and tubing, replace any dedicated equipment, and secure the well.
16. All non-dedicated equipment (water level meter, bladder pump) shall be decontaminated according to the Decontamination SOP in the SAP or in the current HWRB Master QAPP.

QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

QA/QC sampling shall be conducted in accordance with the SAP and generally consists of sample duplicates, equipment blanks, and routine temperature and trip blanks. Refer to the SAP for specific requirements.

At least one duplicate should be collected at a specific sampling depth. Refer to the SAP for details. Field duplicate samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g. VOC sample, VOC duplicate sample, total metals sample, total metals duplicate sample, etc.). Refer to the SAP for the specific well and depth location for the collection of all duplicate samples.

An equipment blank should be collected on non-dedicated equipment to ensure that the decontamination procedure is adequate.

There should be one Temperature Blank per cooler and one Trip Blank per chain-of-custody per cooler of VOCs.

RECORDS AND DOCUMENTATION

Refer to the SAP for specific documentation requirements.

All observations/field measurements shall be recorded in the field log books in permanent pen.

If the sampling results are going into the New Hampshire Department of Environmental Services (NHDES) Environmental Monitoring Database (EMD), sample labeling must follow the labeling constraints established for the EMD. In this case, the deployment depths for each sample in each well will have to be identified by the depth in the comment section only. The sample ID of the well itself (e.g., NHP_MW-102S) will remain the same under the sample ID on the chain of

custody. The various depths where the samples were collected will be in the comments section only. The laboratory will record the depths on each analysis page.

In addition, the equipment blank must be labeled as "EQUIP BLANK" on the chain of custody and "Bladder Pump" should appear in the comment section. If more than one bladder pump equipment blank is required, the specific pump model must also appear in the comment section of the chain-of-custody to distinguish one from another. The laboratory will record the comments on each analysis page.

SPECIAL NOTES

Special Considerations When Using Compressed Gas

When using compressed gas as the compressed air source, be sure to transport tanks upright and properly secured. Always remove regulator when transporting tanks or moving tank to a new sampling location. When using a tank for the first time, connect the regulator valve and shut the regulator valve off, then open the tank valve all the way and then close the tank valve (this seats the valve seal properly). The regulator valve shall use a pressure gauge that is 150 psi (minimum) to 400 psi (maximum).

REFERENCES

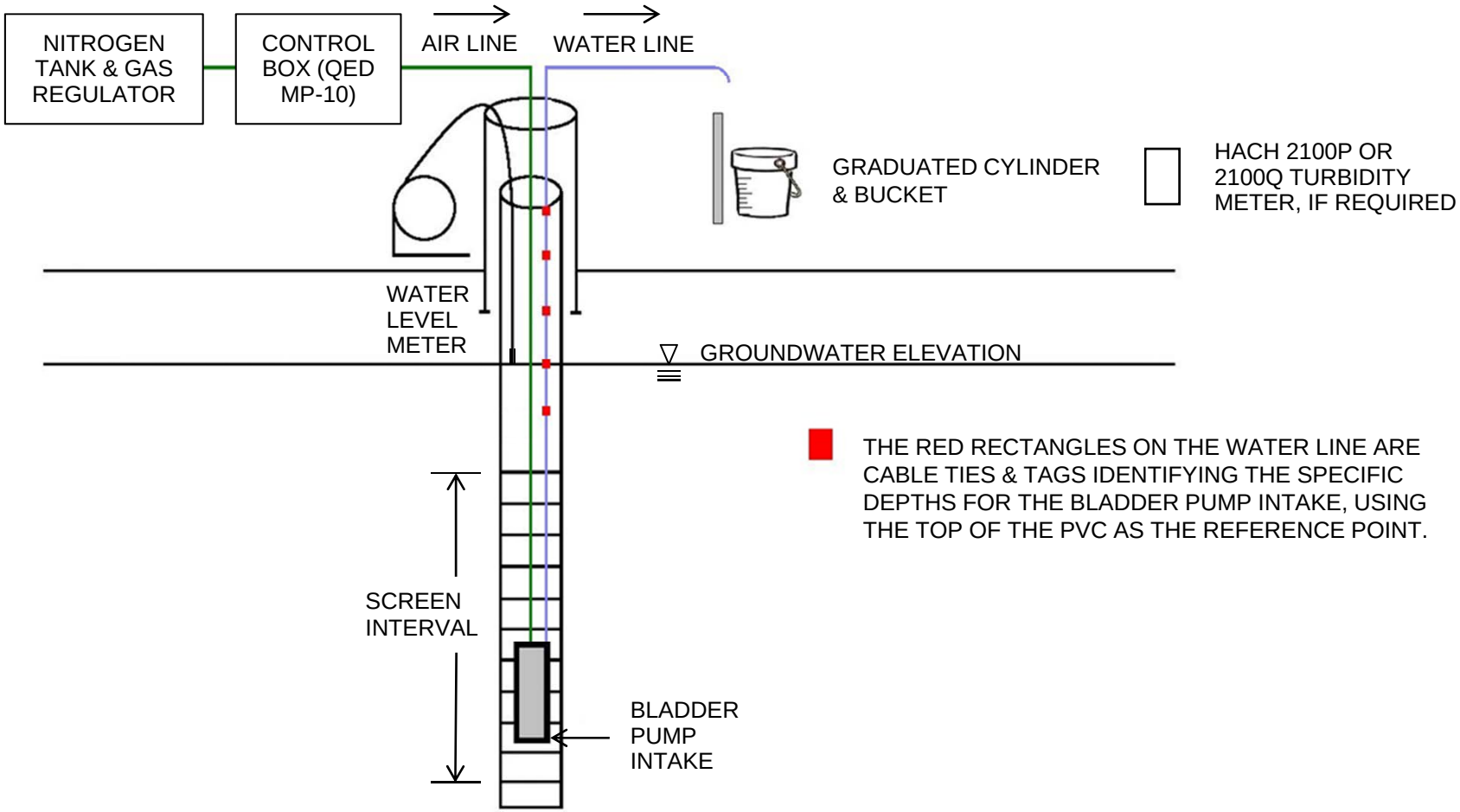
The Purging and Sampling with a Bladder Pump SOP found in the current version of the HWRB Master QAPP.

The Passive Diffusion Bag VOC Sampling SOP found in the current version of the HWRB Master QAPP.

ATTACHMENTS

Equipment Setup Diagram for Interval Sampling Using a Bladder Pump

EQUIPMENT SETUP DIAGRAM FOR INTERVAL SAMPLING USING A BLADDER PUMP



NOT TO SCALE

NHDES SOP
Preservation of VOCs in Soil Samples

Please note that the links found in appendix A and B in the original document below, dated March 2000, have not been updated. Current links have been provided here where possible. In some cases it may be necessary to copy and paste the link into the address bar. EPA now has a Method 5035A in addition to the EPA Method 5035. A link has been provided for the EPA Method 5035A as well. The Article in Appendix B has been attached to the document as a link is not available.

Appendix A
ASTM D 4547-98 and EPA Method 5035

An updated version of **ASTM D 4547-98** is now available on the ASTM website at: **http://www.astm.org.**

In general, EPA Hazardous Waste Test Methods / SW-846 are located on the EPA website at: https://www.epa.gov/hw-sw846

A copy of EPA Method 5035 is available at:
http://www.epa.gov/sites/production/files/2015-12/documents/5035.pdf

A copy of EPA Method 5035A is available at:
http://www.epa.gov/sites/production/files/2015-07/documents/epa-5035a.pdf

Appendix B
Massachusetts Policy and Article

A copy of the Massachusetts Policy (Preservation Techniques for Volatile Organic Compound [VOC] Soil Sample Analyses WSC # 99-415) is available at
http://www.mass.gov/eea/docs/dep/cleanup/laws/99-415.pdf.

A copy of the Article entitled "Collection, handling, and storage: Keys to improved data quality for volatile organic compounds in soil" written by Alan D. Hewitt, Thomas F. Jenkins, and Clarence L. Grant, from the American Environmental Laboratory Vol. 7 No. 1 (February) pg. 25-28, 1995, is now attached to the document.

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

FINAL POLICY

PRESERVATION OF VOCs in SOIL SAMPLES

MARCH 2000

Soil Sampling for VOC Analysis Policy

1.0 INTRODUCTION

This New Hampshire Department of Environmental Services (DES) "Soil Sampling for VOC Analyses" guidance document contains recommendations for soil sampling protocols for all petroleum and hazardous waste sites. The protocols are applicable to all soil samples analyzed for volatile organic compounds (VOC). This guidance was developed in response to a preponderance of scientific evidence indicating the under-reporting of VOC concentrations due to VOC loss during sample collection and storage. The three main mechanisms responsible for the VOC loss are: 1) initial sampling and sub-sampling activities that disturb/destroy soil structure and/or aerate samples, 2) volatilization/diffusion out of the sample container during storage and 3) biodegradation of contaminants during storage.

The EPA has issued soil VOC sampling and analysis methodology [SW 846 Method 5035 (December 1996)]. ASTM has also adopted a standard for low VOC loss sampling [ASTM Standard D4547-98 (Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds)]. In these methods (see Appendix A), methanol is added immediately to the sample while in the field to preserve the soil sample. Region IV and a number of states, including Alaska, Massachusetts, Minnesota, New Jersey, New Mexico, Pennsylvania, South Carolina and Wisconsin, have adopted policies requiring methanol preservation of soil samples containing VOCs. In Massachusetts the methanol preservation requirement was established on October 31, 1997 for the Volatile Petroleum Hydrocarbon (VPH) analysis method and on March 5, 1999 for all soil samples subject to VOC analysis (Preservation Techniques for Volatile Organic Compound (VOC) Soil Sample Analyses: WSC #99-415). The Massachusetts Policy and a general article on VOC loss from samples are included in Appendix B.

DES believes that the availability of specialized soil VOC sample containers with pre-measured methanol and the recent development of alternative low VOC loss sample devices/containers minimizes the costs and logistical requirements for implementing this new sampling approach.

2.0 APPLICABILITY

Sampling protocols contained in this document are required for all soil samples that will be analyzed for VOCs by EPA SW 846 Methods 8015A, 8021B, 8260B or equivalent EPA Standard Methods procedures. The sampling protocols should also be used whenever VOC loss can significantly affect the accuracy of the results, such as the analysis of gasoline contaminated soil for TPH. The policy does not apply to onsite mobile laboratory analyses, when samples are collected and analyzed the same day. The policy also does not apply to field screening methodologies, such as PID/FID headspace screening, UV Fluorescence & Adsorption, Immunoassay Test Kits or portable GC units that are used on a real time basis. All other data obtained from a sampling methodology that does not follow this policy will be considered to be improperly preserved and not scientifically valid. DES may reject the results and require resampling when the soil sampling protocols in this policy are not properly followed. No phase-in of the policy is

recommended because of the general availability of the required sampling equipment, and the familiarity of the laboratories in the region with the required methodologies due to the similarity with Massachusetts' policy. This policy will become effective March 30, 2000.

3.0 PREVIOUSLY OBTAINED OR SUBMITTED DATA

The following table describes how unpreserved VOC soil data will be managed, based upon the sample collection and the report submission date.

Sample Collection Date	Data Submission Date	Comments
Before 3/30/2000	Before 3/30/2000	DES will not reopen sites that were closed based on previous sampling practices, unless new data or information becomes available. DES may require reevaluation of data at active sites, if evidence exists that may be significant health and environmental concerns. Factors that will be considered when making a decision to reevaluate existing data are listed below.
Before 3/30/2000	On or after 3/30/2000	Consultants and site owners should evaluate the data and site characterization to determine whether loss of VOCs is a significant issue. The report should discuss the sampling protocols that were used and recommend whether the soil should be resampled.
After 3/30/2000	On or after 3/30/2000	Proper preservation techniques must be used, or DES will not accept the data. The petroleum reimbursement funds will not reimburse for the cost of the analysis of samples that were collected improperly. Change orders for related costs can be submitted to the reimbursement program for work scopes submitted prior to implementation of the policy.

Data Evaluation Factors

1. VOC headspace and other screening data indicate significant levels of VOCs;
2. The type, toxicity and persistence of VOCs present (e.g., Chlorinated compounds and MtBE generally pose a greater long term threat to groundwater and the environment);
3. High and/or consistent levels of VOCs in groundwater indicate that VOCs in soil may be a continuing source; or
4. The presence of sensitive receptors or exposure pathways at or in the vicinity of the disposal site.

4.0 METHODOLOGY

The methodology in ASTM Standard D4547-98 or EPA Method 5035 should be followed for the collection of all VOC samples. These methods provide additional, valuable guidance on sampling protocols, for example, procedures necessary to successfully sample oily wastes. DES believes that in the vast majority

of cases samples can be collected using the following two soil preservation techniques discussed in ASTM D4547-98 and EPA Method 5035: 1) field preservation with methanol and 2) the use of a low VOC loss sampling system such as the EnCore™ sampler or equivalent. The DES requires that the laboratory report a minimum wet weight estimated quantitation limit of 100 µg/kg for these two methods.

A third methodology can potentially be used to achieve a lower VOC detection limit (<100 µg/kg). This method is known as the low level or sodium bisulfate preservation technique. DES notes that only the following twelve VOC contaminants have S-1 soil cleanup standards equal to or below the <100 µg/kg detection limits achievable by methanol preservation: acrylonitrile, bromodichloromethane, bromoform, chloroform, dibromochloromethane, dibromochloropropane, 1,2-dichloroethane, 1,2-dichloropropane, ethylene dibromide, methylene chloride, 1,1,2,2-tetrachloroethane and 1,1,2-trichloroethane. All of the S-1 soil standards for these compounds were based on a potential threat to groundwater, not direct contact risk. As a result, it is not necessary to achieve the lower detection limit using the sodium bisulfate preservation technique, if data exists indicating that groundwater impacts have not occurred. It should be noted that the bisulfate method has the following shortcomings: a) special equipment is required at the laboratory, b) the sodium bisulfate may react with humic compounds to generate acetone and 2-butanone, c) the sample will effervesce when carbonates are present and d) more complex field protocols are required. DES, as a result, does not recommend the use of the sodium bisulfate preservation technique, unless the lower detection limit is absolutely necessary to identify groundwater contamination source areas containing one of the twelve contaminants with S-1 standards less than or equal to 100 µg/kg.

DES will consider other low VOC loss sampling protocols beyond the three discussed in this document on a case-by-case or site-specific basis. DES approval is required prior to sample collection for any other low VOC loss protocol that is not specifically discussed in this policy.

4.1 Methanol Preservation

The methanol preservation technique must be performed in the field and involves the following key steps:

- Collection of 5 to 25 grams of soil. Typically the lab will mark a level on the bottle that indicates the volume that should result after the addition of the soil to the methanol. A duplicate sample should be collected, in case the sample analysis must be rerun. Additional samples may need to be collected based on site-specific QA/QC requirements (i.e., matrix spike, matrix spike duplicate, etc.)

- Addition of "purge and trap" grade or equivalent methanol to the sample vial at a desired ratio of 1:1 (grams soil/mL methanol). The tolerance for this ratio is +/- 25%. Ratios outside of this range may be acceptable, depending on data quality objectives. Soil samples must be completely immersed in methanol.

- It is not necessary to weigh the sampled soil in the field as long as the weight of the soil can be calculated and the soil weight/volume ratio is +/- 25% of the acceptable 1:1 ratio. There are a number of soil sample collection devices available to facilitate accurate collection of the required

volume of sample.

- An additional unpreserved sample must be collected to allow for a determination of moisture content. Without the additional sample, the laboratory cannot report the results on a dry-weight basis. Moisture effects may become significant at moisture contents greater than 25%. When moisture content is greater than 25%, data reports should discuss the implications of sample dilution resulting from the high moisture content.

- The sample must be analyzed by an EPA or New Hampshire accredited laboratory.

DES prefers the use of sampling bottles obtained from the laboratory with pre-measured quantities of methanol. This will ensure that appropriate purity methanol is used and minimizes handling of methanol by field personnel. DES also recommends using a volumetric sampling device to collect the soil sample. This minimizes the loss of VOCs during sample collection and eliminates the need to weigh samples in the field. Sample containers should not remain open for long periods of time to minimize the potential for cross contamination of the sample and the loss of methanol. Please refer to ASTM D4547-98 and EPA Method 5035 for additional information about proper sampling technique and the sodium bisulfate method (if site specific circumstances warrant its use).

4.2 Alternate Sampling Methods

An EnCore™ sampler or similar DES approved device with proven effectiveness may be used to obtain samples in the field without preservation, provided that the sample is extruded into methanol or extracted by a laboratory within 48 hours of sample collection. The sampler must follow the manufacturer's directions for the sampling device used and all other appropriate sample preservation protocols, such as keeping samples at or below 4º C. Information on the use of EnCore™ samplers is included in ASTM 4547-98 in Appendix A.

5.0 SAMPLE COMPOSITING

Composite samples can be collected using the methanol method of sampling. To accomplish this, grab samples would be collected in accordance with the methodology discussed in section 4.1 of this policy. The laboratory then prepares the composite sample by using a syringe to collect equal amounts of the methanol preserved sample from each of the vials. The subsamples are then combined to yield the required composite sample volume.

An alternate approach to collecting composite samples that does not require compositing of the samples at the laboratory is to use a large VOC vial with septum lid. Methanol is added to the VOC vial in proportion with the number of samples that will be composited to ensure that the desired ratio of 1:1 (grams soil/mL methanol) is maintained. For example, 25 ml of methanol would be added to composite five, 5 gram soil samples. All of the soil samples that are to be composited are then added to the VOC vial containing the methanol with care exercised to prevent methanol from splashing out of the vial.

Soils that are proposed for reuse onsite must be analyzed using a low VOC loss composite sampling methodology such as this, or by representative low VOC loss grab sampling. DES does not require that this policy be used for the purposes of characterizing soil for an offsite disposal facility. It is necessary to use the sampling approach discussed in this policy, however, if the data will be used for both offsite site disposal facility purposes and remedial decision making on whether the soil can remain onsite.

Appendix A
ASTM D 4547-98 and EPA Method 5035

Appendix B
Massachusetts Policy and Article

Copied from AMERICAN ENVIRONMENTAL LABORATORY, Vol. 7, No. 1 (February) pg. 25-28, 1995.

Collection, handling, and storage: Keys to improved data quality for volatile organic compounds in soil

By Alan D. Hewitt, Thomas F. Jenkins, and Clarence L. Grant

OUR DEPENDENCE on petroleum-based fuels and chlorinated solvents has made the volatile organic compounds (VOCs) present in these products almost synonymous with hazardous waste cleanup efforts.[1] The potential carcinogenicity of these VOCs in the environment requires an effort to limit human exposure. The first step in the remediation of hazardous waste sites is to locate sources and pathways of contamination. Soils are often of concern because they serve as a pathway between surface spills or leaks and domestic groundwater.

In spite of the vast numbers of soils analyzed for VOCs each year, there remains no universally accepted procedure for their collection and storage.[2] An all-too-common occurrence is that after detecting the presence of VOCs using field portable instruments, much lower concentrations are obtained for co-located samples analyzed at a fixed (off-site) laboratory. An example is shown in *Figure 1*, in which the differences exhibit both systematic and random error.[3] Only rarely have studies demonstrated a strong correlation between on-site and fixed laboratory purge-and-trap gas chromatography-mass spectrometry (PT-GC-MS) results (*Figure 2*).[3,4]

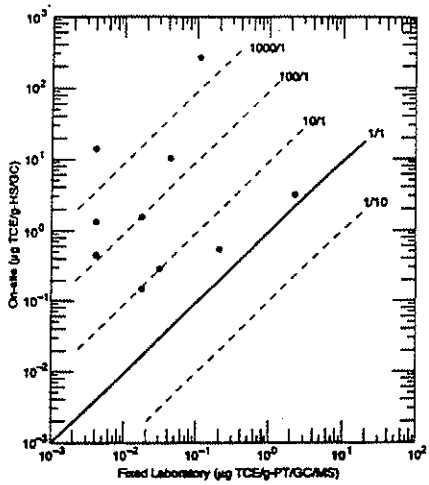


Figure 1 *Correlation between on-site and fixed laboratory results for TCE in co-located soil samples in which the latter used bulk samples obtained by customary procedures.*

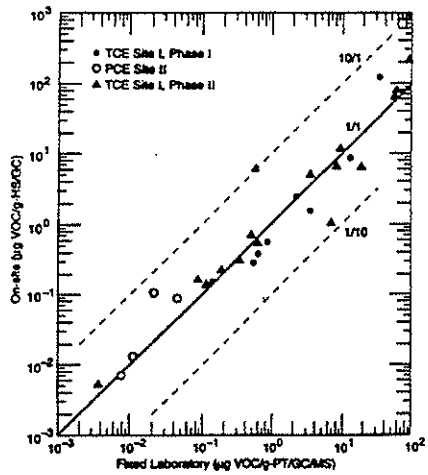


Figure 2 *Correlation between on-site headspace (HS)-GC analysis and fixed laboratory PT-GC-MS analysis for VOC concentrations in colocated soil samples obtained during three different field investigations using a limited soil structure disruption single transfer technique.*

When disparities arise between on-site and fixed laboratory results, they have been attributed to sample collection, handling, holding time, analyte spatial variability, and systematic differences between the analytical methods.[2] Although these problems have long been recognized, corrective measures have not been widely adopted. This report presents experiments that show how VOCs are lost from soils prior to analysis. Specifically we will address each of the following areas of concern: bulk soil sample collection, storage, preservation, and fixed laboratory subsampling. Following this discussion, a promising sampling and analysis protocol will be outlined that limits soil structure disruption, requires only a single transfer step, and includes chemical preservation.

Experimental design and results

The most commonly used soil sampling procedure for VOCs[5] recommends that samplers wearing plastic gloves use clean stainless steel utensils to completely fill either 40- or 250-mL glass bottles that are closed with PTFE-lined caps. The bottles are shipped to an off-site laboratory and stored at 4 °C until opened for subsampling and subsequent analysis. Experiments described here were designed to illustrate the magnitude of potential VOC losses during the several stages of this process.

Bulk soil sample collection

Although most site sampling plans

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stress the need to minimize the time of soil exposure, they seldom provide adequate specific details on soil collection and transfer to bottles. Consequently, bulk sample storage bottles may be filled with little attention to how much soil disaggregation occurs. Furthermore, since these bottles are often filled to capacity with utensils that do not fit inside of the bottle mouth, the threads and brim become soiled, thereby preventing proper sealing. This sampling protocol allows volatilization losses to go unchecked during the transfer of soil to, and after closure of the bottles.

The results of two experiments demonstrate the losses resulting from VOC volatility that can occur during the bulk soil sample collection and storage. In the first experiment the authors evaluate two different sample collection and storage protocols by comparing the analytical results for trichloroethylene (TCE) from co-located soil subsamples taken from the same split spoon.[6] One set of subsamples was transferred in the field from intact split spoon soil cores to volatile organic analysis (VOA) vials, while the other set was first placed in bulk sample storage bottles that were later opened for subsampling. All of the subsamples were taken using a 10-cm^3 tipless plastic syringe and were immediately transferred into VOA vials containing 30 mL of water for headspace gas chromatography (HS-GC) analysis. With this subcoring device, we obtained and transferred 2- to 5-g soil subsamples with minimal structure disaggregation (*Figure 3*).[7,8] Subsamples collected from the intact soil core were analyzed within 1 to 4 days after collection, while those taken from bulk sample bottles were removed for analysis after 1 to 6 days of storage.

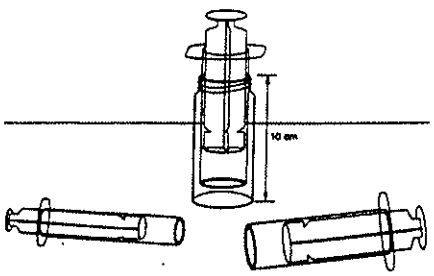

Figure 3 *Illustration of modified syringes used to transfer intact plugs of soil.*

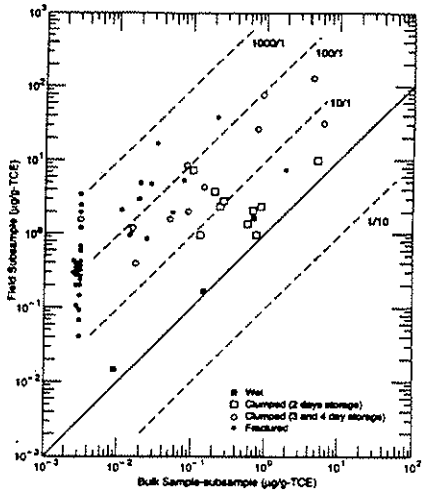

Figure 4 *HS-GC-TCE concentrations (µg/g) for co-located samples obtained directly from a split spoon soil core and from bulk sample storage bottles.*

The results of this experiment are shown in *Figure 4*, in which concentrations for subsamples removed from the intact soil core are plotted versus those taken from the bulk sample storage bottles. In every case, The TCE concentrations obtained for the subsamples taken directly from the soil cores were greater than those from the bulk sample storage bottles. Some of the differences amounted to as much as three orders of magnitude. In addition to showing similar bias and random scatter as shown in Figure 1, Figure 4 calls attention to several distinct populations of points. The classification for these groups was based on visual appearance of the soil in the bulk sample storage bottles, and the elapsed time between collection and subsampling ("wet" were silty clays from perched water tables; "clumped" were silty soils; and "fractured" were sandy soils). The physical state of the soils appears to explain some of the scatter when comparing these two collection and handling methods among the samples in which TCE was found above the detection limit of 3 ng/g. The three co-located subsamples described as wet fall between the 1/1 to 10/1 concentration bands (field/bulk), showing a mean recovery of 60% from the bulk sample storage bottles relative to those obtained from the intact soil core. Likewise, clumped soils were between 1/1 and 100/1, with a mean recovery of 16%, and the majority (11 of 12) of fractured soils were between 10/1 and 1000/1, with a mean recovery of 4.1%.

This data set also can be used to look for a storage period effect on the TCE concentrations determined for the subsamples removed from the bulk sample storage bottles. This comparison was made only for storage bottles with clumped soils because the losses from most of the fractured soils extended below the level of detection, and there were only three samples classified as wet. Distinguishing between those bottles with clumped soil subsampled two days after collection and those subsampled three or four days after collection also appears to create two distinct populations (Figure 4). The majority (8 of 10) of clumped soil subsamples analyzed after two days were between the 1/1 and 10/1 bands, while those subsampled after one or two additional days of storage showed the majority (9 of 10) to exist between the 10/1 and 100/1 bands. The means of the TCE values relative to co-located samples collected in the field for these two storage periods were, respectively, 27% and 4.3%. A nonparametric analysis using the Wilcoxon-Mann-Whitney test found that the three physical state groupings were different at the 95% confidence level, as were the two storage period groups.

The second experiment was designed to examine analyte concentration stability during bulk sample storage in bottles with closures of differing cleanliness.[6] Six randomly chosen bulk sample storage bottles were emptied of their soil contents. Three were completely washed, removing all of the visible soil from the bottle and cap, while the remaining three were only partially washed, removing only the soil from the bottle's interior surface. These 4-oz bottles (total capacity, 135 mL) were then filled with 125 mL of water and spiked with a 1-mL methanol (MeOH) solution containing *trans*-1,2-dichloroethylene (TDCE), trichloroethylene (TCE), benzene (Ben), and toluene (Tol), and tightly capped. After five days of storage at 4 °C, the bottles were opened one at a time and a 5-mL aliquot was transferred to a VOA vial containing 25 mL of water for HS-GC analysis. *Table 1* shows that the bottles with unwashed closures failed to retain these VOCs in

Table 1

Clean vs dirty closures on bottles used to store aqueous solutions containing TDCE, TCE, Ben, and Tol. Concentration estimates for the clean and dirty closures are significantly different at the 95% confidence level using Students' t-test.

	Concentration (µg/L) Clean	Dirty
TDCE	480 ± 50*	260 ± 22
TCE	560 ± 57	320 ± 20
Ben	350 ± 32	200 ± 14
Tol	630 ± 48	370 ± 17

*Average and standard deviation, $n = 3$.

solution as well as the bottles with clean closures. The majority of the bulk sample storage bottles used in the first experiment were found to have soiled closures, thus it is impossible to separate the losses solely attributable to the collection of the bulk sample and subsequent subsample transfer from losses due to vapors escaping during storage.

Based on the findings, the extent of VOC losses when bulk sample collection protocols are used will be proportional to the coarseness and dryness of the material, the length of time samples are stored prior to subsampling, and the cleanliness of the closure surface. These volatilization losses can randomly reduce VOC concentrations by one to three orders of magnitude.

Biodegradation

Significant reductions in VOC concentrations have been reported when soil subsamples were held for a 14-day period at 4 °C without chemical preservation.[9–11] These losses were attributed to both volatilization and biodegradation, but how much loss resulting from each process was unknown. By eliminating the volatilization loss and the use of a spiking solvent we are able to examine the role of biodegradation.[12] In these experiments, vapor-fortified[13] soil subsamples were retained in sealed glass ampules or closed VOA vials during storage and analysis.

Three experimental conditions were tested with soil subsamples vapor-fortified with Ben, Tol, TDCE, and TCE and held at 4 °C. In the first holding time experiment, the VOC-fortified soil subsamples were held in sealed glass ampules during storage and opened just prior to HS-GC analysis. For this analysis they were enclosed in VOA vials with 30 mL of water and shaken, causing the ampule to break and disperse its contents.

In the second and third experiments, sealed glass ampules containing VOC-vapor-fortified soils were placed inside VOA vials that were equipped for either HS-GC or low-level PT-GC-MS analysis. For the purge-and-trap experiment, the VOA vials were fitted with special adapters, the model PT-6005-0002 (Associated Design and Manufacturing Co., Alexandria, VA). The holding period study was initiated for these two experiments once a glass ampule had been broken and the soil was dispersed inside the VOA vial. Analysis by either HS-GC or low-level (<1 µg VOC/g) PT-GC-MS was performed without ever opening the VOA vial.[3,8]

In all three experiments moisture was introduced to facilitate biological activity prior to starting the holding time study. In the first experiment this was accomplished by adding 200 µL of water to the glass ampules just prior to sealing. In the second and third experiments, water was added to each VOA vial prior to introducing the ampule. Thirty milliliters of water was added for the HS-GC subsamples, and 200 µL was added for low-level PT-GC-MS subsamples.

Table 2

Biodegradation experiments

Mean analyte concentrations (µg/g) for soil subsamples stored in sealed glass ampules (experiment 1).

	Day 0	Day 5	Day 11	Day 20
TDCE	3.8 ± 0.2*	3.5 ± 0.2	4.1 ± 0.2	4.0 ± 0.3
Ben	6.1 ± 0.7	5.9 ± 0.2	6.2 ± 0.2	5.7 ± 0.2
TCE	5.8 ± 0.1	5.3 ± 0.2	5.8 ± 0.2	5.8 ± 0.1
Tol	7.4 ± 0.1	7.0 ± 0.4	7.3 ± 0.3	7.2 ± 0.4

Mean analyte concentrations (µg/g) for soil subsamples stored in VOA with 30 mL of water and repeatedly analyzed (experiment 2).

	Day 0	Day 2	Day 5	Day 9	Day 14
TDCE	3.7 ± 0.2	3.6 ± 0.1	3.5 ± 0.1	3.3 ± 0.1	3.2 ± 0.1
Ben	7.1 ± 0.2	6.2 ± 0.2	6.1 ± 0.2	4.8 ± 0.4	<0.1
TCE	6.0 ± 0.2	5.6 ± 0.2	5.4 ± 0.2	4.9 ± 0.1	4.8 ± 0.3
Tol	14 ± 0.4	12 ± 0.4	12 ± 0.5	10 ± 0.7	5.2 ± 1.1

Mean analyte concentrations (ng/g) for soil subsamples stored in VOA vials with purge-and-trap adapter cap (experiment 3).

	Day 0	Day 4	Day 7	Day 14
TDCE	9.5 ± 0.5	9.0 ± 0.2	9.6 ± 0.3	9.2 ± 1.2
Ben	13 ± 0.4	13 ± 0.2	7.4 ± 1.8	ND
TCE	14 ± 0.7	13 ± 0.2	12 ± 0.7	12 ± 1.5
Tol	33 ± 0.5	32 ± 1.0	26 ± 3.8	10 ± 2.5

*Average and standard deviation, $n = 3$.
ND — not detected.

The results for all three experiments are shown in *Table 2*. Fortified soil subsamples held in sealed glass ampules showed a <10% relative change in Ben, Tol, TDCE, and TCE concentration over a 20-day period, and the variations appeared random rather than systematic. Only very small relative changes occurred over a 14-day period for TDCE in experiments 2 and 3, and the maximum decrease in TCE concentration was only 20%. However, there were large reductions in both Ben and Tol (*Figure 5*). Although not shown here, similar experiments have shown Ben and Tol concentration stability to vary with temperature, soil type, and treatment concentration.

The results of the first experiment appear to be consistent with the persistence of VOCs in an oxygen-limited, undisturbed subsurface environment. However, once the subsample was exposed to the atmosphere, as would occur during the transfer of either a bulk or small subsample to their respective storage and/or analysis vessels, losses of Ben and Tol resulted that were proportional to the storage period even

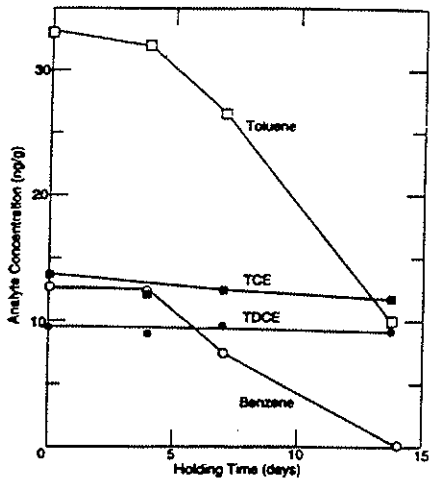

Figure 5 *Stability of Ben, Tol, TDCE, and TCE in soil subsamples prepared for low-level PT-GC-MS analysis.*

though volatilization losses were eliminated.[12] The loss of these two aromatic VOCs and the persistence of the two chlorinated VOCs, in experiments 2 and 3, were consistent with published environmental degradation rates showing half-lives of 5 to 22 days for Ben and Tol, and 4 weeks to 1 year for TCE and TDCE.[14] Thus, depending on the analyte of interest, sample treatment, origin (soil type and microbiological activity), and holding period, biological degradation can greatly influence VOC concentration stability.

Laboratory subsampling

The dynamic range for VOC analysis by GC-MS is less than three orders of magnitude. Because of this limitation, samples have to be prepared in an appropriate manner for analyte concentrations to fall within the calibrated range. Method 8240 of the SW-846 specifies that soil subsamples with VOC concentrations ≤1 µg/g are to be analyzed directly, whereas samples with concentrations ≥1 µg VOC/g are first extracted with MeOH, and a small portion of this extract is transferred for analysis.[5] Regardless of which preparation method is used, the vessel containing the bulk sample shipped from the field must be opened and a subsample removed. This subsample transfer step is usually performed with a stainless steel spatula or similar device and takes place in a sample preparation room. Thus, handling and weighing often occur at a different location than analysis.

To assess the extent of VOC losses that might occur when subsamples are removed for laboratory analysis, bottles that had been subsampled and analyzed during the bulk soil sample collection experiment were reexamined.[6] From two bulk sample bottles containing clumped soils, ten subsamples were removed, five using a tipless 10-cc syringe and five using a stainless steel spatula, in an alternating sequence. Those transferred with the syringe were immediately placed into a VOA vial containing 30 mL of water and capped, while subsamples transferred with a spatula were placed into an empty VOA vial, weighed, and then 30 mL of water was added prior to capping. The subsamples transferred with a spatula were exposed to the atmosphere for a total of 3 min. The authors maintain that this exposure period is typical when several subsamples are weighed out sequentially and then taken to the room in which the analysis occurs.

The results in *Table 3* show that there were substantial losses of TCE when soils were transferred with a spatula into empty vials. This finding is in good agreement with other studies of analyte VOC losses resulting from subsample exposure and transfer.[15–17] These findings demonstrate that when preparing for laboratory analysis, the method of subsample transfer and time of exposure to the atmosphere can have a large influence on VOC concentration estimates.

Table 3
Concentrations (µg/g) of TCE in subsamples transferred from bulk sample storage bottles using two different protocols. Average TCE concentrations for the syringe and spatula transferred subsamples are significantly different at the 95% confidence level using Students' t-test.

	Bottle I		Bottle II	
	Syringe	Spatula	Syringe	Spatula
1	0.042	0.015	0.27	0.15
2	0.020	0.021	0.24	0.15
3	0.034	0.026	0.34	0.14
4	0.025	0.023	0.51	0.17
5	0.038	0.024	0.56	0.27
	0.032*	0.022	0.38	0.18
	0.009†	0.004	0.14	0.054

*Average (µg/g).
†Standard deviation.

Discussion

The degree of sorption/desorption of nonionic VOCs by soils depends principally on moisture and organic matter content.[18] Subsurface soils typically contain little organic matter, therefore the association of VOC vapors is often controlled by the combination of moisture and soil texture/structure. VOCs are thought to sorb onto dry mineral surfaces by a physical process, perhaps involving van der Waals forces.[19] This concept of weak physical interactions has been supported by sorption/desorption studies of VOC vapors on dried clay minerals, which show an initial fast interaction followed by a slower one.[19,20] The faster process is assumed to be surface mineral release/sorption, while the slower process most likely involves diffusion into or out of intra-aggregate micropores. Weakly bound and physically trapped VOCs are lost by means of disaggregation of soils during transfers by various utensils. Furthermore, regardless of the collection and transfer procedures used, the soil becomes exposed to the ambient atmosphere. For these reasons, the current practice of collecting bulk samples from which subsamples are removed is unrealistic with regard to the ease in which these compounds can be lost by volatilization and perhaps biological degradation.

A logical solution is to use a single transfer sampling method that minimizes soil structure disruption and compromising of the containment vessel seals, and preserves aerobically degradable VOCs between collection and analysis. This can be achieved by using a tipless syringe (o.d. 1.6 cm or less) for sampling soils with small- and medium-size grains and with moisture contents ranging from <1% to water-saturated. This device is small enough to fit inside the mouth (i.d. 1.8 cm) of a VOA vial, therefore transfers can be made easily without compromising the sealing surfaces. To eliminate biodegradation, subsamples require chemical preservation. This can be achieved by immersion in MeOH[21] or in water acidified to below pH 2 using $NaHSO_4$.[22,23]

The limited disruption single transfer approach to soil sample collection and analysis was used for all of the determinations shown in Figure 2. This

plot clearly shows that a strong correlation can be obtained between on-site and fixed laboratory analyses when sample collection, handling, and storage procedures limit volatilization and biological losses. For this comparison, aqueous extraction, static HS-GC was chosen for on-site determinations because it is a well-developed analytical Method for the analysis of VOCs.[24–26] In a comparison study of both composite (three or more subsamples immersed in solution) field sample[4] and laboratory vapor-fortified samples,[27] method 8240, PT-GC-MS[5] and HS-GC consistently produced quantitative results that were very comparable for low (<1%) organic content soils. Therefore, the deviations from unity (1/1) shown in Figure 2 may largely reflect co-located subsample analyte spatial variability, which was typically much less than an order of magnitude.

Proposed sampling protocol

The following field sampling outline presents the steps that have been successful in maintaining VOC analyte concentrations between subsample collection and analysis. This method results in more representative VOC concentrations for soils while satisfying the SW-846, Method 8240 analysis protocols. Also included is the collection of samples to be analyzed by HS-GC. This on-site method of analysis is used to indicate which subsamples should be analyzed by fixed laboratory-PT-GC-MS analysis. Equivalent on-site analysis methods could be substituted for HS-GC.

Sample vials. For each sampling location, three 40-mL subsample VOA vials should be prepared.

I. Vial containing 30 mL of Type 1 water, with a PTFE-lined open-face septum cap (aqueous extraction HS-GC).
II. Vial containing 20 mL (or less) of HPLC-grade methanol, with PTFE-lined septum cap (high level ">1 µg VOC/g" PT-GC-MS).
III. Vial containing 3 mL of Type 1 water and equipped with either the modified purge-and-trap adapter or the appropriate caps and septa for the proposed Method 5035[28] (low level "<1 µg VOC/g" PT-GC-MS).

If aerobically degradable VOCs are to be determined, then vials I and III require preservation by acidification to ≤2 pH. This can be achieved by adding 0.25 g or more, if necessary, of $NaHSO_4$. The prepared vials must be weighed prior to adding soil subsamples.

Collection. Obtaining soil subsamples for VOC analysis should always be the first operation performed after a soil surface has been exposed to the atmosphere. Three locations from which samples are typically collected during a site or remedial investigation are split spoons, soil pit walls, and surface grid locations. Soil subsamples should be transferred with a disposable plastic syringe or similar device. Until they are commercially available, plastic syringe subcorers can be made in-house by cutting off the injection tip. Depending on the syringe manufacturer, small air vents may have to be cut into the plunger's tip or the rubber cap, and its retaining post removed. These alterations to the plunger prevent a positive pressure buildup, i.e., air from being forced through or around the soil plug during subcoring and extrusion operations.

Prior to subcoring the freshly exposed soil structure, the plunger should either be removed or pulled back, allowing the open barrel to be inserted into the surface. If the soil being sampled does not have adequate depth, cobbles are present, or it is very dry, the syringe may have to be inserted horizontally in order to obtain the desired amount. After obtaining a plug of soil, the barrel's outer surface is wiped with a clean paper/cloth towel to remove soil grains, and the subcorer barrel is then inserted into the mouth of the VOA vial and the soil plug extruded by gently pushing the plunger, followed by immediate capping.

At each sampling location, the following co-located subsample quantities should be collected:

1) A soil plug of approx 2 cc (2–3 g) should be transferred to VOA vial I, and a similar plug transferred to VOA vial II.
2) A soil plug of approx 4 cc (5–7 g) should be transferred to VOA vial III.

After the subsamples are collected, the VOA vials should be reweighed to establish sample (moist soil) weight. All sample vials should be stored at 4 °C. Regardless of the subsample (I, II, or III), the soil should be completely dispersed in solution (i.e., acidified water or MeOH) soon after collection. Clays and some silty-clay soils that do not disperse easily may require sonication or vortex mixing.

Conclusion

The determination of VOC concentrations in soil will remain unreliable as long as unsuitable bulk sample collection and storage practices are employed. Only those sampling methods that maintain soil structural integrity, use a single soil transfer step, and preserve against biological degradation should be used when establishing VOC concentrations. Proper use of the limited disruption and single subsample transfer protocol described here has resulted in comparable VOC estimates between on-site HS-GC and fixed laboratory-PT-GC-MS analyses, and obtained values that were more representative of the true soil VOC concentrations.

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The State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES

Thomas S. Burack, Commissioner

February 7, 2013

Waste Management Division Update

RE: Revised Vapor Intrusion Screening Levels and TCE Update

To All Professionals:

The New Hampshire Department of Environmental Services (DES) is pleased to provide the following updates for evaluating the vapor intrusion pathway. The enclosed updates should be considered an addendum to the Vapor Intrusion Guidance originally dated July 2006.

Revised Vapor Intrusion Screening Levels

Category GW-2 groundwater is considered to be a potential source of vapors of contaminants to indoor air. The GW-2 values and derivation presented in 2006 have been modified to include updated inhalation risk based values, indoor air method reporting limits, indoor air background values and use of a generic groundwater to indoor air attenuation factor. The updated GW-2 Methodology is enclosed.

Table 1 Vapor Intrusion Screening Levels, enclosed, has been revised to reflect the updates noted above. Because a number of the updated inhalation risk based values are below the TO-15 low level scan mode reporting limits, DES recommends the use of either selected ion monitoring (SIM) mode or simultaneous scan/SIM mode to achieve the lower detection levels necessary to identify certain compounds listed in Table 1.

TCE Update

The United States Environmental Protection Agency (USEPA) posted a Toxicological Review of trichloroethylene (TCE) on its Integrated Risk Information System (IRIS) on September 28, 2011. The review contains both carcinogenic and non-carcinogenic toxicity factors for use in developing screening levels and site-specific risk assessments. The reference concentration (RfC) represents the inhalation route non-cancer toxicity factor. The TCE RfC value of 2 $\mu g/m^3$ is based on the mid-point of two candidate RfCs with the critical effects being a decrease in thymus weight, and an increase in fetal cardiac malformations (FCM) during the first trimester of pregnancy.

The RfC is an estimate, with uncertainty spanning perhaps an order of magnitude, of a continuous inhalation exposure to the human population, including sensitive subgroups, that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfC considers both toxic effects of the respiratory system and effects peripheral to the respiratory system. RfCs are generally used to evaluate chronic exposures, however, the FCM critical effect is a developmental endpoint as a result of short-term exposure during the first trimester of pregnancy.

DES considers the revised TCE indoor air screening levels for residential and commercial scenarios of 0.4 µg/m^3 and 1.8 µg/m^3, respectively, protective of the FCM effect that could result from short term exposure to TCE during the first trimester of pregnancy. If the detected concentration of TCE exceeds 2.0 µg/m^3 for a residential exposure scenario or 8.8 µg/m^3 for a commercial exposure scenario and women of child bearing age are present, DES recommends that the women be informed of the potential short term risk and be relocated as these levels would represent a level of significant risk associated with the FCM effect during the first trimester of pregnancy.

If you have any questions or require additional information regarding these updates please contact Robin Mongeon, P.E. at (603) 271-7378, E-mail: Robin.Mongeon@des.nh.gov

Sincerely,

H. Keith DuBois

H. Keith DuBois, P.G., Assistant Director
Waste Management Division

Enclosure: GW-2 Methodology - Revised February 2013
Table 1 - Vapor Intrusion Screening Levels Revised February 2013

ec: Michael Wimsatt, P.G., Director, WMD
Carl Baxter, P.E., WMD
George Lombardo, P.E., WMD

New Hampshire Department of Environmental Services
Waste Management Division

Table 1
Vapor Intrusion Screening Levels
Revised February 2013

Chemical	Residential Indoor Air Screening Levels (µg/m3)	Commercial Indoor Air Screening Levels (µg/m3)	Residential Soil Gas Screening Levels (µg/m3)	Commercial Soil Gas Screening Levels (µg/m3)	Groundwater to Indoor Air Screening Levels GW-2(1) (µg/L)
Benzene	3.3(2)	3.3(2)	170	170	2,900
Bromoform	2.4	11	120	560	2,800
Bromomethane	1.0	4.4	50	220	10
Carbon Tetrachloride	**0.4**	2.0	20	100	10
Chlorobenzene	10	44	500	2,200	1,500
Chloroform	**0.1**	**0.5**	10	30	70
Dichlorobenzene, 1,2-	40	175	2,000	8,800	14,000
Dichlorobenzene, 1,4-	**0.2**	1.1	10	60	80
Dichloroethane, 1,1-	1.7	7.7	80	380	130
Dichloroethane, 1,2-	**0.1**	**0.5**	10	20	50
Dichloroethylene, 1,1-	40	175	2,000	8,800	630
Dichloroethylene, trans-1,2-	12	53	600	2,600	560
Dichloromethane (Methylene Chloride)	120	526	6,000	30,000	24,000
Dichloropropane, 1,2-	**0.3**	1.2	10	60	50
Ethylbenzene	2.0(2)	4.9	100	250	1,500
Ethylene dibromide	**0.04(3)**	**0.04(3)**	2	2	35
Methyl ethyl ketone	1,000	4,380	50,000	200,000	50,000
Methyl isobutyl ketone	600	2,628	30,000	100,000	50,000
Methyl tert butyl ether (MTBE)	3.3	15	170	770	2,600
Naphthalene	1.1(2)	1.1(2)	60	60	1,700
Styrene	200	876	10,000	40,000	43,000
Tetrachloroethane, 1,1,2,2-	**0.07(3)**	**0.2**	4	10	120
Tetrachloroethylene (PCE)	8.0	35	400	1,800	240
Toluene	1,000	4,380	50,000	200,000	50,000
Trichlorobenzene, 1,2,4-	**0.4**	**1.8**	20	90	150
Trichloroethane, 1,1,1-	1,000	4,380	50,000	200,000	27,000
Trichloroethane, 1,1,2-	**0.04**	**0.2**	2	10	20
Trichloroethylene (TCE)	**0.4**	1.8	20	90	20
Trimethylbenzene, 1,2,4-	3.4(2)	6.1	170	310	1,300
Vinyl chloride	**0.3**	2.8	20	140	4
Xylenes (mixed isomers)	20	29	1,000	4,400	17,000

(1) Revised Risk Characterization and Management Policy GW-2 values.
(2) The indoor air screening levels for these compounds are based on published background values.
(3) The indoor air screening levels for these compounds are based on TO-15 selected ion monitoring (SIM) mode reporting limit.
BOLD For these contaminants TO-15 SIM mode or simultaneous scan/SIM mode may be appropriate to achieve the indoor air screening levels.

New Hampshire Department of Environmental Services
Waste Management Division

GW-2 Methodology
Revised February 2013

The GW-2 Guideline, groundwater to indoor air screening levels, for each contaminant of concern is derived as follows:

(a.) The risk-based indoor air threshold to derive the GW-2 guideline for each contaminant of concern is the **minimum** non-zero value of the following non-cancer, cancer, and odor thresholds:

1. A concentration equal to 20% of a Reference Concentration (RfC) published by the USEPA, or a comparable allowable concentration.
2. An indoor air concentration associated with an Excess Lifetime Cancer Risk of one-in-one million.
3. The concentration in air of the contaminant at which 50% of the population can detect its odor is identified, if available.

(b.) For common indoor air contaminants that are ubiquitous, a background indoor air concentration for the chemical shall be identified, where available.

(c.) The method reporting limit (MRL) applicable to the contaminant, using an appropriately sensitive analytical method for quantifying the concentration of the contaminant in air, shall be identified.

(d.) The target indoor air concentration ($[C]_T$) is the higher of the values from (a), (b), and (c), above.

(e.) A target groundwater contaminant concentration is calculated as:

$$[C]_{gw} = [C]_T/(\alpha \cdot D \cdot H \cdot CF)$$

Where:
- $[C]_{gw}$ = calculated target groundwater concentration (µg/liter, ppb).
- $[C]_T$ = target indoor air concentration identified in (d) above. (µg/m^3).
- α = groundwater to indoor air attenuation factor of 0.0001(dimensionless).
- D = degradation factor equal to 0.1 for petroleum compounds, 1.0 for all other compounds (dimensionless).
- H = Henry's Law Constant for the chemical (dimensionless).
- CF = Units Conversion Factor (1000 L/m^3).

(f.) A groundwater concentration of the contaminant is selected as the minimum value from (e), above, the ceiling concentration of 50,000 µg/liter (ppb), and the solubility (µg/liter at 25 C).

(g.) The MRL applicable to the contaminant using an appropriately sensitive analytical method for quantifying the concentration of the contaminant in water shall be identified.

(h.) The **maximum** value of those determined (e), (f) and (g), above and the ambient groundwater quality standard is selected as the GW-2 guideline for that contaminant.

The State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES

Thomas S. Burack, Commissioner

Waste Management Division Update

RE: Vapor Intrusion Guidance

July 5, 2011

To All Professionals:

The New Hampshire Department of Environmental Services (DES) is pleased to provide the following policy updates for evaluating the vapor intrusion pathway. Please note that the Vapor Intrusion Guidance document (VI Guidance) dated July 2006, has not been rewritten. The enclosed updates should be considered as an addendum to the VI Guidance. Since the VI Guidance was issued in 2006, there have been considerable advances in the understanding of the science of vapor intrusion, however much more still needs to be done. DES will consider making additional updates to the VI Guidance as the state of the science matures in order to continue to protect human health from exposures caused by subsurface vapor intrusion.

Vapor Intrusion Screening Levels

The groundwater, soil gas and indoor air screening level table (Table 1) has been updated. Updates include modifications to the screening levels for ethylbenzene, the addition of screening levels for trans-1,2-dichloroethylene and the elimination of screening levels for 1,3,5-trimethylbenzene. The changes were made based on the most up to date risk based criteria.

Sub-Slab Soil Gas Sampling

In an effort to remain protective of human health, DES has decided to shift away from the use of exterior near building soil gas sampling when evaluating vapor intrusion from a groundwater source below a building. DES prefers the collection of sub-slab soil gas sampling over exterior near building soil gas sampling. The VI Guidance states “The collection of sub-slab soil gas samples from directly beneath a building may provide a better indication of a possible vapor intrusion problem than soil gas samples collected beyond the building foot print”. Soil gas directly beneath a slab or basement is most likely to be representative of what may be entering the building.

Sub-slab soil gas sampling should take into consideration the entire building footprint as vapor concentrations beneath slabs can exhibit significant spatial variability. For the typical residential home, a minimum of 3 sub-slab samples should be collected, one of which should be from the center of the structure. DES recommends that sub-slab soil gas sampling be conducted in conjunction with indoor air sampling during the winter to evaluate potential worst case conditions. Sub-slab soil gas sampling in combination with indoor air sampling results can assist with the identification of background sources in a structure.

In situations where a structure has an earthen floor, indoor air sampling of the basement/crawlspace should be performed. Where a structure has a combination of concrete and earthen floors sub-slab soil gas sampling combined with indoor air sampling of the basement/crawlspace should be considered.

DES recognizes that sub-slab soil gas sampling may not be the most appropriate tool for evaluating the vapor intrusion pathway under all circumstances (i.e., shallow groundwater, preferential pathways that may allow horizontal vapor transport through the sidewall of a building foundation, shallow vadose zone contamination adjacent to a structure). DES also understands that the cooperation of building occupants and/or owners is not always guaranteed. Where occupants and/or owners will not allow building access, DES recommends collecting multiple soil gas points around a structure at multiple depths. Vapor intrusion investigation work plans should be submitted to DES for approval prior to conducting the investigation.

Vapor Intrusion Mitigation Decision Criteria

In an effort to provide additional mitigation criteria to support the VI Guidance, please find attached the Table entitled "Table 2 - Vapor Intrusion Mitigation Decision Criteria" (VI Decision Criteria). The VI decision criteria, contained in the table, uses sub-slab soil gas and indoor air data to make decisions to address current and potential exposures related to soil vapor intrusion. Any action that is proposed for an individual structure (no further action, monitor, or mitigate) should be based on site specific factors, professional judgment and consultation with DES.

A decision of "no action" should be supported by adequate source area characterization, preferential pathway assessment and an evaluation of potential background sources. Where indoor air screening criteria are exceeded and background sources are the cause the investigator should provide DES with supporting justification to support a "no action" decision.

Monitoring of sub-slab soil gas, basement or crawl space air, occupied living space indoor air and outdoor ambient air may be necessary for; assessing conditions over time as source area remediation progresses, evaluating the effectiveness of building controls and/or evaluating exposure point concentrations over time. The type and frequency of long term monitoring associated with the vapor intrusion pathway will be based on site specific factors.

While the decision to mitigate is often a risk management decision, based on site specific factors, there are certain instances mitigation should be implemented where multiple lines of evidence indicate that vapor intrusion is occurring and the indoor air levels are above a significant risk.

Mitigation can take several forms, including source remediation, institutional controls, or building controls. Building controls such as sub-slab depressurization systems are often the quickest, most reliable and most commonly used method to reduce exposures associated with vapor intrusion. Please note that DES considers building controls as a temporary measure to be used until such time as the source of vapors has been eliminated.

Site Specific Risk Assessment

When conducting a site specific health risk assessment using the equations presented in Appendix E of the VI Guidance, the indoor air concentration of the contaminants of concern entered into these equations should represent a **conservative** estimate of the average daily exposure to the site-related chemicals. Due to the uncertainty associated with estimating a true average concentration at a site, DES recommends that the 95% upper confidence limit (UCL) of the arithmetic mean be used. For calculating the 95% UCL, DES recommends using EPA's ProUCL software available at the following link: http://www.epa.gov/osp/hstl/tsc/software.htm. When data is variable or limited, a maximum value should be used in the risk equations presented in Appendix E.

Active Facilities

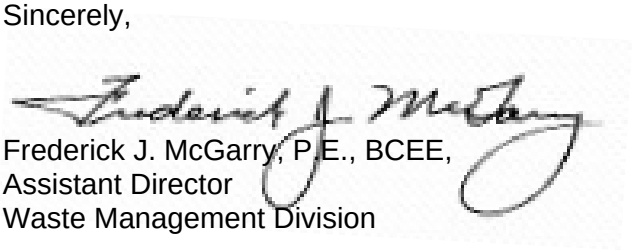
In buildings where active commercial or industrial operations currently use chemicals of concern it may be very difficult to evaluate vapor intrusion. If an indoor air evaluation was conducted, it would be difficult to discern the contribution of subsurface vapors associated with a discharge from common workplace-related vapors associated with facility operations. Examples of this situation may include active dry cleaners and active petroleum dispensing operations. In addition, it may not make sense to implement a vapor mitigation measure (sub-slab depressurization system) at an active facility if ongoing and allowable occupational exposures to the same chemical(s) are substantially higher than that resulting from vapor intrusion.

Vapor discharges into neighboring buildings or spaces that are not currently using chemicals of concern should be considered in a vapor intrusion evaluation. For example businesses in a strip mall containing an active dry cleaner where a discharge has occurred should be evaluated for this pathway where screening criteria are exceeded.

For buildings where active commercial or industrial operations currently use chemicals of concern and there is a potential for vapor intrusion, please contact the DES project manager to determine what follow-up actions, if any, should be considered to address the vapor intrusion pathway. Under most circumstances DES will require a special condition in the groundwater management permit for a site to monitor site use or conditions over time to determine if any changes in site use (facility operations no longer use chemicals of concern) would require an evaluation of the vapor intrusion pathway.

If you have any questions about these guidance updates please contact Robin Mongeon, P.E. at 271-7378.

Sincerely,



Frederick J. McGarry, P.E., BCEE,
Assistant Director
Waste Management Division

Enclosure: Table 1 - Vapor Intrusion Screening Levels Revised July 2011
Table 2 - Vapor Intrusion Mitigation Decision Criteria

ec: Michael Wimsatt, P.G., Director, WMD
Carl Baxter, P.E., WMD
George Lombardo, P.E., WMD

New Hampshire Department of Environmental Services
Waste Management Division Site Remediation Programs

Table 1
Revised July 2011
Vapor Intrusion Screening Levels

Chemical	Residential Indoor Air Screening Levels (µg/m^3)	Commercial Indoor Air Screening Levels (µg/m^3)	Residential Soil Gas Screening Levels (µg/m^3)	Commercial Soil Gas Screening Levels (µg/m^3)	Residential Groundwater to Indoor Air Screening Levels GW-2(1) (µg/L)
Benzene	1.9(2)	1.9(2)	95	95	2,000
Bromoform	2.4	11	120	550	2,000
Bromomethane	1.0	1.5	50	73	10
Carbon Tetrachloride	1.3(3)	1.3(3)	63	63	40
Chlorobenzene	10	15	500	730	2,000
Chloroform	1.0(3)	1.0(3)	49	49	100
Dichlorobenzene, 1,2-	40	58	2,000	2,900	20,000
Dichlorobenzene, 1,4-	160	230	8,000	12,000	50,000
Dichloroethane, 1,1-	100	150	5,000	7,300	10,000
Dichloroethane, 1,2-	0.8(3)	0.8(3)	40	40	300
Dichloroethylene, 1,1-	40	58	2,000	2,900	1,000
Dichloroethylene, trans-1,2-	12	17	600	850	1,000
Dichloromethane (Methylene Chloride)	5.6(2)	26	280	1,300	1,000
Dichloropropane, 1,2-	0.9(3)	1.2	46	59	200
Ethylbenzene	2.8(2)	4.9	140	250	3,000
Ethylene dibromide	1.5(3)	1.5(3)	77	77	700
Methyl ethyl ketone	1,000	1,500	50,000	73,000	50,000
Methyl isobutyl ketone	600	880	30,000	44,000	50,000
Methyl tert butyl ether (MTBE)	5.6(2)	15	280	770	10,000
Naphthalene	2.6(3)	2.6(3)	130	130	2,000
Styrene	200	290	10,000	15,000	50,000
Tetrachloroethane, 1,1,2,2-	1.4(3)	1.4(3)	69	69	1,000
Tetrachloroethylene (PCE)	1.4(3)	2.1	68	100	80
Toluene	1,000	1,500	50,000	73,000	50,000
Trichlorobenzene, 1,2,4-	3.7(3)	3.7(3)	190	190	1,000
Trichloroethane, 1,1,1-	1,000	1,500	50,000	73,000	50,000
Trichloroethane, 1,1,2-	1.1(3)	1.1(3)	55	55	500
Trichloroethylene (TCE)	1.3	6.1	67	310	100
Trimethylbenzene, 1,2,4-	4.3(2)	4.3(2)	220	220	3,000
Vinyl chloride	0.5(3)	2.8	26	140	10
Xylenes (mixed isomers)	20	29	1,000	1,500	30,000

(1) Revised Risk Characterization and Management Policy GW-2 values.
(2) The screening values for these compounds are based on published background values.
(3) The risk based levels for these compounds are below the EPA TO-15 low level reporting limit and therefore the screening value is based on method reporting limit.

New Hampshire Department of Environmental Services
Waste Management Division

Table 2 - Vapor Intrusion Mitigation Decision Criteria

July 2011

Sub-Slab Soil Gas Concentrations	Indoor Air Concentrations		
	<IASL	**>IASL to 10 x IASL**	**> 10 x IASL**
<SGSL	**No Action**	**Repeat sampling; evaluate potential background sources; No Action**	**Repeat sampling; evaluate potential background sources; No Action**
>SGSL to 10 x SGSL	**No Action or Monitor**	**Monitor or Mitigate**	**Investigate further or Mitigate**
>10 x SGSL	**Monitor or Mitigate**	**Monitor or Mitigate**	**Mitigate**

NOTES:

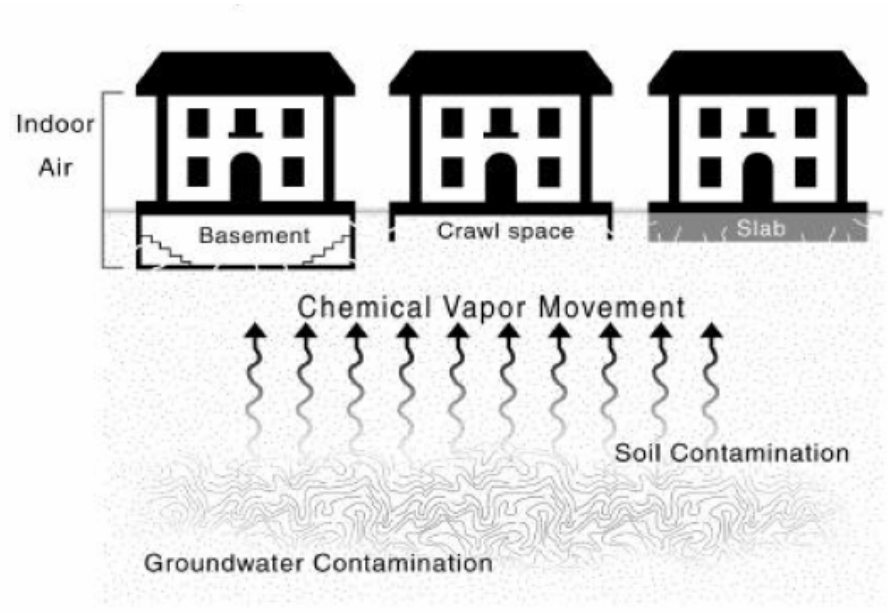
1. Investigators should consider the potential for vadose zone (soil) contamination and/or preferential pathways as well as potential background sources as part of the assessment of vapor intrusion.

2. Investigators should provide DES with supporting justification to support a “no action” decision where indoor air screening criteria are exceeded and background sources are the cause.

3. Investigators should use professional judgment when determining which action is appropriate for a particular structure. Factors to consider include but are not limited to:
   - the relative exceedance of the screening level;
   - the type and location of the source (vadose zone, groundwater, soil);
   - the expected time frame to meet remediation cleanup goals;
   - possible background sources of contamination;
   - the cost to mitigate vs. costs of long term monitoring;
   - the ratio of the sub-slab soil gas and indoor air results; and
   - building construction and current and future use.

4. Where more than one chemical of concern (COC) is present in indoor air, the decision of no action, monitor or mitigate should take into consideration cumulative risk calculations based on a site specific risk assessment using site specific exposure factors.

Vapor Intrusion Guidance



(EPA Region 3)

July 2006

NEW HAMPSHIRE
DEPARTMENT OF
Environmental
Services

Vapor Intrusion Guidance

Prepared by
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1.0 PURPOSE

This document provides guidance for the evaluation and mitigation of vapor intrusion resulting from volatile organic compounds (VOC) at contaminated sites in New Hampshire. Where appropriate this document may be used in conjunction with applicable DES rules for corrective action at contaminated sites and the DES Risk Characterization and Management Policy (RCMP).

An often overlooked exposure pathway involves VOC vapor movement from contaminated soil and/or groundwater and residual or mobile non-aqueous phase liquid (NAPL) through the subsurface into nearby buildings where occupants can be exposed. Commonly referred to as the vapor intrusion pathway, this pathway can be complicated to evaluate in terms of assessing risk to human health as there are many factors that influence the migration of vapors in the subsurface. This document provides the following:

- A review of basic vapor intrusion concepts.
- A discussion of a multiple line of evidence approach for assessing the pathway.
- A review of DES screening levels for groundwater, soil gas and indoor air.
- A review of soil gas sampling techniques.
- A review of indoor air sampling techniques.
- A review of vapor intrusion abatement strategies.
- An approach for conducting a site-specific risk assessment.
- A list of references.

2.0 HOW VAPOR INTRUSION OCCURS

2.1 General Concepts

Vapor intrusion occurs when VOCs migrate from contaminated soil and/or groundwater or residual or mobile NAPL through the subsurface to the indoor air of a building. This pathway can also be a potential issue for future buildings located above or near VOC contamination. Vapor intrusion sites can involve petroleum contaminants from leaking underground storage tanks and spills as well as chlorinated solvents and pesticides from commercial, industrial and landfill sites. This policy does not specifically address issues associated with landfill gases such as methane; however some of the same assessment and mitigation techniques may be appropriate for those sites. Vapor intrusion related to non-VOCs such as mercury, are not specifically addressed in this policy and would continue to be handled on a case by case basis.

In general, VOC vapor intrusion sites are grouped into two categories: petroleum hydrocarbons and chlorinated solvents. Projects involving vapor intrusion of chlorinated solvents have the potential to be more complicated to evaluate than petroleum contaminants because of their greater mobility, the lack of good warning properties such as low odor thresholds, and limited potential to undergo biodegradation.

Figure 1 below presents a simplified vapor conceptual site model of a scenario where the source of contamination is located some distance from an occupied structure. At the top boundary of the subsurface contamination, molecular diffusion results in the movement of chemicals from areas of higher concentration to lower concentration. The contaminant vapors diffuse up towards

the structure until reaching the building's zone of influence. Once the VOCs enter the building's zone of influence differential pressure gradients control the vapor movement in the proximity of the structure. Since the air pressure inside a structure is commonly less than the pressure in the subsurface, the vapor migrates by bulk air flow (advection) through cracks or openings (e.g., floor drains) in the foundation or basement slab into the structure in response to "inward" pressure gradients. Advection can be induced by atmospheric pressure fluctuations and stack effects due to building heating and mechanical ventilation systems. Negative pressure gradients (i.e., lower air pressure inside a structure versus soil vapor pressure) can be greatest when heating systems are in operation. Advection is likely the dominant process near a structure.

Diffusion, which is the concentration gradient-driven migration, is commonly accepted to be the dominant process away from the building foundation or where the water table is shallow and the soil adjacent to the foundation is mostly water saturated. Where preferential pathways exist, the vapor conceptual site model shown below would be different.

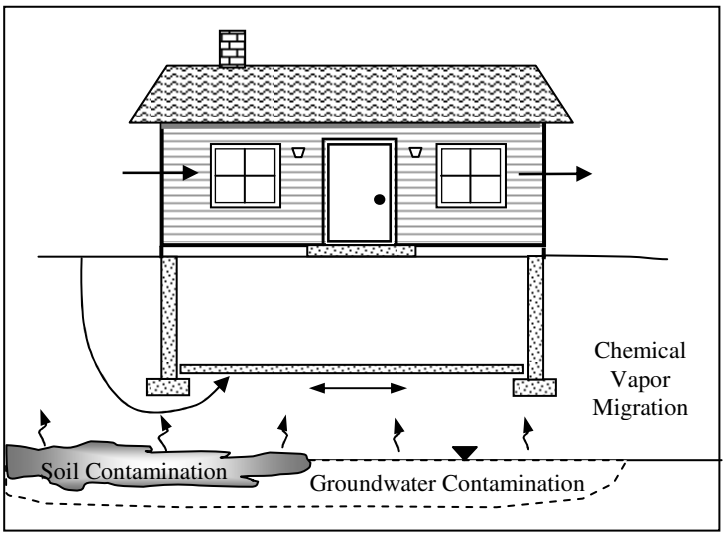

Figure 1. Simplified vapor intrusion conceptual model

2.2 Factors That Affect Vapor Intrusion

Many factors can influence contaminant vapor movement in the subsurface and potentially cause a human health risk to a building occupant. Conditions that influence vapor intrusion can include:

- Construction style – Vapor intrusion occurs in structures with or without basements. Investigation of sites in other states has found that even slab-on-grade construction can be affected by vapor intrusion. The condition and construction of the foundation and presence/absence of an adequate vapor barrier can be important factors to consider. Positive pressure HVAC systems can prevent vapor intrusion.

- Structure age – Older structures are less likely to have adequate vapor barriers incorporated into the foundation construction and the foundation itself is more likely to have developed cracks.

- Dirt floors and stone foundations – Earthen floors or fieldstone foundations are more porous and provide increased opportunity for vapor intrusion.

- Drain tile/sumps – If the building has a foundation drain tile connected to a sump even low level VOC concentrations in the water can contribute to indoor air problems.

- Wet basements – If the building has water infiltrating into the basement dissolved VOCs can volatilize into the indoor air. Wet basements can indicate a shallow water table or be related to drainage problems.

- Utility lines – Gaps or cracks around piping or other utility lines that enter a building can be an important preferential migration pathway for vapors. Permeable soil in a utility trench can also provide a conduit for contaminants to migrate significant distances from the source area.

- Proximity of contamination to buildings – Vapor intrusion should be an obvious concern when buildings are very close to the source of VOC contamination.

- Shallow groundwater – The potential for vapor intrusion typically decreases with increasing depth to groundwater for some chemicals particularly those that are known to biodegrade such as petroleum hydrocarbons.

- Soil type and moisture content– Soil type influences the transport of contaminants in soil vapor and groundwater. Coarse-grained soil types can promote contaminant migration over long distances, but also provides easier venting to the atmosphere. Fine grained or tight soils with higher moisture content will tend to inhibit vapor contaminant transport. The soil stratigraphy is also important in developing a conceptual site model of soil gas migration.

- Fractured bedrock – Shallow fractured bedrock connected to a subsurface source of VOCs can increase vapor intrusion potential by encouraging faster soil gas migration. This becomes a greater concern when the bedrock is at or near the base of a building foundation.

- Degradation – Petroleum hydrocarbons can biodegrade relatively quickly in unsaturated soils. In contrast chlorinated solvents will likely undergo limited biodegradation and, therefore, may have the ability to cause a vapor intrusion impact a long distance away from the VOC source.

3.0 EVALUATING THE VAPOR INTRUSION PATHWAY

3.1 General Considerations

DES recommends that the vapor intrusion pathway be evaluated at sites were there is a source of VOC contamination near an occupied building(s). VOC contaminated groundwater is considered to be a potential source of vapors of contaminants to indoor air. The GW-2 groundwater screening values are intended to provide guidelines on when it may be appropriate to examine the indoor air exposure pathway. The GW-2 groundwater screening values are intended to be used where VOCs (non-petroleum) are detected in groundwater above the GW-2 levels within 100 feet (vertically or horizontally) of an occupied building. At petroleum hydrocarbon sites, the GW-2

screening values are intended to be applied where petroleum VOCs are detected in groundwater above the GW-2 levels within 30 feet (vertically or horizontally) of an occupied building.

In order to evaluate the potential for vapor intrusion into buildings, DES recognizes two methods for evaluating the vapor intrusion pathway. The first is a Method 1 approach using screening levels where multiple lines of evidence are obtained to determine if the vapor intrusion pathway is complete, and if so, whether there is a significant risk to building occupants. The Method 1 approach includes screening levels for groundwater, soil gas, and indoor air. The second approach is a site-specific vapor intrusion pathway assessment. The two methods for evaluating the vapor intrusion pathway are discussed in more detail in Sections 3.2 and 3.3 below.

Vapors emanating from contaminated groundwater at some depth below a building are not the only VOC sources that may result in an indoor air exposure. The scenarios listed below can also result in an indoor air exposure with or with out exceeding a GW-2 screening value. It may be appropriate to evaluate the vapor intrusion pathway for the following scenarios:

- Where a vadose zone VOC source from contaminated soil or a vapor release are located near a building;
- Where a significant preferential pathway exists that connects a VOC source with a nearby building;
- Where NAPL is located near a building;
- Where VOC odors attributable to a release under investigation are detectable inside a structure indicating that the indoor air exposure pathway is likely complete; or
- Where contaminated groundwater has or continues to enter a structure and the VOCs are volatilizing into the indoor air space creating an exposure.

Where the indoor air exposure pathway is complete, indoor air sampling to assess the potential risk to human health is recommended. Where the potential risk is determined to be significant, mitigation efforts should be evaluated and implemented as appropriate including any follow up monitoring. Section 9.0 describes strategies that may be appropriate for mitigating vapor intrusion.

3.2 Method 1 Approach

The Method 1 approach is typically a multiple step process as outlined below. Multiple lines of evidence are used to determine whether the vapor intrusion pathway is complete, and if so, whether there is a significant risk to building occupants. Site data is collected and compared to the appropriate Method 1 screening levels. The screening levels are listed in Table 1 and are further explained in Section 4.0 and are identified as follows:

- Groundwater to indoor air screening levels.
- Soil gas screening levels (residential and commercial).
- Indoor air screening levels (residential and commercial).

The vapor intrusion Method 1 screening value lookup numbers in Table 1 may not be appropriate for all sites, and it may not be necessary to sample all three media (groundwater, soil gas, and indoor air) at all sites to determine if vapor intrusion is a pathway of concern. Each step of the screening process provides additional lines of evidence that the pathway is likely complete, indicating that further

evaluation of the pathway may be necessary or the pathway is incomplete. Figure 2 provides a flow chart on evaluating the vapor intrusion pathway. DES does not have bulk soil sample screening levels for evaluating the vapor intrusion pathway. As a result, where bulk soil sample data indicates a vadose zone source of VOCs, soil gas data and/or indoor air data should be collected to assess the vapor intrusion pathway. When sampling groundwater, soil gas, or indoor air for comparison with the vapor intrusion screening levels, multiple sampling events that cover the expected range of conditions that may influence concentrations, should be conducted (i.e., seasonal, atmospheric, hydrogeologic, etc.).

Typically the first step in the Method 1 approach is comparison of groundwater data collected from the study area to the GW-2 values summarized in Table 1. In general, when evaluating a dissolved phase plume where other potential vapor intrusion factors are not a concern (i.e. NAPL, vadose zone VOC source, contaminated groundwater seeping into a building), if all compounds of concern (COC) in groundwater are less than the respective GW-2 values, the pathway is determined to be incomplete. If a COC in groundwater exceeds the GW-2 value near a structure, further assessment of the pathway should be conducted.

If an exceedance of a GW-2 value has been identified in the study area, the next step in the Method 1 approach would be to conduct an exterior soil gas sampling program to evaluate the soil gas vapor plume. When conducting soil gas sampling to assess the vapor intrusion pathway, DES recommends using the vapor intrusion conceptual site model check list included in Appendix A. Soil gas sampling is further detailed in Section 5.0. Soil gas data collected in the study area would then be compared to the soil gas screening levels in Table 1. If the levels in soil gas are less than the soil gas screening levels, it may be possible to rule out vapor intrusion as a potential pathway. See Section 7.0 for a discussion on evaluating results. If a COC exceeds a soil gas screening value, this provides additional evidence that there is a potential for vapor intrusion to nearby buildings and that further assessment should be conducted.

If an exceedance of a soil gas screening level has been identified during the exterior soil gas sampling program, further assessment will typically involve collection of indoor air samples from structures suspected of being impacted by vapor intrusion.

Indoor air concentrations should be compared to the indoor air screening levels in Table 1. If COC levels in indoor air are less than the indoor air screening levels further evaluation of the vapor intrusion pathway may not be necessary. If an exceedance of an indoor air screening level has been identified, and the pathway is determined to be complete, abatement measures, continued monitoring, or further assessment and/or evaluations may be necessary. Indoor air sampling and related indoor air background issues are discussed in Section 6.0. See Section 7.0 for a discussion on evaluating results.

If the pathway is determined to be complete, or likely complete, at any stage of the investigation a site specific health risk assessment can be completed in lieu of using the screening levels in Table 1. The frame work for conducting a site specific risk assessment for the vapor intrusion pathway is presented in Appendix E.

3.3 Site Specific Vapor Intrusion Pathway Assessment

A site specific vapor intrusion pathway assessment addresses a broad range of site conditions and can involve increasingly more sophisticated site-specific data collection, analysis, and data evaluation than the Method 1 approach.

The following vapor intrusion assessment tools may be useful when conducting a site specific vapor intrusion pathway assessment:

- Completing site specific cumulative risk calculations based on site specific exposure factors.
- Obtaining lateral and vertical soil gas profiles to demonstrate attenuation and/or biodegradation.
- Use of additional investigative tools as described in Section 8 including:
  - Determination of a site-specific soil gas attenuation factor using a conservative tracer
  - Indoor/sub-slab differential pressure measurements
  - Passive soil gas sampling
  - Flux chamber sampling
  - Modeling

The site specific vapor intrusion pathway assessment approach and results should be fully documented in a report that includes a conceptual site model of subsurface vapor transport mechanisms and site specific measurements and analysis. DES recommends that a work plan be submitted to the department for comment prior to completing a site specific vapor intrusion pathway assessment.

4.0 METHOD 1 VAPOR INTRUSION SCREENING LEVELS

DES has developed threshold screening levels for groundwater, soil gas, and indoor air for use in the Method 1 approach for evaluating the vapor intrusion pathway. Where any of the screening levels are exceeded at a site the vapor intrusion pathway should be evaluated further except where the indoor air levels are attributable to background. The following screening levels are based on a conservative inhalation risk exposure scenario.

4.1 Groundwater Screening Levels

As noted above DES recommends that the vapor intrusion pathway be evaluated at sites in New Hampshire where VOCs are detected in groundwater above the GW-2 levels within 100 feet (vertically or horizontally) of an occupied building. For petroleum hydrocarbon sites, the GW-2 levels would apply within 30 feet (vertically or horizontally) of an occupied building.

Where groundwater data exists for a site, the contaminant concentrations should be compared to the GW-2 values in Table 1. The GW-2 screening levels are intended to provide guidance on when it may be appropriate to examine the vapor intrusion pathway from a dissolved phase plume. The GW-2 screening levels will often provide the first step of the Method 1 vapor intrusion pathway assessment as groundwater data is often collected during the initial stages of any site investigation.

When installing groundwater monitoring wells for assessing the vapor intrusion pathway, wells should intersect the water table throughout the year, (i.e., a water table well) and have a water column

thickness of 10 feet or less. Where a clean water lens or a perched water table exists of sufficient thickness, vertical profiling of VOC levels in groundwater may be warranted.

At sites that may have contamination due to a vadose zone source including contaminated soil or vapor leaks, groundwater data may not be an appropriate tool for assessing the vapor intrusion pathway for these sources. Soil gas data would be the more appropriate investigative tool for assessing the risk from vadose zone sources.

4.2 Soil Gas Screening Levels

DES has developed two soil gas screening levels, residential and commercial, which are provided in Table 1. The soil gas screening levels in Table 1 may be used where deep exterior soil gas samples are collected adjacent to the structure(s) under investigation and at a depth below the anticipated depth of the foundation, or where sub-slab soil gas samples are collected immediately beneath the building. For residential structures with basements, DES recommends a depth of 10 feet below grade. Soil gas samples collected more than 10 feet horizontally away from a building may not be appropriate for assessing the vapor intrusion pathway. Due to potential variability in soil gas concentrations, multiple soil vapor probes and multiple sampling events that cover the expected range of conditions that may influence concentrations (depth, seasonal, atmospheric, hydrogeologic, etc.) may be necessary to determine if additional investigation of the vapor intrusion pathway may be necessary at a site. Soil gas sampling procedures are outlined in Section 5.0.

Two soil gas screening values have been developed based on different exposure scenarios that account for a residential exposure and for a commercial exposure. The general equation used to calculate the soil gas screening levels is noted below:

$$SG = C_{AIR} / \alpha_{SG}$$

SG = The soil gas screening level in units of $\mu g/m^3$.
C_{AIR} = Indoor air screening levels for the appropriate exposure scenario, residential or commercial in units of $\mu g/m^3$.
α_{SG} = Soil gas to indoor air attenuation factor of 0.02, dimensionless.

The soil gas screening values in Table 1 are not intended for use in assessing crawl space vapor samples. Where crawl space vapor samples are collected, the results should be compared with the indoor air screening values listing in Table 1.

4.3 Indoor Air Screening Levels

DES has developed two sets of indoor air screening levels for the evaluation of the vapor intrusion pathway. Residential and commercial indoor air screening levels are listed in Table 1. When vapor intrusion is of potential concern, indoor air concentrations may be evaluated using the indoor air screening levels to determine if further evaluation, monitoring or mitigation of the pathway is appropriate. Site-specific background sources should always be considered when interpreting indoor air data. Background contaminant levels, both indoors and from outdoor ambient air, may exceed the Table 1 indoor air screening levels for some compounds. Background determinations should be made on a site-specific basis as part of an overall multiple line of evidence data evaluation.

The indoor air screening levels were derived taking into consideration risk-based criteria, method reporting limits and indoor air background values (residential only). For more information on the risk based criteria and exposure assumptions used to calculate the residential and commercial indoor air screening levels see Appendix E.

For chemicals that have both a carcinogenic and non-carcinogenic value, separate risk-based levels were calculated with the lower (more protective) concentration selected based on the following:

- A concentration equal to 20 percent of a reference concentration (RfC) published by the USEPA or an analogous allowable concentration.
- An indoor air concentration associated with an excess lifetime cancer risk of one-in-one million.

The lower, more protective risk based value was then compared to a background value, if available, and the low level reporting limit for EPA Method TO-15, and the higher number was selected to represent the indoor air screening value listed in Table 1.

5.0 SOIL GAS SAMPLING PROCEDURES

5.1 Overview

The following section provides some basic guidelines for conducting soil gas sampling for assessing the vapor intrusion pathway. Soil gas sampling can be used for a number of purposes including initial site characterization, delineation of a groundwater plume, identification of source areas, evaluation of the vapor intrusion pathway, remediation and post-remediation monitoring. The guidelines outlined below are specific to the evaluation of the vapor intrusion pathway, but may be modified for other corrective action purposes. When soil gas sampling is to be used for assessing the vapor intrusion pathway, DES recommends that work plans be submitted to the department for comment prior to the initiation of fieldwork.

5.2 Designing a Soil Gas Sampling Plan

The development of a soil gas sampling plan, should be site specific, and establish the vapor migration conceptual site model and provide an assessment of the vapor intrusion pathway. DES recommends using the vapor intrusion conceptual site model check list included in Appendix A. General considerations should include the following:

- Identify the objectives of the study.
- Identify the chemicals of concern including parent and breakdown products.
- Identify possible preferential pathways.
- Establish the number, location and analytical method for soil gas samples to satisfy the plan objective including appropriate QA/QC protocols, such as leak testing, sample duplicates, and equipment blanks.
- Establish soil gas probe installation and sampling protocols.
- Determine if vertical profiles are needed to assess potential biodegradation/attenuation.
- Compare the concentrations of the chemicals of concern to the soil gas screening levels.

- Determine if the vapor intrusion pathway is a concern.

5.3 Field Screening

As part of any soil gas sampling plan, field screening should be conducted to evaluate potential preferential vapor migration pathways. The field screening survey should evaluate underground utilities such as water, sewer, gas, electric, and telecommunication lines as well as any foundation penetrations, such as sumps, into the structure(s) in the study area. Field screening should be conducted using either a photoionization detector (PID) or flame-ionization detector (FID) or other instrument appropriate for detecting the COC. As most field screening instruments have detection limits in the part per million range, use of these instruments will only provide an indication of gross contamination.

5.4 Soil Gas Probes

DES recommends active soil gas sampling for assessing the risk to human health as part of a vapor intrusion assessment and for use in comparison with the soil gas screening levels in Table 1. There are two methods used to collect active soil gas samples, where a vapor sample is collected from the vadose zone and then analyzed either at an off-site laboratory, or on-site in a mobile laboratory; temporary soil gas probes that are only sampled once or, permanent soil gas probes that can be sampled over time to account for expected ranges of conditions that may influence concentrations (i.e., seasonal, atmospheric, hydrogeologic, etc.).

Temporary vapor probes can be installed by making a hole with a slide hammer, then placing a sample probe in the pilot hole and sealing the annular space at the top of the rod with an inert impermeable material. Other temporary vapor probes use a retractable or removable drive tip. After the soil gas sample is collected the probe is removed.

Permanent soil gas probes typically consist of a small-diameter tube with a screen or sample port installed at the tip, or a small diameter well. Tubing/well diameter should be small, usually ranging from 1/4 to 1 inch to limit the amount of purge volume. The tube/well is installed to a specific depth in a bore hole created with a slide hammer, direct-push system or a hollow stem auger. Sand is installed in the annulus around the sampling port/well screen and the remainder of the bore hole is sealed with bentonite. The tubing/well is usually capped at the surface and the bore hole is completed with a well cover at ground surface.

Whether installing a temporary or permanent soil gas probe, a competent surface seal is necessary to prevent ambient air from diluting the soil gas sample. Figure 3 shows several types of soil gas probes and well material, and Figure 4 shows a schematic of a permanent soil gas probe.

The collection of sub-slab soil gas samples from directly beneath a building may provide a better indication of a possible vapor intrusion problem than soil gas samples collected beyond the building foot print; however, this sampling method is more intrusive to the building owner/occupant. When contemplating collection of sub-slab soil gas samples care must be taken not to damage the integrity of the slab. Coring through the slab can create a preferential pathway and therefore a proper seal is important when using this method. Figure 5 shows a schematic of a sub-slab soil gas probe.

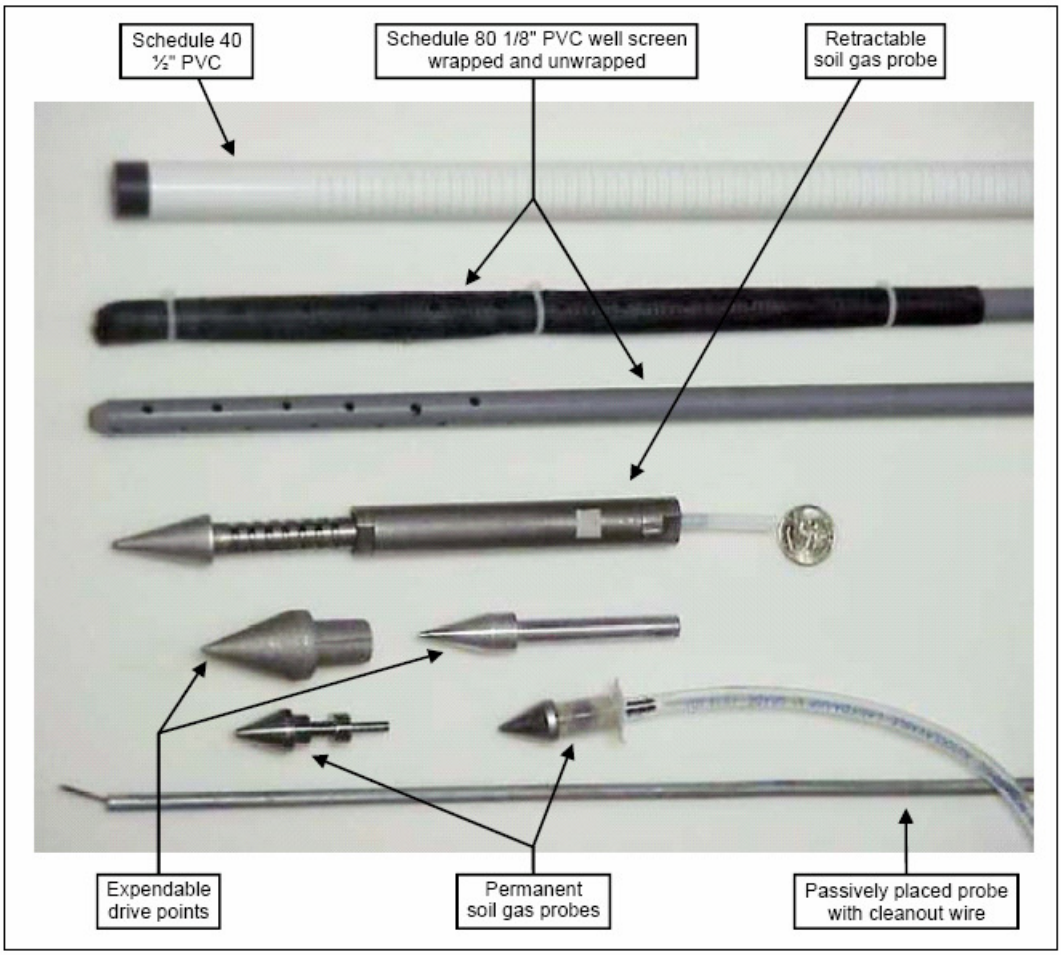

Figure 3 Soil Gas Sampling Probes (NJDEP 2005)

5.5 Sample Collection and Analysis

Soil gas samples should be collected at the location(s) suspected of having the highest vadose-zone contamination immediately adjacent (within 10 feet) to the structure(s) under investigation. Samples from the area immediately adjacent to a structure should be collected at a depth well below the base of the foundation. For residential structures with basements, DES recommends a depth of 10 feet below grade. In situations where shallow groundwater prevents this, other sampling procedures may be employed, including collection of sub-slab samples, or exterior soil gas samples from beneath large impervious surfaces where vapor may accumulate such as an adjacent driveway or parking lot. If collecting sub-slab soil gas samples directly beneath a building slab, groundwater should be at least 6 inches below the slab.

When conducting an exterior soil gas sampling program to evaluate vapor intrusion from a large VOC groundwater plume that may impact a significant number of structures, it may not be practical to collect exterior soil gas samples within 10 feet of each structure. For this scenario, the number, depth and location of soil gas samples should be adequate to conservatively delineate the subsurface soil gas plume, and identify structures that may be susceptible to vapor intrusion.

For undeveloped lots where future structures are planned, deep exterior soil gas samples may be used to assess the potential for vapor intrusion for the future use scenario planned. The number and depth of soil gas samples should be adequate to conservatively delineate concentrations in soil gas.

Short-circuiting of atmospheric air into the soil gas probe can result in diluted soil gas samples that under report actual subsurface soil gas concentrations for the COC. To ensure that valid soil gas samples are collected as part of a vapor intrusion assessment the use of a tracer compound can be used to assess for surface/annular seal leaks around the top of the soil gas probe.

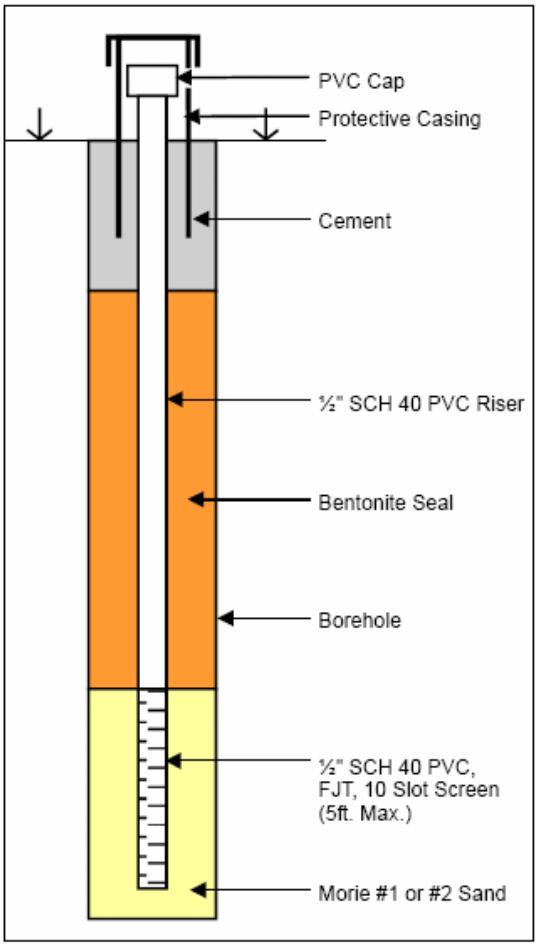

Figure 4 Permanent Soil Gas Probe (NJDEP 2005)

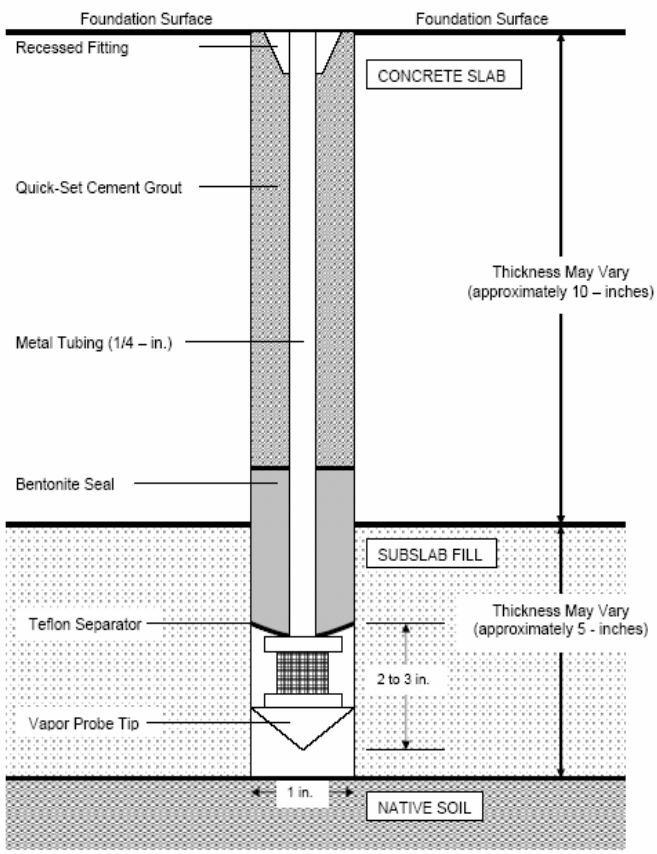

Figure 5 Sub-slab Soil Gas Probe (CAEPA DTSC 2004)

Depending on the nature of the contaminants of concern a number of different compounds can be used as a tracer. Sulfur hexafluoride (SF6) or helium are used as tracers because they are readily available have low toxicity and can be monitored with portable measurement devices. Iso-propanol, the main ingredient in rubbing alcohol, could also be used as a tracer but would require laboratory analysis for the tracer. In all cases the same tracer application should be used for all probes at any given site. The leak test should be conducted using a tracer that is not expected to be present in the soil gas being tested.

Because minor leakage around the probe seal should not materially affect the usability of the soil vapor sampling data the presence of low concentrations of the tracer gas in the sample may not be a major cause for concern. If elevated levels of tracer gas are observed in a sample, the soil gas data should not be considered reliable and the probe seal should be modified to reduce the infiltration of ambient air and the probe re-sampled. Portable field monitoring devices with detection limits in the low ppm range should be adequate for screening samples for tracer leak testing.

Potential short circuiting of atmospheric air during sampling can also be indirectly evaluated through examination of oxygen and carbon dioxide data collected from soil gas probes and ambient air. For example if oxygen concentrations at a probe installed within a petroleum hydrocarbon source area are at atmospheric levels the soil gas data should not be considered reliable and the probe seal should be modified and the probe re-sampled. DES recommends collecting oxygen and carbon dioxide data when conducting soil gas surveys to assess the vapor intrusion pathway. DES recommends using the Soil Gas Probe Field Data Report Form in Appendix B when conducting soil gas evaluations.

Prior to collecting the soil gas sample for analysis DES recommends a minimum of one to a maximum of five purge volumes be evacuated from the soil gas probe. The purge volume should be consistent for all samples collected from the study area. When purging or collecting samples using a vacuum pump or a canister the vacuum applied to the soil gas probe should be kept to the minimum necessary to collect the sample and the flow rate should not exceed 200 milliliters per minute. This should limit the potential for ambient air being drawn into the soil gas sample from the ground surface and it should limit desorbing of vapors from contaminated soils. Depending on the scope of the study and the data quality objectives, soil gas samples may be collected using gas-tight syringes, sorbent media, canisters or tedlar bags. Gas tight syringes and tedlar bags are appropriate when an on-site field laboratory is utilized and samples are analyzed immediately following sample collection. The following table provides a list of several soil gas analytical methods.

Method No.	Collection Device Methodology	Type of Compounds	Detection Limit Range
TO-1	Tenax solid sorbent GC/MS or GC/FID	VOC	0.02 – 200 ug/m^3 (0.01-100 ppbv)
TO-2	Molecular sieve sorbent GC/MS	VOC	0.2 – 400 ug/m^3 (0.1-200 ppbv)
TO-3	Cryotrap GC/FID	VOC	0.2 – 400 ug/m^3 (0.1-200 ppbv)
TO-13A	Polyurethane foam GC/MS	PAH	0.5-500 ug/m^3 (0.6 – 600 ppbv)
TO-15	Canister GC/MS	VOC (polar/nonpolar)	0.4 – 20 ug/m^3 (0.2-2.5 ppbv)
TO-17	Single/multi-bed adsorbent GC/MS FID	VOC	0.4 – 20 ug/m (0.2-2.5 ppbv)
8021B	Tedlar Bag Canister GC/PID	VOC	4.0 – 60.0 ug/m^3 (0.3 ppbv to 30 ppbv)
8260B	Tedlar Bag Canister GC/MS	VOC	10.0 – 50.0 ug/m^3 (0.6 ppbv to 25 ppbv)
8270C	Tedlar Bag Canister GC/MS	SVOC	1000 ug/m^3 (20000 ppbv to 100000 ppbv)

To maintain sample integrity:

- Maximum holding times for soil gas samples should not be exceeded.

- Soil gas samples should not be chilled during storage.

Soil gas samples should be analyzed for the appropriate COC including breakdown products as part of the vapor intrusion assessment. The analytical method used should be able to identify and quantify the target analytes and be capable of meeting the soil gas screening levels listed in Table 1. DES recommends that all soil gas analysis be done using gas chromatography. Soil gas sample results submitted to DES should be reported in units of ug/m^3. Soil gas sampling field data should be detailed on the Soil Gas Probe Field Data Report Form and submitted with the results.

5.6 Soil Gas Data Evaluation

The evaluation of soil gas data should determine if the pathway is likely complete or if additional data is needed to evaluate the pathway. A data quality evaluation should be completed to determine if the data is sufficient to be used for the pathway assessment, by reviewing tracer results and detection limits to determine data usability.

If the levels in soil gas below or immediately adjacent to a building are above the soil gas screening levels indicating that the indoor air pathway is likely complete future actions may include the following:

- Conduct additional soil gas sampling to develop a more complete understanding of the distribution of chemicals in soil gas.
- Conduct indoor air sampling to correlate soil gas levels to indoor air levels for COC taking in to account indoor air background levels.
- Implement abatement actions.
- Use additional investigative tools as described in Section 8.

If the concentrations of COC in soil gas at or near the building are below the soil gas screening levels and the data quality objectives are satisfactory then the vapor intrusion pathway may not be a concern; however, due to potential variability in soil gas concentrations, multiple soil vapor probes and multiple sampling events that cover the expected range of conditions that may influence concentrations (depth, seasonal, atmospheric, hydrogeologic, etc.) may be necessary.

6.0 INDOOR AIR SAMPLING

6.1 General Approach

There are inherent problems with sampling indoor air and also with interpreting the results. Indoor air sampling should be conducted after groundwater and/or soil gas data indicate the potential for vapor intrusion. Indoor air sampling may also be necessary under other circumstances including contaminated groundwater intrusion into buildings, before, during or after corrective actions have been taken, where preferential pathways exist that would limit the usefulness of groundwater or soil gas data, at residential fuel oil spill sites or where there are odor complaints.

When conducting indoor air sampling as part of a vapor intrusion pathway assessment there are several steps that should be taken into account.

- Define the study goals.
- Identify the COC including parent and breakdown products.
- Select number and location of sampling locations.
- Select duration of sampling event.
- Select sampling method with appropriate detection limit.
- Establish QA/QC requirements.

When contemplating indoor air sampling to assess large plumes that have the potential to impact a significant number of structures, DES recommends identifying primary and secondary structures for indoor air sampling. Conduct indoor air sampling at the primary structures first based on groundwater and exterior soil gas concentrations. Expand the scope of indoor air sampling to the secondary structures if some of the primary structures show vapor intrusion impacts. This investigative strategy, or "step-out process," should be conducted in a sequential manner until a perimeter of no impacts is defined.

6.2 Site Inspection, Product Inventory and Field Screening

Prior to collecting indoor air samples a site inspection should be conducted and a building inventory of potential VOC sources should be completed. Field screening of potential preferential pathways into the structure should also be conducted. The field screening survey should evaluate any foundation penetrations such as water, sewer, gas, electric and telecommunication lines, as well as sumps. In addition, field screening of potential VOC building sources should be conducted to determine if any products may be leaking VOC vapors into the building. Field screening should be conducted using either an FID or PID appropriate for detecting the COC.

6.3 Sample Collection and Analysis

When collecting indoor air samples, it is advisable to sample under conditions that are the most likely to represent conservative or worst case conditions (refer to Section 6.5). Samples should be collected from the lowest level of the structure where vapors are expected to enter (typically the basement or crawl space), a common area living space/work space on the first floor, and an outdoor location representative of background outdoor ambient air. DES recommends that indoor air samples be collected concurrent with soil gas samples, where appropriate, for a better understanding of the vapor conceptual model at a site.

DES recommends the collection of time integrated indoor air samples for risk assessment purposes as part of the vapor intrusion pathway assessment. The sample duration should be reflective of the site specific exposure scenario that represents the true time-integrated average concentration that an inhabitant may be exposed to. If evaluating low concentration long term exposure for a residential scenario, a 24-hour sample duration should provide a representative sample. For non residential sampling, such as a work place scenario, an 8-hour sampling duration may be more appropriate. Ideally the duration and frequency of sampling should cover the range of conditions that may influence concentrations (i.e., seasonal, atmospheric, hydrogeologic, etc.). For collection of time integrated samples for VOC analysis used for risk assessment purposes DES recommends the use of pre-evacuated stainless steel canisters.

The indoor air samples should be analyzed for the appropriate COC including breakdown products as part of the vapor intrusion assessment. The analytical method should be able to identify and quantify the target analytes and be capable of meeting the indoor air screening levels in Table 1. Laboratories performing low level air analysis should be able to demonstrate the ability to deliver acceptable results. DES recommends that laboratory analysis for VOCs be done using gas chromatography/mass spectrometry (GC/MS) and where appropriate using the high resolution selected ion monitoring (SIM) mode for low level detection. When conducting indoor air sampling the Indoor Air Sampling Form in Appendix C should be completed and sampling should be conducted in accordance with the Indoor Air Sampling Protocol in Appendix D. All indoor air sample results submitted to DES should be reported in units of ug/m^3. The following table provides a list of several indoor air analytical methods. For VOC analysis DES recommends EPA Method TO-15 including SIM mode where appropriate.

Method Reference	**Description**	**Types of Target Compounds**	**Detection Limit Range**
TO-4A	High Volume sampling PUF media GC/ECD analysis	Pesticides & PCBs	Pesticides: 0.5 –1 ug/sample PCBs: 1 – 2 ug/sample
TO-10A	Low Volume sampling PUF media GC/ECD analysis	Pesticides & PCBs	Pesticides: 0.5 –1 ug/sample PCBs: 1 – 2 ug/sample
TO-13A	High Volume sampling PUF/XAD media GC/MS analysis	SVOCs	5 – 10 ug/sample
TO-15LL	Canister collection GC/MS analysis	Non-Polar & Polar VOCs	0.5 – 3 ug/m^3
TO-15 SIM	Canister collection GC/MS (SIM mode) analysis	Low level VOCs	0.011 – 0.5 ug/m^3

TCE is a primary contaminant at many sites in NH and the toxicity of TCE is the subject of considerable debate. In 1989 EPA withdrew the TCE cancer toxicity values from its Integrated Risk Information System (IRIS) database. Since that time, EPA has come out with draft health information that TCE is suspected of being more toxic than previously thought. Due to the uncertainty associated with the toxicity of this chemical DES recommends that when conducting indoor air sampling for the vapor intrusion pathway where TCE is a COC, analysis be completed using selected ion monitoring (SIM) when appropriate, to achieve the lowest detection limit possible to determine if TCE is present in indoor air.

6.4 Background

There are two types of background associated with indoor air sampling, indoor air background and ambient outdoor background. Either may exceed the indoor air screening levels listed in Table 1. Although there is a simple way to measure ambient outdoor background it is difficult to reliably measure indoor air background. For these reasons collection of indoor air data without additional lines of evidence to indicate the potential for vapor intrusion from subsurface sources is not advised. Where vapor intrusion COC are expected to be present as background sources in a building, DES recommends collecting sub-slab soil gas samples concurrent with the collection of indoor air samples.

There have been several studies that have measured indoor air and ambient outdoor air background levels. The New York State Department of Health collected samples from 104 single family homes heated with fuel oil between 1997 and 2003. More than 600 samples were collected from basements, living spaces and outdoor ambient air. The US EPA Building Assessment and Survey Evaluation (BASE) study was conducted on 100 public and commercial office buildings between 1994 and 1998. The 25th to 75th percentile range of concentrations from these two studies have been summarized in the Table below for some of the more common VOCs detected in groundwater at contaminated sites. Units are in $\mu g/m^3$.

Compound	NYSDOH Study (1997-2003)		EPA BASE Data (1994-1998)	
	Residential Single Family Homes		Commercial Office Buildings	
	Indoor	Outdoor	Indoor	Outdoor
Trichloroethane, 1,1,1-	<0.25 – 1.1	<0.25 – 0.38	2.6 – 11	<0.6 – 1.7
Dichloroethane, 1,2-	<0.25	<0.25	<0.6	<0.6
Trimethylbenzene, 1,2,4-	0.69 – 4.3	<0.25 – 0.81	1.7 – 5.1	<1.6 – 3.1
Trimethylbenzene, 1,3,5-	<0.27 – 1.7	<0.25 – 0.34	<1.5	<1.4
Benzene	1.1 – 5.9	0.57 – 2.3	2.1 – 5.1	1.2 – 3.7
Ethylbenzene	0.41 – 2.8	<0.25 – 0.48	<1.6 – 3.4	<1.4 – 1.6
Methylene chloride	0.31 – 6.6	<0.25 – 0.73	<1.7 – 5.0	<1.8 – 3.0
Xylenes (m&p)	0.50 – 4.6	<0.25 – 0.48	4.1 – 12	<3.6 – 7.3
Methyl-tert-butyl-ether	<0.25 – 5.6	<0.25 – 0.86	<1.7 - 12	<1.8
Tetrachloroethylene	<0.25 – 1.1	<0.25 – 0.34	<1.9 – 5.9	<1.4 – 3.0
Toluene	3.5 – 24.8	0.61 – 2.4	10.7 - 26	5.9 - 16
Trichloroethylene	<0.25	<0.25	<1.2 – 1.2	<1.5
Vinyl chloride	<0.25	<0.25	<0.9	<1.0

To minimize the impact of indoor air background for residential sampling, indoor activities such as smoking, use of sprays, solvents, paints, etc., should be suspended immediately prior to and during sampling. Outdoor activities that could influence indoor air levels such as mowing, painting, and asphalting, should also be suspended during sampling.

6.5 Sampling under Conservative Conditions

Sampling under conservative conditions is a matter of where and when the samples are collected. Conservative samples are generally located in the basement or lowest portion of the building (crawl space) where vapors first enter a structure. Conservative samples would also be defined under certain ambient conditions as noted below.

Parameter	Most conservative	Least conservative
Season	Late winter/early spring	Summer
Temperature	Indoors 10^0F greater than outdoors	Indoor temp. less than outdoor
Wind	Steady greater than 5 mph	Calm
Soil	Saturated with rain	Dry
Doors/Windows	Closed	Open
Mechanical Heating System	Operating	Off
Mechanical fans	Off	On

Modified from Massachusetts Indoor Air Sampling and Evaluation Guide (2002)

6.6 OSHA Considerations

The Occupational Safety and Health Act of 1970 (OSHA) uses permissible exposure limits (PELs) to regulate work place exposure to chemicals. OSHA PELs are based not only on risk but are adjusted to account for factors including economic feasibility. PELs are different than the DES indoor air screening levels, which have been established for chemicals that are released to the environment and are generally based on risk exposure criteria. For most of the identified VOCs in Table 1 the DES indoor air screening levels are well below the established OSHA PELs.

The following examples illustrate where OSHA PELs would apply or where the use of this guidance would be more appropriate to evaluate exposures due to vapor intrusion at contaminated sites.

- If an industrial worker is exposed to vapors from a subsurface source of contamination regulated by DES (regardless of whether that contamination is derived from that facility or another) and are simultaneously exposed to the same hazardous vapors in the work place and is knowledgeable of their exposures then the exposure would be regulated under OSHA.

- If an industrial worker is exposed to vapors from subsurface contamination and exposed to different hazardous chemicals in the work place that they protect themselves against but not those associated with the subsurface contamination then the exposure associated with the release may be managed in accordance with this guidance. The employer has the option of incorporating the additional environmental exposure into their employee protection program in which case OSHA requirements would apply.

- If a worker is exposed to vapors from subsurface contamination that is not associated with the normal operating conditions of that work place, such as a commercial office building, restaurant or daycare center, then the employee's exposure may be managed in accordance with this guidance.

In general, DES recommends using this guidance where employees within buildings have not voluntarily accepted a risk associated with environmental contamination in connection with their employment. This can include buildings located at the spill site, and properties down gradient of the spill site.

7.0 EVALUATION OF RESULTS

When conducting a vapor intrusion investigation, the goals are to determine if vapor intrusion is occurring, and if so is mitigation necessary to protect building occupants. Once all the analytical results have been collected the data should be compared to the appropriate screening levels. DES recommends a multiple line of evidence approach when evaluating the vapor intrusion pathway.

Groundwater data should be evaluated to determine if the extent of the VOC plume has been adequately delineated. Groundwater data should be compared with the GW-2 groundwater screening values, and all buildings within 100 feet horizontally (30 feet for petroleum hydrocarbons) of groundwater that exceeds the screening levels should be identified for further evaluation.

Once groundwater data indicates the potential for vapor intrusion an exterior soil gas sampling program should be conducted to delineate the extent of the subsurface vapor plume. The results of exterior soil gas sampling should then be compared with the appropriate soil gas screening levels. Where soil gas samples do not exceed the screening levels, but groundwater exceeds the screening levels, a site specific evaluation is recommended to determine if vapor intrusion may be ruled out. This evaluation would require an understanding of the site conceptual model and should take into consideration the following:

- Shallow groundwater concentrations will not likely increase in the future.
- Site conditions at the time of soil gas sampling are not likely to result in higher soil gas concentrations due to seasonal, atmospheric, hydrogeologic, or other reasons.

Due to the potential for variability in soil gas concentrations, DES does not recommend the averaging of soil gas samples. Each data point should be evaluated separately. Where groundwater exceeds the GW-2 screening levels, DES recommends that a minimum of two rounds of exterior soil gas data be collected to rule out vapor intrusion as a potential exposure pathway due to potential variability in soil gas concentrations. If exterior soil gas samples exceed the screening values then additional investigation of the vapor intrusion pathway may consist of collecting indoor air samples from structures that may be at risk of vapor intrusion.

Determining if there is an exceedance of the indoor air screening levels attributable to vapor intrusion can be difficult. When reviewing indoor air data as part of a vapor intrusion pathway assessment it is important to distinguish between background VOCs in indoor air from VOCs determined to be the result of vapor intrusion. A few examples are illustrated below:

- Compare the relative concentration of COC at different locations in a structure;

  If the ratio of benzene to xylene in the basement is 1:1 and there is three times as much xylene as benzene on the first floor there is probably a background source of xylene located on the first floor.

- Evaluate concentration gradients of contaminants of concern within a structure.

  If the concentration of a contaminant is highest in the basement and decreases as you move up to the first and second floors vapor intrusion may be the primary source. If the concentrations are higher in the upper floors than the basement a background source unrelated to vapor intrusion is probably located in the structure and may be the primary source.

- Compare sub-slab soil gas data to indoor air data.

  Contaminants detected in indoor air that are not detected in sub-slab samples indicates there is likely a background source unrelated to vapor intrusion. If a concentration gradient exists where sub-slab concentrations are higher than indoor air concentrations of COC this is an indication that vapor intrusion is occurring that may warrant further evaluation, abatement or continued monitoring.

As illustrated above when developing the conceptual vapor migration model for a site and determining contributions from background, sub-slab soil gas data combined with indoor air data can be helpful particularly when COC are likely to be present from background sources not related to vapor intrusion. In some instances it may be more economical to mitigate an anticipated vapor intrusion exposure than to conduct rigorous indoor air testing.

If indoor air sampling indicates there is no exceedance of the indoor air screening levels then further evaluation of the pathway may not be necessary, however, multiple sampling events may be necessary to rule out vapor intrusion as a pathway of concern.

If the levels in indoor air exceed the indoor air screening levels as a result of vapor intrusion, abatement measures and/or continued monitoring or further assessment may be warranted.
Further assessment may consist of a site specific health risk assessment. A site specific health risk assessment should demonstrate that the contribution of VOCs from vapor intrusion is not presenting a significant risk to building occupants. The frame work for conducting a site specific health risk assessment for the vapor intrusion pathway is presented in Appendix E.

8.0 ADDITIONAL INVESTIGATIVE TOOLS

There are a number of different tools available to evaluate VOC vapor migration as part of a site specific vapor intrusion assessment or simply to aide in the understanding of the vapor conceptual site model.

8.1 Determination of a Site-specific Soil Gas Attenuation Factor

Measurement of a conservative tracer inside of a structure and in the sub-slab soil gas below a structure can be used to determine a site-specific soil gas attenuation factor. The calculated site-specific soil gas attenuation factor may then be used to estimate the indoor air concentration of the COC from a measured sub-slab soil gas concentration. This method assumes that all sub-slab vapor phase contaminants are entering the building at equal rates. Naturally occurring radon is a commonly used conservative tracer. If sub-slab samples are being collected concurrent collection of radon may be useful especially if the potential exists for indoor air background levels of the COC.

8.2 Indoor/sub-slab Differential Pressure Measurements

Measurement of the pressure gradient between the sub-slab and overlying structure can assist in interpreting the direction of vapor transport, whether into or out of the structure. If the building is over-pressured relative to the sub-slab, measured indoor concentrations might be more likely attributed to above-ground sources from within the building. Conversely if the building is under-pressured relative to the sub-slab, measured indoor concentrations might be more likely attributed to below-ground sources associated with vapor intrusion. Differential pressure measurements are easy and inexpensive, and can be collected continuously around the clock. The success of this approach may require multiple indoor air measurements to establish long term patterns.

8.3 Passive Soil Gas

DES considers passive soil gas sampling as a qualitative tool. Sampling devices which house an adsorbent material are placed in the subsurface and left to collect vapors over several days. VOCs migrating through the subsurface are colleted onto the adsorbent material. The sampling devices are then retrieved and analyzed. Passive soil gas sampling can be an effective tool in understanding the composition and the location of subsurface vapor plumes. DES does not recommend using passive soil gas samples for quantifying contaminant concentrations in soil gas and therefore should not be used for comparison with the soil gas screening levels listed in Table 1.

Passive soil gas sampling methods can be used to collect soil gas from low-permeability and high moisture settings where conventional active soil gas sampling may be problematic. Passive soil gas sampling methods are capable of detecting compounds present in very low concentrations. Passive soil gas samplers can be placed into potential preferential vapor migration pathways such as utility corridors and foundation cracks to determine if these pathways are acting as significant VOC migration pathways into a structure.

8.4 Flux Chamber

Flux chambers are enclosures that are placed directly on a surface for a few hours to a few days, and the resulting contaminant concentration in the enclosure is then measured which yields the contaminant flux at a surface.

Flux chambers are a qualitative tool that can be used to locate surface fluxes of VOC contamination and entry points into structures. Flux chambers may be suitable for structures with dirt floors, larger slabs in good condition, and for future use scenarios on undeveloped land. Specialized equipment and experienced staff is necessary when conducting flux chamber evaluations.

8.5 Modeling

Modeling can assist in evaluating the potential for vapor intrusion from subsurface contamination. One of the most common vapor intrusion models is the Johnson and Ettinger (J/E) model used by EPA. The J/E vapor transport model was originally developed by P. Johnson and R. Ettinger in 1991 and has subsequently been modified by EPA. The J/E model is based on the basic principles of contaminant fate and transport, contaminant partitioning between media and the physical and chemical properties of the contaminants. The model incorporates both diffusion and advection as mechanisms of transport of subsurface vapor into the indoor air environment. The J/E model is based on the following assumptions:

- Steady-state conditions.
- Infinite source of contamination.
- Homogeneous subsurface.
- Uniform air mixing in the structure.
- No preferential pathways.
- No biodegradation.
- Homogeneous distribution of contaminants.

- Contaminant vapors enter structure through cracks in the foundation and walls.
- Structures are slab-on-grade or have basements.
- Ventilation rates and pressure differences are assumed to remain constant.

Using a range of potential input parameters the model can predict a wide range of indoor air impacts spanning orders of magnitude. When using the J/E model, input parameters for a given site should match site-specific conditions. It is important to understand the sensitivity of the input parameters on the results of the model and therefore DES recommends that vapor intrusion evaluations that involve modeling include a sensitivity analysis.

9.0 VAPOR INTRUSION ABATEMENT STRATEGIES

When evaluation of the vapor intrusion pathway shows that vapor intrusion is a concern, abatement strategies can eliminate or mitigate the potential exposure pathway. Strategies for abating vapor intrusion involve both passive and active techniques. A combination of strategies may be most effective. Techniques can include the following:

- Sealing of cracks, utility conduits, sumps etc. in the basement, or crawl space.
- Passive Barriers, i.e. thin plastic liners, heavy HDPE liners, spray on elastomers, etc.
- Sub slab depressurization (SSD), or radon system.
- Natural ventilation.
- Heating recovery ventilation.
- Building pressurization.
- Soil pressurization.
- Indoor air treatment.

If passive techniques are insufficient to limit risk a more active technique may be necessary to prevent the entry of contaminant vapors into a building.

The most common technique for eliminating the vapor intrusion pathway for a residential structure is the installation of a SSD system. This technique has been used for many years to eliminate radon vapor issues. The system works by depressurizing the soil beneath the building envelope thus creating a negative pressure zone that becomes a "sink" for the contaminated vapors. The contaminated vapors are collected and discharged to ambient air typically above the building's roof line. SSD systems can be used in buildings with a basement, crawl space or slab-on-grade foundation. If the floor of the basement or crawl space is dirt, a membrane/vapor barrier must be placed and sealed to the foundation wall as part of the overall system. Figure 5 shows a schematic of a residential SSD system. SSD systems have been successful in reducing the health risks associated with vapor intrusion for building occupants.

The components of a typical residential SSD system include: an extraction pit beneath the slab or membrane, PVC piping and a blower. A couple of important considerations prior to installation of the SSD system are that groundwater should be more then 6 inches below the foundation and that all entry points such as cracks in the foundation floor and walls and sumps must be sealed.

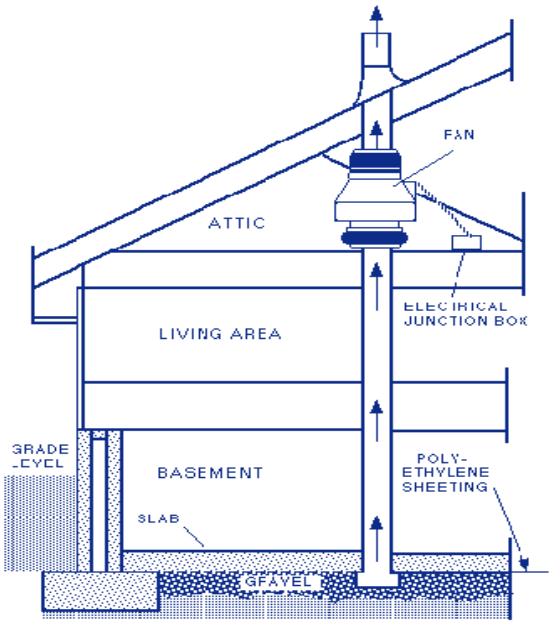

Figure 6 Sub slab Soil Depressurization System (EPA April 2001)

When designing an SSD system there are other considerations. A visible or audible alarm may be desirable to indicate when a loss of system pressure has occurred. The possibility of back drafting occurring in the system should also be considered. This is especially important in buildings with heating systems that vent combustion gases to the ambient air.

DES recommends that SSD systems be designed and installed by professionals with prior experience with these type of radon systems and preferably are certified by either the National Environmental Health Association or the National Radon Safety Board. All designs should have site specific performance standards along with a plan to monitor these standards.

For proposed buildings that are to be constructed over a VOC source that has the potential to cause vapor intrusion, DES recommends at a minimum that a passive venting system be installed, that can be modified to an active system at a later date if necessary.

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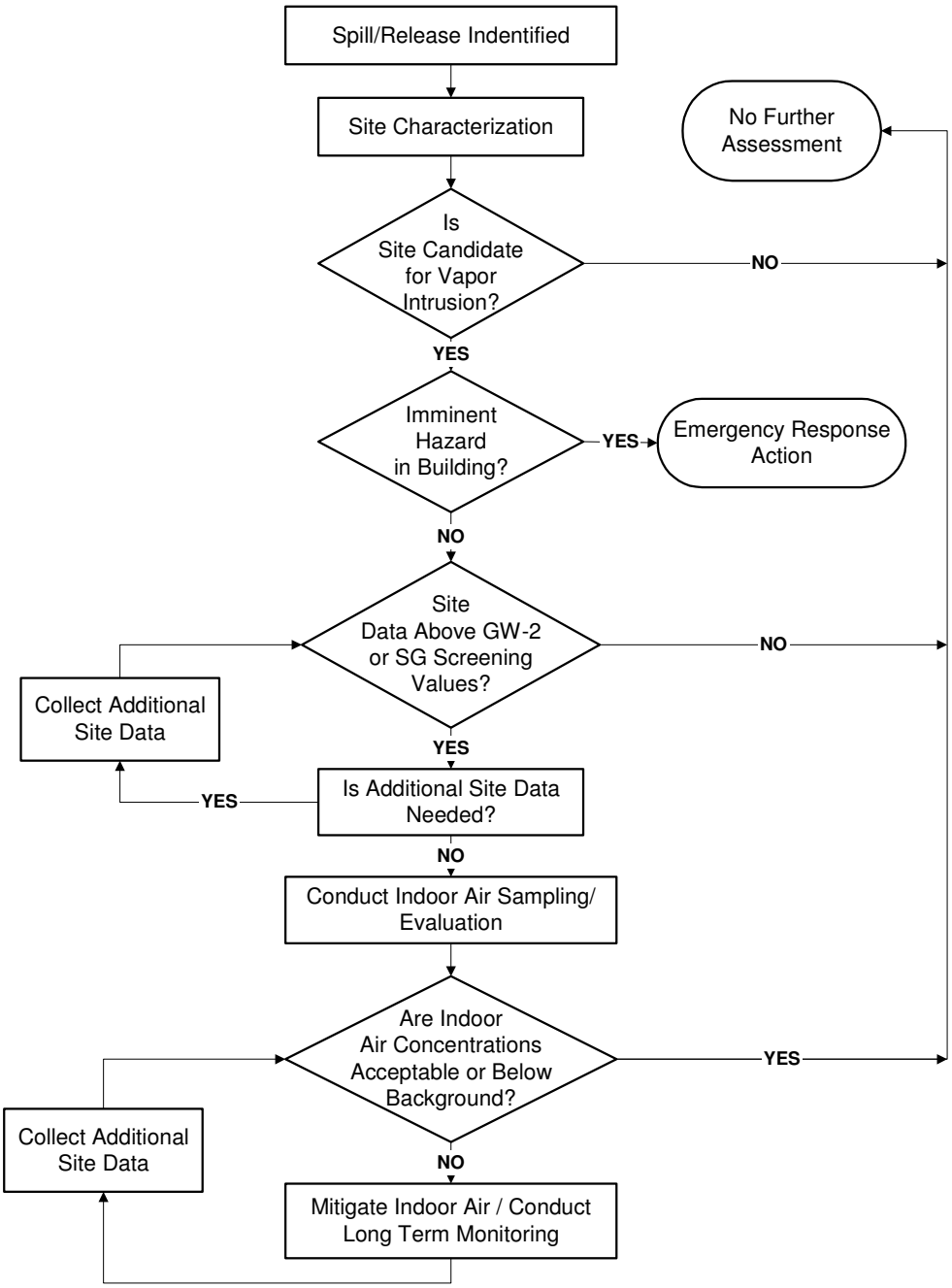
New Hampshire Department of Environmental Services
Waste Management Division Site Remediation Programs

Table 1
Vapor Intrusion Screening Levels

Chemical	Residential Indoor Air Screening Levels (µg/m³)	Commercial Indoor Air Screening Levels (µg/m³)	Residential Soil Gas Screening Levels (µg/m³)	Commercial Soil Gas Screening Levels (µg/m³)	Groundwater to Indoor Air Screening Levels GW-2(1) (µg/L)
Benzene	1.9(2)	1.9(2)	95	95	2,000
Bromoform	2.4	11	120	550	2,000
Bromomethane	1.0	1.5	50	73	10
Carbon Tetrachloride	1.3(3)	1.3(3)	63	63	40
Chlorobenzene	12	18	600	880	3,000
Chloroform	1.0(3)	1.0(3)	49	49	200
Dichlorobenzene, 1,2-	40	58	2000	2900	20,000
Dichlorobenzene, 1,4-	160	230	8000	12000	50,000
Dichloroethane, 1,1-	100	150	5000	7300	10,000
Dichloroethane, 1,2-	0.8(3)	0.8(3)	40	40	300
Dichloroethylene, 1,1-	40	58	2000	2900	1,000
Dichloromethane (Methylene Chloride)	5.6(2)	26	280	1300	1,000
Dichloropropane, 1,2-	0.9(3)	1.2	46	59	200
Ethylbenzene	200	290	10000	15000	50,000
Ethylene dibromide	1.5(3)	1.5(3)	77	77	700
Methyl ethyl ketone	1000	1500	50000	73000	50,000
Methyl isobutyl ketone	600	880	30000	44000	50,000
Methyl tert butyl ether (MTBE)	5.6(2)	15	280	770	10,000
Naphthalene	2.6(3)	2.6(3)	130	130	2,000
Styrene	200	290	10000	15000	50,000
Tetrachloroethane, 1,1,2,2-	1.4(3)	1.4(3)	69	69	1,000
Tetrachloroethylene (PCE)	1.4(3)	2.1	68	100	80
Toluene	1000	1500	50000	73000	50,000
Trichlorobenzene, 1,2,4-	3.7(3)	3.7(3)	190	190	1,000
Trichloroethane, 1,1,1-	440	640	22000	32000	20,000
Trichloroethane, 1,1,2-	1.1(3)	1.1(3)	55	55	500
Trichloroethylene (TCE)	1.1(3)	1.1(3)	54	54	50
Trimethylbenzene, 1,2,4-	4.3(2)	4.3(2)	220	220	3,000
Trimethylbenzene, 1,3,5-	1.7(2)	1.8	85	88	1,000
Vinyl chloride	0.5(3)	2.8	26	140	10
Xylenes (mixed isomers)	20	29	1000	1500	30,000

(1) Revised Risk Characterization and Management Policy GW-2 values.
(2) The screening values for these compounds are based on published background values.
(3) The risk based levels for these compounds are below the EPA TO-15 low level reporting limit and therefore the screening value is based on method reporting limit.

Figure 2 - Evaluating the Vapor Intrusion Pathway



APPENDIX A
New Hampshire Department of Environmental Services
Waste Management Division
Site Remediation Programs

Vapor Intrusion Conceptual Site Model Checklist

To assist in the development of the site-specific vapor migration conceptual site model, and for planning a soil gas sampling strategy for a site, the following information should be compiled.

Utilities and Process Piping

☐ Identify on a site plan all underground utilities near the soil or groundwater impacts; pay particular attention to utilities that connect impacted areas to occupied buildings.

☐ Identify on a site plan all underground process piping near the soil or groundwater impacts.

Buildings

☐ Identify on a site plan all existing and planned future buildings under investigation.

☐ Identify the occupancy and use of each building (e.g., residential, commercial)

☐ Describe building construction materials (e.g., wood frame, block,), openings (e.g., windows, doors), and height (e.g., one-story, two-story, multiple-story); identify if there is an elevator shaft in the building.

☐ Describe building foundation construction including:

- Type (e.g., basement, crawl space, slab on grade)
- Floor construction (e.g., concrete, dirt)
- Depth below grade.

☐ Describe the building HVAC system including:

- Furnace/air conditioning type (e.g., forced air, radiant)
- Furnace/air conditioning location (e.g., basement, crawl space, utility closet, attic, roof)
- Source of return air (e.g., inside air, outside air, combination)
- System design considerations relating to indoor air pressure (e.g., positive pressure is often the case for commercial buildings).

☐ Identify sub-slab ventilation systems or moisture barriers present on existing buildings.

Source Area

☐ Identify the COC's related to the vapor intrusion pathway.

☐ Describe the distribution and composition of any NAPL at the site.

☐ Identify on a site plan all source areas for the COC's related to the vapor intrusion pathway.

☐ Identify on a site plan soil and groundwater results for the COC, between the source area and the

buildings under investigation.

- ☐ Identify on a geologic cross section soil and groundwater results including depth.
- ☐ Describe the potential migration characteristics (e.g., stable, increasing, decreasing) for the distribution of COC.

Geology/Hydrogeology

- ☐ Review all boring logs and soil sampling data to understand the locations of:
  - Sources: NAPL, soil, groundwater, suspected vapor leaks.
  - Soil types:
    - Finer-grained soil layers
    - Higher-permeability layers that may facilitate vapor migration.
- ☐ Identify on a geologic cross section distinct strata (soil type and moisture content – e.g., "moist," "wet," "dry") and the depth intervals between the vapor source and ground surface, and include the depth to groundwater.
- ☐ Describe groundwater characteristics (e.g., seasonal fluctuation, hydraulic gradient).

Site Characteristics

- ☐ Estimate the distance from GW-2 groundwater concentration contour interval for each COC to buildings under investigation.
- ☐ Estimate the distance from vadose zone source area to buildings under investigation.
- ☐ Describe the surface cover between the vapor source and buildings under investigation.

APPENDIX B
New Hampshire Department of Environmental Services
Waste Management Division
Site Remediation Programs

Soil Gas Probe Field Data Report							
Site:							
Date:							
Instrument(s) used:							
Tracer used:							
Weather:							
Technician:							
Soil Gas Probe Number	**Probe Depth (ft.)**	**Probe Volume (l)**	**Purge Rate (lpm)**	**Volume Purged (l)**	**Tracer Field Analysis (ppm)**	**% CO_2**	**% O_2**

ND=Non Detect
NM=Not measured

APPENDIX C
New Hampshire Department of Environmental Services
Waste Management Division
Site Remediation Programs

Indoor Air Sampling Form

DES Site # _____

DES Site Name _____

Address _____

_____

Occupant Information

Name _____

Address _____

_____

Telephone No (H) (____)_____

(W) (____)_____

Number and Age of Occupant_____

Does anyone smoke inside the building?_____

Building Characteristics

Type of building: (circle) Residential/Industrial/School/Commercial/Multi-use/Other? _____

If residential, what type (circle) Single family/Condo/Multi-family/Other?_____

If the property is commercial, indicate the business ? _____

How many floors does the building have?_____

Does the building have a (circle) Basement/Crawl space/Slab-on-grade/Other? _____

Is the basement used as a living/work space area?_____

What type of foundation does the building have (circle) Field stone/Poured concrete/Concrete block /Other?_____

Describe the heating system and type of fuel used?_____

Is there an attached garage?_____

Spill/Contaminant Source Information

Type of petroleum/VOC release? _____

When did the release occur? _____

What areas of the building have been impacted by the release?_____

Are there any odors? _____ If so describe the odors: _____

Where can release odors be detected? _____

Sampling Information

Sampling Date _____

Sampler Type Sorbent SUMMA (Please circle one)

Analysis Method TO-4A TO-10A TO-13A TO-15LL TO-15-SIM Other:__ (Please circle one)

Consulting Firm _____

Contact Person _____

Telephone No (____)_____

Laboratory _____

Telephone No (____)_____

Table 1: Sorbent Tube Sampler Information

Sample ID#	Floor	Room	Tube ID#	Pump ID#	Volume (liters)	Duration (minutes)	Comments

Table 2: Canister Sampler Information

Sample ID#	Floor	Room	Canister ID#	Initial On-site Pressure*	Pressure* On-site Following Sample Collection	Pressure Received at the Laboratory

* Indicate pressure in units of inches of mercury.

Please provide a sketch of spill area and location of sampler unit(s).

Pre-Sampling Inspection and Product Inventory

List products or items which may be considered potential sources of VOCs such as paint cans, gasoline cans, gasoline powered equipment, cleaning solvents, furniture polish, moth balls, fuel tank, woodstove, fireplace, etc.

Date and time of pre-sampling inspection _____

Table 3: Pre-sampling Inspection Product Inventory

Potential VOC source	Present (Y/N)	Location	Field screening Results (ppm)	Product Condition
Paints or paint thinners				
Gas powered equipment				
Gasoline storage cans				
Cleaning solvents				
Furniture polish				
Moth balls				
Fuel tank				
Wood stove				
Fireplace				
Perfumes/colognes				
Other:				
Other:				
Other:				

Table 4: Potential vapor migration entry point information

Potential Vapor entry points	Present (Y/N)	Field screening results (ppm)	Comments
Foundation penetrations in floor or walls			
Cracks in foundation floor or walls			
Sump			
Floor drain			
Other			
Other			

Was the building aired out prior to sample collection? _____
How long was the airing out process? _____

Were vapor control methods in effect while the samples were being collected?

Windows open? Yes / No Ventilation fans? Yes / No Vapor barriers? Yes / No

Vapor phase carbon treatment system? Yes / No Other site control measures_____

Weather Conditions during Sampling

Outside temperature (^{o}F) _____ Inside temperature (^{o}F)_____

Prevailing wind speed and direction _____

Describe the general weather conditions (e.g. sunny, cloudy, rain) _____

Significant precipitation (0.1 inches or more) within 12 hours of the sampling event? _____

General Comments

Is there any information you feel is important related to this site and the samples collected which would facilitate an accurate interpretation of the indoor air quality?

_____

APPENDIX D
New Hampshire Department of Environmental Services
Waste Management Division
Site Remediation Programs

Indoor Air Sampling Protocol

Introduction

Indoor air sampling for specific volatile organic compounds (VOC) can be performed to assist in determining if a contaminant is adversely affecting indoor air quality in a building. In general, certain conditions should be met and certain procedures should be followed to ensure integrity of the test results and to limit variables that may effect the success and interpretation of the data. This protocol is intended to ensure that air sampling data is collected in a consistent and useful manner during corrective action. The protocol outlines the steps to be followed when conducting indoor air sampling for VOCs in a residential setting however it may be modified for use in other situations. The resulting data obtained will provide a conservative indication of health risks posed to building occupants; however DES understands that under emergency response actions it may not be appropriate to complete the 24-hour pre-sampling inspection procedures outlined below. DES recommends that an indoor air sampling work plan be submitted to the department for comment prior to sampling unless the sampling is being conducted as part of an emergency response action.

Pre-sampling Inspection

A pre-sampling inspection and product inventory should be performed prior to sampling in order to characterize the structure layout and physical conditions of the home under evaluation. DES recommends completing the pre-sampling inspection 24 hours prior to sampling. In addition the inspection will allow for the identification of potential interfering sources of VOCs that may make data interpretation difficult. If the target VOCs are petroleum-related, interfering sources can include gasoline cans, gasoline powered equipment, paints and cleaning supplies containing petroleum distillates. If the target VOC is non-petroleum, such as tetrachloroethylene, other products or conditions that may be sources of these compounds, such as recently dry cleaned clothes, should be identified. Removing potential sources of VOCs from the indoor environment prior to testing is the most effective means of reducing interferences. If potential interferences can not be eliminated prior to sample collection it may make data interpretation more difficult. Field screening of potential sources may help to document if the sources are contributing to indoor air VOC concentrations and may help determine which sources should be removed prior to sampling.

If interfering sources are removed, DES then recommends ventilation of the building prior to testing to eliminate residual contamination from the interfering sources. The house should be ventilated by opening windows and doors for a period of 10 to 20 minutes. DES does not recommend building ventilation where no interfering VOC sources are observed or if potential VOC sources can not be removed from the building. The inability to eliminate potential interferences may be justification for not sampling. The primary objective of the indoor air test is to obtain a representative sample that provides a conservative indication of the health risk posed to the occupants by the VOC associated with the spill. Ventilation of the building should be minimized in the 24 hours prior to and during sampling.

Many variables can influence indoor air sampling including air exchange rates, operation of the building HVAC system, hydrogeologic and meteorological conditions, household activities and chemical usage. All of these variables combine to create site-specific exposure conditions that should be considered in evaluating the indoor air sample results from a home. To account for these variations the following measures should be considered:

- Perform sampling in the lowest level of the structure where vapors are likely to enter, typically the basement or crawl space.

- Perform living area sampling in a room that is used regularly in the lowest level of the structure suitable for occupancy such as a living room, den or playroom.

- Avoid kitchens and laundry rooms where use of personal products and other chemical products may interfere with sample results.

- Close windows and outside doors and keep them closed as much as possible during sampling except for normal entry and exiting.

- Place indoor samplers on stands approximately 1 meter above the floor in a central part of the room away from heaters, heating vents, high humidity, exterior walls, drafts (vents, open doors, and windows, air conditioners, fans) and obstructions to air flow.

- Place the source area sampler near the spill or where vapors may be entering the home (most likely in the basement) approximately 1 meter above the floor.

- All sampling equipment should be placed away from family traffic patterns and out of reach of pets and children.

- Only operate air conditioning units that recirculate interior air.

- Samplers should not be placed close to attached garages, ash trays or other possible VOC sources that might provide results that do not reflect contamination related to the spill/vapor source under investigation.

- Remove or tightly seal obvious indoor sources of petroleum constituents and other VOC sources during indoor air sampling, such as fuels, paints, cleaning solvents and mothballs.

- Document household characteristics, resident activities and potential ambient sources that may influence indoor air sampling results by completing the "Indoor Air Sampling Form".

- Complete a sketch of sampling locations.

The residents of the home should be given the instructions listed below to follow 24 hours prior to and during the sampling event:

- **Do not** open any windows, fireplace openings or vents.
- **Do not** operate ventilation fans unless special arrangements are made.
- **Do not** smoke in the home.
- **Do not** use paints or varnishes.
- **Do not** use wood stove, fireplace or auxiliary heating equipment, e.g., kerosene heaters.
- **Do not** operate or store automobiles in an attached garage.
- **Do not** store containers of gasoline or oil within the house or attached garage (except for fuel oil tanks).
- **Do not** clean or polish furniture or floors with petroleum or oil-based products.
- **Do not** use air fresheners or odor eliminators.
- **Do not** engage in hobbies that use materials containing VOCs.
- **Do not** use cosmetics including hair spray, nail polish, nail polish removers, etc.
- **Do not** apply pesticides.

Quality Control/Quality Assurance

Follow the manufacturer's guidelines for use of sampling equipment and holding times. Field blanks trip blanks and duplicate samples should be kept with and submitted with the samples. Analyze samples as soon as possible after sampling. Record general weather conditions during sampling including ambient temperature. Maintain chain-of-custody forms.

Appendix E
New Hampshire Department of Environmental Services
Waste Management Division
Site Remediation Programs

Derivation of the Indoor Air Screening Levels

This appendix describes the assumptions, toxicity information, equations, indoor air background information and analytical reporting limits used by DES Environmental Health Program (EHP) to develop the indoor air screening levels, provided in Table 1. The approach described in this appendix can also be used to develop indoor air screening guidelines for chemicals not identified in Table 1. In addition, equations are provided in this appendix that can be used to conduct a site-specific risk assessment to determine the potential human health risk to a building occupant based on a site-specific exposure scenario.

The chemicals contained in Table 1 are those identified on DES's Site Remediation Programs Full List of Analytes for Volatile Organics. The list has been limited to those chemicals with inhalation based toxicity factors and a Henry's Law Constant of 1×10^{-5} atm-m^3/mol or greater. EHP developed carcinogenic and non-carcinogenic risk based values for both a residential exposure scenario and a commercial work place exposure scenario using standard exposure factors to estimate contaminant concentrations in indoor air that are considered to be protective of human health. The risk based values were then compared to published background values (residential only) and low level reporting limits for USEPA Method TO-15-LL with the higher value selected as the indoor air screening value.

Dose-Response Information

Dose-response information provides a quantitative evaluation of the toxicity data and allows for characterizing the relationship between the inhaled concentration and the adverse health effect(s) in the exposed population. The scientific literature has been reviewed by various federal agencies and for certain chemicals these agencies have derived and reported dose-response values. Examples of these values include EPA's reference concentrations (RfC) and inhalation Unit Risk (URi).

Estimating the health effects from a mixture of chemicals is of particular concern since most sites contain two or more contaminants present at the same time. When more than a single contaminant is present there is the potential for a diverse array of interactive effects. Such interactions can be in the form of additive, antagonistic, synergistic or other interactive effects. Unfortunately, for most chemical mixtures there is a lack of toxicological data. In addition, when there is data available for mixtures it is difficult to evaluate the effects because of the infinite proportions that could be possible. Therefore, the dose-response values are based on experimental data from exposure to a single chemical and do not consider the effects of exposure to chemical mixtures.

The concentration of a chemical in the air that is inhaled and the amount that reaches the circulatory system and eventually the target organ(s) to elicit the toxic effect is dependent on many variables. These variables include the physiological and metabolic differences in the regions of the respiratory tract, genetic differences between individuals and the health status of the individual. In addition, the physiochemical properties of the inhaled chemical will also influence the systemic or tissue dose and ultimately the toxic effect. Because of the uncertainty involved with determining the tissue dose the

toxicity factors used to develop the risk-based screening guidelines are based on RfCs and URi, which were developed from inhalation studies. If there were no inhalation based toxicity values available from the identified sources EHP chose not to develop a risk-based screening guideline from an extrapolation of an oral toxicity value (cancer slope factor and/or reference doses) to an inhalation value with the exception of trichloroethylene (TCE).

"The RfC methodology used to estimate benchmark values for non-cancer toxicity of inhaled chemicals significantly departed from the RfD approach. The same general principles were used but the RfC methodology was expanded to account for the dynamics of the respiratory system as the portal of entry. The major difference between the two approaches therefore is that the RfC methodology includes dosimetric adjustments to account for the species-specific relationships of exposure concentrations to deposited/delivered doses. The physicochemical characteristics of the inhaled agent are considered key determinants to its interaction with the respiratory tract and ultimate disposition." (USEPA 1994) In summary, a chemical may have a vastly different absorption, distribution, metabolism and portal of entry effect that is not captured by the extrapolation introducing greater uncertainty than values based on inhalation studies.

Toxicity Factors

In 2003, the EPA's Office of Solid Waste and Emergency Response (OSWER) issued Directive 9285.7-53, which provides recommended sources of toxicity data for developing screening levels for various media and conducting site-specific human health risk assessments. The hierarchy of toxicity information recommended by OSWER Directive 9285.7-53 is:

Tier 1– EPA's Integrated Risk Information System (IRIS)

Tier 2 – EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs)

Tier 3 – Other (CAL EPA, ATSDR, HEAST)

The EPA's IRIS database is the generally preferred source of URi and RfCs for evaluating inhalation exposure. The PPRTVs are provisional toxicity values recommended by EPA's National Center for Environmental Assessment (NCEA). PPRTVs are the second recommended tier of toxicity values, however, EPA has restricted access to this database. When IRIS values were not available EHP consulted EPA Region 9's Preliminary Remediation Goals (PRG) table, which contains the latest recommended toxicity factors according to the OSWER directive. Please note that the toxicity values identified on IRIS are frequently updated. It is incumbent upon the users of this guidance to check IRIS and EPA Region 9's PRG Table to verify that the most current toxicity information is being when completing site-specific human health risk assessments.

Carcinogenic Effects

For carcinogenic chemicals an assumption is made that there are no thresholds and that exposure introduces some potential of developing cancer. The risk based values for carcinogenic chemicals are based on an excess lifetime cancer risk (ELCR) of one-in-one million (1.0E-6) exposed for a residential scenario that assumes an individual is exposed 22 hours per day, 350 days per year for a duration lasting 30 years. The risk based values for a commercial worker assumes exposure for 8 hours per day, 5 days per week for 50 weeks per year (250 days per year total) for a duration lasting 25 years.

EHP has elected to calculate the carcinogenic risk-based screening values using the URi. The URi defines quantitatively the relationship between the dose and the response and is defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air.

Non-carcinogenic Effects

For non-carcinogens a range of exposures are believed to exist that can be tolerated with little likelihood of expression of an adverse health effect. The dose-response value derived by the EPA to protect against non-carcinogenic threshold effects is the reference concentration (RfC). The RfC is defined as "an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious non-cancer health effects during a lifetime." (USEPA IRIS)

For this guidance, EHP has selected 20 percent of the chronic non-cancer dose-response value as the risk-based non-cancer value for a residential scenario. For a commercial scenario, EHP used 20 percent of the adjusted RfC. The RfC was adjusted to account for the assumed exposure of 5 days per week for 50 weeks per year (250 days per year total) over a duration lasting 25 years. By using 20 percent of the adjusted RfC, the commercial risk based value is still below the full RfC and therefore portal of entry effects should not be a concern.

Screening Level Equations

Carcinogens:

Equation #1 C_{cancer} ($\mu g/m^3$) = (TCR * AP * HD) / (EF * ED* URi * ET)

Non-carcinogens:

Equation #2 $C_{non\text{-}cancer}$ ($\mu g/m^3$) = (HQ * RfC)

Where:

C_{cancer} = target indoor air concentration for a carcinogen ($\mu g/m^3$)
TCR = target cancer risk (1.0E-6)
AP = averaging period carcinogens (25550 days)
HD = hours in a day (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
URi = unit risk factor inhalation ($\mu g/m^3$)
ET = exposure time (hours/day)

$C_{non\text{-}cancer}$ = target indoor air concentration for a non-carcinogen ($\mu g/m^3$)
HQ = target hazard quotient (0.2)
RfC = reference concentration ($\mu g/m^3$)

The carcinogenic and non-carcinogenic risk based values, for residential and commercial exposure scenarios are provided in Table E-1.

Indoor Air Background Values

In order to take into account background levels of chemicals, DES reviewed two indoor air studies listed below.

- "Study of Volatile Organic Chemicals in Air of Fuel Oil Heated Homes." New York State Department of Health, 1997-2003.

- "Background Indoor Air Levels of Volatile Organic Compounds (VOCs) and Air-Phase Petroleum Hydrocarbons in Massachusetts Residences," completed by Rich Rago and Rose McCafferty, Haley & Aldrich, and Andy Rezendes, Alpha Analytical, presented to NHDES October 2005.

Where a chemical was detected in at least 25% of homes sampled in the studies noted above, the 75th percentile values for each study were compared and the lower value was selected to represent a residential background value for indoor air. The indoor air background values used in the derivation of the residential indoor air screening levels are presented in Table E-2.

Selection of the Indoor Air Screening Levels

For the indoor air screening levels, DES took into account risk based values, method reporting limit and indoor air background values (residential only). For the development of the residential indoor air screening levels, DES compared the most conservative (lowest) risk based value, the EPA Method TO-15-LL reporting limit and a residential indoor air background value, where available. The higher of these values was selected to represent the residential indoor air screening levels provided in Table 1 of the guidance. For the development of the commercial indoor air screening levels DES selected the most conservative (lowest) risk based value compared to the EPA Method TO-15-LL reporting limit and selected the higher of the two values as the commercial indoor air screening levels provided in Table 1 of the guidance. The risk based values for residential and commercial exposures, EPA Method TO-15-LL reporting limit and the residential background values used to generate the indoor air screening levels are detailed in Table E-2.

Site-Specific Risk Assessments

The risk-based indoor air values are based on conservative scenarios. A site-specific risk assessment can be conducted when an indoor air screening guideline is exceeded or when the exposure scenario is different from the scenario used to develop the risk-based screening guidelines. The object of the site-specific risk assessment is to evaluate the reasonable maximum exposed (RME) individual at the site which is the highest possible exposure that is reasonably expected to occur. The RME should be used for both the current and future uses of the building. To account for the different exposure scenarios possible the following formulas can be used to determine the potential risk at a site. Please note that these equations are to evaluate the inhalation pathway. If other media are impacted the risk from all other potential pathways should be included in a Method 3 risk characterization. Guidelines for conducting a Method 3 risk characterization are outlined in the DES Contaminated Sites Risk Characterization and Management Policy.

Equation #3 $ADE = C * ET * EF * ED * C1 * C2 / AP$

Carcinogenic risk:

Equation #4 Risk = ADE * URi

Non-carcinogenic risk:

Equation #5 HQ = ADE / (RfC)

Where:

ADE = average daily exposure ($\mu g/m^3$)
URi = inhalation unit risk $(\mu g/m^3)^{-1}$
C = concentration chemical specific ($\mu g/m^3$)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
C1 = conversion factor (day/hour) (0.042)
C2 = conversion factor (year/day) (0.003)
AP = averaging period (years)
carcinogens = 70 years
non-carcinogens = site-specific (ED)
HQ = hazard quotient (chemical specific)
RfC = reference concentration chemical specific ($\mu g/m^3$)

For multiple carcinogenic chemicals at a site the site-specific cancer risk should be totaled.

$Risk_T$ = Sum $Risk_i$ (expressed to one significant figure)
Where:

$Risk_T$ = the total cancer risk expressed as a unitless probability
$Risk_i$ = the risk estimate for the ith substance

If $Risk_T$ is greater than 1.0E-5, the DES considers the risk from the inhalation pathway to be significant.

When more than one non-carcinogenic substance is at the site the quantification of the non-cancer hazard can be determined by:

Hazard Index (HI) = Sum HQ_i

Where:

HQ = hazard quotient (ADE_i/RfC_i)
ADE = the intake for the ith toxicant
RfC = reference concentration for the ith toxicant

The ADE and RfC are expressed in the same units and represent the same exposure periods. If the HI is greater than unity (1.0) as a consequence of summing several hazard quotients of similar value it

would be appropriate to segregate the compounds by effect on target organ and to derive a separate hazard indice for each target organ. Table E-1 contains the RfCs for chemicals listed in this guidance document. For chemicals not contained in this document the user should consult IRIS or EPA Region 9's RBC table.

For some chemicals there are both carcinogenic and non-carcinogenic toxicity factors available. For the development of screening guidelines EHP has calculated separate screening values using both types of toxicity values if available and selected the most conservative (lowest) to represent the risk-based screening guideline. The risk-based guideline is then compared to the reporting limit of EPA Method TO-15-LL. Please note that it is incumbent upon the risk assessor to account for both potential carcinogenic and non-carcinogenic end points in a site-specific risk assessment if appropriate.

Exposure Variables

The exposure variables EHP typically recommends for the residential and occupational scenarios are identified below. Exposure parameters that are adjusted based on a site-specific basis should be protective of current and future use scenarios. When exposure parameters are different from those recommended in this guidance, DES encourages the use of EPA's Exposure Factors Handbook. If an exposure is expected to be less than seven years consideration should be given to using sub chronic RfCs from a published source. If a sub chronic RfC is not available, the chronic RfC should be used unless justification is provided for altering the chronic RfC.

Residential:

EF	= exposure frequency	=	350 days/year
ED	= exposure duration total	=	30 years
	= exposure duration average	=	9 years[13]
ET	= exposure time	=	22 hours/day

Occupational:

EF	= exposure frequency	=	250 days/year
ED	= exposure duration	=	25 years
ET	= exposure time	=	8 hours/day

TABLE E-1

Chemical	CAS No.	URi (µg/m^3)	Residential 1.0E-6 ELCR (µg/m^3)	Commercial 1.0E-6 ELCR (µg/m^3)	Source	RfC (µg/m^3)	Residential 20 % RfC (µg/m^3)	Commercial 20 % RfC (µg/m^3)	Source
Benzene	71-43-2	7.80E-06	0.34	1.57	IRIS	30	6.00	8.76	IRIS
Bromoform	75-25-2	1.10E-06	2.41	11.15	IRIS				
Bromomethane	74-83-9					5	1.00	1.46	IRIS
Carbon tetrachloride	56-23-5	1.50E-05	0.18	0.82	IRIS				
Chlorobenzene	108-90-7					60	12.00	17.52	PPRTV
12-Dichlorobenzene	95-50-1					200	40.00	58.40	HEAST
14-Dichlorobenzene	106-46-7					800	160.00	233.60	IRIS
11-Dichloroethane	75-34-3					500	100.00	146.00	HEAST
12-Dichloroethane	107-06-2	2.60E-05	0.10	0.47	IRIS				
11-Dichloroethylene	75-35-4					200	40.00	58.40	IRIS
Dichloromethane (Methylene chloride)	75-09-2	4.70E-07	5.65	26.09	IRIS	3000	600.00	876.00	HEAST
12-Dichloropropane	78-87-5					4	0.80	1.17	IRIS
Ethylbenzene	100-41-4					1000	200.00	292.00	IRIS
Ethylene dibromide	106-93-4	6.00E-04	0.004424	0.020440	IRIS	9	1.80	2.63	IRIS
Methyl ethyl ketone	78-93-3					5000	1000.00	1460.00	IRIS
Methyl isobutyl ketone	108-10-1					3000	600.00	876.00	IRIS
Methyl-t-butyl ether (MTBE)	1634-04-4	8.00E-7	3.3	15.3		3000	600.00	876.00	IRIS
Styrene	100-42-5					1000	200.00	292.00	IRIS
1122-Tetrachloroethane	79-34-5	5.80E-05	0.05	0.21	IRIS				
Tetrachloroethylene	127-18-4	5.90E-06	0.45	2.08	Cal EPA	35	7.00	10.22	Cal EPA
Toluene	108-88-3					5000	1000.00	1460.00	IRIS
124-Trichlorobenzene	120-82-1					3.5	0.70	1.02	PPRTV
111-Trichloroethane	71-55-6					2200	440.00	642.40	PPRTV
112-Trichloroethane	79-00-5	1.60E-05	0.17	0.77	IRIS				
Trichloroethene	79-01-6	1.10E-04	0.02	0.11		40	11.68		NCEA
Trichloromethane (Chloroform)	67-66-3	2.30E-05	0.12	0.53	IRIS				
124-Trimethylbenzene	95-63-6					6	1.20	1.75	PPRTV
135-Trimethylbenzene	108-67-8			2.79		6	1.20	1.75	PPRTV
Vinyl chloride	75-01-4	8.80E-06	0.30		IRIS	100	20.00	29.20	IRIS
Total Xylenes	1330-20-7					100	20.00	29.20	IRIS
Naphthalene	91-20-3					3	0.60	0.88	IRIS

TABLE E-2

Chemical	CAS No.	Groundwater Screening Value GW-2 (µg/L)	Residential Soil Gas Screening Value (µg/m3)	Commercial Soil Gas Screening Value (µg/m3)	Residential Indoor Air Screening Value (µg/m^3)	Commercial Indoor Air Screening Value (µg/m^3)	Residential Indoor Air Background Value (µg/m^3)	Residential Indoor Air Risk Based Value (µg/m^3)	Commercial Indoor Air Risk Based Value (µg/m^3)	Method Reporting Limit TO-15 LL (µg/m^3)
Benzene	71-43-2	2,000	95	95	1.9	1.9*	1.9	0.34	1.57	0.64
Bromoform	75-25-2	2,000	120	550	2.4	11	NA	2.41	11.15	2.07
Bromomethane	74-83-9	10	50	73	1.0	1.5	NA	1.00	1.46	0.78
Carbon Tetrachloride	56-23-5	40	63	63	1.3	1.3	0.59	0.18	0.82	1.26
Chlorobenzene	108-90-7	3,000	600	880	12	18	NA	12	17.52	0.92
Chloroform	67-66-3	200	49	49	1.0	1.0	0.54	0.12	0.53	0.98
Dichlorobenzene 12-	95-50-1	20,000	2000	2900	40	58	NA	40	58	1.20
Dichlorobenzene 14-	106-46-7	50,000	8000	12000	160	230	0.54	160	234	1.20
Dichloroethane 11-	75-34-3	10,000	5000	7300	100	150	NA	100	146	0.81
Dichloroethane 12-	107-06-2	300	40	40	0.8	0.8	NA	0.10	0.47	0.81
Dichloroethylene 11-	75-35-4	1,000	2000	2900	40.0	58	NA	40	58	0.79
Dichloromethane (Methylene Chloride)	75-09-2	1,000	280	1300	5.6	26	4.2	5.65	26	1.74
Dichloropropane 12-	78-87-5	200	46	59	0.9	1.2	NA	0.80	1.17	0.92
Ethylbenzene	100-41-4	50,000	10000	15000	200	290	2.2	200	292	0.87
Ethylene dibromide	106-93-4	700	77	77	1.5	1.5	NA	0.004	0.02	1.54
Methyl ethyl ketone	78-93-3	50,000	50000	73000	1000	1500	7.3	1000	1460	1.47
Methyl isobutyl ketone	108-10-1	50,000	30000	44000	600	880	0.86	600	876	2.05
Methyl tert butyl ether	1634-04-4	10,000	280	770	5.6	15	5.6	3.3	15	1.80
Naphthalene	91-20-3	2,000	130	130	2.6	2.6	NA	0.60	0.88	2.62
Styrene	100-42-5	50,000	10000	15000	200	290	0.64	200	292	0.85
Tetrachloroethane 1122-	79-34-5	1,000	69	69	1.4	1.4	NA	0.05	0.21	1.37
Tetrachloroethylene (PCE)	127-18-4	80	68	100	1.4	2.1	1.1	0.45	2.08	1.36
Toluene	108-88-3	50,000	50000	73000	1000	1500	18	1000	1460	0.75
Trichlorobenzene 124-	120-82-1	1,000	190	190	3.7	3.7	NA	0.70	1.02	3.71
Trichloroethane 111-	71-55-6	20,000	22000	32000	440	640	1.1	440	642	1.09
Trichloroethane 112-	79-00-5	500	55	55	1.1	1.1	NA	0.17	0.77	1.09
Trichloroethylene (TCE)	79-01-6	50	54	54	1.1	1.1	NA	0.02	0.11	1.07
Trimethylbenzene 124	95-63-6	3,000	220	220	4.3	4.3*	4.3	1.20	1.75	0.98
Trimethylbenzene 135	108-67-8	1,000	85	88	1.7	1.8	1.7	1.20	1.75	0.98
Vinyl chloride	75-01-4	10	26	140	0.5	2.8	NA	0.30	2.79	0.51
Xylenes (mixed isomers)	1330-20-7	30,000	1000	1500	20.0	29	7.7	20	29	0.87

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EVALUATION OF SEDIMENT QUALITY GUIDANCE DOCUMENT

April 2005

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NEW HAMPSHIRE
DEPARTMENT OF ENVIRONMENTAL SERVICES

EVALUATION OF SEDIMENT QUALITY
GUIDANCE DOCUMENT

April 2005

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EVALUATION OF SEDIMENT QUALITY

BACKGROUND

This document paper sets forth DES guidance for the application of Surface Water Quality Standards to freshwater, estuarine, and marine sediments. The narrative standards of Env-Ws 1703.19 *Biological and Aquatic Community Integrity* and Env-Ws 1703.21 *Water Quality Criteria for Toxic Substances* are applicable to sediment chemistry and biology. In addition, Env-Ws 1703.08 *Benthic Deposits* applies to sediments and refers to the physical, chemical, and biological nature of these substrates.

Sediments found in streams, rivers, lakes, and estuaries are habitat for many forms of aquatic life. This bottom-dwelling aquatic life -- including, but not limited to, amphipods, bivalves, midges, polychaetes, oligochaetes, mayflies, and cladocerans -- is intimately linked via nutrient and energy exchange webs to additional ecological resources, including finfish, shellfish, birds and other wildlife associated with surface water ecosystems. Sediments can serve as a repository and source of persistent and potentially toxic inorganic and organic chemicals. Contaminated sediments may adversely impact these ecological resources or humans who consume these resources.

APPLICABLE LAWS / REGULATIONS

Env-Ws 1703.08 **Benthic Deposits**

a. Class A waters shall contain no benthic deposits, unless naturally occurring.

b. Class B waters shall contain no benthic deposits that have a detrimental impact on the benthic community, unless naturally occurring.

Env-Ws 1703.19 **Biological and Aquatic Community Integrity**

a. The surface waters shall support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region.

b. Differences from naturally occurring conditions shall be limited to non-detrimental differences in community structure and function.

Env-Ws 1703.21 **Water Quality Criteria for Toxic Substances**

a. Unless naturally occurring or allowed under part Env-Ws 1707, all surface waters shall be free from toxic substances or chemical constituents in concentrations or combinations that:

(1) Injure or are inimical to plants, animals, humans or aquatic life; or

(2) Persist in the environment or accumulate in aquatic organisms to levels that result in harmful concentrations in edible portions of fish, shellfish, other aquatic life, or wildlife that might consume aquatic life.

GUIDANCE DOCUMENT

Introduction

Risk posed to sediment-dwelling organisms should be assessed according the Sediment Quality Triad approach, described in Section I below.

Certain contaminants in sediment may bioaccumulate in intermediate to higher trophic organisms. Associated risks, which increase if the contaminant has low water solubility and high lipid solubility (Log K_{ow}>4.2), should be assessed according to Section II on page 10. The document EPA-823-R-00-001 lists the "Important Bioaccumulative Compounds" (USEPA, 2000c). The EPA also addresses these persistent, bioaccumulative, and toxic pollutants (PBTs) according to their multimedia strategy, which aims to protect human and ecosystem health from these highly toxic, long-lasting substances. According to http://www.epa.gov/opptintr/pbt/cheminfo.htm, PBTs include, **but are not limited to**:

- aldrin/dieldrin
- benzo(a)pyrene
- chlordane
- DDT, DDD, DDE
- hexachlorobenzene
- alkyl-lead
- mercury and its compounds
- mirex
- octachlorostyrene
- PCBs
- dioxins and furans
- toxaphene

I. Sediment Quality Triad Approach for Sediment-Dwelling Organisms (addresses Env-Ws 1703.08 and 1703.19)

Adverse effects on sediment aquatic life will be assessed using the Sediment Quality Triad approach (USEPA, 1992). This methodology integrates both chemical and biological data in

order to assess ecological resource risk. The methodology has three components that are applied sequentially and yield complementary data. The components are:

A. Sediment chemical analyses
B. Sediment toxicity bioassays (laboratory)
C. Community assessment (field)

The Sediment Quality Triad (chemistry, toxicity, and community) will be performed as this guidance document specifies in the description of each component. As outlined in the flowchart presented in Figure 1, the assessor will weigh the results of each component, as it becomes necessary to perform, to conclude whether or not the chemical contamination is impacting the benthic community. Considering the weight of evidence, the decision making process follows a matrix of outcomes (Table 1) that, if applicable, also considers the characterization of bioaccumulation risk, as determined according to Section II.

While an exceedance of the appropriate thresholds, determined in Component A of the triad, mandates further risk characterization, the severity of the risk may be so strongly predictive of impairment that the waterbody will be listed as impaired if not further characterized within an assessment period. With further characterization, the assessor may assume that Component B will reveal sediment toxicity. In this case, the assessor could skip Component B and proceed directly to Component C, i.e., community assessment. However, if the community assessment does not reveal any impact, the assumption of positive sediment toxicity must figure into the weight of evidence and typically mandates at least continued monitoring of the site for future impacts. Justification to omit Component B without this mandate may be made site-specifically. For example, any impacts would already have occurred at a site where the contamination source has been eliminated and sediment contaminants have been present for a significant (depending on site conditions) length of time. This determination will be made at the discretion of DES. Another option would be to perform Components B and C concurrently.

In the case of free product and observable ecological impacts that clearly indicate a violation of water quality standards, it may be more efficient to initially skip the triad and move directly to remediation. Following remediation, as a performance standard to ensure effectiveness, sediment sampling should be performed and the triad applied as applicable.

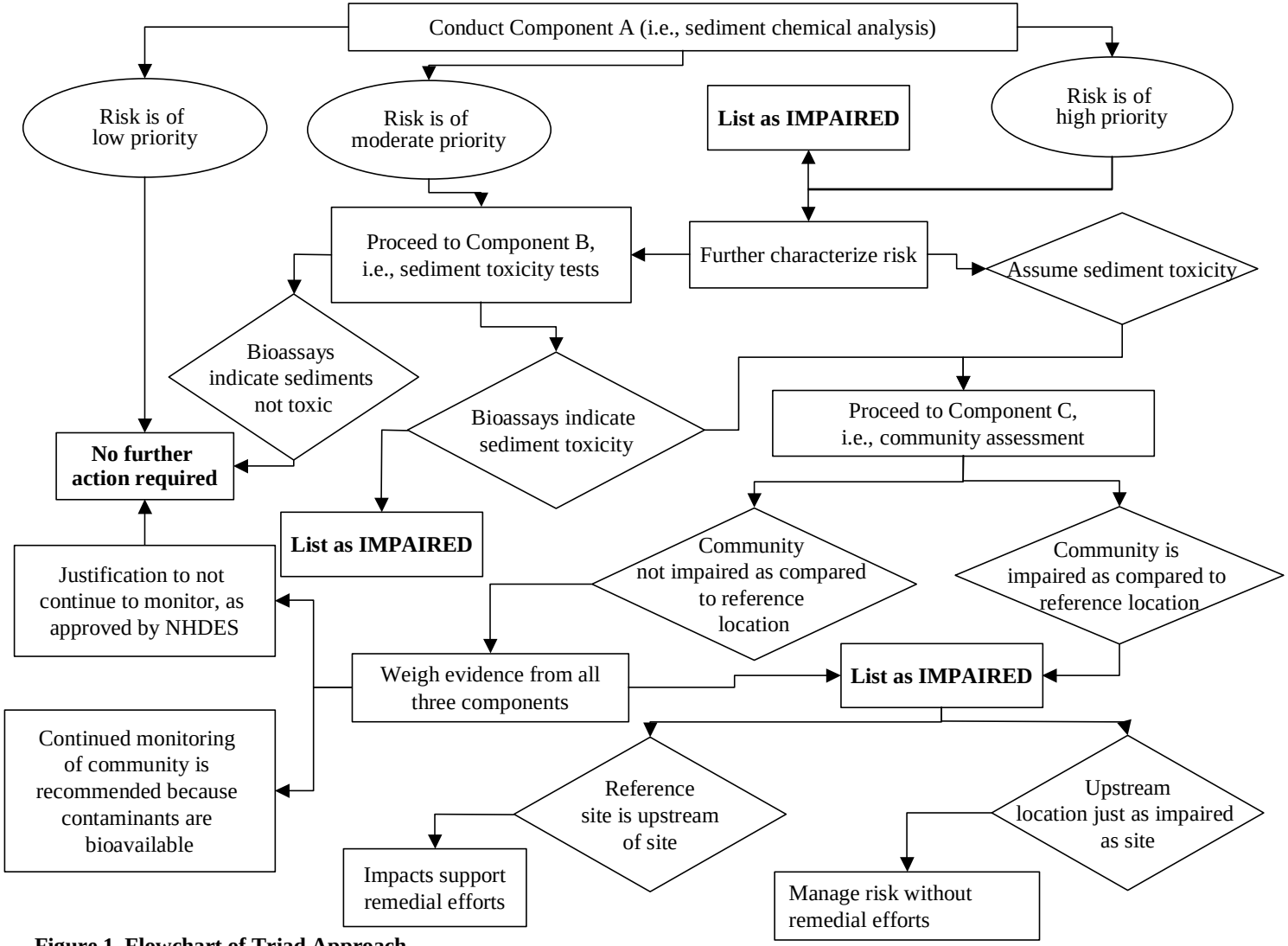

Figure 1 Flowchart of Triad Approach

Triad Components

A. Conduct sediment chemical analyses. Chemical profiles of sediment samples are compared with standard screening level reference values.

Sediment samples shall be collected in accordance with standard protocols (e.g., USEPA EPA-823-B-01-002, 2001; refer to www.epa.gov/waterscience/cs/collection.html for downloading this manual). The two main categories of sampling equipment are coring and grab devices. Data quality objectives and site specifics control the choice of sampling equipment.

Besides chemical concentrations, total organic carbon (TOC) and grain size should be quantified for each sample. The spatial distribution of contaminants at the site should be evaluated and compared to that at a reference near the site yet not impacted by the site, i.e., local conditions. If evidence suggests the concentrations of contamination of potential concern exceed those of local conditions, chemical concentrations of samples will be compared with published, peer-reviewed screening level contaminant lists, which include, but are not limited to:

1) NOAA 1999 – SQuiRT Tables (NOAA Hazmat Report 99-1).
2) Oak Ridge National Laboratory 1997 – Toxicological Benchmarks (ORNL ES/ER/TM-95/R4).
3) US Environmental Protection Agency 1996 – Ecotox Thresholds (USEPA EPA 540/F-95/038).
4) MacDonald *et al.*, 2000 – Arch. Environ. Contam. and Toxicology Vol 39: 20-31.

The following steps, as outlined in the flowchart presented in Figure 2, specify the sequence of events for screening at each sediment sampling location. The number of sample locations increases the statistical significance of the site risk characterization. Contaminants that have the potential to bioaccumulate must be further evaluated according to Section II.

Steps

1. For each contaminant, choose an appropriately conservative **THRESHOLD EFFECT CONCENTRATION (TEC)** and **PROBABLE EFFECT CONCENTRATION (PEC)** from available guidelines for each contaminant of concern. TEC values are screening thresholds **below which adverse effects are unlikely**. Data are typically from studies with sensitive species in laboratory exposures. PEC values are screening thresholds **above which adverse effects are likely.** For freshwater environments, although consensus-based (CB) TEC and PEC values (MacDonald *et al.*, 2000) are not the most conservative, they do have the most statistical justification. Assessors may choose thresholds from other sources provided they are at least as conservative as the CB thresholds. For contaminants with no available threshold, calculate a standard using the contaminant's surface water standard with appropriate partitioning coefficients.

For less sensitive ecosystems, as determined site-specifically and approved by DES in advance, comparisons to the contaminant's PEC alone may suffice.

2. Calculate the hazard quotient (HQ) for each contaminant detected in each sample by dividing the sediment contaminant concentration by the threshold value. An HQ calculated with a TEC (HQ-TEC) of one or greater indicates the possibility that the contaminant may adversely affect sediment organisms. An HQ calculated with a PEC (HQ-PEC) of one or greater indicates the likelihood that the contaminant will adversely affect sediment organisms.

3. According to Section II, contaminants with high bioaccumulative potential that have HQ>1 (HQ calculated with TEC) or for which a TEC is not available, must concurrently assess the risk to higher trophic organisms.

4. Qualify risk from each contaminant according to HQ as low (HQ-TEC<1), moderate (HQ-TEC>1), and high (HQ-PEC>1). Contaminants classified as moderate to high risk are retained as contaminants of concern (COCs).

5. If the sample location has at least one COC, determine its maximum HQ (HQ_{max}) calculated with TEC and PEC (or just with PEC if approved by NH DES) and proceed to Step 6. Otherwise, eliminate that location from concern.

6. Include the location in the priority list for further assessment according to its maximum level of risk. Qualify risk at each location as moderate ($HQ\text{-}TEC_{max}>1$) or high ($HQ\text{-}PEC_{max}>1$). Moderate to high risk may indicate a surface water quality violation.

7. Sample locations with moderate risk priority require additional risk characterization according to Component B of the triad. Sample locations with high-risk priority are assumed to be impaired and will be listed as such unless additional risk characterization according to Components B and/or C suggest otherwise.

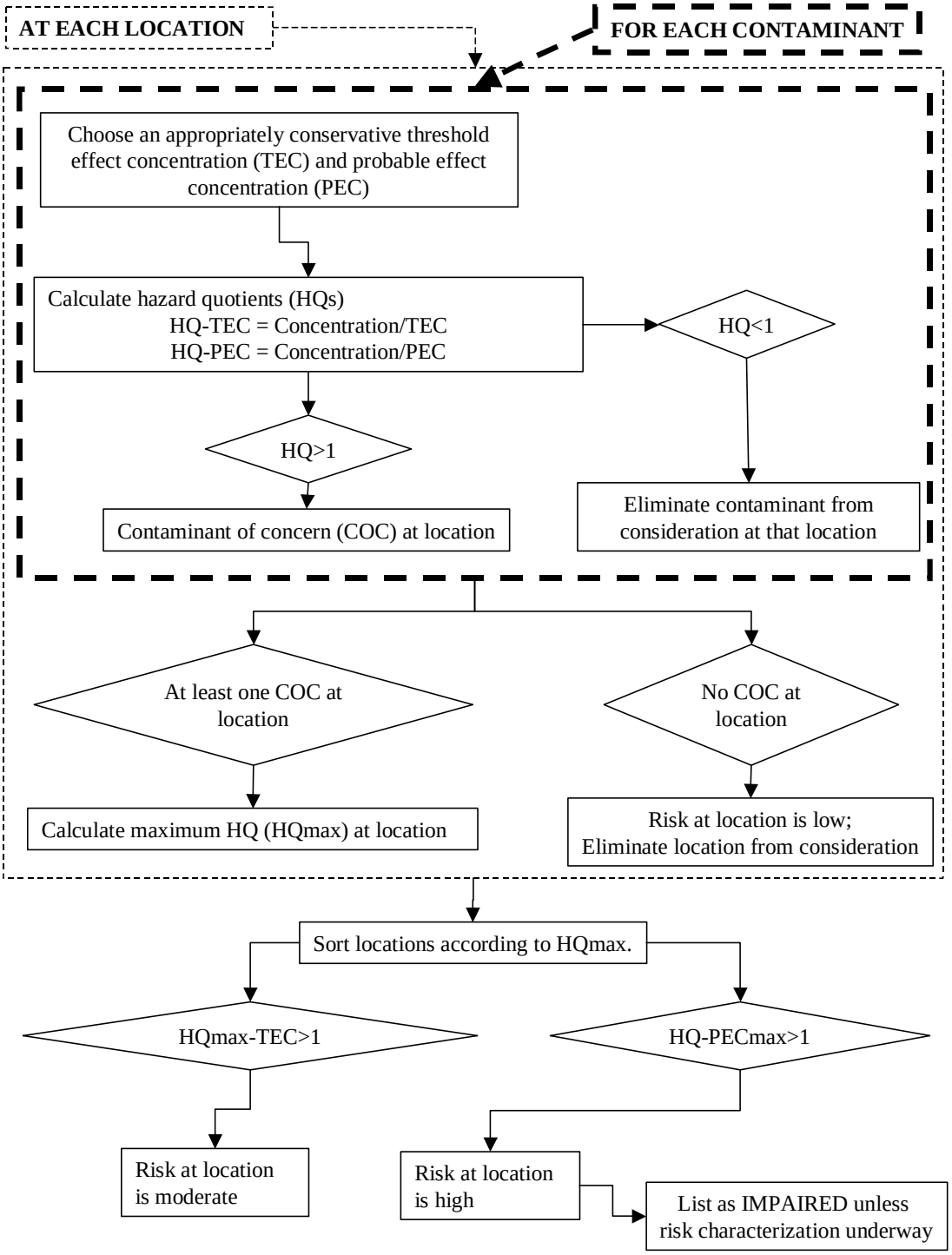

Figure 2 Flowchart of Component A of Triad Approach

B. Conduct sediment toxicity bioassays using sediment samples from potentially impacted sites

Additional sediment samples will be collected by standard protocols (e.g., USEPA EPA – 823-B-01-002, 2001) and used in standard sediment acute and chronic toxicity tests (e.g., EPA 600/R-99/064, 2000, EPA 600/R-01/020, 2001, EPA 600/R-94/025) with test organisms most appropriate for the site. Typical test organisms appropriate for freshwater environments include the amphipod *Hyalella azteca (H. azteca)* and the chironomids *Chironomus dilutis (C. dilutus*) (formerly known as *C. tentans)* and *Chironomous riparius*. Typical test organisms appropriate for marine environments include the amphipods *Rhepoxynius abronius, Eohaustorius estuaries, Ampelisca abdita, and Grandidrerella japonica*. More than one organism should be evaluated for each sample location. Sample methodology, toxicity test, and test organism(s) are subject to review and approval by DES. If sample collection is not feasible due to sediment characteristics, alternative analyses, e.g., pore water analyses/toxicity, may be substituted for sediment toxicity bioassays, but only upon prior approval by DES.

Although assessment endpoints are site-specific, an effect of 20 percent on the endpoint will indicate positive toxicity. In particular, a decrease in survival of more than 20 percent is generally unacceptable (Kuhn *et al.* 2002; Long *et al.*, 2001). However, when growth is the endpoint, literature (e.g., Kubitz *et al.*, 1996) supports a growth inhibition of an organism of 25 percent to be indicative of non-lethal effects.

Potential endpoints are a function of the duration of the bioassay. Tests may be categorized as acute (e.g., 48 to 96 hours), short-term chronic (e.g., 10 days), or long-term chronic (e.g., at least 20 days). The chronic bioassays are critical to evaluate impacts on survival and growth. Cost and time considerations associated with this requirement have typically rendered the 10-day bioassay to be performed. However, toxicity is sometimes observed only after this test would be terminated, as indicated by the long-term chronic test. Research suggests and the NH DES now recommends that, at a minimum, the long-term chronic bioassay be conducted for at least one of the organisms for samples from certain key locations. Survival and growth must be reported at the short-term and long-term marks. If significant toxicity is observed at the short-term mark, the test may be terminated then.

In the event that laboratory testing reveals acute or chronic sediment toxicity, the assessment may progress to Component C, i.e., benthic community assessment, or be deemed to pose risk. The ability and practicality of performing this third component with enough statistical power for relatively small sites, which are more typical than not at the State level, may eliminate its merit. The triad approach for which the evidence is also weighed supports the approach that if the chemistry and bioassays lead to a benthic assessment but that assessment is not rigorous enough, then the site will still be considered impacted. If chemistry indicates moderate risk, i.e., HQ-TEC>1$\geq$HQ-PEC, and bioassays indicate toxicity, then the benthic assessment may be the deciding factor. However, if chemistry indicates high risk, i.e., HQ-PEC>1, and bioassays indicate toxicity, then the benthic assessment is not likely robust enough to outweigh the evidence of risk and may be omitted. Furthermore, sites where the

aquatic chemistry is likely to change dramatically, such as for a dam removal project, may render Component C irrelevant.

On the contrary, negative toxicity for samples with high risk potential according to Component A should be considered cautiously. Prior to accepting the results, the assessor should exclude reasons for false negatives, .e.g., poor choice in test organism.

C. Conduct an assessment of community integrity

A community assessment must involve a field evaluation of the sediment community. Specifically, it is necessary to conduct a sediment biological community survey at the sampling site and compare the results with those from an appropriate, less adversely impacted reference site. The composition and structure of the benthic community will be characterized at the sample location and compared to a survey or surveys at a reference location of similar habitat but subject to less of the chemical contaminants. Standard ecological community metrics will be used to characterize the biota at both locations. The methods for benthic biological survey shall be reviewed and approved by DES in advance.

The reference location is used as a comparison to determine the level of actual risk to the site. The reference is a location that is neither impacted by the site nor by other sources. The comparison of contaminant spatial distributions for Component A may aid in locating the reference. For a river, brook, or stream, it is preferably upstream of the site. If such a location cannot be found near the site, then the reference location should be chosen from a similar watershed and metrics extrapolated to the site. If results of this comparison suggest the site is in fact impaired, a nearby location that is not impacted by the site, despite its impairments from other sources, should also be characterized as a control site so that the risk manager may make an informed decision about the relative increase in risk that is posed by the site. The risk at the site may not warrant remedial actions if nearby locations are just as impaired from other sources. Nevertheless, it is still important to understand the level of risk at hand as determined by comparison to the reference site.

II. Bioaccumulation Risk Potential (addresses Env-Ws 1703.21)

Sediment contamination can have adverse ecological effects on the benthic community and on shellfish, finfish, avian, amphibian, reptile, and/or mammal communities that are linked to benthic communities via the food web structure. Free-swimming organisms may bioconcentrate contaminants directly from the water column. However, they may also bioaccumulate contaminants via direct or indirect sediment exposure or diet.

Through the ecological processes of *bioaccumulation* (organism intake of contaminants via both water column and diet) and *biomagnification* (increased organism body burden of persistent contaminants as we move to higher tropic levels in ecosystems) contaminants in the sediments may be transferred to shellfish, finfish, avian, and terrestrial wildlife communities associated with the contaminated aquatic systems. Predator fish, birds, and other wildlife may become contaminated from being linked to bottom-feeding fish or benthic invertebrates that are laden with sediment associated pollutants via food-web transfer. This transfer can continue to human beings if contaminated fish, birds, or mammals are consumed.

The risk of bioaccumulation from sediments increases if the contaminant has low water solubility and high lipid solubility (Log K_{ow}>4.2). Heavy metals or non-polar organic chemicals, which may bioaccumulate to toxic levels in shellfish, finfish, and birds or render organisms unfit for human consumption, generally will be located in the sediments of aquatic systems. Detailed information on the chemistry and toxicity of many of the most common bioaccumulative contaminants is provided in USEPA EPA-823-R-00-001, 2000c and EPA-823-R-00-002, 2000a.

A sediment contaminant with bioaccumulation potential and, if a TEC is available, HQ-TEC>1 (determined in Component A of the triad) mandates the evaluation of actual or predicted tissue concentrations for assessment of adverse impact on relevant organisms. Relevant organisms include those species that use the contaminated site for resting, feeding, rearing, or reproduction.

A. Determine contaminant tissue concentrations for relevant organisms

Three alternative methods are available to determine contaminant tissue concentrations for relevant organisms of intermediate to higher trophic levels.

1. Use published **Biota-Sediment Accumulation Factors (BSAFs)** to estimate tissue concentrations of contaminants for relevant organisms.

   The National Sediment Quality Survey, 2nd Edition (USEPA EPA-823-R-01-01, 2000c) provides **BSAFs** for fish tissue for numerous heavy metal and non-polar organic contaminants. The Appendix to Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment (USEPA EPA-823-R-00-002, 2000a) contains additional **BSAFs** for finfish, shellfish, birds, invertebrates, plants, and other organisms.

2. Use approved models to predict tissue concentrations for relevant organisms.

   Bioaccumulation of heavy metals or non-polar organic contaminants in fish or other organisms can be predicted from sediment concentrations using equilibrium (e.g. Thomann *et al.*, 1992), fugacity (e.g., Burmaster *et al.*, 1991), or other appropriate models approved by DES.

3. Use direct measurement to determine tissue concentration of contaminants for relevant organisms.

   Direct tissue measurement is the most confident approach to determine bioaccumulation in aquatic organisms or aquatic-dependent wildlife. Direct determination can be conducted using either laboratory-exposed or field-collected organisms. For organic contaminants with a Log K_{ow} >6.5, there is a loss of linear relationship between K_{ow} and bioaccumulation. This results in uncertainty in modeled predictions of biological uptake. For contaminants with K_{ow} >6.5, direct measurement is the preferred method for assessing bioaccumulation.

B. Compare tissue contaminant concentrations with published acute and chronic toxicity values and calculate risk ratios for relevant organisms.

Acute and chronic toxicity values for ecological resources are available in numerous publications and databases. TOXNET (http://www.toxnet.nlm.nih.gov/) is sponsored by the National Library of Medicine and contains a cluster of databases on toxicology, hazardous chemicals, and related topics. The USEPA developed ECOTOX (http://www.epa.gov/med/databases/databases text.html). This database integrates AQUIRE, PHYTOTOX and TERRETOX, which are three databases that contain ecotoxicity information for aquatic life, terrestrial plants, and wildlife, respectively. Sample *et al.* (1996) provides toxicological benchmarks for wildlife. The US Army Corps of Engineers developed the Environmental Residue-Effects Database (ERED) (http://www.wes.army.mil/el/ered/index.html). It is a compilation of data from 736 studies published between 1964 and 2001 on the biological effects of many environmental contaminants found in tissues of organisms in which the effects were observed.

Risk ratios are calculated by dividing organism tissue concentrations by appropriate acute and/or chronic toxicity levels. Risk quotients of one or greater indicate the possibility of adverse effect of the contaminant on the organism. This latter outcome may indicate a Surface Water Quality violation and necessitate further action, which may be remediation, restoration, or monitoring, depending on the specifics of the site.

TABLE 1: MATRIX OF RISK CHARACTERIZATION ACCORDING TO THE SEDIMENT QUALITY TRIAD AND BIOACCUMULATION POTENTIAL				
Triad Components			**Bioaccumulation Potential**	**Outcome**
A. Chemistry	**B. Toxicity**	**C. Benthic Community**		
+	-	Not Assessed	Not Assessed	Sediment contaminants are not adversely impacting the benthic community.
+	+ (or not assessed)	-	Not Assessed	Weigh the evidence to characterize risk. If sufficient weight to Component C, the benthic community may still be at future risk for adverse impact due to sediment chemistry, requiring continued monitoring to evaluate future impacts.[1] Contaminant characteristics do not warrant bioaccumulation assessment.
+	+ (or not assessed)	-	-	Weigh the evidence to characterize risk. If sufficient weight to Component C, the benthic community may still be at future risk for adverse impact due to sediment chemistry, requiring continued monitoring to evaluate future impacts.[1] Contaminant characteristics warrant bioaccumulation assessment but impact to relevant organisms is not expected.
+	+ (or not assessed)	+ (or not assessed)	Not Assessed	Sediment contaminants at the site are adversely impacting the benthic community.[2] Contaminant characteristics do not warrant bioaccumulation assessment.
+	+ (or not assessed)	+ (or not assessed)	-	Sediment contaminants at the site are adversely impacting the benthic community.[2] Contaminant characteristics warrant bioaccumulation assessment but impact to relevant organisms is not expected.
+	+ (or not assessed)	+ (or not assessed)	+	Sediment contaminants at the site are adversely impacting the benthic community and bioaccumulation of sediment-associated contaminants has the potential to adversely impact relevant organisms.[2]
+	-	Not Assessed	+	Sediment contaminants at the site are not adversely impacting the benthic community, but bioaccumulation of sediment-associated contaminants has the potential to adversely impact relevant organisms.[2]

[1] A monitoring plan will be presented to DES for approval.
[2] This outcome indicates a surface water quality violation and necessitates further action, which may be remediation, restoration, or monitoring, depending on the specifics of the site.

GLOSSARY

BCF – Biological concentration factor; ratio of tissue residue to water column concentration at steady state.

BSAF - Biota-sediment accumulation factor; ratio of tissue residue to sediment concentration at steady state normalized to lipid and sediment organic carbon.

Biomagnification - A special case of bioaccumulation where body burdens of contaminants, normalized to an organisms lipid content, increase at successive, higher levels of an ecosystem's food web.

CB – Consensus-based; geometric mean of thresholds from a variety of sources, providing a more statistically based threshold.

COC - Contaminant of concern.

HQ- Hazard quotient; contaminant concentration divided by screening threshold concentration.

PBTs - Persistent, bioaccumulative, and toxic pollutants.

TEC - Threshold effect concentration; screening thresholds below which adverse effects are unlikely.

PEC - Probable effect concentration; screening thresholds above which adverse effects are likely.

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Approved: _____ Date: _____

Harry Stewart, P. E., Director
Water Division
NH Department of Environmental Services

APPENDIX D

THE NHDPHS LABORATORY

CHAIN OF CUSTODY FORM

NHDPHS LABORATORY SERVICES LOGIN AND CUSTODY SHEET

(Laboratory Policy: Samples not meeting method requirements will be analyzed at the discretion of the NHDPHS Laboratory.)

Samples must be delivered in a cooler with loose ice (no ice packs).

LAB ACCOUNT (Billing) #_____ One Stop Project ID# _____ DES Site Number _____Temp. ^{0}C. _____

Description: _____ Town: _____ NHDES Contact & Phone#: _____

Comments: **Contractor Contact & Phone #_____**

Collected By & Phone#:_____

_____

_____

Sample Location / ID	Date/Time Sampled	# of Containers	Matrix											Other / Notes	Lab Login ID # (For Lab Use Only)

Preservation: _____

Relinquished By_____Date and Time_____Received By_____ ☐ Temperature Blank Included in Cooler

Relinquished By_____Date and Time_____Received By_____

Matrix: A= Air S= Soil SED = Sediments AQ= Aqueous (Ground Water, Surface Water, Drinking Water) Other: _____

Section No.: 22.0
Revision No.: 8 (HWRB)
Date: 1-8-15

Page _____ of _____ Data Reviewed By_____ Date_____

APPENDIX E

WELL SAMPLING WORKSHEET

HAZARDOUS WASTE REMEDIATION BUREAU

WELL SAMPLING WORKSHEET

For use with Bladder Pumps

Site Name

Date : _____ **Well ID :** _____

Weather Conditions : _____

Sampler's Name (Print) _____

Purging Device & Serial # (pump type): _____

Reference Measuring Point (Top of PVC/Top of Casing): _____

Well Depth (ft., ref. to measuring point): _____

Screen Interval (ft., ref. to measuring point): _____

PVC/Inner Well Casing ID (inches): _____ Tubing ID (inches): _____

Purging Start Time : _____ (24 hour cycle) Sample Time: _____ (24 hour cycle)

Initial Water Level (ft., ref. to measuring point): _____

Pump Intake (ft., ref. to measuring point): _____

Head Above Pump Intake (ft., ref. measuring point): _____

Total Purge Volume (gallons, ml or liters): _____

Indicator Parameter Stabilization: **yes** OR **no** (circle one)

For PVR: Total Drawdown <0.3 ft. OR > 0.3 ft. at Parameter Stabilization (circle one)

Two Hour Time Limit Reached ? yes OR no (circle one)

Samples Collected: _____

Time at Sample Completion: _____ (24 hour cycle)

Bladder Pump Control Box Cycle Setting should be set to "1"

Clock Time	**Water Level**	**Drawdown**	**Cumulative Drawdown**	**Bladder Refill Time**	**Bladder Discharge Time**	**Pressure**	**Purge Rate**	**Temp. +/- 1 ºC**	**Spec. Cond. +/- 3%**	**DO +/- 10% if > 0.5**	**pH +/- 0.1**	**ORP +/-10**	**Turbidity +/- 10% if > 5**	**Comments/Adjustments**
(24 HR.)	**(ft.)**	**(ft.)**	**(ft.)**	**setting**	**setting**	**(psi)**	**(ml/min)**	**(ºC)**	**(µS/cm)**	**(mg/l)**	**units**	**(mV)**	**(NTU)**	
PVR =	Calculations:													

Notes: 1. All depths in feet below the referenced measuring point, unless specified. 2. "NR" indicates no reading taken. 3. ID = Inside Diameter

4. When recording pH and dissolved oxygen data, only use one decimal place. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers.
When DO data is less than 0.5 mg/l, data should be recorded as "<0.5" or "less than 0.5". DO values between 0.5 and 1.0 are typically considered stable within +/- 0.1 mg/l.
When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". Turbidity values between 5 and 10 are typically considered stable within +/- 1 NTU.

5. Tubing Factors - Milliliters to purge standing water in tubing: 1/2" ID: length in ft. x 38.6 = ml needed; 3/8" ID: length in ft. x 21.7 = ml needed; 1/4" ID: length in ft. x 9.7 = ml needed; 0.17" ID: length in ft. x 4.5 = ml needed.

6. Purge volume requirement (PVR) . If the total drawdown is <0.3 ft., the PVR = one tubing volume of water, so the PVR = Total Tubing Length x Unit Tubing Capacity. Note: Include the length of tubing that is outside the well in the Total Tubing Length.
If the total drawdown is >0.3 ft., the PVR = one tubing volume of water & the volume of water in the well between the initial water level and the current water level, so the PVR = (Total Tubing Length x Unit Tubing Capacity) + (Total Drawdown x Unit Well Capacity).

_____
Sampler's Signature

APPENDIX F

EXAMPLE OF A SAP OUTLINE

SAP OUTLINE EXAMPLE

At a minimum, all SAPs shall include the information provided in this outline. See the QAPP text and other QAPP Appendices for examples of Tables identified here. The current HWRB Master QAPP must be referenced in the SAP and be onsite, typically as a separate document.

TITLE PAGE
SIGNATURE PAGE
TABLE OF CONTENTS
LIST OF ACRONYMS (as appropriate)

1.0 INTRODUCTION

1.1 Site Description and History
1.2 Summary of Site Hydrogeology
1.3 Site Cleanup Levels: Including a table of contaminants of concern and appropriate regulatory standards such as the Ambient Groundwater Quality Standards (AGQS) and the Interim Cleanup Levels
1.4 Data Quality Objectives

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Description of responsibilities including an Organization Chart
The Organization Chart is typically in Appendix A

3.0 MONITORING AND SAMPLING

Multi-Media Sampling and Analysis (as appropriate)

3.1 Groundwater Sampling
Including water level and well depth measurement information
3.2 Surface Water Sampling
3.3 Sediment Sampling
3.4 Soil Sampling
3.5 Pore Water Sampling
3.6 Residential Drinking Water Sampling

4.0 QUALITY CONTROL

4.1 Equipment Calibration and Maintenance
Table listing equipment, maintenance and frequency
Table listing equipment, calibration frequency, calibration standards, calibration acceptance criteria and corrective action
4.2 Field Quality Control
Table listing quality control samples, frequency, acceptance criteria and corrective action
4.3 Data Verification and Validation
Including data usability
4.4 Quality Assurance Field Audits
Including frequency of internal and external assessments

5.0 DOCUMENTATION

5.1 Documentation of Field Activities – Field Data Management
5.2 Chain-Of-Custody Procedures
5.2.1 Sample Identification
5.3 Reports
Specify type, number and contents
5.3.1 Quality Assurance/Quality Control (QA/QC) Section
Must include statements summarizing whether or not the quality control criteria in the SAP & QAPP were met in the field and in the lab. Listing any QA/QC problems and how they were resolved. Noting anything unusual that will affect the quality or usability of the data.

6.0 REFERENCES (as applicable)

FIGURES

Site Locus
Figures of all sampling locations, including residential sampling locations, if appropriate.

TABLES

1. Site Analytes, Chemicals of Concern, Associated Interim Cleanup Levels and Regulatory Standards Criteria (e.g., AGQS, Drinking Water Standards, Surface Water Standards, Soil Standards) and Lab Criteria (for all compounds tested on site)
2. Monitoring Locations, Sampling Methods and Analytical Parameters
3. Media and Laboratory Requirements (Media, Analysis, Test Methods, Containers/Sample Volume, Preservation & Hold Time)
4. Monitoring Well Construction Information / Monitoring Location Information
5. Summary of Quality Assurance Samples (Trip Blanks, Duplicates, Equipment Blanks, MS/MSD)

APPENDIXES

A. Organizational Chart
B. Standard Operating Procedures (SOPs) including set up diagrams and work sheets.
Examples:

1. Calibration of Field Instruments SOP
   Calibration Log
2. Chain of Custody SOP
   Chain of Custody Forms
3. Low Flow Sampling SOP
   Low Flow Setup Diagram
   Well Sampling Worksheet
4. Surface Water Sampling SOP
   Surface Water Worksheet
5. Drinking Water Sampling SOP
6. Decontamination SOP

APPENDIX G

EXAMPLE TABLE OF

SITE ANALYTES, REGULATORY STANDARDS & LAB CRITERIA

Example Table:
Site Analytes, Associated Regulatory Standards and Lab Criteria

GROUNDWATER
(There should be one Table for each Media: Groundwater, Surface Water, Sediments, etc.)

Test Methods / Analytes (NHDPHS Lab)	ROD Interim Concentration Levels (ICLs)	NHDES Ambient Groundwater Quality Standards (AGQS) (Env-Or 600)	Lab Reporting Detection Limits (RDLs)
Contaminants of Concern			
VOC Full List (NHDES 8260B) - (µg/L)			
Vinyl Chloride	95	2	2
Benzene	340	5	2
Trichloromethane (Chloroform)	1,505	70	2
Tetrachloroethylene (Tetrachloroethene, PCE)	57	5	2
Trichloroethylene (Trichloroethene, TCE)	1,500	5	2
Methyl Ethyl Ketone (2-Butanone, MEK)	8,000	4,000	10
Monochlorobenzene (Chlorobenzene)	110	100	2
Dichloromethane (Methylene Chloride)	12,250	5	2
Toluene	2,900	1,000	2
1,1-Dichloroethane	81	81	2
1,2-Dichloroethane	1,800	5	2
1,1,1-Trichloroethane	200	200	2
SVOCs by EPA Method 8270 (µg/L)			
Extraction Method 3510			
Bis-(2-ethylhexyl)phthalate	6	---	5
Naphthalene	20	20	10
Metals by EPA Method 200.8 (mg/L)			
Arsenic	0.05	0.01	0.001
Additional Analytes			
1,4 Dioxane by EPA Method 522 (µg/L)	---	3	0.2
Metals by EPA Method 200.7/200.8 (mg/L)			
Lead	---	0.015	0.001
Iron	---	---	0.05
Manganese	---	0.84	0.02
Chloride by LACHAT 10-117-07-1-B (mg/L)	---	---	3
Nitrite by LACHAT 10-107-04-1-C (mg/L)	---	1	0.05
Nitrate by LACHAT 10-107-04-1-C (mg/L)	---	10	0.05
Nitrate + Nitrite by LACHAT 10-107-04-1-C (mg/L)	---	10	0.05
Sulfate by LACHAT 10-510-00-1-E (mg/L)	---	500	1

Notes:
Record of Decision (ROD)
"---" indicates no standard was available for the analyte.

APPENDIX H

EXAMPLE TABLE OF

MEDIA AND LABORATORY REQUIREMENTS

(MEDIA, ANALYSIS, TEST METHODS, CONTAINERS/SAMPLE VOLUME, PRESERVATION AND HOLD TIME)

Example Table of Media and Laboratory Requirements (Media, Analysis, Test Methods, Containers/Sample Volume, Preservation and Hold Time)

Analytes	Analytical Method	Containers (Type and Size)	Preservation Requirements (5)	Maximum Holding Time
Groundwater Samples				
VOCs	NHDES VOC Full List (NHDPHS Lab's 8260B)	3-40 mL VOA (1)	HCL. 4° C +/-2° C	14 days
1, 4-Dioxane	Method 522	1 - 1L Amber (2)	NaHSO4, 4° C +/-2° C	28 days to extract, 28 days to analyze
SVOCs	Method 8270 Extraction Method 3510	2-1 Liter Amber glass bottles (3)	4° C +/-2° C	7 days to extract, 40 days to analyze
Total As, Pb, Fe & Mn	EPA Method 200.7 / 200.8	1-500 mL Plastic	HNO_3	6 months
Chloride	LACHAT 10-117-07-1-B	1-500 mL Plastic	4° C +/-2° C	28 days
Nitrate/Nitrite	LACHAT 10-107-04-1-C			48 hours
Sulfate (SO4)	LACHAT 10-510-00-1-E			28 Days
Surface Water Samples				
VOCs	NHDES VOC Full List (NHDPHS Lab's 8260B)	3-40 mL VOA (1)	HCL. 4° C +/-2° C	14 days
Total As, Pb, Fe & Mn, Hardness	EPA Method 200.7 / 200.8	1-500 mL Plastic	HNO_3	6 months
Dissolved As, Pb, Fe & Mn	EPA Method 200.7 / 200.8	1-500 mL Plastic	HNO_3	6 months
Field Parameters for Low Flow and Surface Water Sampling				
Temperature, oxygen reduction potential (ORP), Dissolved oxygen (DO), specific conductivity and pH (4)	YSI 600XL/XLM or 6820 Multi-Parameter Water Quality Meter	N/A	N/A	N/A
Turbidity	Hach 2100P or 2100Q Turbidity Meter	N/A	N/A	N/A
Sediment Sampling				
Total As, Pb, Fe, Mn & % Solids	EPA Method 200.7 / 200.8	8 oz plastic	4° C +/-2° C	6 months
Total Organic Carbon (TOC), % Solids	LLOYD KAHN	1-4 oz glass	4° C +/-2° C	14 days
Grain Size	ASTM D422	Minimum of 500-grams, glass jar	None	None
Drinking Water Sampling				
VOCs	NHDES VOC Full List (NHDPHS Lab's 524.2)	3-40 mL VOA (1)	HCL. 4° C +/-2° C	14 days

Notes:

(1) Trip blanks will be included in each cooler containing VOC samples. Trip blanks will include HCL-preserved blanks for Full List VOC samples (2 VOA vials). There will be one temperature blank per cooler.

(2) Quality Control (QC) Samples: For every 10 samples going to the NHDPHS Lab for 1,4-dioxane analysis, the lab requires one extra 1-liter amber sample bottle be collected for Lab QC (MS/MSD). For any sampling event where 1, 4-dioxane is sampled at all locations, the lab requires a minimum of two extra 1-liter amber bottles.

(3) QC Samples: For every 10 samples going to the NHDPHS lab for SVOCs, the lab requires two extra 1-liter SVOC sample bottles be collected for MS/MSD Lab QC. For any sampling event where SVOCs are sampled at all locations, the lab requires a minimum of four extra 1-liter amber bottles. One set of two bottles is required to be from groundwater; the remaining sets can be from another aqueous media (e.g., surface water).

(4) The field parameters for temperature, ORP, DO, specific conductivity and pH for surface waters will be collected in-situ.

(5) The pH requirement for samples preserved via acid is less than 2 units; via base is greater than 12 units.

APPENDIX I

EXAMPLE TABLE OF

SUMMARY OF QUALITY ASSURANCE SAMPLES

EXAMPLE TABLE OF SUMMARY OF QUALITY ASSURANCE SAMPLES

Sampling Media	Associated Sampling Equipment	Sample ID	Designated NOTE to be used on Chain-of-Custody	Analyses
EQUIPMENT BLANK SAMPLES				
Lab provided deionized (DI) water (collected prior to sampling)	DI Water	EQUIP BLANK	“DI Water”	VOCs, SVOCs, 1,4-Dioxane, Total As
Groundwater	Water level	EQUIP BLANK	Water Level	VOCs, SVOCs, 1,4-Dioxane, Total As
Surface Water	Filter and syringe set up for dissolved metals samples	EQUIP BLANK	“Metals Filter/Syringe”	Total As
Surface Water	Glass jar or stainless steel sampling container to collect surface water samples (if not dedicated)	EQUIP BLANK	“SW Container”	VOCs, Total As
Pore Water	Pore water samplers	EQUIP BLANK	"Pore Water Sampler”	Total As
Sediment	Ponar dredge, stainless steel bowl and utensils	EQUIP BLANK	"Sediment Equip"	TOCs, Total As
DUPLICATE SAMPLES				
Groundwater	Bladder Pump	GIL_HA5-A DUP	N/A	VOCs, SVOCs, 1,4-Dioxane, Total As, Cl, $N0_3$, $N0_4$, $S0_4$
Groundwater	Peristaltic Pump	GIL_T-13-1	N/A	
Groundwater	Bailer	GIL_T-24-1 DUP	N/A	
Groundwater	Barcad	GIL_T-12-4 DUP	N/A	
Surface Water	Glass jar or stainless steel sampling container	GIL_SW-2A DUP	N/A	VOCs, Total As, Hardness, Dissolved As
Pore Water	Pore Water Sampler	GIL_PORE-2B DUP	N/A	Total As
Sediment	Ponar dredge, stainless steel bowl and utensils	GIL_SED-4 DUP	N/A	TOCs, Total As

EXAMPLE TABLE OF SUMMARY OF QUALITY ASSURANCE SAMPLES

Sampling Media	Associated Sampling Equipment	Sample ID	Designated NOTE to be used on Chain-of-Custody	Analyses
TRIP BLANK/TEMPERATURE BLANK SAMPLES				
Aqueous VOCs [1] 1 per cooler with VOCs samples (2 VOA Vials - HCL)	N/A	TRIP BLANK	1 trip blank per matrix per chain-of-custody per cooler only	VOCs
Solid VOCs 1 per cooler with solid VOC samples (1 VOA Vial - Methanol)	N/A	TRIP BLANK	1 trip blank per matrix per chain-of-custody per cooler only	VOCs
Temperature Blank (1 per cooler)	N/A	TEMP BLANK	Indicate on COC that a temperature blank has been included in the cooler (there may be a box to check)	Temperature
LABORATORY MATRIX SPIKE/MATRIX SPIKE DUPLICATE (MS/MSD) SAMPLES				
Groundwater	Bladder Pump Collect a total of two 1-liter bottles for 1,4-dioxane instead of one (This is separate from any duplicate sample)	GIL_HA-5-C	"Lab MS/MSD QC" [2]	1,4-Dioxane (Method 522)
Groundwater	Bladder Pump Collect a total of four 1-liter bottles for SVOCs instead of two (This is separate from any duplicate sample)	GIL_HA-5-B	"MS/MSD Report Results" [3]	SVOCs

Notes:

1. 1,4-Dioxane samples may require a separate trip blank with a different preservative (e.g., 4° C +/-2° C only; no HCL) depending on the analytical method used. Method 522 does not require trip blanks.
2. A laboratory may require the collection of extra sample bottles for their internal lab MS/MSD quality control. If so, indicate that in the comments section on the chain-of-custody (e.g., "Lab MS/MSD QC). The lab typically does not report these results. Refer to the specific lab and the site-specific Sampling and Analysis Plan (SAP) for MS/MSD requirements.
3. A site-specific SAP may require MS/MSD samples to be collected, and require the lab to report those results, as part of a site-specific sampling program. If so, indicate that in the comment section on the chain-of-custody (e.g., "MS/MSD Report Results"). Refer to the specific lab and the site-specific SAP for MS/MSD requirements.

APPENDIX J

HAZARDOUS WASTE REMEDIATION BUREAU

RECORDS RETENTION POLICY

HAZARDOUS WASTE REMEDIATION BUREAU RECORDS RETENTION POLICY

Retention and archiving of records is done in accordance with specific statutory or regulatory requirements (additional guidance is provided in Chapter 6 of the current NHDES QMP located at http://des.nh.gov/organization/commissioner/pip/publications/co/documents/r-co-06-3.pdf).

All records of the Federal Sites Superfund program shall be maintained according to the attached Federal Sites Superfund Record Retention Schedule approved by NHDES, the State Records Manager and the State Archivist, dated June 24, 2004.

All records for all other sites under the Sites Remediation Program shall be maintained according to the attached Sites Remediation Program Record Retention Schedule approved by NHDES, the State Records Manager and the State Archivist, dated February 24, 2004.

Contractor records shall be maintained for seven (7) years following completion of the project. At the end of the retention period, the Contractor shall offer the records to the State. If the State declines to accept the records, the records become the property of the Contractor.

New Hampshire Division of Archives & Records Management

RECORDS RETENTION AUTHORIZATION

Department: **044 Dept of Environmental Services** Division: **14 Division of Waste Management**

Item No.	Suffix No.	Record Description	Approved Retention Office	Record Ctr	Total	Comments
01		Site Remediation Programs				Existing Item
	08	Superfund Contract Management Records – Site Specific (EPA #020)	2 years	28 years	**30 years**	cost recovery litigation & enforcement
	09	Enforcement Actions: No Legal Action required or routine cases (EPA 025)	2	28	**30**	cost recovery litigation & enforcement
	10	Enforcement Actions: Landmark Cases (EPA 025)	2	Perm	**Perm**	cost recovery litigation & enforcement
	11	Hazardous Waste Compliance Site Files (EPA 012)	2	Perm	**Perm**	documents cleanup
	12	Grants & Support Agreements: Records Not Needed for Cost recovery (EPA 001)	2	5	**7**	
	13	Grants & Support Agreements: Records Needed for Cost Recovery (EPA 001)	2	28	**30**	cost recovery litigation & enforcement

(over)

	14	Remedial Site Files – Site Specific (EPA 014)	2	Perm	**Perm**	cost recovery litigation & enforcement
	15	Removal Records – Site Specific (EPA 013)	2	Perm	**Perm**	cost recovery litigation & enforcement
	16	Sampling & Analytical Data files Site Specific (EPA 018)	2	28	**30**	cost recovery litigation & enforcement
	17	Site Assessments – "No Further Remedial Action Planned" (NFRAP) (EPA 010)	2	38	**40**	Property Transfer
	18	Site Assessment – [redacted] Sites (NPL) (EPA 010)	2	Perm	**Perm**	cost recovery litigation & enforcement
	19	Site Assessment – Removal Action Sites (EPA 010)	2	Perm	**Perm**	cost recovery litigation & enforcement

Notes: the Hazardous Waste Remedial B[redacted] (HWRB) is following the Environmental protection Agency guidelines for record retention for Superfund Activities as outlined on the EPA website at **http://www.epa.gov/records/policy/schedule/prog-42.htm**; EPA numbers indicate the EPA schedule counterpart. File Break (Cutoff): Breaking, or ending, files at regular intervals, usually at the clos of a fiscal year or calendar year, to permit their disposal or transfer in complete blocks and, for correspondence files, to permit the establishment of new files. Case files are generally cut off at the end o the year in which the case is closed.

CLB 7/1/04

Prepared By _____ / CARL BAXTER / 7/1/04 / 271-2909
Signature — Typed or printed name — Date Signed — Telephone

Approved By _____ / Michael J. Walls / Ass't. Comm. / 7/6/04
Signature — Typed or printed name — Title — Date Signed

Approved by State Records Manager _____ June 23, 2004
Signature — Date

Approval to begin transfer to Records _____ June 24, 2004
Director/State Archivist — Date

revised Dec. 2003

New Hampshire Division of Records Management & Archives

Record Retention Authorization

Department: Environmental Services

Division: Waste Management

Item No.	Suffix No.	Record Description	Approved Retention in years			Remarks
			Office	Record Center	Total	
044 Department of Environmental Services						
14 Waste Management Division						
01 Site Remediation Programs						
		01 Storage Tanks Facility Files	100 years after closure of file		100 years after closure of file	Information needed for real estate transactions and future liability determinations
		02 Reimbursement Claim Submittals	2 years after claim is processed		2 years after claim is processed	Claim and invoices applied toward claim
		03 Site Remediation/Spills Files	100 years after closure of file		100 years after closure of file	Information needed for real estate transactions and future liability determinations
		04 Grants	4 years after grant closed out		4 years after grant closed out	
		05 Special Project/UNH Research Files	10 years after grant is closed out		10 years after grant is closed out	
		06 Confidential Files				
		Confidential Settlement Agreements	2 years after closure of file		2 years after closure of file	
		Confidential Business (Proprietary) Information	2 years after closure of file		2 years after closure of file	
		EPA Confidential Documents	2 years after closure of file		2 years after closure of file	
		Priviledged Client/ Attorney Correspondence	2 years after closure of file		2 years after closure of file	
		Complaints	2 years after closure of file		2 years after closure of file	
		07 Notice of Reimbursements	100 years after closure of file		100 years after closure of file	Record of actual reimbursement paid; information needed for future liability determinations

Note: Shaded cells denote schedule changes

Prepared by: George Lombardo (Signature) — George Lombardo, Administrator ORCB (Type or Print Name) — 1/8/04 (Date Signed) — 271-3645 (Telephone #)

Approved by: Michael J. Walls (Signature), — Michael J. Walls, Assistant Commissioner DES (Type or Print Name) — 1/16/04 (Date Signed)

Approved by State Records Manager: Brian Nelson Bishop, 2/24/2004 (Date Signed)

Approval to begin transfer of Records: Director / State Archivist, 2-24-04 (Date Signed)

as to addition of #07, and revision to #02. bnb 2/24/2004

Jan-04

APPENDIX K

CROSSWALK BETWEEN HWRB MASTER QAPP

AND EPA REQUIREMENTS

Crosswalk between HWRB Master QAPP and USEPA Requirements

USEPA REQUIRED INFORMATION	NHDES QAPP
A1 Title and Approval Page	Title Page and Approval Page (Page 2)
A2 Table of Contents Program Information	Table of Contents (Page 3) 1.0 Introduction (Page 9) 1.1 Overview of Hazardous Waste Remediation Bureau (Page 9)
A3 Distribution List Project Personnel Sign-off Sheet	Distribution List (Page 6) Project Personnel Log Sheet (Appendix L)
A4 Project Organizational Chart / Communication Pathways / Personnel Responsibilities & Qualifications A8 Special Training Requirements / Certification	Program Organization and Responsibility, Organizational Chart (Appendix A) 1.2 Program Organization, Responsibility and Communication Pathways (Page 10) 1.5 Training, Personal Protection and Safety (Page 13)
A5 Project Definition/ Site History and Background Project Planning	Project definition, site description and background information shall be addressed in site specific SAPs
A6 Project Description	1.0 Introduction (Page 9) 1.3 Project Description (Page 11)
A7 Project Quality Objectives	1.4 Quality Assurance Objectives (Page 11)
B1 Sampling Process Design	Sampling process design is site specific and shall be addressed in site specific SAPs
B2 Sampling Procedures Cleaning and Decontamination of Equipment/Sample Containers B7 Equipment Calibration B6 Equipment Maintenance, Testing and Inspection Requirements Sampling Container, Volumes and Preservation	Standard Operating Procedures (Appendix C) 2.3 Decontamination (Page 23) 2.4 Instrument Calibration and Maintenance (Page 23) 2.5 Field Screening Instruments (Page 25) 2.7 Sampling Volume, Containers and Labeling (Page 27) 2.8 Sampling Preservation and Holding Times (Page 27)
B3 Sample Handling, Tracking and Custody Requirements Sample Collection Documentation	2.7 Sample Volume, Containers and Labeling (Page 27) 2.9 Chain of Custody Procedures (Page 27) 2.10 Laboratory Sample Management (Page 28) 1.6 Documentation and Records (Page 14)
B4 Analytical Method Requirements Analytical Methods and SOPs B7 Laboratory Instrument Calibration B6 Laboratory Instrument/ Equipment Maintenance, Testing and Inspection B8 Laboratory Inspection and Acceptance for Supplies	1.4 Quality Assurance Objectives (Page 11) Analytical services shall be provided by laboratories which are currently certified by EPA or accredited by the New Hampshire Environmental Laboratory Accreditation Program, Env-C 300, (National Environmental Laboratory Accreditation Conference [NELAC] standards) and have their own quality assurance manual and standard operating procedures (SOPs).
B5 Quality Control Requirements	2.11 Sample Quality Control (Page 28)
A9, B10 Documentation, Records and Data Management	1.6 Documentation and Records (Page 14)
C1 Assessments and Response Actions	1.7 Data Assessment (Page 19) 1.8 Corrective Action (Page 21)
C2 QA Management Reports	See Response to B4 above,
D1 Verification and Validation Requirements	See Response to B4 above
D2 Verification and Validation Procedures	See Response to B4 above
D3 Data Usability/Reconciliation with Project Quality Objectives	1.7 Data Assessment (Page 19)

APPENDIX L

HWRB MASTER QAPP PERSONNEL LOG SHEET

(Found only in the original QAPP that is kept with the QA Coordinator)

QAPP Project Personnel Log Sheet

Project Personnel	Position	Signature	Date
John Regan	Administrator		
Robin Mongeon	Supervisor of Federal Sites Section Civil Engineer		
Andrew J. Hoffman	Civil Engineer		
Michael Summerlin	Civil Engineer		
Ken Richards	Sanitary Engineer		
Sharon G. Perkins	QA Coordinator / Environmentalist		
Scott E. Hilton	Hydrogeologist		
Peter Sandin	Hydrogeologist		
Karlee Kenison	Supervisor of State Sites Section Hydrogeologist		
Vacant	Brownfields Hydrogeologist		
Mike McCluskey	Sanitary Engineer		
John Liptak	Supervisor		
Paul Rydel	Groundwater Remediation Permitting Hydrogeologist		
Peter Beblowski	Hydrogeologist		
Dave Bowen	Hydrogeologist		
Lea Anne Atwell	Hydrogeologist		
Charles A. Crocetti	Sanborn, Head & Associates		
Steven R. Lamb	GZA Environmental		
Todd Walles	Weston Solutions		

This form must be signed by ALL HWRB Project Managers and project personnel along with the contact person for each contractor approved by NHDES to perform work for the HWRB, to indicate that they have reviewed the HWRB Master QAPP and will implement the QAPP as described.