QUALITY ASSURANCE PLAN

FOR

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION'S LEAKING UNDERGROUND STORAGE TANKS PROGRAM

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1.0 INTRODUCTION

1.1 Project Description

Under the Resource Conservation and Recovery Act (RCRA), Subtitle I, a number of Cooperative Leaking Underground Storage Tank (LUST) Trust Fund Agreements have existed between the United States Environmental Protection Agency (USEPA) and the Maine Department of Environmental Protection (MEDEP) since 1988. The purpose of the agreements has been to assist in the development and maintenance of a statewide remediation program pertaining to leaking motor fuel underground storage facilities. This is accomplished, in part, through a grant to MEDEP to investigate and effectively remediate motor fuel LUST sites.

Maine's petroleum remediation program is broad in scope and also addresses oil discharges from other underground storage tanks (USTs) (e.g., heating oil) and other sources (e.g., aboveground tank facilities). Several divisions of the MEDEP Bureau of Remediation and Waste Management (BRWM) are involved in the LUST Program including Response Services, Technical Services, and Petroleum Management. Response Services will typically be the first MEDEP responders to a reported spill. If the site requires long-term corrective action, it will be referred to Technical Services for follow-up investigation. Technical Services and/or Response Services may request assistance from the Division of Petroleum Management for project management expertise and/or enforcement action.

Under the LUST program, UST Facility owners and operators are responsible to report any evidence of a spill to the MEDEP. Under most circumstances, such reports are initially forwarded to the Response Services Division, MEDEP/BRWM. In few cases, reports can be managed and documented by Petroleum Management Division staff. Many reported releases are resolved quickly, and they do not require long-term corrective actions. These sites will be closed by staff in the division that initially responds, and will not require formal, written remediation or site work plans. When a release cannot be resolved quickly, responding staff will forward the initial site assessment and all pertinent information to the Division of Technical Services, MEDEP/BRWM. Sites involving complicated long-term corrective action may be assigned a project manager from the Petroleum Unit of the Division of Petroleum Management, MEDEP/BRWM. These sites will typically require more planning and subsequently require more detailed work plans and documentation. Sites involving potential or actual enforcement activities will be referred to the Division of Petroleum Management.

Environmental and released-product samples may be taken for chemical analysis to detect the presence of gasoline or other fuel oil and for concentration determination in connection with remediation and/or compliance-related activities. Program staff are responsible for the collection, documentation, and maintenance of chain-of-custody of such samples until they have been properly relinquished to the laboratory. The laboratory analyzes the samples and generates data reports and electronic data deliverables (EDDs) to the MEDEP for evaluation and consideration in remediation and/or compliance-related actions.

1.2 QAP Implementation

The USEPA requires that all environmental monitoring and measurement efforts mandated or supported financially by USEPA participate in a centrally managed Quality Assurance Plan (QAP).

Any party generating data under this Program has the responsibility to implement minimum procedures to assure that the precision, accuracy, completeness, and representativeness of its data are known and documented.

As stated in USEPA Order CIO 2105.0 (formerly 5360.1 A2) “Policy and Program Requirements for the Mandatory Agency-Wide Quality System” (approved May 5, 2000), the primary goal of the QAP is to ensure that all environmentally related measurements performed or supported by USEPA produce data of adequate quality and usability for their intended use. The quality of the data is known when all components associated with its derivation are thoroughly documented, with such documentation being verifiable and defensible.

All Quality Assurance/Quality Control (QA/QC) procedures must be in accordance with applicable professional technical standards, USEPA requirements, government regulations and guidelines, and specific project goals and requirements.

This document serves as the MEDEP/LUST Program QAP. This document will describe, or reference attached documents that describe:

(a) The MEDEP/LUST Program organization;

(b) Personnel responsible for assuring the standards set in the QAP are met;

(c) Quality standards goals;

(d) The basic flow of project activities;

(e) Equipment available to MEDEP/LUST Program;

(f) Standard Operating Procedures for conducting field work; and

(g) MEDEP/LUST Program procedures for obtaining analytical support.

2.0 QUALITY ASSURANCE STATEMENT

It is the goal of the MEDEP/LUST Program to implement a QAP for all environmental activities that generate analytical data. The QAP is a management tool that will help guarantee that data are of sufficient known quality to withstand scientific and legal challenge relative to the use for which the data are obtained.

3.0 MEDEP/LUST PROGRAM ORGANIZATION

3.1 Organizational Hierarchy

The MEDEP/LUST Program organizational chart can be found in Appendix A.

3.2 Personnel Responsible for QAP Implementation

MEDEP's Quality Management Plan (QMP) (Revision 8.1, May 13, 2021) 1.4 reads, in part, "[c]ommitment to and responsibility for the quality objectives and operations detailed in…any QAP…begins with the commissioner and continues through all levels of management and staff." As such, division and program-level managers, as outlined in the LUST Organizational Chart, bear primary responsibility for ensuring that the QA standards specified in this QAP are met.

3.2.1 Program Manager

Name:	Molly King
Title:	Director, Division of Technical Services
Phone:	(207) 458-8839

Responsibilities: Grant administration and semi-annual LUST 4 Report submission, completion of public record, fund tracking, journaling state match requirements and allotments, policy and regulation development, establishment of priorities and general program management.

3.2.2 Department Quality Assurance Officer

Name: Julie Churchill
Title: Quality Assurance Manager, Office of the Commissioner
Phone: (207) 881-9236

Responsibilities: Communicates all QAP updates to USEPA, and communicates QMP and USEPA requirements to MEDEP/LUST Program personnel responsible for QAP implementation.

3.2.3 Project Quality Assurance Chemist

Name: Kelly Perkins
Title: Chemist III, Division of Technical Services
Phone: (207) 641-9150

Responsibilities: Review QAP annually, and send a review report to the Program Manager and Department QA Officer; send all approved QAP updates to Program personnel responsible for QAP implementation; report any unresolved laboratory issues to the Maine Laboratory Certification Officer, and provide technical guidance to project staff as requested.

3.2.4 Quality Assurance Team

Quality assurance is the responsibility of MEDEP/BRWM statewide supervisory technical, emergency response, and project management staff whose names, titles, and phone numbers follow:

Name, Office	Title	Phone Number
Sean Dougherty, CMRO	Environmental Hydrogeology Manager	(207) 441-7159
Matt Burke, CMRO	Senior Environmental Hydrogeologist	(207) 458-8572
Jason Langley, EMRO	Senior Environmental Hydrogeologist	(207) 458-3258
Mark Woodruff, SMRO	Senior Environmental Hydrogeologist	(207) 458-9534
Tim MacMillan, CMRO	Environmental Engineering Services Manager	(207) 458-9484
Peter Eremita, SMRO	Senior Environmental Engineer	(207) 592-0592
Ed Cousins, CMRO	Senior Environmental Engineer	(207) 458-9440
Chris Hopper, CMRO	Director, Division of Response Services	(207) 816-0133
Jon Woodard, CMRO	Oil and Hazardous Materials Responder III	(207) 287-3692
Bob Shannon, EMRO	Oil and Hazardous Materials Responder III	(207) 941-4570
Greg O’Brien, SMRO	Oil and Hazardous Materials Responder III	(207) 446-9885

Name, Office	Title	Phone Number
Chris Fournier, CMRO	Director, Division of Petroleum Management	(207) 287-7860
Stacy Ladner, CMRO	Environmental Specialist IV	(207) 530-2247

CMRO - Central Maine Regional Office
EMRO - Eastern Maine Regional Office
SMRO - Southern Maine Regional Office

Responsibilities: Perform, or delegate, periodic observation of sampling and sample handling techniques for conformity with MEDEP/LUST Program guidance documents; and provide technical guidance to Program Manager and project staff as requested.

4.0 QAP ASSESSMENT

As required by the Policy to Assure the Competency of Organizations Generating Environmental Measurement Data under Agency-Funded Assistance Agreements (Agency Policy Directive Number FEM-2012-02 Revision 1; Approved March 13, 2013, Updated December 21, 2016), activities involving the use or generation of environmental data are evaluated to ensure they are performed by individuals competent to perform the activity.

4.1 Laboratory Services Evaluation

All analyses used to assess petroleum contamination must conform to methods listed in the Remedial Action Guidelines for Contaminated Sites in Maine, November 15, 2023 (RAGs) and Appendix S of Rules for Underground Oil Storage Facilities, 06-096 C.M.R. ch. 691 (amended September 26, 2018) (Chapter 691). The LUST Program will only accept data results from a Maine accredited laboratory. The Maine Laboratory Accreditation Program administered by the Department of Health and Human Services maintains a list of laboratories accredited to perform these analyses in water, soil, and indoor air as well as other matrices. Under the Maine Laboratory Accreditation Program, accredited laboratories must annually pass performance evaluation samples for each accredited analysis.

4.2 Internal Assessment

Personnel responsible for performing field and laboratory sampling activities are responsible for continually monitoring individual compliance with the QAP. The Quality Assurance Team will perform, or delegate, periodic observation of sampling and sample handling techniques for conformity with MEDEP/LUST Program guidance documents. The results of this internal assessment are discussed with appropriate staff with suggestions and/or recommended requirements for a plan to correct observed deficiencies.

4.3 External Evaluation

Field activities may be reviewed by personnel external to the MEDEP/LUST Program, such as the Department QMP Audit Team or USEPA. Such an assessment is an extremely valuable method for ensuring that the QAP is appropriately implemented. The results of an external assessment will be submitted to the LUST Program Manager. The Program Manager, with input from staff will respond to the audit report with a plan to correct observed deficiencies. Appropriate corrective actions will be communicated to all program staff.

4.4 Yearly QAP Review

The Project QA Chemist will conduct an annual review of the QAP, and a review report will be sent to the Program Manager and the Department QA Officer. QAP revisions will be sent to the Quality Assurance Team as outlined in Section 3.2.

A meeting of project personnel responsible for environmental sampling will be scheduled annually as appropriate to review sampling procedures and any QAP updates.

5.0 DATA QUALITY OBJECTIVES

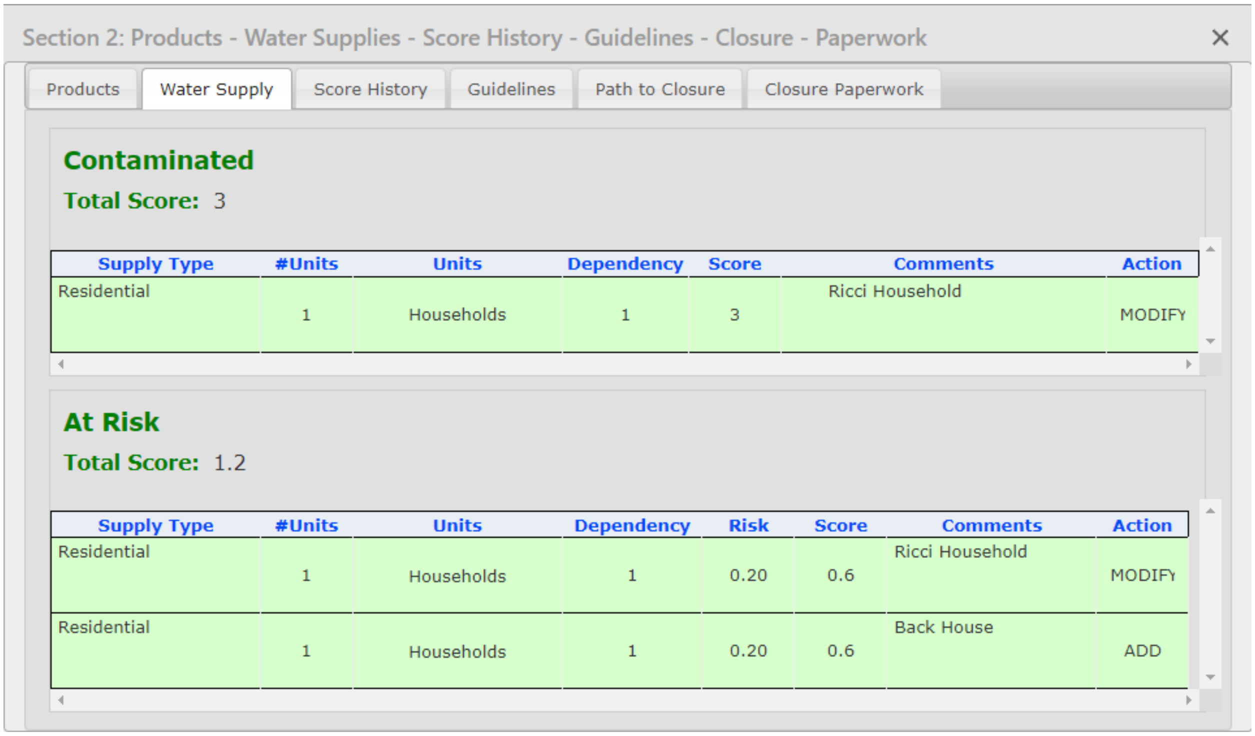
The Quality Assurance objective of this program is to assure valid and reproducible data. All laboratory tests performed for the LUST program must be in accordance with Appendix S of Chapter 691. The laboratories performing Volatile Petroleum Hydrocarbons (VPH), Extractable Petroleum Hydrocarbons (EPH) and Air-Phase Petroleum Hydrocarbons (APH) analyses must be Maine accredited, and are required to adhere to established standard operating procedures (QAP, Appendix C) for measurement of concentrations of petroleum analytes. Laboratories performing new drinking water supply analyses must also be Maine accredited, and are required to adhere to USEPA approved drinking water methods. The sampling and analytical procedures outlined in this QAP are intended to produce data which are of appropriate accuracy for assessing public health risks, remediation decision making, and defensible for any required enforcement and litigation purposes.

Some analyses, as an exception to the above requirement, may be performed using formerly standard methods should this be found necessary to maintain consistency for litigation or enforcement purposes in a specific instance.

5.1 Sample Collection and Preservation

Samples are taken as needed for the purposes of establishing site-specific compliance or non-compliance with existing regulations and to support remediation decisions. The number and type of samples to be collected is governed by the project and data quality objectives and is documented in the project file. The project and data quality objectives are defined by the remediation guidelines applicable to the discharge and site as contained in the RAGs and included as Appendix D to this QAP. Media determined to be at risk and the applicable guidelines are documented for each long-term remediation LUST site in the Division of Technical Services Priority List Database.

Below is a screenshot from the Priority List Database of a list of wells for a site that are either impacted or at risk. Based on the guideline applicable to the site, these wells will be monitored, mitigated, or remediated according to the RAGs. Below this screenshot is a screenshot of the Guideline record in the Priority List Database.



Contaminated

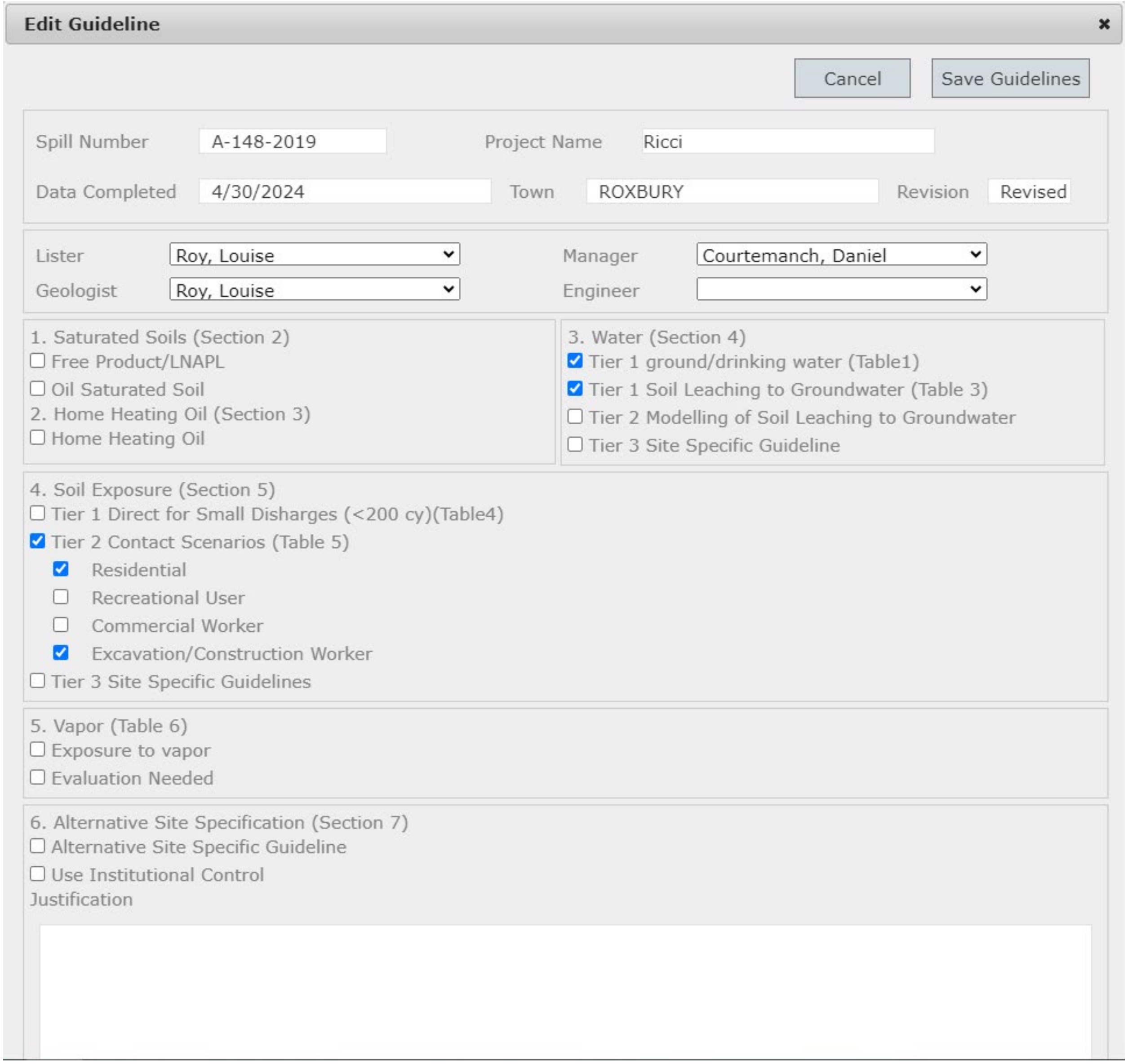
Total Score: 3

Supply Type	#Units	Units	Dependency	Score	Comments	Action
Residential	1	Households	1	3	Ricci Household	MODIFY

At Risk

Total Score: 1.2

Supply Type	#Units	Units	Dependency	Risk	Score	Comments	Action
Residential	1	Households	1	0.20	0.6	Ricci Household	MODIFY
Residential	1	Households	1	0.20	0.6	Back House	ADD



Spill Number: A-148-2019
Project Name: Ricci
Data Completed: 4/30/2024
Town: ROXBURY
Revision: Revised

Lister: Roy, Louise
Manager: Courtemanch, Daniel
Geologist: Roy, Louise
Engineer:

1. Saturated Soils (Section 2)
☐ Free Product/LNAPL
☐ Oil Saturated Soil
2. Home Heating Oil (Section 3)
☐ Home Heating Oil

3. Water (Section 4)
☑ Tier 1 ground/drinking water (Table1)
☑ Tier 1 Soil Leaching to Groundwater (Table 3)
☐ Tier 2 Modelling of Soil Leaching to Groundwater
☐ Tier 3 Site Specific Guideline

4. Soil Exposure (Section 5)
☐ Tier 1 Direct for Small Disharges (<200 cy)(Table4)
☑ Tier 2 Contact Scenarios (Table 5)
  ☑ Residential
  ☐ Recreational User
  ☐ Commercial Worker
  ☑ Excavation/Construction Worker
☐ Tier 3 Site Specific Guidelines

5. Vapor (Table 6)
☐ Exposure to vapor
☐ Evaluation Needed

6. Alternative Site Specification (Section 7)
☐ Alternative Site Specific Guideline
☐ Use Institutional Control
Justification

Initial discharge or leak investigations must conform to requirements in Section 12(C)(4), Discharge and Leak Investigation, Response and Corrective Action Requirements and Appendix P, Requirements for a Site Assessment at Facility Closure or Abandonment, in Chapter 691.

Typically, all ground and surface water samples will be collected and handled as described in Appendix B, MEDEP/LUST Program Standard Operating Procedures (SOPs). Appendix B, SOP TS003, Field Quality Control Guidance, Attachment 1 outlines basic sampling criteria including sample collection and preservation parameters.

5.2 Sample Custody

Samples are maintained under documented custody, as described below, until accepted by the analytical laboratory. The laboratory is responsible for subsequent custody control and documentation.

Chain-of-custody provides defensible documentation of sample integrity from the point of collection to analysis. Chain-of-custody consists of two components: documentation and actual physical custody. It includes custody in the field and in the laboratory. When handling samples from the point of collection until delivery to the laboratory, the custodian will keep the containerized sample in their physical possession, or in view, or secured to prevent tampering or inadvertent contamination in a locked storage area.

Using an appropriate chain of custody form, all applicable information will be completed by the person(s) collecting the sample. Any person(s) assuming custody prior to delivery to the laboratory will adhere to these custody procedures and will document transfer of custody by entering signature, date, and time on the chain of custody form.

Upon receipt of the sample by the laboratory, documented by signature, date and time on the chain of custody form, the laboratory is responsible for following equivalent internal SOPs regarding maintenance of custody to ensure sample and data integrity. Sample handling procedures for laboratories utilized by this program must be documented in the Laboratory's Quality Assurance Manual.

5.3 Data Use

The data use(s) will be identified on a project specific basis. Data collected for the MEDEP's LUST Program may be used to meet any of the following objectives:

(a) To determine the need for emergency action;

(b) To identify any waste materials and contaminants;

(c) To determine the quantity and levels of contamination;

(d) To identify impacted targets/receptors and natural resources; or

(e) To document the needs for further action or no further action.

Data use can be broken down into three basic categories: initial investigation of a site, routine monitoring of a site, and site closure. Data collected for milestone remediation decisions and site closure generally require the highest level of quality. Staff collecting or using data must be competent in the activity performed. Samplers must strictly adhere to appropriate sampling SOPs, and analytical data must adhere strictly to the quality control requirements of the appropriate methods.

5.4 Data Quality Necessary for Project

Data quality needs depend on several factors including data use and analytical requirements of the site. Analytical requirements and data quality goals for site investigations are based on the RAGs and Appendix Q, Section 2, Notification Requirements of Chapter 691. At a minimum, data QA/QC will be evaluated for the items included in the BRWM Basic Data Review Checklist (QAP, Appendix I).

The quantity of data needed will vary based on site-specific conditions, available usable data, data use, and analytical methods used.

6.0 PROCEDURAL REQUIREMENTS FOR MEETING QAP

In order to assure the generation of quality data, procedural steps described in the QAP and Chapter 691, Rules for Underground Oil Storage Facilities, Section 12, Discharge and Leak Investigation, Response and Corrective Action Requirements must be followed. These steps include:

(a) Site assessments shall be conducted by facility owners in accordance with procedures outlined in Appendix P of Chapter 691 (included in Appendix G);

(b) Field determination of soil hydrocarbon content shall be conducted according to Standard Operating Procedure: TS004, Compendium of Field Testing of Soil Samples for Gasoline and Fuel Oil, Revision 2.1, October 15, 2012 (included in Appendix B) or according to the methods outlined in Appendix Q of Chapter 691 (included in Appendix G;

(c) Laboratory methods and performance standards found in Appendix S of Chapter 691 shall be used (included in Appendix G);

(d) Field notes shall be taken either in bound field books or on appropriate field note forms. Notes shall be signed and contain at a minimum:

   (i) Date, site name, and location;

   (ii) Weather conditions;

   (iii) Personnel present;

(iv) Purpose of the visit;

(v) Field measurements, if taken;

(vi) Sample locations, if taken; and

(vii) Any information the field staff believes may be useful or pertinent in the project file.

(e) Field quality control samples shall be collected during sampling events in accordance with Standard Operating Procedure: TS003, Field Quality Control, Revision 4, February 28, 2007 (included in Appendix B).

(f) Written work plans shall be developed for sites requiring long-term corrective action if: (a) a non-transient public water supply is contaminated or at risk of becoming contaminated, (b) two or more wells are contaminated, or (c) long-term corrective action costs are expected to exceed $100,000. At a minimum, the work plan shall include:

(i) Names of personnel responsible for site work, including MEDEP team and any contractors responsible for environmental sampling;

(ii) Objectives established in accordance with the RAGs;

(iii) Modifications and limitations to objectives, and/or site-specific objectives;
(iv) Site map;

(v) Sampling locations and methods;

(vi) Field QC samples;

(vii) Analytical methods; and

(viii) Any special training required.

(g) Work plans for sites directly managed by MEDEP staff shall be reviewed for the eight elements described above, and a dated page carrying the approval signature of the MEDEP project manager shall be included in the project file. Work plans developed by external contractors shall be reviewed and approved by the MEDEP project manager, signed, and filed as above. All active work plans shall be reviewed annually by the MEDEP project manager, and documentation of this review, including any changes to the work plan, shall be filed as above. Any review of workplans (e.g., for technical validation) by a person other than the MEDEP project manager shall likewise be documented.

(h) Project managers and/or project scientists will maintain communication with remediation personnel during remediation activities and will periodically visit the site to monitor cleanup progress. All site visits will be documented in field notes.

(i) Data will be assessed to determine if the Data Quality Objectives (DQOs) are met in accordance with Section 10 of this QAP.

(j) Findings and conclusions of the initial hydrogeological investigation will be reported to the Department for review and approval;

7.0 EQUIPMENT AND SUPPLIES

7.1 Equipment

A variety of equipment is available to the MEDEP/LUST Program for conducting soil, groundwater, and indoor air investigations. A list of the available equipment can be seen in Appendix B. All equipment is maintained and calibrated according to the manufacturers' instructions and in accordance with the appropriate analytical methods. Manufacturers' instructions and other instructional documentation will be kept in the equipment logbook maintained by support staff in MEDEP/Division of Technical Services. As new equipment is purchased or other otherwise made available to MEDEP/LUST Program, the equipment list and SOPs will be updated.

Equipment that requires calibration for use, such as photoionization detectors (PIDs), pH meters, etc., shall be calibrated routinely on a monthly basis or as directed by the manufacturer, and prior to its use in the field at the beginning of each working day and checked at the end of each working day. Additional calibration may also be conducted throughout the work day as directed by the manufacturer, as required by SOP RWM-PP-008 (included in Appendix B), or as deemed necessary by the field personnel when equipment appears to be reporting suspect results. Documentation of routine calibration and maintenance shall be kept in the equipment calibration and maintenance logbook maintained by designated MEDEP/Division of Technical Services staff. Documentation of calibration of equipment prior to and during its use in the field will be noted in the field notes of the person conducting the calibration.

Staff must be determined to be competent in the use of all equipment prior to the use of the equipment to collect samples for soil, groundwater, or indoor air investigations. In addition, staff must complete annual refresher training to demonstrate ongoing competency. Documentation of initial and ongoing equipment use competency for MEDEP staff is maintained by the MEDEP/Division of Technical Services Hydrogeology Unit or other designated personnel. Non-MEDEP personnel are responsible for maintaining their own competency demonstrations. Competency demonstrations for non-MEDEP personnel should be provided to the MEDEP upon request.

7.2 Supplies

Supplies needed to perform sampling under this program are ordered and managed by the Hydrogeology Unit or support staff in MEDEP/Division of Technical Services, and stored in a clean, secure room. Stocks are continually checked to ensure that an adequate supply is maintained.

Organic free water used for trip blanks and field blanks is either purchased or provided by the laboratory performing the analytical support for the project. All water is tested for volatile organic compound (VOC) content prior to use.

Sample bottles, preservatives, and chain of custody forms are supplied by Maine accredited laboratories for appropriate analyses. Unused VOC sample bottles taken into the field will not be returned to clean bottle storage unless proven to be free of contamination.

8.0 LABORATORY SERVICES

The LUST Program will only accept drinking water supply well, water, soil, and air analytical results from Maine accredited laboratories using approved methods. These laboratories have been contracted to perform analyses for which they are accredited by the Maine Laboratory Accreditation Program. The Maine Laboratory Accreditation Program maintains a list of laboratories certified to perform these analyses. A listing of these laboratories, current as of May 29, 2024, is included in Appendix F. An up to date list of all tests for which each laboratory is certified can be found at the Maine Laboratory Accreditation Program webpage.

For some large remediation sites, a non-accredited on-site laboratory may be employed for quick turn-around analyses to guide cleanup. It is standard practice to send replicates of 10% of such samples to a Maine accredited laboratory as a check for accuracy of the on-site analyses. In these cases, confirmation samples must be analyzed by an accredited laboratory.

Laboratories must submit electronic data formatted to the current version of MEDEP's EDD as outlined on the Environmental and Geographic Analysis Database (EGAD) webpage. In addition, all hardcopy and electronic data must include the minimum QA/QC elements as outlined on the EGAD webpage. Data from LUST sites are stored in the EGAD and shared with staff and the public as applicable.

9.0 STANDARD OPERATING PROCEDURES (SOP)

MEDEP/LUST Program's standard operating procedures for conducting sampling and other data collection activities can be found in Appendix B, MEDEP/LUST Program Standard Operating Procedures Manual. Additional sampling methods for vapor intrusion investigations are found on the Vapor Intrusion Guidance section of the webpage. Additional standard operating procedures are found at http://www.maine.gov/dep/spills/publications/sops/index.html.

Depending on circumstances and needs, it may not be possible or appropriate to follow these procedures exactly in all situations due to site conditions, equipment limitations, and limitations of the standard procedures. In some instances it may be necessary to perform an activity that does not have a specific SOP. Whenever SOPs cannot be followed, they may be used as general guidance with any and all modifications fully documented in field notes.

The MEDEP Program Manager must approve any changes in MEDEP/LUST Program SOPs. The SOPs are controlled documents and revisions should be indicated on each page in the upper right hand corner along with the revision date.

10.0 DATA QUALITY ASSESSMENT

Given that imperfections in sampling and analytical procedures exist, it is sometimes commonplace to find that the reported concentration and actual concentration are not identical. The difference between the reported concentration and the actual concentration of a sample is a function of both the sampling and analytical error. Sampling error may be assessed with field QC samples including field duplicates and trip blanks, and it will be minimized by following standardized sampling protocols. The potential magnitude of analytical error may be assessed by evaluating laboratory quality control samples, and will help determine the significance of a reported concentration.

Data review is a three step process evaluating data completeness, data integrity, and data usability. The level of data review will vary depending on the use of the data. Even data of poor precision and/or accuracy may still be useful. At a minimum, data quality assessments will include the review of the items detailed in the BRWM Basic Data Review Checklist (QAP, Appendix I). The project scientist (Hydrogeologist or Environmental Engineer) or Environmental Specialist, with input from the Project QA Chemist as needed, will determine the usefulness of data that may be of poor quality.

All data generated will be reviewed by the MEDEP/Division of Technical Services Chemistry Unit for the following data quality indicators: precision, accuracy, representativeness, completeness, comparability, and sensitivity as described below in Sections 10.1 through 10.6. Additionally, field notes, custody forms, and sample extraction and analysis dates will be reviewed by the project scientist or Environmental Specialist to assure holding times and other standard procedures are met. The project scientist may also review QC sample results to assure that recoveries are within acceptable ranges, as well as reviewing blank, spike, and duplicate samples to assure they are within acceptance criteria.

If data of questionable quality are reported (i.e., outside the acceptance criteria presented in Section 10.1 through 10.6 of this QAP) or other quality control issues uncovered, the project scientist or Environmental Specialist will be notified. At a minimum, any data quality issues will be outlined in the final report for which the data were generated. Need for additional corrective action, including the collection of new or additional samples, will be determined after review of the DQOs for the project on a case by case basis with input from the project scientist or Environmental Specialist, and any other appropriate personnel. If additional corrective action is necessary, it will be implemented as described in Section 12.0 - Corrective Action of this QAP.

10.1 Precision

The precision required for a particular study will depend upon the difference between background levels and the action level. Laboratory precision is only one part of the total precision of the measurement process leading from sample collection through data reporting. Selection of an acceptable precision level should not be based solely on what is attainable in the laboratory. Once the sample has been submitted to the laboratory much of the sample to sample variation has already been introduced into the sample by activities in the field.

Replicate or duplicate QC samples are submitted from the field to provide a means of determining the precision of the measurement process. The following formula will be used for precision measured from duplicative samples, as defined by the relative percent difference (% RPD).

$$\% \text{ RPD} = 100 \times \left(|X1 - X2| / ((X1 + X2)/2) \right)$$

where: X1 is the concentration of duplicate #1; and
X2 is the concentration of duplicate #2.

The RPD should be less than 50% for soil and 30% for water unless specified otherwise in the analytical method. RPDs outside these criteria shall at a minimum be noted in the final report for the data.

10.2 Accuracy

Accuracy is controlled primarily by the laboratory and usually reported as percent recovery. Analysis of surrogate recovery and known concentrations in Laboratory Control Samples should be within the recovery range listed in the referenced analytical method. Recovery outside appropriate criteria shall at a minimum be noted in the final report for the data.

10.3 Representativeness

Representativeness is the ability to collect a sample that reflects the conditions of a particular site. Representativeness is measured by how well the sampling followed the proposed Sampling and Analysis Plan so as to provide results that accurately depict the media and environmental conditions being evaluated.

Documentation of field events confirms that proper protocols were followed and all planned samples were collected and analyzed.

10.4 Completeness

Completeness is the number of valid measurements divided by the number of samples taken. The project scientist or Environmental Specialist will be responsible for determining the completeness of the data; if completeness falls below 90%, it shall be noted in the final report for the data.

10.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved through the use of standard techniques to collect and analyze representative samples and reporting analytical results in appropriate units. All laboratory samples for EPH, VPH, and APH must be analyzed by the approved method.

When available, analytical data will be compared to data collected from previous sampling events and other secondary source data. If currently collected data differs from previously collected data, it shall be evaluated to determine if the current data reflect a data quality issue or a change in site contaminant concentration trends. Unresolved data quality issues shall be, at a minimum, reported to the Project QA Chemist, Senior Hydrogeologist or Environmental Engineer as applicable. Need for corrective action will be determined after review of the DQOs for the project and follow the procedures listed in Section 12.0 - Corrective Action of this QAP.

10.6 Sensitivity

Sensitivity is a quantitative measure indicating the lower limit that a compound of interest may be accurately quantified. The quantitation limits (reporting limits) of the method and those achievable by the analytical laboratory should be low enough to accurately report the contaminant at a specific concentration. The reporting limits should be based on the lowest calibration standard, not the method detection limit (MDL). Reported positive results between the reporting limit and the MDL should be flagged with an appropriate qualifier (“J” qualifier). The analytical methods chosen for a particular project need to be sensitive enough to characterize the environmental conditions. When a project involves making a decision related to a specific regulatory limit, the analytical methods utilized should be sensitive enough to reach these limits.

11.0 DOCUMENT CONTROL

Document control is a systematic procedure for ensuring that all sampling and monitoring documents are properly identified and accounted for during and after the completion of investigations and project reports. Document control will conform to MEDEP’s Quality Management Plan Appendix 4, Section 4.5, Control of Documents and Records, and encompass document inventory and assignment record, and document file repository.

The term document control, as it applies to MEDEP/LUST Program inspections and investigations, refers to the maintenance of inspection, investigation, and report project files. All project files shall be maintained by the appropriate project manager, and may be kept with the project manager's files or in the respective Regional Office Central Files. When sites are closed, project files shall be placed in the Regional Central Files, and a copy of the closure report sent to the MEDEP/BRWM Central File, located at the CMRO of MEDEP.

11.1 Project File

The following documents shall be placed in the project file:

(a) The original Chain of Custody records and analytical data sheets;

(b) A copy of field notes;

(c) A complete copy of investigative reports and memorandums transmitting analytical or other data obtained during investigations;

(d) Work Plans and Health and Safety Plans (HASPs);

(e) All official correspondence received, or issued, by the MEDEP/LUST Program relating to the investigation including records of telephone calls;

(f) Applicable forms such as field worksheets;

(g) Contracts and contract amendments for site work;

(h) Any relevant permits; and

(i) Any other relevant documents related to the original investigation/inspection or follow-up activities related to the investigation/inspection.

Under no circumstances is any personal observation or irrelevant information to be filed in the official project files. The project manager or designee shall review the file at the conclusion of the project to ensure that the file is complete.

11.2 Public Records

“Public records” shall mean all documents, papers, letters, maps, field notes, books, photographs, video, sound recordings, or other material regardless of physical form or characteristics made or received pursuant to law or ordinance or in connection with the transaction of official business by the MEDEP/LUST Program.

The following records shall not be deemed public unless specifically authorized:

(a) Trade secrets and commercial or financial information obtained from a person, firm, or corporation, which are of a privileged or confidential nature according to *Uniform Trade Secrets Act,* 10 M.R.S. § 1542(4)(A) & (B);

(b) Preliminary drafts, notes, impressions memoranda, working papers, and work products;

(c) The contents of real estate appraisals, engineering or feasibility estimates and evaluations made for or by MEDEP/LUST Program relative to the acquisition of property or to prospective public supply and construction contracts, until such time as all of the property has been acquired or all proceedings or transactions have been terminated or abandoned; provided the law of eminent domain shall not be affected by this provision;

(d) All investigatory records of public bodies pertaining to possible violations of statute, rule or regulation other than records of final actions taken provided that all records prior to formal notification of violations or noncompliance shall not be deemed public; and

(e) Records, reports, opinions, information, and statements required to be kept confidential by federal or state law, rule, rule of court, or regulation by state statute.

12.0 CORRECTIVE ACTION

Corrective actions must be taken immediately when data or field procedures are of questionable quality. These corrections may range from modifying certain procedures to reconducting an entire field investigation or resampling. Any suspected problems will be brought to the attention of the Project QA Chemist, Senior Hydrogeologist or Environmental Engineer as applicable.

The need for corrective action may be identified during performance audits, standard QC procedures, or when data seems erroneous. The steps in the corrective action are:

(a) Identifying and defining the problem;

(b) Investigating the problem;

(c) Determining the cause of the problem and appropriate corrective action;

(d) Implementing the corrective action; and

(e) Verifying the problem has been corrected.

The Senior Hydrogeologist or Environmental Engineer is responsible for ensuring effective corrective actions have been taken regarding sampling activities and other field work. The Project QA Chemist is responsible for ensuring effective corrective actions have been taken regarding laboratory activities.

13.0 IMPLEMENTATION SCHEDULE

This QAP will be implemented by MEDEP/LUST Program upon USEPA approval. This QAP is to be considered a working document and will be periodically updated as technology, policy, and protocol change.

14.0 DISTRIBUTION LIST

Upon approval and implementation of this QAP, the original shall be kept with the MEDEP/LUST Quality Assurance Chemist, and copies sent to the MEDEP/LUST Program Manager, MEDEP Quality Assurance Officer and USEPA. Copies will also be made available to all personnel responsible for implementing the QAP (see Section 3.2) who will be required to review this QAP within 120 days of implementation and sign the QAP Log Sheet found in Appendix E. The remaining MEDEP/LUST Program staff will be required to review and sign within 360 days of implementation. New staff hired by the MEDEP/LUST Program will be required to review the QAP within 90 days of the hiring date and sign the QAP Log Sheet found in Appendix E. The completed signature page is kept by the Quality Assurance Chemist.

A copy of the approved QAP is available on the MEDEP website at http://www.maine.gov/dep/spills/petroleum/lustqaplan.html.

15.0 USEPA REPORTING

15.1 LUST 4 Report

The MEDEP LUST Program Manager completes the LUST 4 Report on a semi-annual basis with data provided from MEDEP Divisions of Response Services, Technical Services, and Petroleum Management. The data includes UST universe performance measures, UST inspections performance measures, UST compliance performance measures, and LUST performance measures.

15.2 Public Record

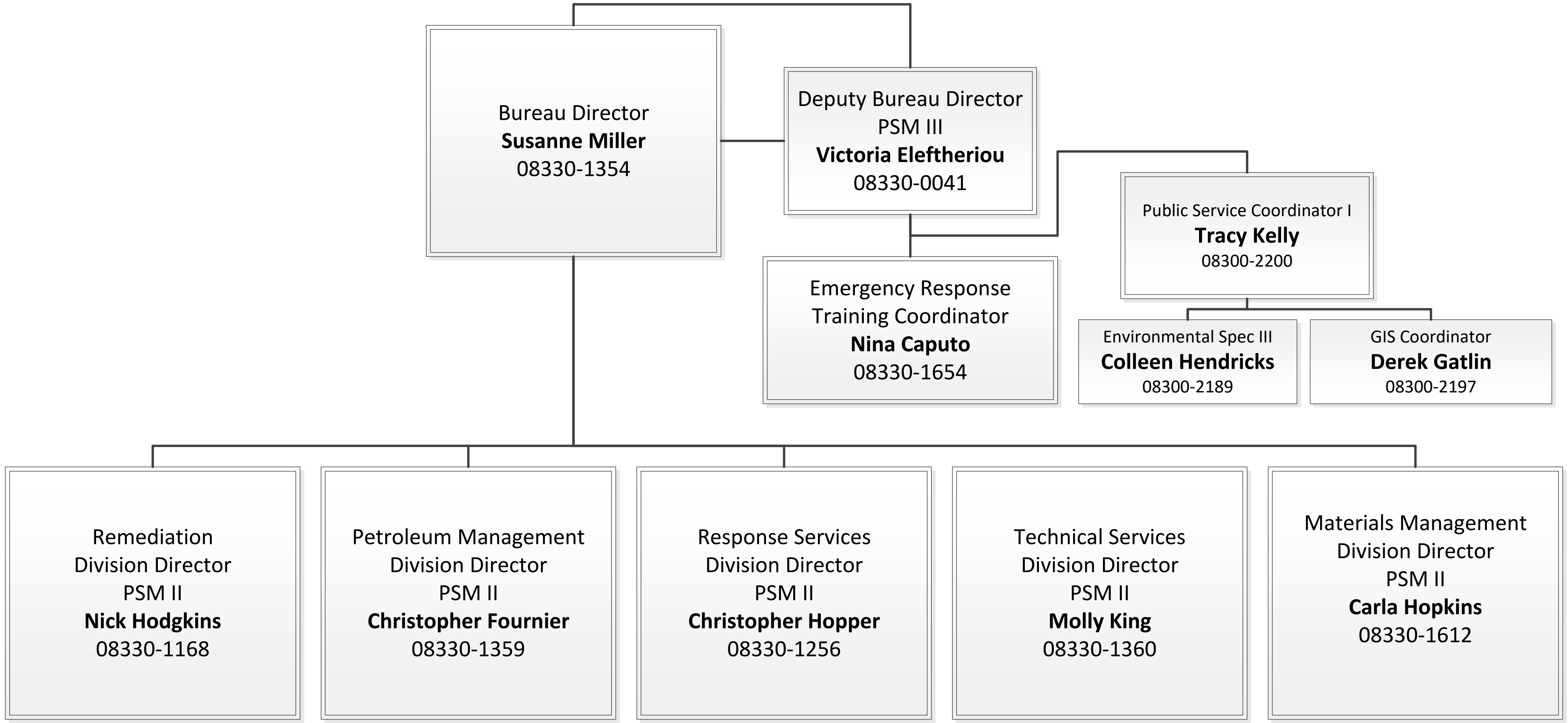
The Public Record is completed by the MEDEP LUST Program Manager annually with data provided by MEDEP Divisions of Response Services and Petroleum Management. The Public Record is a record of information relating to underground storage tanks regulated under Subtitle I. See Appendix J, Process for the Collection of EPA LUST Trust Data for Motor Fuel Discharges for additional information on the Public Record. The Public Record is posted on MEDEP's webpage at http://www.maine.gov/dep/waste/ust/pubs.html.

16.0 LIST OF ACRONYMS AND ABBREVIATIONS

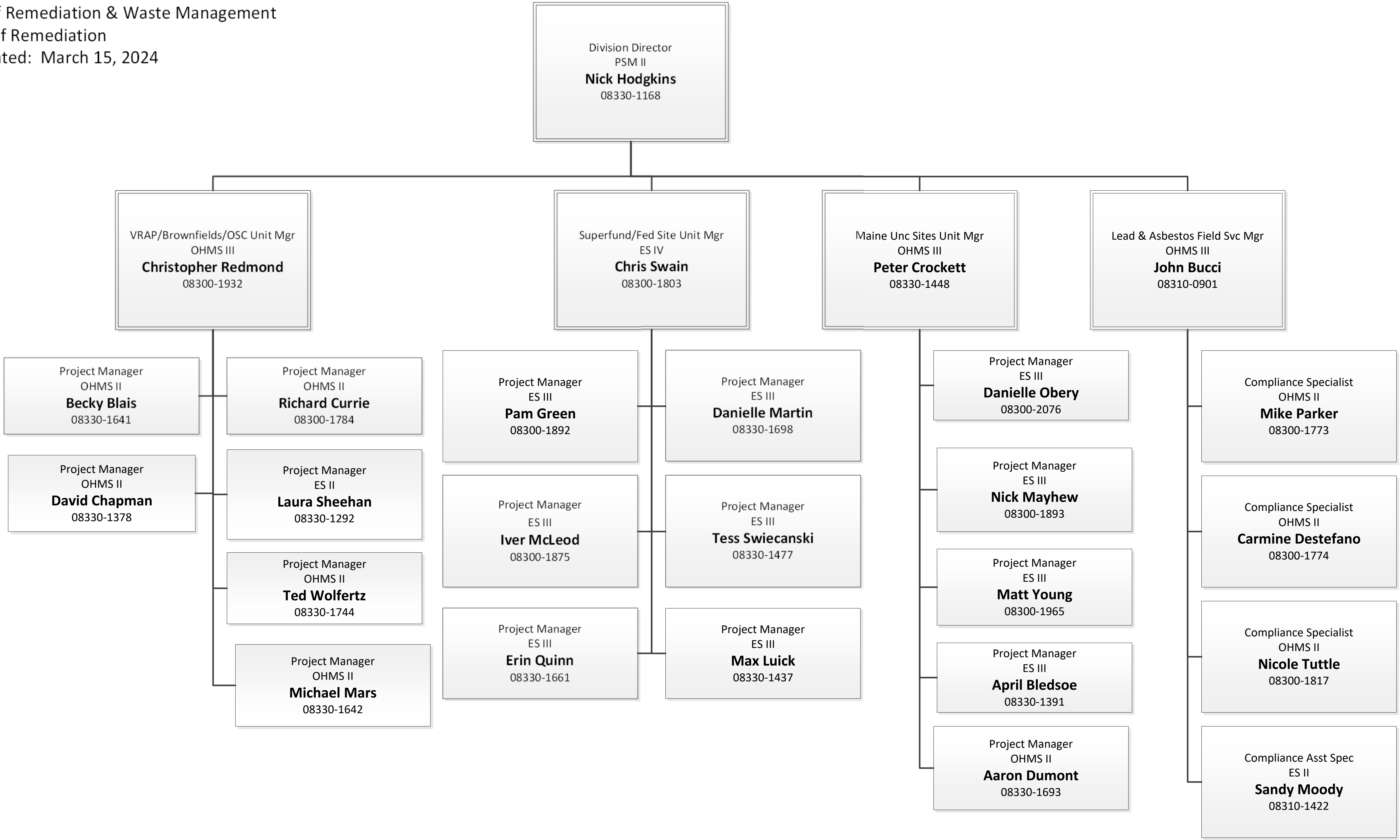
Acronym	Description
APH	Air-Phase Petroleum Hydrocarbons
CMRO	Central Maine Regional Office
DQ	Data Quality
DQO	Data Quality Objective
EMRO	Eastern Maine Regional Office
EPH	Extractable Petroleum Hydrocarbons
HASP	Health and Safety Plan
LUST	Leaking Underground Storage Tank
MEDEP	Maine Department of Environmental Protection
PID	Photoionization Detector
QA	Quality Assurance
QC	Quality Control
QAP	Quality Assurance Plan
RAGs	Remedial Action Guidelines for Contaminated Sites in Maine
RCRA	Resource Conservation and Recovery
RPD	Relative Percent Difference
project scientist	Environmental hydrogeologist, quality assurance chemist or environmental engineer assigned to the project
SMRO	Southern Maine Regional Office
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency, Region I
UST	Underground Storage Tank
VOC	Volatile Organic Compound
VPH	Volatile Petroleum Hydrocarbons

Appendix A

Department of Environmental Protection
Bureau of Remediation & Waste Management
Last Updated: September 12, 2023



Bureau of Remediation & Waste Management
Division of Remediation
Last Updated: March 15, 2024



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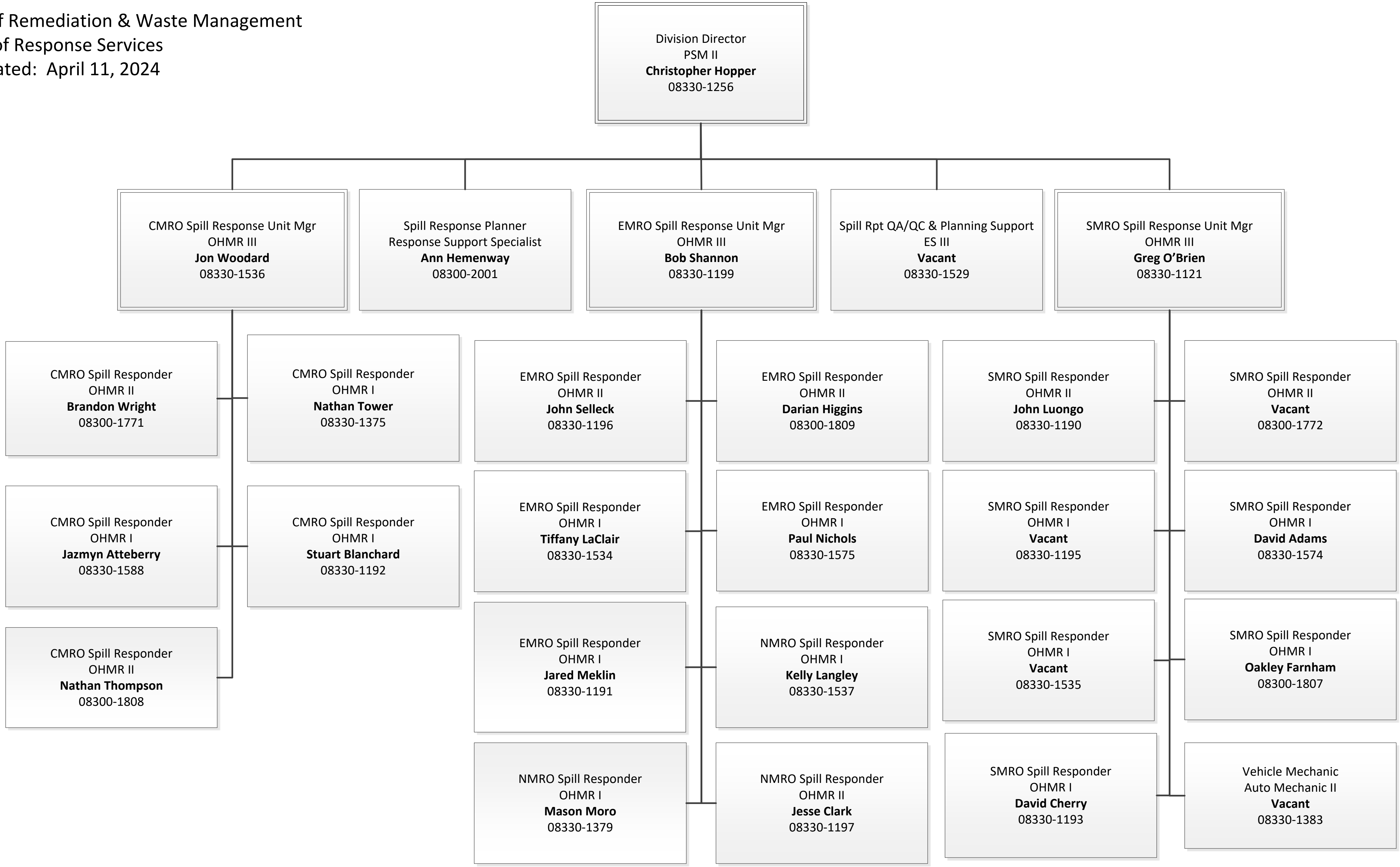
Bureau of Remediation & Waste Management
Division of Response Services
Last Updated: April 11, 2024



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Bureau of Remediation & Waste Management
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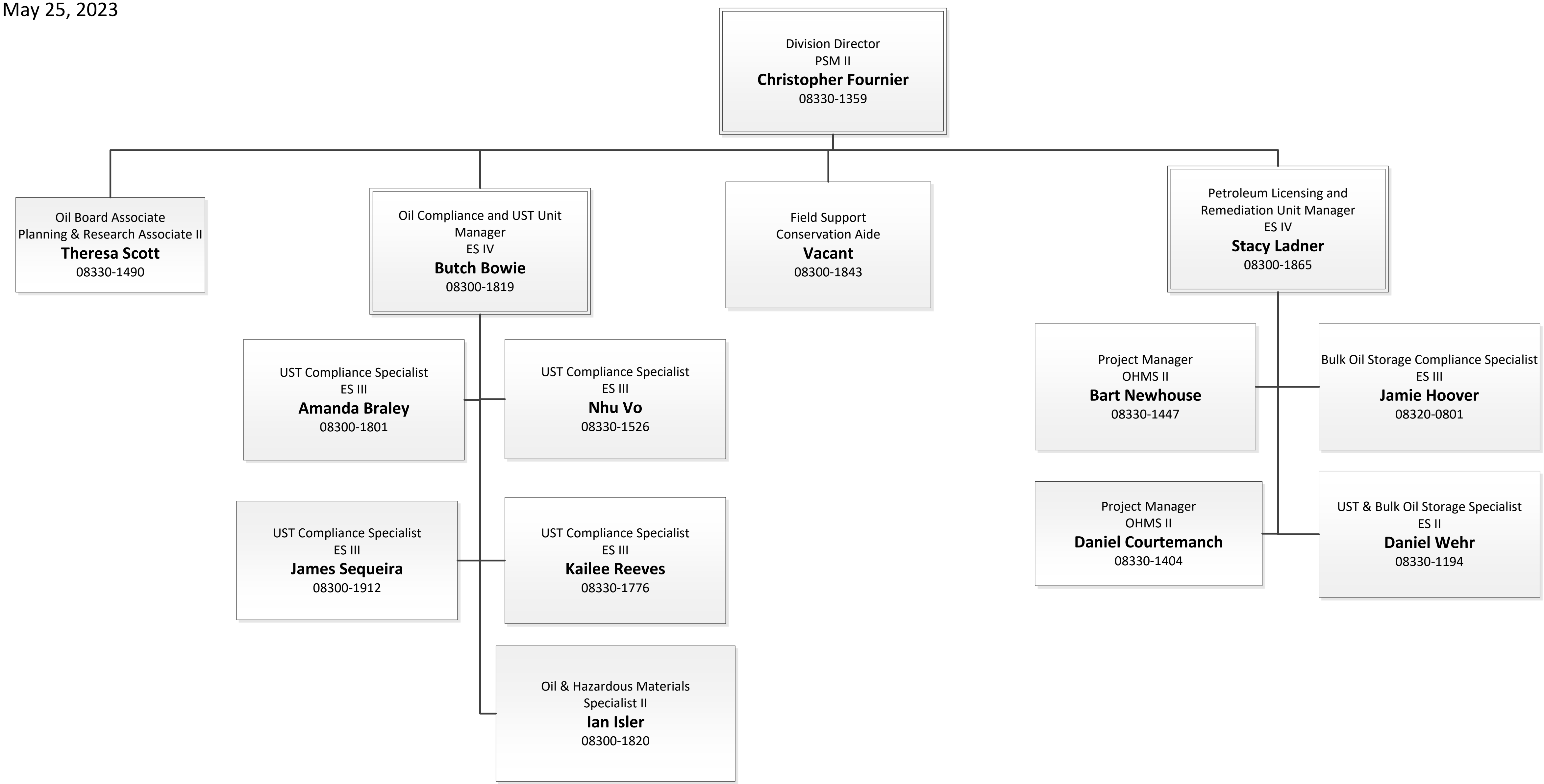
Last Updated: May 25, 2023



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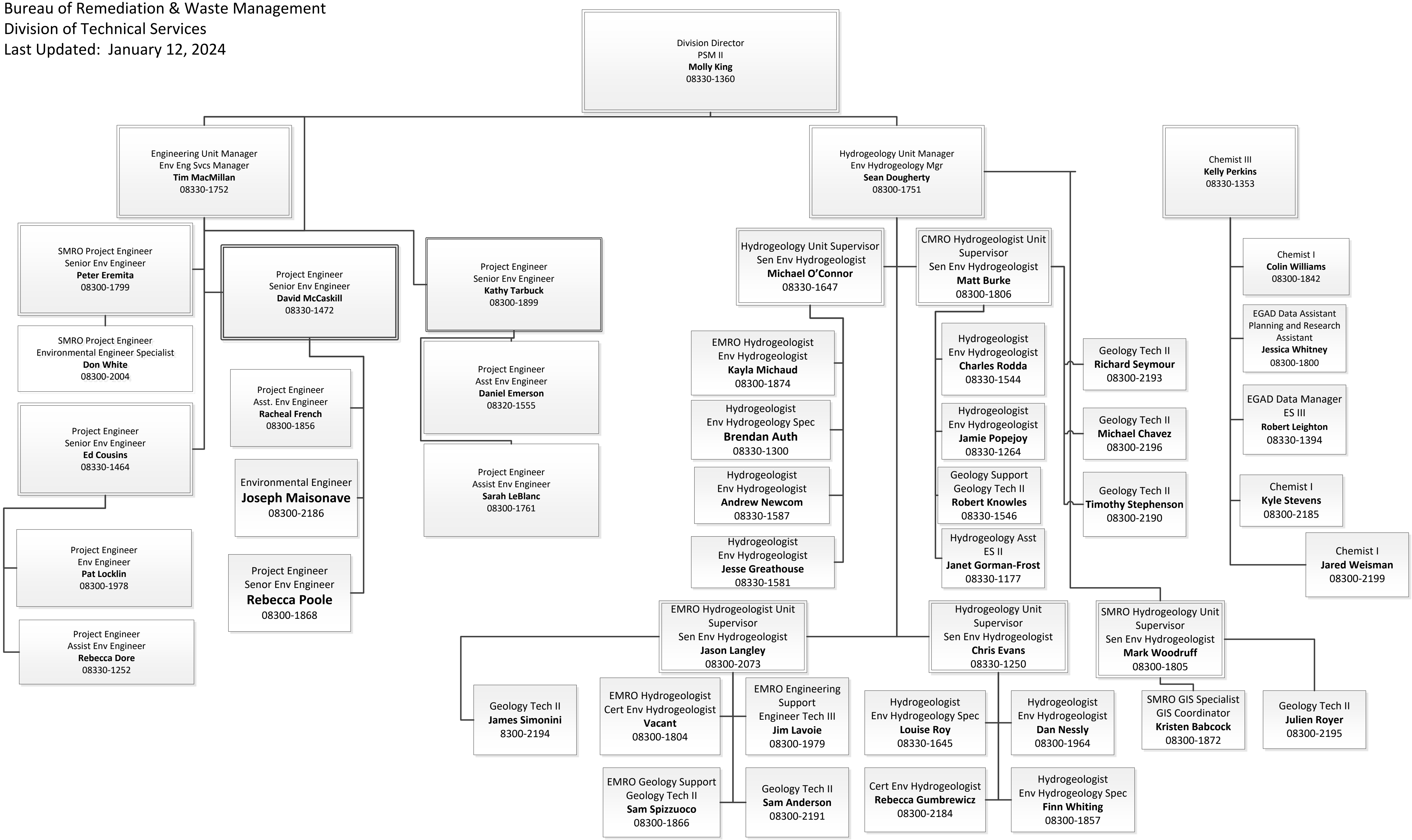
Bureau of Remediation & Waste Management
Division of Technical Services
Last Updated: January 12, 2024



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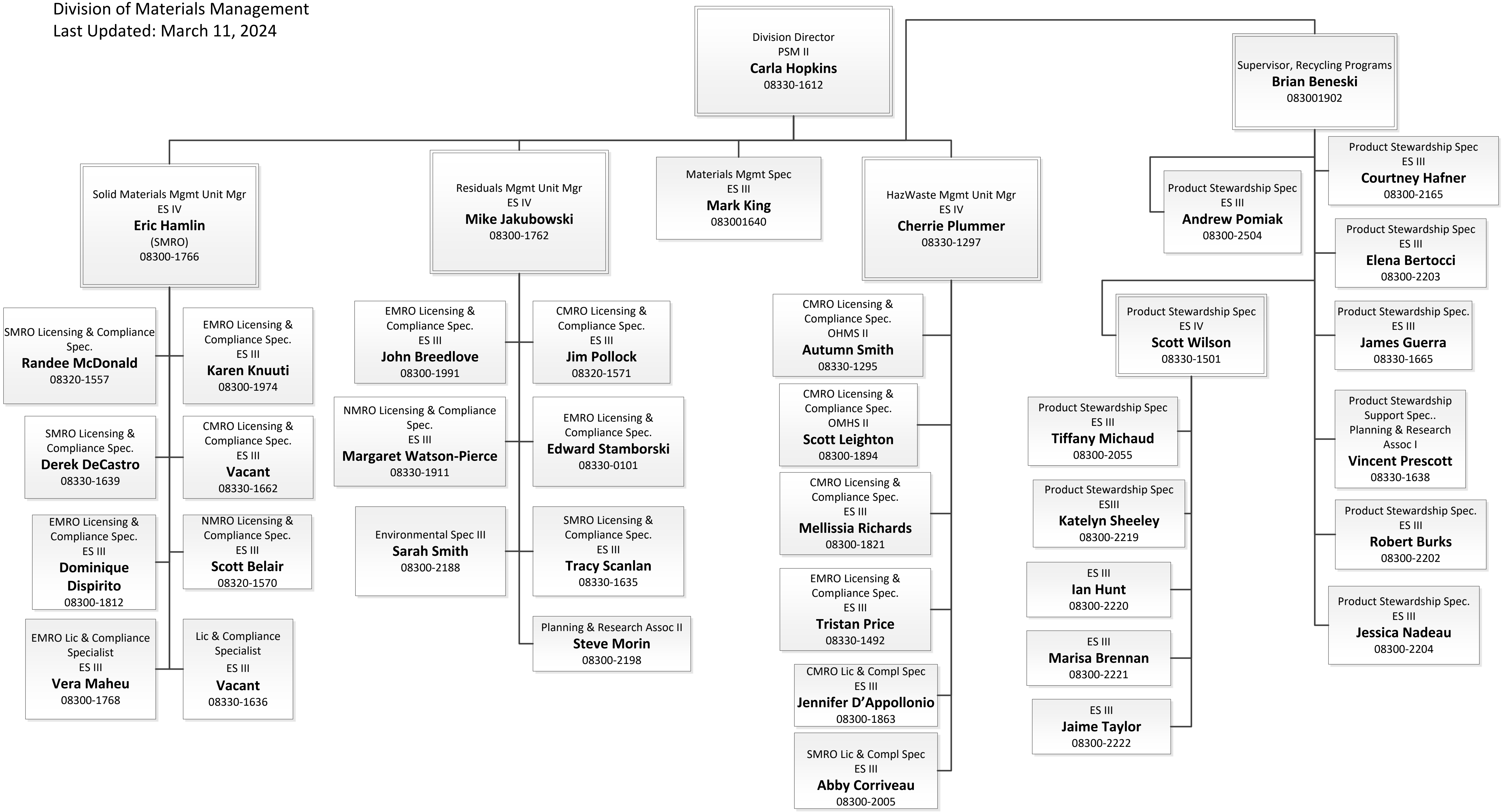
Bureau of Remediation & Waste Management
Division of Materials Management
Last Updated: March 11, 2024



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      - Product Stewardship Spec ES III **Tiffany Michaud** 08300-2055
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      - ES III **Ian Hunt** 08300-2220
      - ES III **Marisa Brennan** 08300-2221
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Appendix B

DEPARTMENT OF ENVIRONMENTAL PROTECTION · STATE OF MAINE ·

COVER SHEET
STANDARD OPERATING PROCEDURE

Operation Title: **DEVELOPING A SAMPLING AND ANALYSIS PLAN FOR PETROLEUM REMEDIATION SITES**

Originator: **Kelly Perkins**
Quality Assurance Coordinator
Division of Technical Services
Bureau of Remediation and Waste Management

APPROVALS:

Division of Technical Services Director:

Molly King	Molly King Molly King (Aug 31, 2021 08:24 EDT)	Aug 31, 2021
Print name	*Signature*	*Date*

Bureau of Remediation and Waste Management Director:

Susanne Miller		Sep 7, 2021
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QMSC Chair:

Bill Longfellow	Bill Longfellow Bill Longfellow (Sep 7, 2021 16:42 EDT)	Sep 7, 2021
Print name	*Signature*	*Date*

Department Commissioner:

Melanie Loyzim	Melanie	Sep 8, 2021
Print name	*Signature*	*Date*

DISTRIBUTION;

( ) Division of Technical Services .... By:________________Date:________

1. APPLICABILITY

This Standard Operating Procedure (SOP) applies to all BRWM staff working on petroleum remediation sites within the Petroleum Program. It is applicable to all petroleum remediation sites after a referral has been made from Response Services. It is applicable to all parties that investigate, mitigate, remediate, or monitor petroleum releases.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2. PURPOSE

The purpose of a Sampling and Analysis Plan is to provide a method for proper planning prior to completing a sampling event. A SAP outlines the goals of the activity and methodology that will be used to achieve the goal. A well-developed SAP will assure that the goals are obtainable, the methodology is consistent, and the data generated will meet the Data Quality Objectives (DQOs) for the project. A SAP will be developed in accordance with the site specific conceptual site model (RWM-PP-006) and reviewed by all Project Team members in accordance with RWM-PP-006 and RWM-PP-017.

The purpose of this document is to describe the MEDEP BRWM requirements for the development of a Sampling and Analysis Plan (SAP).

3. RESPONSIBILITIES

All MEDEP/BRWM Staff must follow this procedure when performing this task. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/BRWM staff reviewing data by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4.0 DEFINITIONS

4.1 CONCEPTUAL SITE MODEL (CSM) - See RWM-PP-006. A written or pictorial representation of an environmental system, the extent of the contaminant source, and the biological, physical and chemical processes that determine the transport of contaminants from sources through environmental media to environmental receptors within the system. (ASTM E1689 - 95 (2014), Standard Guide for Developing Conceptual Site Models for Contaminated Sites).

4.2 CONTAMINANT OF CONCERN (COC) - A contaminant that has been released at a site and risk evaluation indicates that mitigation or remediation is necessary to prevent exposure to the contaminant.

4.3 DATA QUALITY OBJECTIVE (DQO) - Data Quality Objectives (DQOs) are qualitative and quantitative statements that specify the quality and quantity of data needed to support technical

4.4 PROJECT LEAD – As defined in the RAGs, the "project lead" is the agency, group, or organization that is the primary leader and funder for remedial activities at the site and generally hires the contractor that undertakes the remediation. The project lead may be the site owner/operator or other Potential Responsible Party, a state or federal agency, a developer, or other person.

4.5 PROJECT TEAM - The project team includes DEP staff within BRWM that are simultaneously assigned and actively involved in a petroleum release case that requires remediation of soil, water, or air. The project team may include members of the Division of Response Services, Division of Technical Services, Division of Petroleum Management, and the Division of Remediation. Additionally, the team may include environmental consulting technical staff hired by the MEDEP or a responsible party.

4.6 PROJECT TEAM LEADER - The project leader is the BRWM staff member who is directing actions to be taken at the site, maintains communications with affected property owners, occupants of the property, and other project team members, documents site activities, and approves payment of invoices for the project. During the initial response action, the OHMR is the project team leader until a referral has been made. After the referral is completed, the project team will decide who the project leader shall be based on the site specific needs. If a referral is made to the Petroleum Project Management Unit then the assigned project manager becomes the project team leader.

4.7 SAMPLE POINT NAME – The specified sample point name for the monitoring well (e.g. MW-1), water supply well (e.g. Smith), pore water location (e.g. PW-1), The sample point name is consistent with the designated sample location on the Chain of Custody, recorded in EGAD, GIS, and the sample location map.

5. GUIDELINES AND PROCEDURES

5.1 INTRODUCTION

A SAP includes a narrative document accompanied by sample location map(s) and tables with the designated sample point name as they appear on the chain of custody. Sampling events that require a SAP include both single-event investigation sampling and multiple-event monitoring sampling, also known as routine monitoring.

Attachment 1 of this SOP presents a template for single-event investigation sampling. The SAP can be updated for each phase of investigation where previous data exists and is reviewed for data gaps. Typical sampling activities covered under the Attachment 1 includes testpits, soil borings, groundwater sampling from temporary monitoring wells, neighborhood water supply sampling events, borehole evaluations, surface water, and porewater sampling.

Attachment 2 of this SOP presents a template for multiple-event sampling at the same locations associated with routine monitoring. One SAP can be developed and used for the entire monitoring period of a petroleum remediation site where the same sample points are sampled more than once. Typical sampling activities covered under the Attachment 2 includes two templates that can be used for routine monitoring of water supplies, monitoring wells, groundwater treatment system sampling, vapor monitoring, indoor air screening, and air sampling.

Attachment 1 and Attachment 2 can be supplemented with the CSM attachment (RWM-PP-006), maps, and tables for reference and clarity to avoid duplication and improve efficiency.

Attachments 1 or 2, together with a sample location map, and the Chain of Custody can be used to document sampling events as required in SOP RWM-PP-017.

Regardless of the type of sampling event (monitoring or site investigation) a SAP will contain the following elements.

5.2 ASSESSMENT OF EXISTING DATA

The project leader for the site will ensure the review of any existing information on the site. Analytical data will be analyzed for completeness, quality and usability.

5.2.1 SITE RECONNAISSANCE

Prior to sampling events, it is recommended that a site reconnaissance be conducted to work out any logistical problems that may arise during sampling. This would include site access issues, physical impediments to sampling, access issues with surface water sampling, etc. Any logistical issues discovered during the site reconnaissance, along with recommendations for overcoming these issues, should be discussed in the SAP. For routine monitoring, where staff have already conducted field investigations or remedial actions, a separate site reconnaissance is not necessary.

4.2.2 CONCEPTUAL SITE MODEL

The first step in developing any sampling plan is to develop a conceptual site model (CSM). The CSM is a dynamic tool to be updated as new information becomes available, and therefore it should be amended, as appropriate, after each stage of investigation.

Refer to MEDEP SOP RWM-PP-006 for the procedure on developing a Petroleum Program CSM. Considerations specific to a Petroleum Program site CSM include, but are not limited to, the following:

1. The product type, volume, duration, and date of the release
2. Site history
3. Remaining impacts to environmental media following emergency remediation
4. The location of the release relative to water supplies, ground water resources, and surface water resources
5. Impact or risk of impact to indoor air quality – consider heating, ventilation, and air conditioning (HVAC) system

6. The location of the release relative to structures on the site – inside or outside of the building
7. Impacts to preferential pathways such as sumps, floor drains, perimeter drains, etc.
8. Types and characteristics of at-risk water supplies – casing condition and depth, well depth, etc.
9. Impacted building components - construction of building and foundation type
10. Site topography
11. Groundwater geochemistry changes and non-petroleum vapor impacts caused by the petroleum release

5.3 TITLE SECTION

The title section of an SAP will contain the name and town of project, the MEDEP Spill #, other relevant project numbers (EGAD, Tank Registration, REMO), and the name and title of the person developing the SAP.

5.4 INTRODUCTION

The introduction will state the DQOs which include the goals of the sampling plan and the end use of the data relative to the criteria that the data will be compared to. The introduction will state the purpose of the sampling (i.e. monitor at-risk property, monitor effects of emergency actions, monitor effects of remedial actions, monitor on-going mitigation actions, monitor for site closure). The purpose will include a statement justifying the need for the sampling related to the spill, actions taken, action not taken due to site-specific conditions including the nature of the migration pathway and/or the nature of the receptor(s). At a minimum, petroleum sites require a Level 2 data deliverable and 95% data usability. If a higher level data deliverable or a different data usability percentage is required, it must be specified in the project SAP. Provide references to specific SOPs that will be followed during the sampling event(s).

5.5 BACKGROUND INFORMATION

At a typical Petroleum Program site, the background information is documented by the Division of Response Services in the spill report file. Reference to the spill number is sufficient for providing background information.

5.6 SITE SPECIFIC HEALTH AND SAFETY CONCERNS

This document should reference the site safety plan (RWM-PP-071).and note any special safety concerns that exist at the site that pose a safety risk to samplers.

If below grade sampling is part of the SAP, Dig-Safe and Ok To Dig and/or nonmember utilities must be notified at least 3 working days prior to the sampling event. Sample locations must be marked on the ground prior to calling Dig-Safe.

5.7 SAMPLING METHODOLOGY/EQUIPMENT

A description of the sampling methodology will be included in the SAP. In instances where a MEDEP SOP is available, reference to SOPs by either name or document number is sufficient. Any site-specific modification to the methodology must be documented.

5.8 SAMPLES AND PARAMETERS

5.8.1 SAMPLE LOCATIONS

A map or labeled photograph showing planned sampling locations shall be included in the Petroleum Program project file. If locations are not pre-determined, the method that samples will be chosen and collected (field observations, random, etc.) will be outlined in the SAP. Also outlined will be any composite procedures, if applicable.

This section should also indicate sampling collection priority and order, to assure that the most important samples are obtained, and that sampling is generally done from low areas of contamination to higher levels of contamination. It is recommended that critical samples be collected in duplicate.

5.8.2 MEDIA SAMPLED

A chart outlining the media collected and sample analysis will be included in the SAP. Generally, the media sampled will be:

- Soil;
- Groundwater (via monitoring wells and residential wells);
- Porewater;
- Soil gas and/or sub-slab soil gas;
- Indoor air;
- Surface Water;
- Sediment;
- Neat waste material.

5.8.3 ANALYTICAL PARAMETERS

Parameters will be identified by either laboratory analysis methodology number and name of analysis, or by field test type

Containers, preservation, and holding times will be as recommended by the laboratory providing analytical services. Special or out of the ordinary containers or preservation should be noted in the SAP.

5.8.4 FIELD ANALYSES

Field instruments will be identified and the purpose of their use (direct lab sampling, evaluate data quality control, making field decisions related to remedial actions, or evaluating air and water quality) will be documented. Include appropriate references to specific field procedures (such as soil gas, vapor source material identification, identification of gasoline contaminated soil, etc.) using appropriate SOP references. Appropriate reference to field instrument calibration should be noted (RWM-PP-008).

5.9 FIELD QUALITY CONTROL SAMPLES

The specific needs for Quality Control (QC) samples for the project will be outlined; including, but not limited to:

- Background samples;
- Field duplicates;
- Trip blanks; and
- Equipment blanks

5.10 REPORT GENERATION

Every sampling event will be documented in the project file. Data obtained as part of the SAP will be assessed and documented in the project file.

6. QUALITY ASSURANCE/QUALITY CONTROL

Data quality objectives should be stated in the SAP. Quality Assurance/Quality Control (QA/QC) samples may be collected if needed to meet DQOs. Typical types of QA/QC samples that may be collected or prepared at the laboratory include replicate MIS samples to allow determination of a UCL for the DU, laboratory control blank spikes, and analysis of reference material containing known concentrations of the target analytes. All samples should be accompanied by a Chain of Custody and should be properly preserved from the time they are collected to the time they are analyzed.

All analytical data should be reviewed and assessed to determine if DQOs have been met. If review indicates DQOs have not been met, corrective action will be recommended by the reviewer. At a minimum, petroleum sites require a Level 2 data deliverable and 95% data usability.

7. REFERENCES

ASTM E1689 - 95 (2014), Standard Guide for Developing Conceptual Site Models for Contaminated Sites.

SOP RWM-PP-006 Conceptual Site Model for Petroleum Contamination
SOP RWM-PP-017 Site Activity Tracking and Site Closure

ATTACHMENT 1

SAMPLING AND ANALYSIS PLAN TEMPLATE

FOR SINGLE EVENT SITE SAMPLING

MEDEP Petroleum Program

SAMPLING and ANALYSIS PLAN

SITE NAME:

DATE of SAMPLING:

MEDEP PERSONNEL: (list names, titles and roles such as person responsible for ordering containers and completing trip reports)

OTHER PERSONNEL: (list name affiliation, title and role)

CONCEPTUAL SITE MODEL:
(ASTM defines a CSM as "a written or pictorial representation of an environmental system and the biological, physical and chemical processes that determine the transport of contaminants from, sources through environmental media to environmental receptors within the system." The CSM is a dynamic tool to be updated as new information becomes available, and therefore it should be amended, as appropriate, after each stage of investigation.)
Staff should work with their geologist to develop and update this as necessary. Provide the following information for the site from the CSM.

Hydrogeologic Setting: (prepare a narrative describing what is known about the site-specific geology and hydrology with respect to its effect on contaminant distribution and migration.

Contaminants of Concern: (list contaminants and their chemical properties that will influence how they act in the environment)

Method of Release: (look at all releases)

Migration/Exposure Pathways: (groundwater, soil, surface water and or air)

Receptors: (list potential receptors and describe the risk to the receptor posed by contamination).

EVALUATION OF PREVIOUS DATA and DATA GAP ANALYSIS:

(Review previous data to determine the environmental and physical conditions existing at the site. For example, if wells are present, well diameter and depth to water will govern the type of sampling equipment that is necessary to sample the wells. Other information such as whether it is necessary to filter samples may also be available. If samples were previously collected, were they analyzed for the appropriate parameters? In addition, previous studies may indicate there is a high degree of confidence with data that has been collected in one portion of the site, but not the other. In order to avoid or fill data gaps, all available data should be assessed and compared to the current CSM. This will result in an efficient and complete site assessment.)

SITE RECONNAISSANCE:

(Depending on the objectives of the sampling and the date of the last site visit staff may need to visit the site prior to conducting the sampling. List the date of last site visit or reconnaissance)

INVESTIGATION PURPOSE and DATA QUALITY OBJECTIVES:

(fill out and attach forms for the pathway which will be sampled)

___ Groundwater Sampling

___ Soil Sampling

___ Surface Water/Sediment Sampling

____ Air Sampling

ADDITIONAL ATTACHMENTS:

_____Sample SUMMARY OF SITE INVESTIGATION Table- (example attached)

_____Sample location map

_____Container list

_____HASP

_____Equipment Checklist

_____Previous “flow sheets”

GROUNDWATER SAMPLING:

DQOs:

____ To determine if contamination onsite has impacted groundwater
____ To determine if contamination in groundwater poses a risk to receptors
____ To determine if concentrations of contaminants have changed
____To determine if groundwater is discharging to surface water
____ Other____

Sample Point:
___ Existing monitoring wells (list date last sampled, attach previous "flow sheets")
___ Wells which will be installed (with _____________)
___ Pore water
___ Residential Wells
___ Other:_________________________

Regulatory Standards/Guidelines that will be used for comparison:
___ MEGs/MCLs/RAGs
___ Background

Sample Method:
___ Low Flow
___ Peristaltic Pump
___ Submersible Pump
___ Other:_____________

Field Screening:
___ pH
___ eh
___ conductivity
___ turbidity
___ DO
___ Temperature
___ Water level
___ Flow rate
___ Other:____________________

Analytical Method: (list the method and make sure the method meets the objective)
___ VOCs:
___ Metals (field filtered for dissolved, unfiltered for total):
___ Pesticides/Herbicide:
___ SVOCs:
___ Petroleum:
___ Other:_________________________

SOIL SAMPLING:

DQOs:
___ To determine if a release of contaminants has occurred
___ To determine if contaminants pose a risk to residential/recreational receptors
___ To determine if contaminants pose a risk to commercial and/or construction workers
___ To determine the lateral and vertical extent of contamination
___ Determining disposal criteria
___ Other:______________________

Regulatory Standard/Guideline:
___ RAGs:
___ Waste Disposal Criteria:
___ Background:
___ Other:________________________

Sample Method: **(CALL DIG SAFE and OK To Dig)**
___ Shovel/trowel
___ Geoprobe
___ Hand
___ Drill Rig
___ Excavator
___ Other:______________________________

Field Screening:
___ PID
___ FID
___ XRF
___ Other:______________________________

Analytical Method: (list the method and make sure the method meets the objective)
___ VOCs:
___ Metals:
___ Pesticides/Herbicide:
___ SVOCs:
___ Petroleum:
___ PCBs:

SURFACE WATER/SEDIMENT SAMPLING

DQOs:
___ To determine if contaminants from the site are discharging to surface water
___ To determine the extent of contamination in surface water
___ To determine if contamination in the surface water body exceeds regulatory standards
___ To determine if contamination in sediments exceeds ecological toxicity criteria
___ Other:__________________________

Media:
___ Surface water
___ Pore water
___ Sediment

Regulatory Standard/Guideline:
___ AWQC
___ SQIRT
___ PEC/TEC
___ Background
___ Other:______________________________

Sample Methods:
___ Shovel/Trowel
___ Ponar
___ Beta/Kemmerer
___ Peristaltic pump:
___ Other:____________________________________

Field Screening:
___ PID
___ XRF
___ DO
___ Eh
___ pH
___ Conductivity
___ Temperature
___ Other:__________________________________

Analytical Method: (list the method and make sure the method meets the objective)
___ VOCs:
___ Metals:
___ Pesticides/Herbicide:
___ SVOCs:
___ Petroleum:
___ PCBs:
___ Other:____________________________________

AIR SAMPLING

DQOs:
___ To determine if vapors are present in soil gas at levels that pose a threat to receptors.
___ To determine how vapors are migrating from the site.
___ To determine if vapors are present in indoor air at levels that pose a risk to receptors.

___ To determine if landfill gases are present at a site.
___ Other:______________________________

Sample Point:
___ Soil gas
___ Preferential pathway
___ Subslab
___ Indoor Air
___ Ambient air
___ Other:____________________________

Regulatory Guideline:
___ Ambient Air Guideline
___ Indoor Air Target
__ Residential 1 compound
___ Residential Multiple compounds
___ Commercial 1 compound
___ Commercial multiple compounds
___ Residential sub chronic
___ Commercial sub chronic
___ Soil Screening level (this assumes an attenuation factor for soil gas to indoor air)
___ Other:____________________________

Sample Method:
___ Tedlar bag
___ Summa canister
___ Other:______________________________

Field Screening:
___ PID (ppm or ppb)
___ FID
___ Oxygen (%)
___ Carbon Dioxide (ppm)
___ Hydrogen Sulfide
___ Methane (% LEL)
___ Other:______________________________

Analytical Method:
___ Mobile lab
___ TO-15
___ TO-17
___ APH
___ Other:____________________________

ATTACHEMNT 2

SAMPLING AND ANALYSIS PLAN TEMPLATE

FOR MULTIPLE EVENT SITE SAMPLING AND ROUTINE MONITORING

Routine[1] Sampling and Analysis Plan (SAP) for ____
(Site Name) (Town) (Spill #)

SAP Developed By: ______________________________ Date:____________________________

Refer to the project file for site map, CSM, and background information.

Data Quality Objectives:

☐ Meet the Petroleum Guidelines
☐ Other:____

Groundwater – Water Supply Wells

Sample Point Name(s):			
Well Type: ____________ Sample Location:______________ Collection Method:____________			
	Before Filters	Between Filters	After Filters
Sample Frequency	_______________	_______________	_______________
Laboratory Analysis Method*			

Sample Point Name(s):			
Well Type: ____________ Sample Location:______________ Collection Method:____________			
	Before Filters	Between Filters	After Filters
Sample Frequency	_______________	_______________	_______________
Laboratory Analysis Method*			

Sample Point Name(s):			
Well Type: ____________ Sample Location:______________ Collection Method:____________			
	Before Filters	Between Filters	After Filters
Sample Frequency	_______________	_______________	_______________
Laboratory Analysis Method*			

Groundwater – Monitoring Wells

	Sample Point Name			
Sample Collection Method	__________	__________	__________	__________
Sample Frequency	__________	__________	__________	__________
Laboratory Analysis Method*				

Groundwater – Recovery Well

	Sample Point Name:					
	FORT event		Treatment Trailer			No treatment
	before pumping	after pumping	before filters	between filters	after filters	
Sample Collection Method	_______	_______	_______	_______	_______	_______
Sample Frequency	_______	_______	_______	_______	_______	_______
Laboratory Analysis Method*						

Vapor

	Sample Point Name				
Location	__________	__________	__________	__________	__________
Screening Method	__________	__________	__________	__________	__________
Screening Frequency	__________	__________	__________	__________	__________
Sample Method	__________	__________	__________	__________	__________
Sample Frequency	__________	__________	__________	__________	__________
Laboratory Analysis Method*					

*Commonly used sample analysis methods are listed below. For a method not included in the list, look up or ask the Chemistry Unit for the name and number of the method.

EPH- MADEP-EPH Rev 1.1
VPH- MADEP-VPH Rev 1.1
TEPH- MADEP-EPH Rev1.1
VOA- EPA 524.2
VOA- SW8260 C/D
SVOA- SW8270 D/E
APH- MADEP-APH Rev 1.0
TO-15

1. This SAP is designed for Routine sampling events at Petroleum Program sites. For all other sampling events, including soil, sediment, surface water, and neat material sampling, develop a site-specific SAP or use Attachment A of MEDEP SOP No. RWM-DR-014.

RWM-PP-007_SamplingandAnalysisPlan

Final Audit Report 2021-09-08

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COVER SHEET
STANDARD OPERATING PROCEDURE

Operation Title: **Field Instrument Calibration and Documentation**

Originator: **Kelly Perkins**
Quality Assurance Coordinator
Division of Technical Services
Bureau of Remediation and Waste Management

APPROVALS:

Division of Technical Services Director:

Molly King	Molly King Molly King (Aug 31, 2021 08:25 EDT)	Aug 31, 2021
Print name	*Signature*	*Date*

Bureau of Remediation and Waste Management Director:

Susanne Miller		Sep 7, 2021
Print name	*Signature*	*Date*

QMSC Chair:

Bill Longfellow	Bill Longfellow Bill Longfellow (Sep 7, 2021 16:43 EDT)	Sep 7, 2021
Print name	*Signature*	*Date*

Department Commissioner:

Melanie Loyzim	Melanie	Sep 8, 2021
Print name	*Signature*	*Date*

DISTRIBUTION;

( ) Division of Technical Services .... By:________________Date:________

1.0 APPLICABILITY

This Standard Operating Procedure (SOP) applies to all BRWM staff working on petroleum remediation sites within the Petroleum Program. It is also applicable to all parties that investigate, mitigate, or remediate petroleum releases.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2.0 PURPOSE

The purpose of this document is to describe the MEDEP/TS procedure for field instrument calibration and documentation, as required by Section 7.1 of the Department's LUST QAPP. A variety of equipment is available to the MEDEP/TS Program for conducting soil, groundwater and indoor air investigations. A subset of the available equipment can be seen in Table 2.0. All equipment is maintained and calibrated according to the manufacturers' instructions and in accordance with the appropriate analytical methods. Manufacturers' instructions and other instructional documentation will be kept in the equipment logbook maintained by support staff in MEDEP/TS. As new equipment is purchased or other otherwise made available to MEDEP/LUST Program, the equipment list and SOPs will be updated, as needed.

3.0 RESPONSIBILITIES

All MEDEP/TS Staff must follow this procedure when using field equipment. Staff must be determined to be competent in the use of all equipment prior to the use of the equipment to collect samples for soil, groundwater or indoor air investigations. In addition, staff must complete annual refresher training to demonstrate ongoing competency. Documentation of initial and ongoing equipment use competency for MEDEP staff is maintained by the MEDEP/TS Hydrogeology Unit or other designated personnel. Non-MEDEP personnel are responsible for maintaining their own competency demonstrations. Competency demonstrations for non-MEDEP personnel should be provided to the MEDEP upon request.

4.0 DEFINITIONS

4.1 ACCEPTANCE CRITERIA – The conditions that instrument must meet to ensure that data obtained will be valid and acceptable for decision making.
4.2 BUMP TEST – Measure known concentration to determine if the instrument meets the acceptance criteria.
4.3 CALIBRATION GAS – Containerized gas certified to have known concentrations of volatile compounds.
4.4 CALIBRATION STANDARDS – packets of liquid standards that are used with the water quality meters.
4.5 NEW EQUIPMENT – Any equipment, not currently listed here, purchased by the Department, intended for field measurement of site conditions, that require calibration by the manufacturer.
4.6 PID/FID – An instrument designed to measure ionizable organic compounds in air using either a Photo Ionizing Detector (PID) or a Flame ionizing detector (FID).
4.7 WATER QUALITY METERS – Instruments that measure common components found in groundwater, usually by connecting to a probe (i.e. specific conductance, temperature, pH, Eh, DO, etc.).
4.8 WATER QUALITY TEST KITS – Colorimetric kits that measure common components found in groundwater (i.e. DO, Fe, Mn).
4.9 ZERO AIR – Ambient air conditions assumed to contain no appreciable volatile components.
4.10 ZERO GAS – Containerized gas certified to have no volatile components.

5.0 GUIDELINES AND PROCEDURES

5.1 INTRODUCTION

To ensure that all field equipment is performing within specifications and will provide accurate readings on current conditions at remedial sites, all field instruments are to be bump tested or calibrated, and then documented before and after use. Bump test and calibration results must be recorded in the equipment log and the staff field book. Bump test results must be compared to the acceptance criteria to assure that the instrument responds appropriately to the calibration gas. If bump test results are outside the acceptance criteria, the instrument must be calibrated prior to use. Instruments used to make field decisions related to remediation of contaminated media must be bump tested after field use to document the accuracy of the instrument. All instrument calibrations and bump tests should be recorded in the instrument log book.

5.2 PLANNING

A well-developed Conceptual Site Model (CSM) is imperative for effective use of this technique (see MEDEP/TS SOP# RWM-PP-006 – Conceptual Site Model for Petroleum Contamination). Prior to conducting any sampling event, a Sampling and Analysis Plan (SAP) should be developed (see MEDEP/TS SOP# RWM-DR-014 - Development of a Sampling and Analysis Plan).

5.3 PROCEDURE

5.3.1 OVERVIEW

The Division of Technical Services maintains indoor air and soil gas instruments (PID/FID, 4-gas meter, MSA Altair, GEM 5000, etc.), water meters with probes (pH, eH, DO, etc.), and water test kits (Hach, CheMets, etc.). The equipment that is maintained by the Division of Technical Services changes periodically, so procedures listed below should be updated with the addition and retirement of equipment.

5.3.2 PROJECT SPECIFIC CONSIDERATIONS

The project-specific methodology needs to consider factors such as:

Is the field instrument appropriate for the site conditions:

- Contaminants of concern
- Range of possible concentrations
- Cleanup guidelines
- Exposure points

5.3.3 AIR MONITORING EQUIPMENT

5.3.3.1 PID/FID

5.3.3.1.1 PID/FID BUMP TEST

Start the instrument and allow it to warm up. Connect it to a supply of the calibration gas of a known concentration. The acceptance criteria for this type of instrument is 5% +/- if the readings will be used to make remedial decisions for the site. The acceptance criteria is 10% +/- if the readings are to be used to check for trends or to provide a line of evidence to be combined with other lines of evidence to make an intermediate site decision.

5.3.3.1.2 PID/FID CALIBRATION –

Calibration should follow the manufacturer's instructions using a calibration standard gas, e.g. Isobutylene or a site specific VOC of concern.

Air monitoring equipment shall be bumped and/or calibrated routinely on a monthly basis or as directed by the manufacturer and prior to its use in the field at the beginning of each working day and checked at the end of each working day. Data from these calibrations should be recorded in the user's field book and then copied into the designated instrument log book upon the meter's return to the office.

5.3.3.2 4-GAS METER

Calibration should follow the manufacturer's instructions using a calibration standard gas and a carbon dioxide scrubber to make sure the CO2 sensor is properly functioning.

Air monitoring equipment shall be calibrated routinely on a monthly basis or as directed by the manufacturer and prior to its use in the field and at the beginning of each working day. Data from these calibrations should be recorded in the user's field book and then copied into the designated instrument log book upon the meter's return to the office.

5.3.3.3 MSA Altair

Calibration should follow the manufacturer's instructions using a calibration standard gas.

Air monitoring equipment shall be calibrated routinely on a monthly basis or as directed by the manufacturer and prior to its use in the field and at the beginning of each working day. Data from these calibrations should be recorded in the user's field book and then copied into the designated instrument log book upon the meter's return to the office.

5.3.3.4 GEM 5000

See SOP RWM-TS-LG03, Protocol for Use of the GEM^{tm} 5000 Gas Analyzer, March 19, 2015

5.3.4 WATER QUALITY PROBES

Water quality probes, such as the Hanna Combo pH/EC pens, shall be calibrated routinely as directed by the manufacturer, Attachment A. Pens shall be calibrated prior to their use in the field at the beginning of each working day and checked at the end of each working day. Data from these calibrations should be recorded in the user's field book and then copied into a designated field book upon the probe's return to the office. **Standard Methods** recommend calibrating according to manufacturer's procedure, making sure to bracket the expected range of the samples. Some instruments will require a three-point calibration (i.e. pH 4-7-10), some only need a two-point calibration (i.e. pH 0-10).

5.3.5 WATER QUALITY KITS

Water Quality Kits shall be used as directed by the manufacturer, including the use of reagents. Staff shall confirm that all reagents and other dated solutions are not expired prior to its use in the field. Confirmation of this check should be recorded in the user's field book.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

Data quality objectives should be stated in the SAP. Quality Assurance/Quality Control (QA/QC) samples may be collected if needed to meet DQOs. Typical types of QA/QC samples that may be collected or prepared at the laboratory include replicate MIS samples to allow determination of a UCL for the DU, laboratory control blank spikes, and analysis of reference material containing known concentrations of the target analytes. All analytical data should be reviewed and assessed to determine if DQOs have been met. If review indicates DQOs have not been met, corrective action will be recommended by the reviewer.

7.0 REFERENCES

7.1 Standard Methods, 18th Edition 1992, ed. A Greenberg, L Clesceri, A Eaton

7.2 https://www.epa.gov/hw-sw846

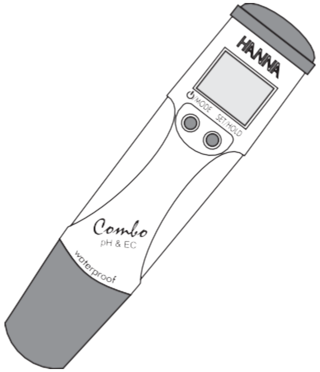
7.3 SOP RWM-TS-LG03, Protocol for Use of the GEM^{tm} 5000 Gas Analyzer, March 19, 2015

Attachment A
Hannah Instruments Instruction Manual pH/EC/TDS/Temperature (HI98129) and Hannah Instruments Instruction Manual pH/ORP & Temperature (HI98121)

Instruction Manual

HI 98129 • HI 98130

pH/EC/TDS/Temperature with Only One Tester



HANNA instruments

www.hannainst.com

WARRANTY

HI 98129 and HI 98130 are warranted for one year against defects in workmanship and materials when used for their intended purpose and maintained according to instructions. The electrode is warranted for a period of six months. This warranty is limited to repair or replacement free of charge.

Damages due to accident, misuse, tampering or lack of prescribed maintenance are not covered.

If service is required, contact the dealer from whom you purchased the instrument. If under warranty, report the model number, date of purchase, serial number and the nature of the failure. If the repair is not covered by the warranty, you will be notified of the charges incurred. If the instrument is to be returned to Hanna Instruments, first obtain a Returned Goods Authorization Number from the Customer Service department and then send it with shipment costs prepaid. When shipping any instrument, make sure it is properly packaged for complete protection.

All rights are reserved. Reproduction in whole or in part is prohibited without the written consent of the copyright owner, Hanna Instruments.

Hanna Instruments reserves the right to modify the design, construction and appearance of its products without advance notice.

Dear Customer,

Thank you for choosing a Hanna product.

This manual will provide you with the necessary information for a correct operation. Please read it carefully before using the meter.

If you need additional technical information, do not hesitate to e-mail us at tech@hannainst.com.

These instruments are in compliance with the CE directives.

PRELIMINARY EXAMINATION

Remove the instrument from the packing material and examine it carefully. If any damage has occurred during shipment, immediately notify your Dealer or the nearest Hanna Customer Service Center.

Each meter is supplied with:
- HI 73127 pH electrode
- HI 73128 electrode removal tool
- batteries (4 x 1.5V) and instructions

Note: Conserve all packing material until the instrument has been observed to function correctly. Any defective item must be returned in its original packing.

US DESIGN PATENT
D462,024

GENERAL DESCRIPTION

HI 98129 and HI 98130 are waterproof pH/EC/TDS/temperature meters. The housing has been completely sealed against humidity and designed to float.

All pH and EC/TDS readings are automatically temperature compensated (ATC), and temperature values can be displayed in °C or °F units.

For EC/TDS readings, the EC/TDS conversion factor (CONV) is selectable by the user, as well as the temperature compensation coefficient β (BETA).

The meters can be calibrated at one or two points for pH (with auto-buffer recognition and against five memorized buffer values), and at one point for EC.

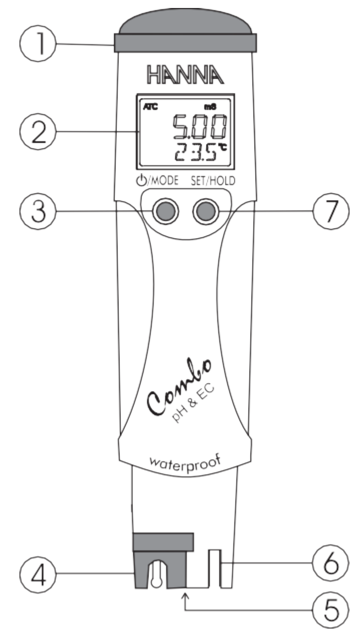
Measurements are highly accurate with a unique stability indicator right on the LCD.

These meters are also provided with battery level indication at start-up, and with a low battery symbol which warns the user when the batteries need to be replaced. In addition the Battery Error Prevention System (BEPS) avoids erroneous reading caused by low voltage level by turning the meter off.

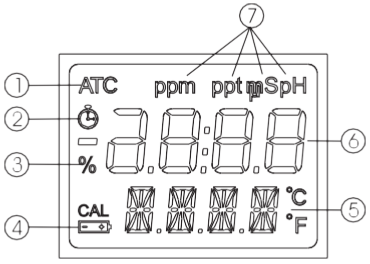
The HI 73127 pH electrode, supplied with the meter, is interchangeable and can be easily replaced by the user.

The stainless steel encapsulated temperature sensor facilitates faster and more accurate temperature measurement and compensation.

FUNCTIONAL DESCRIPTION



1. Battery compartment
2. Liquid Crystal Display (LCD)
3. ON/OFF/MODE button
4. **HI 73127** pH electrode
5. Temperature sensor (behind)
6. EC/TDS probe
7. SET/HOLD button



1. Automatic temperature compensation indicator
2. Stability indicator
3. Battery life percentage indicator
4. Low battery indicator
5. Secondary display
6. Primary display
7. Measuring units for primary display

SPECIFICATIONS

Range	0.0 to 60.0°C / 32.0 to 140.0°F 0.00 to 14.00 pH 0 to 3999 µS/cm (HI 98129) 0.00 to 20.00 mS/cm (HI 98130) 0 to 2000 ppm (HI 98129) 0.00 to 10.00 ppt (HI 98130)
Resolution	0.1°C / 0.1°F 0.01 pH 1 µS/cm ; 1 ppm (HI 98129) 0.01 mS/cm ; 0.01 ppt (HI 98130)
Accuracy (@20°C/68°F)	±0.5°C / ±1°F ±0.05 pH ±2% f.s. (EC/TDS)
Typical EMC Deviation	±0.5°C / ±1°F ±0.02 pH ±2% f.s. (EC/TDS)
Temperature Compensation	automatic, with β=0.0 to 2.4%/°C (EC/TDS)
Environment	0 to 50°C (32 to 122°F); RH 100%
TDS Factor	0.45 to 1.00 (CONV)
Calibration	automatic, 1 or 2 point with 2 sets of memorized buffers (pH 4.01/7.01/10.01 or 4.01/6.86/9.18) for pH; automatic, at 1 point for EC/TDS
EC/TDS Cal.solutions	
HI 98129:	HI7031 (1413 µS/cm) HI7032 (1382 ppm; CONV=0.5) HI70442 (1500 ppm; CONV=0.7)
HI 98130:	HI7030 (12.88 mS/cm) HI70038 (6.44 ppt; CONV=0.5 or 9.02 ppt; CONV=0.7)
Electrode (included)	HI 73127 pH electrode
Battery Type/Life	4 x 1.5V with BEPS/approx. 100 hours
Auto-off	after 8 minutes of non-use
Dimensions	163 x 40 x 26 mm (6.4 x 1.6 x 1.0")
Weight	100 g (3.5 oz.)

Recommendations for Users

Before using this product, make sure that it is entirely suitable for the environment in which it is used. Operation of this instrument in residential areas could cause unacceptable interferences to radio and TV equipment.

The glass bulb at the end of the electrode is sensitive to electrostatic discharges. Avoid touching this glass bulb at all times.

Any variation introduced by the user to the supplied equipment may degrade the instrument's EMC performance. To avoid electrical shock, do not use this instrument when voltages at the measurement surface exceed 24 Vac or 60 Vdc. To avoid damages or burns, do not perform any measurement in microwave ovens.

IST98129R4 07/05

OPERATIONAL GUIDE

To turn the meter on and to check battery status

Press and hold the ⏻/MODE button for 2-3 seconds. All the used segments on the LCD will be visible for a few seconds, followed by a percent indication of the remaining battery life (Eg. % 100 BATT).

To change the temperature unit

To change the temperature unit (from °C to °F), from measurement mode, press and hold the ⏻/MODE button until TEMP and the current temperature unit are displayed on the lower LCD (E.g. TEMP °C).
Use the SET/HOLD button to change the temperature unit, and then press the ⏻/MODE button twice to return to normal measuring mode.

To freeze the display

Press the SET/HOLD button for 2-3 seconds until HOLD appears on the secondary display.
Press either button to return to normal mode.

To turn the meter off

Press the ⏻/MODE button while in normal measurement mode. OFF will appear on the lower part of the display. Release the button.

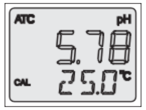
Notes:

- Before taking any measurement make sure the meter has been calibrated.
- To clear a previous calibration, press the ⏻/MODE button after entering the calibration mode. The lower LCD will display ESC for 1 second and the meter will return to normal measurement mode. The CAL symbol on the LCD will disappear. The meter will be reset to the default calibration.
- If measurements are taken in different samples successively, rinse the probe thoroughly to eliminate cross-contamination; and after cleaning, rinse the probe with some of the sample to be measured.

pH MEASUREMENTS & CALIBRATION

Taking measurements

Select the pH mode with the SET/HOLD button.
Submerge the electrode in the solution to be tested.
The measurements should be taken when the stability symbol D on the top left of the LCD disappears.



The pH value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

Calibration buffer set

- From measurement mode, press and hold ⏻/MODE until TEMP and the current temperature unit are displayed on the lower LCD (E.g. TEMP °C).
- Press the ⏻/MODE button again to show the current buffer set: pH 7.01 BUFF (for pH 4.01/7.01/10.01) or pH 6.86 BUFF (for NIST set, pH 4.01/6.86/9.18).
- Press the SET/HOLD button to change the buffer value.
- Press the ⏻/MODE button to return to the normal measuring mode.

Calibration procedure

From measurement mode, press and hold the ⏻/MODE button until CAL is displayed on the lower LCD. Release the button. The LCD will display pH 7.01 USE or pH 6.86 USE (if you have selected the NIST buffer set). The CAL tag blinks on the LCD.

For a single-point pH calibration, place the electrode in any buffer from the selected buffer set (eg. pH 7.01 or pH 4.01 or pH 10.01). The meter will recognize the buffer value automatically.
If using pH 4.01 or pH 10.01, the meter will display OK for 1 second and then return to the normal measuring mode.
If using pH 7.01, after recognition of the buffer the meter will ask for pH 4.01 as second calibration point. Press the ⏻/MODE button to return to measurement mode or, if desired, proceed with the 2-point calibration as explained below.

Note: It is always recommended to carry out a two-point calibration for better accuracy.

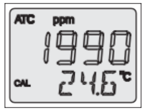
For a two-point pH calibration, place the electrode in pH 7.01 (or 6.86 if you have selected the NIST buffer set). The meter will recognize the buffer value and then display pH 4.01 USE.
Rinse the electrode thoroughly to eliminate cross-contamination.
Place the electrode in the second buffer value (pH 4.01 or 10.01, or, if using NIST, pH 4.01 or 9.18). When the second buffer is recognized, the LCD will display OK for 1 second and the meter will return to the normal measuring mode.

The CAL symbol on the LCD means that the meter is calibrated.

EC/TDS MEASUREMENTS & CALIBRATION

Taking measurements

Select either EC or TDS mode with the SET/HOLD button.
Submerge the probe in the solution to be tested. Use plastic beakers to minimize any electromagnetic interferences.
The measurements should be taken when the stability symbol Don the top left of the LCD disappears.



The EC (or TDS) value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

To change the EC/TDS conversion factor (CONV) and the temperature compensation coefficient β (BETA)

- From measurement mode, press and hold the ⏻/MODE button until TEMP and the current temperature unit are displayed on the lower LCD. Eg. TEMP °C.
- Press the ⏻/MODE button again to show the current conversion factor. Eg. 0.50 CONV.
- Press the SET/HOLD button to change the conversion factor.
- Press the ⏻/MODE button to show the current temperature compensation coefficient β. Eg. 2.1 BETA.
- Press the SET/HOLD button to change the temperature compensation coefficient β.
- Press the ⏻/MODE button to return to the normal measuring mode.

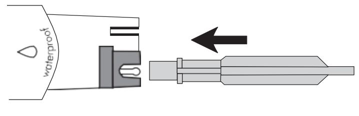
Calibration procedure

- From measurement mode, press and hold the ⏻/MODE button until CAL is displayed on the lower LCD.
- Release the button and immerse the probe in the proper calibration solution: HI7031 (1413 µS/cm) for HI98129 and HI7030 (12.88 mS/cm) for HI98130.
- Once the calibration has been automatically performed, the LCD will display OK for 1 second and the meter will return to normal measurement mode.
- Since there is a known relathionship between EC and TDS readings, it is not necessary to calibrate the meter in TDS

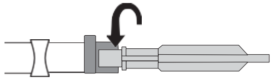
The CAL symbol on the LCD means that the meter is calibrated.

pH ELECTRODE MAINTENANCE

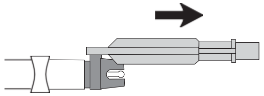
- When not in use, rinse the electrode with water to minimize contamination and store it with a few drops of storage (HI 70300) solution in the protective cap after use. DO NOT USE DISTILLED OR DEIONIZED WATER FOR STORAGE PURPOSES.
- If the electrode has been left dry, soak in storage solution for at least one hour to reactivate it.
- To prolong the life of the pH electrode, it is recommended to clean it monthly by immersing it in the HI 7061 cleaning solution for half an hour. Afterwards, rinse it thoroughly with tap water and recalibrate the meter.
- The pH electrode can be easily replaced by using the supplied tool (HI 73128). Insert the tool into the electrode cavity as shown below.



- Rotate the electrode counterclockwise.



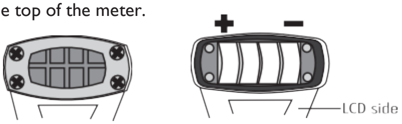
- Pull the electrode out by using the other side of the tool.



- Insert a new pH electrode following the above instructions in reverse order.

BATTERY REPLACEMENT

The meter displays the remaining battery percentage every time it is switched on. When the battery level is below 5%, the ▭ symbol on the bottom left of the LCD lights up to indicate a low battery condition. The batteries should be replaced soon. If the battery level is low enough to cause erroneous readings, the meter shows "0%" and the Battery Error Prevention System (BEPS) will automatically turn the meter off.
To change the batteries, remove the 4 screws located on the top of the meter.



Once the top has been removed, carefully replace the 4 batteries located in the compartment while paying attention to their polarity.
Replace the top, making sure that the gasket is properly seated in place, and tighten the screws to ensure a watertight seal.

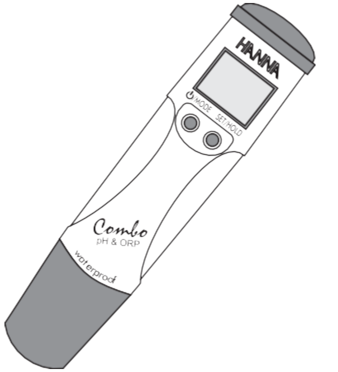
ACCESSORIES

HI 73127	Replaceable pH electrode
HI 73128	Electrode removal tool
HI 70004P	pH 4.01 solution, 20 mL sachet (25 pcs)
HI 70006P	pH 6.86 solution, 20 mL sachet (25 pcs)
HI 70007P	pH 7.01 solution, 20 mL sachet (25 pcs)
HI 70009P	pH 9.18 solution, 20 mL sachet (25 pcs)
HI 70010P	pH 10.01 solution, 20 mL sachet (25 pcs)
HI 77400P	pH 4 & 7 solutions, 20 mL sachet (5 each)
HI 7004M	pH 4.01 solution, 230 mL bottle
HI 7006M	pH 6.86 solution, 230 mL bottle
HI 7007M	pH 7.01 solution, 230 mL bottle
HI 7009M	pH 9.18 solution, 230 mL bottle
HI 7010M	pH 10.01 solution, 230 mL bottle
HI 70030P	12.88 mS/cm solution, 20 mL (25 pcs)
HI 70031P	1413 µS/cm solution, 20 mL (25 pcs)
HI 70032P	1382 ppm solution, 20 mL (25 pcs)
HI 70038P	6.44 ppt solution, 20 mL (25 pcs)
HI 70442P	1500 ppm solution, 20 mL (25 pcs)
HI 7061M	Electrode cleaning solution, 230 mL bottle
HI 70300M	Electrode storage solution, 230 mL bottle

Instruction Manual

HI 98121

Waterproof pH / ORP & Temperature Meter



HANNA instruments®

www.hannainst.com

WARRANTY

HI 98121 is warranted for one year against defects in workmanship and materials when used for its intended purpose and maintained according to instructions. The electrode is warranted for a period of six months. This warranty is limited to repair or replacement free of charge.

Damages due to accident, misuse, tampering or lack of prescribed maintenance are not covered.

If service is required, contact the dealer from whom you purchased the instrument. If under warranty, report the model number, date of purchase, serial number and the nature of the failure. If the repair is not covered by the warranty, you will be notified of the charges incurred. If the instrument is to be returned to Hanna Instruments, first obtain a Returned Goods Authorization Number from the Customer Service department and then send it with shipment costs prepaid. When shipping any instrument, make sure it is properly packaged for complete protection.

All rights are reserved. Reproduction in whole or in part is prohibited without the written consent of the copyright owner.

Hanna Instruments reserves the right to modify the design, construction and appearance of its products without advance notice.

Dear Customer,

Thank you for choosing a Hanna product. This manual will provide you with the necessary information for correct operation. Please read it carefully before using the meter.
If you need additional technical information, do not hesitate to e-mail us at tech@hannainst.com.

This instrument is in compliance with the CE directives.

PRELIMINARY EXAMINATION

Remove the instrument from the packing material and examine it carefully. If any damage has occurred during shipment, immediately notify your Dealer or the nearest Hanna Customer Service Center.
Each meter is supplied with:
- HI 73127 pH electrode
- HI 73128 Electrode removal tool
- 4 x 1.5V batteries

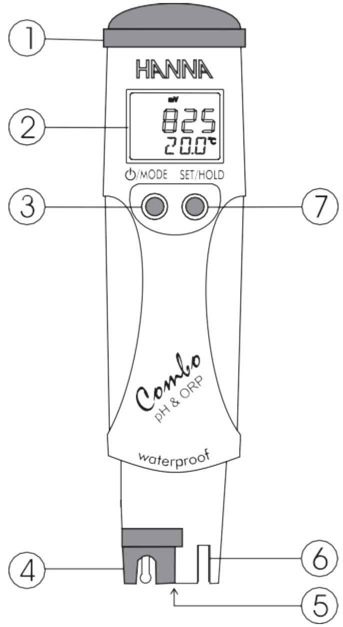
Note: Conserve all packing material until the instrument has been observed to function correctly. Any defective item must be returned in its original packing.

US DESIGN PATENT
D462,024

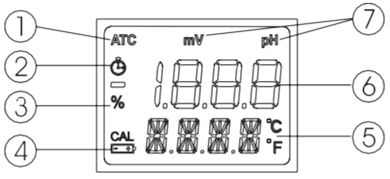
GENERAL DESCRIPTION

HI 98121 is a waterproof pH, ORP and temperature meter. The housing has been completely sealed against humidity and designed to float.
All pH readings are automatically temperature compensated (ATC), and temperature values can be displayed in °C or °F units.
The meter can be calibrated at one or two points for pH (with auto-buffer recognition and against five memorized buffer values), while the mV (ORP) range is factory calibrated.
Measurements are highly accurate with a unique stability indicator right on the LCD.
This meter is also provided with battery level indication at start-up, and with a low battery symbol which warns the user when the batteries need to be replaced. In addition the Battery Error Prevention System (BEPS) avoids erroneous reading caused by low voltage level by turning the meter off.
The HI 73127 pH electrode, supplied with the meter, is interchangeable and can be easily replaced by the user. The stainless steel encapsulated temperature sensor facilitates faster and more accurate temperature measurement and compensation.

FUNCTIONAL DESCRIPTION



1. Battery compartment
2. Liquid Crystal Display (LCD)
3. ON/OFF/MODE button
4. HI 73127 pH electrode
5. Temperature sensor (behind)
6. ORP electrode
7. SET/HOLD button



1. Automatic Temperature Compensation Indicator
2. Stability indicator
3. Battery life percentage indicator
4. Low battery indicator
5. Secondary display
6. Primary display
7. Measuring unit for primary display

CE DECLARATION OF CONFORMITY

HANNA instruments

CE

DECLARATION OF CONFORMITY

We

Hanna Instruments Italia Srl
via E.Fermi, 10
35030 Sarmeola di Rubano - PD
ITALY

herewith certify that the pH / ORP & temperature meter

HI 98121

has been tested and found to be in compliance with EMC Directive 89/336/EEC and Low Voltage Directive 73/23/EEC according to the following applicable normatives:

EN 50082-1: Electromagnetic Compatibility - Generic Immunity Standard
IEC 61000-4-2 Electrostatic Discharge
IEC 61000-4-3 RF Radiated

EN 50081-1: Electromagnetic Compatibility - Generic Emission Standard
EN 55022 Radiated, Class B

EN61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use

Date of Issue: 13.02.2002

A.Marsilio - Technical Director
On behalf of
Hanna Instruments S.r.l.

Recommendations for Users

Before using this product, make sure that it is entirely suitable for the environment in which it is used.
The glass bulb at the end of the electrode is sensitive to electrostatic discharges. Avoid touching the glass bulb and the ORP electrode at all times.
Any variation introduced by the user to the supplied equipment may degrade the instrument's EMC performance.
To avoid electrical shock, do not use this instrument when voltages at the measurement surface exceed 24 VAC or 60 VDC. To avoid damages or burns, do not perform any measurement in microwave ovens.

ACCESSORIES

HI 73127	Replaceable pH electrode
HI 73128	Electrode removal tool
HI 70004P	pH 4.01 solution, 20 mL sachet (25 pcs)
HI 70006P	pH 6.86 solution, 20 mL sachet (25 pcs)
HI 70007P	pH 7.01 solution, 20 mL sachet (25 pcs)
HI 70009P	pH 9.18 solution, 20 mL sachet (25 pcs)
HI 70010P	pH 10.01 solution, 20 mL sachet (25 pcs)
HI 7004M	pH 4.01 solution, 230 mL bottle
HI 7006M	pH 6.86 solution, 230 mL bottle
HI 7007M	pH 7.01 solution, 230 mL bottle
HI 7009M	pH 9.18 solution, 230 mL bottle
HI 7010M	pH 10.01 solution, 230 mL bottle
HI 7021M	ORP test solution (240 mV), 230 mL bottle
HI 7022M	ORP test solution (470 mV), 230 mL bottle
HI 7061M	Electrode cleaning solution, 230 mL bottle
HI 70300M	Electrode storage solution, 230 mL bottle
HI 7091M	Pretreatment reducing solution, 230 mL
HI 7092M	Pretreatment oxidizing solution, 230 mL

SPECIFICATIONS

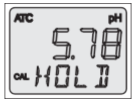
Range	-2.00 to 16.00 pH ±1000 mV -5.0 to 60.0°C / 23.0 to 140.0°F
Resolution	0.01 pH 1 mV 0.1°C or 0.1°F
Accuracy (@20°C/68°F)	±0.05 pH ±2 mV ±0.5°C or ±1°F
Typical EMC Deviation	±0.02 pH ±2 mV ±0.3°C or ±0.6°F
Temp.Compensation	Automatic for pH
Calibration	pH: at 1 or 2 points with 2 sets of memorized buffers (pH 4.01/7.01/10.01 or pH 4.01/6.86/9.18) ORP: factory calibrated
Electrode	HI 73127 pH electrode (included)
Environment	-5 to 50°C (23 to 122°F); RH 100%
BatteryType / Life	4 x 1.5V / approx. 250 hours
Auto-off	After 8 minutes of non-use
Dimensions	163 x 40 x 26 mm (6.4 x 1.6 x 1.0”)
Weight	100 g (3.5 oz)

OPERATIONAL GUIDE

To turn the meter on and to check battery status

Press and hold the ⏻/MODE button until the LCD lights up. All the used segments on the LCD will be visible for 1 second (or as long as the button is pressed), followed by the percent indication of the remaining battery life (E.g. % 100 BATT).

To freeze the display



While in measurement mode, press the SET/HOLD button until HOLD appears on the secondary display. The reading will be frozen on the LCD.

Press any button to return to normal mode.

To turn the meter off

While in measurement mode, press the ⏻/MODE button. OFF will appear on the secondary display. Release the button.

Note: If measurements are taken in different samples successively, rinse the probe thoroughly to eliminate cross-contamination; and after cleaning, rinse the probe with some of the sample to be measured.

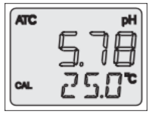
pH MEASUREMENTS & CALIBRATION

Taking measurements

Select pH mode with the SET/HOLD button.

Submerge the electrode in the solution to be tested while stirring it gently.

The measurements should be taken when the stability symbol D on the top left of the LCD disappears.



The pH value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

Note: Before taking any pH measurement make sure the meter has been calibrated (CAL tag present on the LCD).

pH Calibration

For better accuracy, frequent calibration of the instrument is recommended. In addition, the instrument must be recalibrated whenever:

a) The pH electrode is replaced.

b) After testing aggressive chemicals.

c) Where high accuracy is required.

d) At least once a month.

Calibration procedure

From normal measuring mode, press and hold the ⏻/MODE button until OFF on the secondary LCD is replaced by CAL. Release the button. The LCD enters the calibration mode displaying “pH 7.01 USE” (or “pH 6.86 USE” if the NIST buffer set was selected).

After 1 second the meter activates the automatic buffer recognition feature. If a valid buffer is detected then its value is shown on the primary display and REC appears on the secondary LCD. If no valid buffer is detected, the meter keeps the USE indication active for 12 seconds, and then it replaces it with WRNG, indicating the sample being measured is not a valid buffer.

- For a single-point calibration with buffers pH 4.01, 9.18 or 10.01, the meter automatically accepts the calibration when the reading is stable; the meter displays the accepted buffer, with the message “OK 1”. After 1 second the meter automatically returns to the normal measuring mode.

If a single-point calibration with buffer pH 7.01 (or pH 6.86) is desired, then after the calibration point has been accepted the ⏻MODE button must be pressed in order to return to normal mode. After the button is pressed, the meter shows “7.01” (or “6.86”) - “OK 1” and, after 1 second, it automatically returns to the normal measuring mode.

Note: It is always recommended to carry out a two-point calibration for better accuracy.

- For a two-point calibration, place the electrode in pH 7.01 (or pH 6.86) buffer. After the first calibration point has been accepted, the “pH 4.01 USE” message appears. The message is held for 12 seconds, unless a valid buffer is recognized. If no valid buffer is recognized, then the WRNG message is shown. If a valid buffer (pH 4.01, pH 10.01, or pH 9.18) is detected, then the meter completes the calibration procedure. When the buffer is accepted, the LCD shows the accepted value with the “OK 2” message, and then the meter returns to the normal measuring mode.

Note: When the calibration procedure is completed, the CAL tag is turned on.

To quit calibration and to reset to the default values

- After entering the calibration mode and before the first point is accepted, it is possible to quit the procedure and return to the last calibration data by pressing the ⏻/MODE button. The secondary LCD displays “ESC” for 1 second and the meter returns to the normal measuring mode.

- To reset to the default values and clear a previous calibration, press the SET/HOLD button after entering the calibration mode and before the first point is accepted. The secondary LCD displays “CLR” for 1 second, the meter resets to the default calibration and the CAL tag on the LCD disappears.

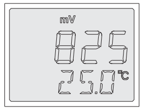
ORP MEASUREMENTS

Taking measurements

Select ORP mode with the SET/HOLD button.

Submerge the electrode in the solution to be tested.

The measurements should be taken when the stability symbol D on the top left of the LCD disappears.



The ORP (mV) value is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

The ORP range is factory calibrated

Contact your nearest Hanna Service Center for recalibration, if necessary.

SETUP

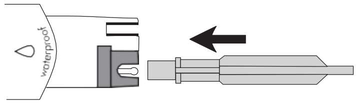
Setup mode allows the selection of temperature unit and pH buffer set.

To enter the Setup mode, select pH mode and then press the ⏻/MODE button until CAL on the secondary display is replaced by TEMP and the current temperature unit (E.g. TEMP °C). Then:

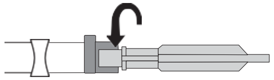
- *for °C/°F selection*: Use the SET/HOLD button. After the temperature unit has been selected, press the ⏻/MODE button to enter the buffer set selection mode; press the ⏻/MODE button twice to return to the normal measuring mode.
- *to change the calibration buffer set*: After setting the temperature unit, the meter will show the current buffer set: “pH 7.01 BUFF” (for 4.01/7.01/10.01) or “pH 6.86 BUFF” (for NIST 4.01/6.86/9.18). Change the set with the SET/HOLD button, then press ⏻/MODE to return to the normal measuring mode.

ELECTRODE MAINTENANCE

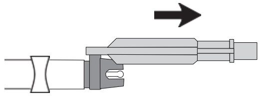
- When not in use, rinse the electrodes with water to minimize contamination and store them with a few drops of HI 70300 storage solution in the protective cap after use. DO NOT USE DISTILLED OR DEIONIZED WATER FOR STORAGE PURPOSES.
- If the electrodes have been left dry, soak in storage solution for at least one hour to reactivate them.
- To prolong the life of the electrodes, it is recommended to clean them monthly by immersing them in the HI 7061 cleaning solution for half an hour. Afterwards, rinse it thoroughly with tap water and recalibrate the meter.
- The pH electrode can be easily replaced by using the supplied tool (HI 73128). Insert the tool into the probe cavity as shown below.



Rotate the electrode counterclockwise.



Pull the electrode out by using the other side of the tool.

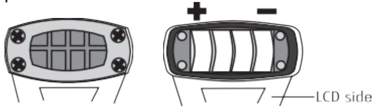


Insert a new pH electrode following the above instructions in reverse order.

BATTERY REPLACEMENT

The meter displays the remaining battery percentage every time it is switched on. When the battery level is below 5%, the ▭ symbol on the bottom left of the LCD lights up to indicate a low battery condition. The batteries should be replaced soon. If the battery level is low enough to cause erroneous readings, the meter shows “0%” and the Battery Error Prevention System (BEPS) will automatically turn the meter off.

To change the batteries, remove the 4 screws located on the top of the meter.



Once the top has been removed, carefully replace the 4 batteries located in the compartment while paying attention to their polarity.

Replace the top, making sure that the gasket is properly seated in place, and tighten the screws to ensure a watertight seal.

RWM-PP-008-FieldInstrumentCalibration

Final Audit Report 2021-09-08

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By:	Lindsay Caron (LINDSAY.ER.CARON@MAINE.GOV)
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Attachment 5

COVER SHEET
STANDARD OPERATING PROCEDURE

Operation Title: **VAPOR SOURCE MATERIAL (VSM) INVESTIGATION AND REMEDIATION AT PETROLEUM REMEDIATION SITES**

Originator:
Kelly Perkins
Quality Assurance Coordinator
Division of Technical Services
Bureau of Remediation and Waste Management

APPROVALS:

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Melanie Loyzim — Melanie — Sep 13, 2021
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DISTRIBUTION;

( ) Division of Technical Services .... By:________________Date:________

1.0 APPLICABILITY

1.1 Introduction: This Standard Operating Procedure (SOP) applies to all programs in the Maine Department of Environmental Protection's (MEDEP) Bureau of Remediation and Waste Management (BRWM) divisions that respond to, investigate and/or or remediate air and vapor contamination related to petroleum releases that impact and pose risk to occupied building.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

Indoor air contamination related to heating oil spills constitutes the bulk of DEP's work related to petroleum vapor and this SOP is weighted toward heating oil spills. The SOP has 3 components, including:

1. Residential Heating Oil Tank Spill (RHOS) – Vapor Source Material Investigation and Remediation
2. Indoor Air Multi Contaminant Risk Calculator for RHOS
3. Vapor Intrusion Screening at Sites with Historical Gasoline Contamination

Components 1 and 2 above apply to heating oil sites. The following sections provide a general discussion of all three components and the appendices provide specific procedures for each component.

Appendix A - Residential Heating Oil Tank Spill (RHOTS) - Vapor Source Material (VSM) Investigation and Remediation

Appendix B – Indoor Air Multi Contaminant Risk Calculator for Residential Heating Oil Tank Spill (RHOTS)

Appendix C – Vapor Intrusion (VI) Screening at Sites with Historical Gasoline Contamination

1.2 Residential Heating Oil Tank Spill – Vapor Source Material Investigation and Remediation: Maine has hundreds of thousands of properties with heating oil tanks within or immediately adjacent to the building. Heating oil tanks are vulnerable to damage and aging and Maine DEP receives thousands of reports of leaking heating oil tanks annually. The release of heating oil from the oil storage tanks within or at homes and businesses constitute the majority of the Department's petroleum resources.

Heating oil releases within or immediately adjacent to an occupied structure (home or business) often result in a completed human health risk pathway to occupants through inhalation of petroleum vapors exceeding indoor air guidance values (chronic, sub-chronic, and frequently acute exposure values). DEP staff typically manages RHOTS sites because of the high risk level to human health and the need for immediate and aggressive actions to successfully mitigate the exposure. This is in contrast to a release of heating oil at a bulk oil facility or a transportation incident where there is typically not an immediate human exposure and the responsible party has at least in part, the lead.

Appendix A provides guidance pertaining to responding, investigating and remediating heating oil tank spills at or within buildings. Other heating oil spill locations and situations that are not adjacent to or not within a building and do not immediately impact or pose a risk to indoor air (such as transportation and bulk plant facilities) are not covered in this guidance.

1.3 Indoor Air Multi Contaminant Risk Calculator for Residential Heating Oil Tank Spills This SOP pertains to evaluating indoor air concentrations relative to the RAGs using a subchronic exposure for the multiple petroleum contaminants present in the indoor air at an occupied residence or commercial building. The use of the indoor air risk calculator assessment tool at residential and commercial heating oil spills is only appropriate when the spill is promptly reported, thoroughly investigated and the identified vapor source material is aggressively remediated and or comprehensively managed within 90 days of the release. The risk calculator provides a risk summation when multiple contaminants are present (typical with petroleum mixtures) and uses the sub-chronic (7 year) risk scenario. This exposure criteria is supported by the Maine CDC and is consistent with the RAGs. criteria for . This document is a companion to Maine DEP's Excel Program "Home Heating Oil Indoor Air Input Sheet and Summary of Total Incremental Lifetime Cancer Risks and Endpoint-Specific Hazard Indices" dated February 2019. Appendix B provides detail on applying the calculator.

1.5 VI Screening at Sites with Historical Gasoline Contamination:

This guidance is not applicable in situations where there is a catastrophic or recent release of gasoline, or there are reports of gasoline odors. Gasoline releases and indoor gasoline odors are to be immediately reported to emergency responders and occupants smelling gasoline should be advised to vacate the premises.

This SOP pertains to assessing petroleum vapor intrusion (PVI) potential associated with residual, gasoline contamination from historic releases. This SOP replaces the 2010 VI Guidance. Appendix C provides details on VI screening at gasoline sites to determine human health risks.

A site assessment in response to the release must consider the vapor potential, migration and exposure in accordance with "Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air" from EPA's Office of Solid Waste and Emergency Response, dated June 2015. Therefore, environmental professionals must have experience with this document and follow the document when investigation PVI from an historic gasoline release.

2.0 PURPOSE

The purpose of this SOP is to identify the presence of petroleum contaminated media that impacts or has the potential to impact indoor air quality above an acceptable risk-based concentration (herein referred to as Vapor Source Material or VSM). Additionally, this SOP outlines steps to evaluate the VSM and remediate the VSM when the indoor air quality exceeds the RAG or mitigate the pathway when indoor air quality is below the RAG.

At RHOS sites, Vapor Source Material (VSM) is defined as petroleum contaminated media that meet **all** the following conditions:

1. sufficient concentration to propagate vapor transmission,
2. located in close proximity to the building and
3. there is a direct vapor migration pathway connected to
4. an occupied building with measurable impacts to the indoor air quality.

National[1] and State[2] guidance is available on investigating vapor intrusion risk, and this guidance is primarily for situations where the inhalation pathway is complete, as is often the case with residential heating oil tank spills. By identifying the location and relative strength of VSM contributing to the complete pathway, mitigative and remedial actions can be effectively scoped and targeted.

In identifying VSM and monitoring the progress of a clean-up and/or mitigation, MEDEP relies on a formatted methodology of collecting, recording and tabulating spatial, temporal and experiential information. The information is reviewed and weighted based upon staff judgement and consideration of factors including conformance with the CSM, correlation with coincidental information, representativeness, frequency, and validity. Validity can be a qualitative measure of developing and adhering to a routine with respect to collecting and documenting information including routine, personnel, equipment, location, timing and influences. Information considered strong, reliable and defensible can be used to make decisions with respect to delineating the extent of impact, identifying VSM, determining effectiveness of corrective actions and completing involvement with a spill. This approach, of collecting, observing and documenting direct and indirect information to develop a comprehensive understanding, is referred to as a “multiple lines of evidence” (MLE) approach. It is particularly useful and important with regard to identifying and resolving vapor impacts as air/vapor is in a greater flux than other forms of contamination (water, soil) which presents difficulty in establishing a stable concentration to compare to clean up and performance guidelines.

3.0 RESPONSIBILITIES

All MEDEP/BRWM Staff must follow this procedure when performing this task. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/BRWM staff reviewing data by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4.0 DEFINITIONS

4.1 BUILDING ENVELOPE : The below grade interface and connections between the building elements and the surrounding environment (foundation, backfill, piping, sump, utilities, penetrations, groundwater, soil) where an exchange or transmission of vapors is possible. The zone of the building envelope can change with seasons and groundwater table elevation.

4.2 Complete inhalation Pathway A pathway is considered complete when the indoor air concentration exceeds the RAG for the appropriate risk scenario and the exceedance is directly attributed to the vapor migration pathway between the VSM to the occupied building.

4.3 LINES of EVIDENCE also referred to as MULTIPLE LINES of EVIDENCE: Lines of Evidence is an approach of collecting, observing, documenting direct and indirect information to develop a dimensional understanding of a situation that can be evolving, as in the impacts or remedial progress at a residential heating oil tank spill. Typically, there is not a solitary piece of information (evidence) that adequately defines the situation, so it is necessary to collect multiple pieces of information to confidently comprehend the situation or status.

4.4 ONE-WAY FLOOR DRAIN. A one-way valve for floor drains allows water to pass through while sealing out soil gases including odor. A typical brand name for one-way valves is Dranjer™. Dranjer™ floor drains can retrofit existing non-valved floor drains or be installed during the construction of a new floor depending on the type of Dranjer™ floor drain used.

4.5 PHOTO-IONIZATION DETECTOR (PID). A PID measures volatile organic compounds (VOCs) and other gases in concentrations from parts per billion (ppb) to 10,000 parts per million (ppm). The PID is an efficient and inexpensive detector for many gas and vapor analytes. PIDs are hand-held portable instruments that produce instantaneous readings and operate continuously. Their primary use is for monitoring possible exposure to VOCs from petroleum fuels, solvents, and degreasers. Other applications include assessing performance of a SSDS by measuring the VOC concentration of the soil gas inside the exhaust pipe and assessment of vapor source strength and location, by measuring the concentration of the soil gas in test holes and cracks in the floor.

4.6 SMOKE PEN. Smoke pen is a small “pen shaped” device that emits an inert smoke. It can be used to test pressure gradients and air movement. Disposable puffers using titanium tetrachloride and moisture to make smoke are not recommended for use since a byproduct of making smoke with titanium tetrachloride is hydrochloric acid.

4.7 SUB SLAB DEPRESSURIZATION SYSTEM (SSDS). A SSDS is withdrawing air from the soil immediately below a foundation slab in order to manipulate the pressure to prevent the soil gas from entering the building. It is widely used in radon mitigation. In order to be effective, the foundation slab needs to be of relatively low permeability in comparison to the sub slab soil in order to maximize influence below the slab. In addition to the low permeability slab, an SSDS consists of an extraction pipe, an in-line fan, and exhaust pipe. The intercepted soil gas is discharged to and dispersed to the atmosphere, away from receptors.

4.8 VAPOR INTRUSION - Vapor Intrusion is the migration of hazardous vapors from a subsurface contaminant source, such as contaminated soil or groundwater or contaminated conduit(s), into an overlying building or unoccupied structure via any opening or conduit.

4.9 VAPOR BARRIER. A vapor barrier is plastic sheeting used to prevent the migration of soil vapors and water vapor from the soil into the building. A recommended product is 15-mil yellow plastic sheeting ("Stego® Wrap") from Stego® Industries, LLC with 0.0086 perms. Stego® Wrap is a vapor barrier that is very durable and puncture resistant and has an extremely low perm rating. In comparison, readily available 6-mil polyethylene has a perm rating of 0.06. It is important to note that the installed, effective permeance is largely dependent on the installation technique.

5.0 GUIDELINE PROCEDURES

5.1 Introduction

The procedural guidelines and planning aspects are developed in the following Appendices:

Appendix A - Heating Oil Investigation and -up
Appendix B - Petroleum Vapor Risk Calculator
Appendix C - VI Screening at Gasoline Sites

5.2 PID Use

A PID does not respond linearly to increasing fuel oil contamination concentrations in soil because many of the components that comprise the greatest mass of fuel oil are outside the ionization potential of the instrument. PID use to determine the presence or absence of fuel oil contamination in soil is permitted in the SOP under the following conditions:

- The PID lamp has been cleaned in accordance with the manufacturer's instructions
- The lamp cleaning is documented
- PID is calibrated before use at the site and bump tested after one hour of use
- The PID readings are used in conjunction with other lines of evidence and is not used exclusively as the only evidence

6.0 QUALITY ASSURANCE/QUALITY CONTROL

Data quality objectives should be stated in the SAP. Quality Assurance/Quality Control (QA/QC) samples may be collected if needed to meet DQOs. Typical types of QA/QC samples that may be collected or prepared at the laboratory include replicate MIS samples to allow determination of a UCL for the DU, laboratory control blank spikes, and analysis of reference material containing known concentrations of the target analytes. All analytical data should be reviewed and assessed to determine if DQOs have been met. If review indicates DQOs have not been met, corrective action will be recommended by the reviewer.

7.0 REFERENCES

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[1] OSWER Publication 9200.2-154 OSWER TECHNICAL GUIDE FOR ASSESSING AND MITIGATING THE VAPOR INTRUSION PATHWAY FROM SUBSURFACE VAPOR SOURCES TO INDOOR AIR U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response June 2015 https://www.epa.gov/sites/production/files/2015-09/documents/oswer-vapor-intrusion-technical-guide-final.pdf

[2] Supplemental Guidance for Vapor Intrusion of Chlorinated Solvents and other Persistent Chemicals Effective Date: February 5, 2016 https://www.maine.gov/dep/spills/publications/guidance/rags/VI-Persistent-Chems-Guidance-final-020516.pdf

Appendix A - Residential Heating Oil Tank Spill (RHOTS) - Vapor Source Material (VSM) Investigation and Remediation

State of Maine – Department of Environmental Protection
Bureau of Remediation and Waste Management

Petroleum Remediation Guidelines SOP 009

Appendix A - Residential Heating Oil Tank Spill (RHOTS) Vapor Source Material (VSM) Investigation and Remediation

Preliminary Draft Date: June 29, 2020

INTRODUCTION

Maine has hundreds of thousands of heating oil tanks within or immediately adjacent to occupied buildings. A Residential Heating Oil Tank Spill (RHOTS) can be very disruptive to the function and occupation of a residence by immediately contaminating indoor air. In addition to the building and indoor air, a RHOTS can quickly contaminate drinking water wells, ground water, soil, surface water, and septic systems.

The inhalation pathway between the release and the occupants of the building is often complete and urgency is required to rapidly mitigate the exposure and evaluate the impacts. The complete pathway is often obvious and identified and reported by the occupant due to the acrid, distinct odors associated with vapors from heating oil. Occupants usually notify their service provider and subsequent DEP notification is usually quick, which facilitates a rapid DEP response. This appendix summarizes proven methods to investigate and mitigate/remediate Vapor Source Material (VSM) at RHOTS.

Although it is the vapor phase of fuel oil that is completing the inhalation pathway, fuel oil contaminated building components, household items, soil, and groundwater are typical vapor source material and need to be evaluated in a timely manner to successfully mitigate/remediate a RHOTS . This appendix is based upon decades of environmental professional experience and is applicable to heating oil spills at residential commercial, and industrial buildings.

GUIDANCE PREMISE

Sections 6 and 8 of the OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air covers methods for identifying vapor source material and mitigation/remediation. This same approach, in general, is adopted to heating oil spills that impact indoor air. RHOTS are somewhat unique in comparison to other vapor forming chemicals (mercury, radon, dry cleaner solvents, etc.) because the release is usually inside or very close to an occupied residential building, the odor threshold is very low, and the effects of the release is often observed immediately by the homeowner (no heat, visible product, oil taste, smell, etc.) Similarly, the completed pathway is also observed immediately without the need for laboratory samples to be collected.. Key components of reducing the magnitude and duration of the exposure, protecting resources, and restoring property value are:

- an immediate report of a discharge,
- timely response by DEP and service provider,

- early identification of situations where teaming with Response Services, Tech Services staff, and Project Managers is warranted and early formation of the DEP project team,
- Communication between DEP team and property owner, building occupants, and any outside parties (oil companies, service technicians, fire departments, local government officials, etc.)
- thorough assessment and documentation of impacts and source areas, and
- aggressive removal and thorough control of source areas.

This appendix presents proven practices of DEP staff with decades of experience successfully investigating and remediating more than 15,000 RHOTS.

Diligent and thorough identification of VSM is a critical preface/component of a successful clean-up. Taking the time to assess and thoroughly remove the VSM is the preferred approach as it eliminates the exposure by the most effective means – at its source. A removal (a form of remediation) can be limited by costs, structural concerns, owner cooperation, weather, seasons, resources, and a variety of other factors. When removal is limited, supplemental actions may be necessary to mitigate the vapor inhalation risk..

Typical mitigation measures include concrete cleaning, concrete surface sealing, groundwater control, and installation of a sub slab depressurization system - SSDS. Several rounds of investigation, monitoring, and remediation may be necessary to facilitate vapor and air equilibration after remedial actions are taken so that weak and remote locations of VSM can be identified and remediated to achieve a successful site closure.. When the spill circumstances are known and the impact and amount of VSM is low, a single, cursory, confirmatory investigation may be adequate to complete actions and successfully close a site.

DEP staff time involved in assessing, remediating, and documenting heating oil spills is critical to::

- Completing time-sensitive steps to stop the leak and provide immediate steps to reduce human health risks
- Establish a well-developed conceptual site model
- Execute a timely and focused investigation.
- Develop an appropriate vapor control plan
- Implement effective mitigation and remedial actions that eliminate vapor inhalation risks permanently s
-

- Provides immediate protection of public health, and
- Establishes long term liability protection with respect to 3rd Party Damage Claims.

Emergency measures for building occupants may include voluntary and temporary relocation. DEP does not have the authority to require evacuation, but the option can be discussed with the property owner, local, and state public health officials as deemed appropriate by DEP staff on-site.

A PID may be used in accordance with Section 5.2 of this SOP.

Procedure

This appendix focuses on petroleum vapors/odors caused by heating oil spills and provides BRWM staff with:

1. Objectives for investigating and remediating the spill
2. Communications and Responsibilities between the property owner/occupant and DEP
3. Methodology
4. Best Management Construction Practices/
5. Related references and SOPs

1. Objectives for investigating and remediating the spill

    a. Develop and validate a Conceptual Site Model – CSM. Indoor air impacts are most times obvious. Understanding, locating and controlling primary vapor source material can take time and effort but it is a critical objective upon arrival. Success of decisions ranging from "wait and see" to an aggressive pursuit of VSM are contingent upon constructing and validating the conceptual site model in order to effectively design and plan the investigation(s), monitoring and remediation.
    b. Develop and implement a remedy and verify that it is performing adequately (demonstrate reliable influence on the residual VSM in order to declare that the environmental exposure condition is under control).
    c. Closure: Continue periodic performance monitoring checks, look for trends over time and seasons, compare to closure criteria, and document that DEP is satisfied with the clean-up by closing out the project.

2. Communications, Interactions and Expectations between Owner/Occupant and DEP.

   In order to establish an informed and cooperative relationship between the parties involved in the investigation, clean up and administration, there are many items that are to be discussed at the onset and continued throughout the investigation and clean-up. Items include program scope, program administration, expectations, health (including the range of sensitivities and tolerances), work scope, access, disruptions, scheduling, and finances. Details to cover with the owner/occupants include:

   a. Identifying parties with <u>knowledge of the spill and or influences</u> on the spill impact.

   b. Provide DEP Objective: Inform occupants/owner that DEP's mission is to <u>identify and control vapor source material (VSM) to reduce exposures</u> and protect the environment. Emergency, temporary ventilation and filters are available while the assessment is ongoing and the clean up actions will be presented prior to implementation. Multiple rounds of monitoring, observation and communications will be necessary to complete the understanding of the impacts, complete the evaluation of the remedy, convey status, and make decisions. Occupant assistance in reducing exposure and understanding progress will be requested by avoiding source areas and reporting experience/impression following remedial/mitigation actions.

   c. Health Affects / Risk Guidance: As a matter of course at heating oil spills, DEP does not conduct health risk assessments or have the authority and qualifications to determine if oil impacted indoor air is "safe" to habitate. <u>Inform occupants that it is their decision on whether they can stay in the building</u>. Inform owners/occupants that fuel oil vapors are not an imminent threat with regard to ignition or explosion. Recommend that they avoid/limit exposure to fuel oil product, contaminated media and vapor. Inform them that if they or their family have respiratory illness, vulnerable due to age (pre-teens and elderly), or are experiencing symptoms that they are uncomfortable with, they should consider alternative accommodations. Inform them that DEP's workplace PID action level (SOP RWM-PS-002 Last Revised 11/26/19) is 10 parts per million (PPM) and with adjustments for a 24 hour/7 day per week residential exposure, DEP recommends against occupying areas, rooms and buildings where PID measurements are sustained above 3 PPM.

d. Health Affects / Risk Referrals The State of Maine's Center for Disease Control has an Environmental Health Unit (EHU) that can be contacted to discuss health effects and reactions with fuel oil vapors. If it is a situation with multiple families or individuals (commercial/office, multi housing) and/or sensitive population (small children/elderly, respiratory conditions) or both (school, hospital, assisted living/elder care), advise owner/manager/administrator that immediate involvement of CDC provides valuable assistance in communicating and decision making with respect to health and safety. When EHU is involved, DEP can serve as field staff with regard to information and sample collection, risk calculation, and comparison to "typical background" levels detected in Maine homes. Site/exposure/population specific interpretations are the domain of the EHU unit.

e. Alternative Temporary Housing: Accounting for finances, site safety, availability of alternate housing through family and friends, sensitivity of population, perceived timeline and degree of difficulty in achieving "under control" status, Response Staff, at their discretion, are authorized to offer assistance in finding and funding alternative accommodations. Refer to 2017? memo regarding Red Cross and relocation policy.

f. Timeframe: The timeline of marked improvement can range from a few hours to a few weeks. The time frame can be affected by many factors including the volume of oil lost, the lag time between the spill and the reporting, proximity of groundwater, building drainage, building construction, building HVAC, and the season. Typically, the VSM is considered "under control" within a month. Operation and maintenance of engineering controls for the residual VSM typically are necessary for 2 to 5 years.

g. Inform them of the Clean-up Lead Options available to them and document their decision.

h. Inform them of the Ground and Surface Water Response Clean-up Fund (G&SWRCF) available through the State Fire Marshall's Office and administered by DEP.

i. Beyond the basic emergency measures of stopping the leak, collecting readily available free phase oil, and minimizing the exposure (such as temporary ventilation), provide the property owner and occupants with recommended measures, in writing, at each step, and acquire consent as you proceed through the investigative and remedial steps.

j. Where the amount of the discharge is significant yet the recovery is limited so a significant amount of oil is lost to the environment, conduct "due diligence" to ensure lost product is not shallow or within the building envelope where it poses risk of future impact to building, well or nearby surface water when influenced by groundwater and/or heating season. Depending upon the situation, due diligence may involve monitoring for a period to evaluate seasonal influences.

3. Methodology

A. Establish Multiple Lines of Evidence. Multiple Lines of Evidence are used to assess the impacts and evaluate the effectiveness of a remedy. In selecting points to monitor along a particular line, it is important to pick points that are representative (of the impact and or progress) and in locations that provide a baseline reference and are repeatable in that it is expected to endure the corrective actions. For instance, a point on a section of concrete floor may be a useful point to mark the extent and/or level of impact but if a portion of the impacted floor is removed and the monitoring point is removed with it, the "baseline" reference is lost. If that point is cleaned and sealed rather than removed, it would continue to serve as a progress marker, however its value may be temporarily impaired due to the PID interference associated with the drying/curing time with cleaning solvents and sealing products.

As the site progresses, some lines may become irrelevant and others may increase in value. In order to have flexibility in lines to carry forward and to establish a strong understanding of baseline conditions to illustrate progress over time, it is important to establish multiple types and locations of monitoring points, and to monitor all the points frequently early in the process, especially before and after corrective actions, to gain a relative sense of the location of VSM and to understand progress in the control of VSM.

B. Gather Multiple Lines of Evidence. Record influences on those results such as weather, groundwater level, stage of investigation/clean-up, investigative/remedial activity, the presence and operational status of remedial equipment (both temporary and long term), occupant presence/activity, and building operations (HVAC). Lines of evidence may include:

a. Collected and chronicled information from parties involved with the spill, living with the spill impacts, frequent visitors, and staff/contractors managing and cleaning up the spill.
b. Concentration/impact results from observations, field screening equipment, lab samples

C. Example of Establishing and Gathering Multiple Lines of Evidence: In terms of a RHOTS, a developed and consistent methodology can be PID screening, observing and soliciting occupant impressions at each monitoring location from clean to dirty, starting in the outside fresh air, entering the upper floor (assuming the VSM is in the basement), the headspace at the top of the basement stairway, the stairway landing in the basement, basement location(s) that are representative of the indoor air impacts in the breathing zone and expected to be available despite the range of investigative and remedial activities that may take place. For instance the top of the hot water tank and/or the 7th step of the basement stairway are locations that are likely to endure. Once the ambient air impact has been assessed, move on to source area assessments, again proceeding from clean to dirty to identify VSM and to monitor progress and performance of prior remedial activities.

D. Review lines of Evidence and Make Determinations: Tabulate observations, experiences, results collected over time and space and look for patterns and trends and identify strong lines based upon that review. Strong lines are considered representative and are corroborated with other lines (for instance PID readings are consistently an order of magnitude higher on stained versus unstained portions of a concrete floor – stains correspond with the PID readings so stains and PID can be considered strong lines of evidence). Continue building upon the strong lines by returning to those locations/features each monitoring event and document the findings. Use the data to develop understandings in the CSM, identify areas/locations of residual VSM, and to make decisions regarding the need for further corrective actions, continued monitoring and closure. An example of tabulated monitoring results is in the attached Table 1. Representative results from Table 1 can be applied to Table 2 which provides criteria and thresholds to consider in making decisions regarding:

a. Identifying VSM within the building and building envelope
b. Determining the status (controlled or uncontrolled) of the VSM
c. Qualify the relative extent and level of VSM contamination to assist in determining removal versus mitigation/control

d. Identify when the residual VSM is reduced in extent and strength so that the risk of unacceptable exposures has been satisfactorily addressed. At this point, remediation, mitigation, and monitoring activities can be concluded and the closed status can be conferred upon the oil spill.

Incorporate site specific factors in determinations including: sensitivity of occupants, use of the building (seasonal/primary/rental residence), building style/age/construction/systems, extent and severity of the spill impacts, degree of difficulty in mitigating, time to mitigate, weather, season, water table, clean-up contractor availability, K-1 vs #2 fuel oil. All the gathered evidence and site specific factors influence the timeframe, urgency, and options available to control VSM. The lines of evidence methodology and decision criteria are provided as reference or default guide. It is not intended to void individual/regional methodologies and criteria. However it is recommended to arrive with a conceptual methodology and criteria that can be explained and defended.

Photoionization Detectors (PIDs) provide valuable information in identifying the presence and relative strength of vapor source material, understanding the progress of corrective actions and communicating the status to interested parties. However it is important to note that DEP's Standard Operating Procedure #TS004, "Compendium of Field Testing of Soil Samples for Gasoline and Fuel" does not address the vapor pathway and does not accept use of the PID bag headspace method for field screening of fuel oil contaminated soil. PIDs have a nonlinear response to heating oil so that independent field screening thresholds representative of risk cannot be developed with PIDs and fuel oil. Furthermore, weather, equipment manufacturing, equipment age/use, user methodology, and background levels of non-spill related volatile organic compounds (VOCs) all influence the response of PIDs. Recognizing this conflict, between the availability, use and experience with PIDs and the nonlinear response to fuel oil, DEP recommends developing site specific context for the PID readings and compensating for variability across days, users and instruments by conducting multiple visits with the same equipment, same methodology, at valued locations, over a range of conditions and operations/activities, and noting the conditions and operations. Of note is the weather, groundwater elevation, fan(s) on/off, HVAC status, windows and doorways open/closed, remedial and household activities), and personal observations such as visual staining, odor level, homeowner experience and odors in clothing upon departure. **It is the pattern or trend observed and understood over time that builds confidence that the vapor source is properly identified and remediated, not the day's PID reading. The use of a PID must adhere to Section 5.2 of this SOP.**

4. Best Management Construction Practices This section of the guidance provides an "awareness" summary of construction practices, methods and standards adopted from other trades and developed through DEP and contractor experience. The practices are promoted to provide immediate and long term protection for workers and occupants. A list of related SOPs is also provided.
    a. Expand the site safety plan to address the potential for spreading oil through a building by "Foot Tracking" (workers, occupants and inspectors walking through oil impacted areas and spreading oil by walking with dirty shoes into previously un-impacted areas.) Foot Tracking can be limited by immediately limiting personnel, limiting routes and identifying/marking accepted routes, placing and maintaining pads along accepted routes.

    b. Photos for assessment: Photos can sometimes capture and document impacts better than the naked eye. Wicking up a sheetrock wall is an example of impacts identified by photos but not first hand visual. Photos can be used to document remedial progress about the impact to a sump water quality over time or stain lightening after each cleaning event.

    c. Inventory/tag/segregate between impacted and unimpacted goods. Items can be shuffled during emergency clean-up and documenting the initial location of goods with respect to oil impacts helps draw the line between suspected and unsuspected oiled items. Documentation and marking reduces the chances of oiled goods being returned to areas that have been screened and cleaned. Documentation and marking can assist the homeowner in identifying items for disposal and salvage and in future insurance claims. Photos and color coding with tape are helpful inventory tools.

    d. Temporary ventilation: Locate temporary ventilation fans outside: If a leak develops in the pressurized discharge side of the fan, the contamination is discharged outside rather than inside the building. Ramfans and radons fans are suitable for outdoor use. Where practical, provide security and weather protection for exterior fans.

    e. Vapor/dust barriers (zippered systems are now available) are recommended for concrete work and interior excavation. Negative pressure within the enclosure is necessary to contain dust and vapor and reduce the exposure.

f. “Permanent” Barriers can include insulation, sealants, poly sheeting, and false partition walls and false floor. Where vapor source material removal is not feasible, a barrier must be applied to protect indoor air from the petroleum vapors. In areas where a spill has occurred outside a fieldstone foundation, the foundation should be sealed on the inside with a closed-cell spray foam insulation to create a barrier to vapors entering the basement.

   When interior oil impacts cannot be removed such as in a wall, ceiling or floor, “false” walls, ceilings and floors can be installed to enclose the source and where warranted, negative pressure can be applied to the cavity between the contaminated material and the “false” barrier.

   Poly Sheeting Barriers are generally used in areas with a dirt floor, or under a mobile home. Poly should be White Cap type crawlspace vapor barrier, 12 mil, sealed to the walls with slats or double-sided tape. It should also be sealed to any support posts located in the area of concern. In dirt basements, it should be protected by covering with sand and pea stone. Poly sheeting is also used between backfill and the new slab to impede residual sub slab contamination.

g. Indoor Air Treatment: Granular activated carbon air scrubbers are most often used in occupied areas of a building to decrease petroleum vapor concentrations in the initial days or weeks following a spill, while source removal is taking place. Scrubbers can be used to remove lingering petroleum odors after source removal efforts are complete. They can also be used to provide peace of mind for sensitive homeowners. The DEP has two types of air scrubbers – the “R2D2” units and the “big blue” units. The R2D2 units have more carbon and circulate air at a slower flow rate. The big blue unit has only a thin carbon filter and circulates air at a much higher flow rate.

h. Permanent ventilation: See Sub Slab Depressurization System (SSDS) SOP RWM=PP-019 for application and guidance. Note that pre-emptive SSDS, can be a relatively low cost investigative tool. Guidance for alternative permanent ventilation such as Air Exchangers is under development.

i. Wet saws are recommended for concrete cutting to reduce dust and vapor generation.

j. Observe Building Science principles, particularly in measuring air flow direction with respect to vapor source material and when altering pressure fields in a building which can affect the draft on combustion appliances.

   Use of smoke pens at the doorway to the cellar or at basement window or bulkhead will help assess air flow under natural conditions. Natural air flow can provide the desired flushing (when air from the first floor is being drawn in to the basement and exhausted through a cellar bulkhead or window opening) however often-times the open cellar bulkhead or window acts as an intake. Although outside fresh air is entering, it may be drawn across VSM on its way to an upper occupied floor. Ideally, the area of VSM is under negative pressure with respect to other areas and floors of the home and this may be accomplished by measuring the natural air flow direction and designing and constructing ventilation to induce a negative pressure in the VSM area.

   When a spill occurs at a site with a larger HVAC system, such as at a school or at a commercial property, the operation of the HVAC system can often be altered. The goal is to isolate the area of the building where the spill occurred so that petroleum vapors are not circulated throughout the entire building.

   Prior to air flow manipulation and installation of vapor barriers, identify combustion appliances in the building. Do not include combustion appliances within an area designed to maintain a negative pressure (such as a poly sheeting enclosure). Where significant changes in air flow and pressures are involved (such as a ram fan in the heating season), have a qualified individual monitor the draft of the combustion to determine the effect of ventilation on performance of the appliance. Significant ventilation operations and effects should be continually monitored and shut down when they cannot be monitored.

k. Identify structural elements of a building within the impacted area and establish "limits/bounds" of slab and soil removal earthwork to maximize removal of VSM without jeopardizing the structure. This is the realm of structural engineers and beyond the scope of this SOP. For conventional sized and constructed residences with standard 8” concrete walls and 6” footings, general guidelines and rules of thumb are under development with respect to a percentages, length, and width of floor that can be removed, the amount of concrete floor to leave in place around the perimeter and posts, excavation depth and slope with respect to footings, allowable amount of exposed footing, and backfill operations and specifications. Use of qualified contractors is recommended for work within and around structures. Identification and location of utilities (sewer, water, gas, fuel, electrical, radiant floor heating) is necessary before probing and removal. Control measures are an acceptable alternative to removal work around and within older and sub-standard foundations.

l. Design and construction of backfill and concrete floors. Ventilation and drainage (both subslab and slab surface) need to be considered when backfilling a basement excavation and placing a concrete floor. If a sump is a component of the vapor control system, it needs to accommodate subslab and slab surface drainage and it needs to be vapor tight and accessible for monitoring and product recovery. Details on incorporating a sump into vapor control systems are provided in the attached FIGURE 1. In order to pick up surface drainage when the sump is sealed, waterless trap seals are available for the sump cover as well as at a designed low point in the new floor. A one-way valve creates a seal to reduce petroleum vapors from coming up through a floor drain but still allows surface water to flow into the drain.

m. Worker safety: electrical, excavation/heavy equipment, noise, petroleum vapor, radon gas, silica dust, mold, sewer, vapor, infectious disease from vermin, vermin waste, sewer, buried utilities, protective pets.
n. Protect from liability claims for construction damages or unauthorized disposal of oil impacted goods. Take photos to document foundation, yard, drainage, household items conditions before investigating and remediating. Engage in frequent , thorough, documented discussions about saving or tossing impacted items. Segregate and cover clean and dirty items outside the home to verify the status and allow the homeowner time to go through the piles and confirm final disposition

5 Related documents and references include:
   i. SSDS SOP RWM-PP-019Floor Cleaning and Sealing Whitepaper
   ii. Treatment Trailer SOP RWM-PP-013

iii. Clean-up Options “Tool – kit”

State of Maine – Department of Environmental Protection – Bureau of Remediation and Waste Management
Petroleum Remediation Guidelines SOP 009
Vapor Source Material (VSM) Investigation and Remediation
Appendix A - Table 1 Residential Heating Oil Tank Spill (RHOTS)
TABULATING DATA TO DEVELOP and INTERPRET LINES OF EVIDENCE

Date	Staff	Time	Instrument	Bump	Outside Ambient	Kitchen	Carbon Air Filter Exhaust	2nd Floor Head Stairway	Basement Top Hot Water Tank	SSDS Exhaust	Complete pathway	Product	Living Space Vapor	Surface Water Impact	GW Plume	
1/21/2020	PME and SGB	13:00	PPB RAE 4937	9880	Not Recorded	38000			48000		Yes	Yes	Yes	Yes	Yes	Tank blew in am. Product inside basement and outside in drain ditch. NRC cleaned floor.Installed carbon air filter.
1/22/2020	PME and SGB	13:15	PPB RAE 4937	9916	70	7000	<2300		12380							Drilled holes in slab and PID screened. Notably less oil smell.
1/24/2020	PME	9:00	PPB RAE 4937	9731	0	2003	<1000		4900							Dave and Mark from Air and Water Quality Treatment install SSDS.
1/27/2020	PME w MW	13:00	PPB RAE 4937	9575	32	765	<450		4271	4420						NRC cleaned basement floor earlier in day: contribute to PID? No oil smell but Simple Green odor. SSDS bleed valve full open. Jenny asked about moving carbon air filter to upstairs where oil smell is strongest.
2/3/2020	PME meet SGB	9:00	PPB RAE 4937	10050	30	590	<700	1080	2200	2540	Contained /Under Control	Contained/ Under Control	No	Negligible	No	**No oil odor kitchen**. NRC Camera and jet drain lines - no oil generated
2/4/2020	PME	15:05	PPB RAE 3035	9742	15	856	<350	1463	2905	3010	Contained /Under Control	Contained/ Under Control	No	Negligible	No	SSDS Bleed valve closed when screen. Pre Binz PID survey of floor and wall
2/5/2020	PME	8:45	PPB RAE 3035	10740	150	475			2030	1245	Contained /Under Control	Contained/ Under Control	No	Negligible	No	**No oil odor kitchen**. NRC applying BINZ to floor and wall
2/10/2020		13:30	PPB RAE 3035	10250	6	438	<500	610	478	441	Contained /Under Control	Contained/ Under Control	No	Negligible	No	**No oil odor kitchen**. Post BINZ PID survey. Nate England reported that he went away this weekend and oil odor improved upon return. Noi oil discharging in ditch.

“Kitchen” column shows PID readings stabilize below 1000 PPB and “no oil odor kitchen” starting on 1/27/2020 where the VSM can be declared “under control”

Petroleum Remediation Guidelines SOP 009
Vapor Source Material (VSM) Investigation and Remediation
Appendix A - Table 2 Residential Heating Oil Tank Spill (RHOTS)
SCREENING CRITERIA in ASSESSING EXTENT, IMPACT, CONTROL and CLOSURE of VSM

UNMANAGED VAPOR SOURCE MATERIAL (VSM) IMPACTING INDOOR AIR

Corrective Action indicated when supported by the weight of following lines of evidence

^Sustained moderate fuel oil odors in occupied area
^Sensitive population and complaints of health effects
^Heating season and low confidence in immediate, thorough, reliable control of vapor source material
^Significant amount of LNAPL or oil stained goods and/or building materials within building
^Sustained PID greater than 3[a] parts per million in an occupied area

MANAGED VAPOR SOURCE MATERIAL (VSM) IMPACTING INDOOR AIR

Montoring Indicated when supported by the weight of following lines of evidence and conditions

^Slight/Tolerable/Infrequent fuel oil odors and odors not detected in clothing upon departure
^Documented understanding of spill impacts, extent, migration, pathways
^Removal of primary VSM and reliable control of residual VSM
^Stable PID less than 1[b] parts per million in occupied areas

REMOVAL of UNATTACHED / NON -STRUCTURAL FINISHES and STORED GOODS

^When material has absorbed or been in direct contact with liquid LNAPL

REMOVAL of BUILDING COMPONENTS, SLAB and SUB SLAB SOIL

Removal indicated when supported by weight of following lines of evidence and conditions & practical to apply

^Slab/Building Component: Oil was in contact long enough to saturate/permeate/severely stain
^Slab/Building Component: After thorough cleaning, PID attributed to oil and registers > 5[b] PPM over > 20 sq ft
^Subslab Soil: Oil saturated soil per Oleophylic Dye, or Shake Test. Or PID Bag Headspace > 100 PPM over > 50 sq ft
^Prior to persuing soil, verify subslab source extent and level of impact with soil bag headspace samples
^Clean, seal and SSDS when slab/element/subslab is not saturated/absorbed and impacts are weak/limited in extent

CLOSURE - EVIDENCE that RESIDUAL VSM CONTAMINATION is STABLE, LIMITED and LOW

^Upon multiple checks and under a range of conditions including conceptual worst case
^0.3 PPM < Source Area Indoor Air < 0.7 PPM, without controls, and PID response not primarily attributed to spill
^Subslab source area < 5[b] PPM PID in drill hole headspace without controls operating
^Acceptable risk calculation with results of subslab source area vapor samples without controls operating
^Groundwater within 3 feet of building envelope < 10[b] times Maine Groundwater Remedial Action Guidelines
^SSDS Stack exhaust < 1.0[b] PPM
^Correlating lines of evidence, including support of closure from occupant and CDC (if involved)
^Acceptable risk calculation with results of indoor air sample(s) w/o controls operating.

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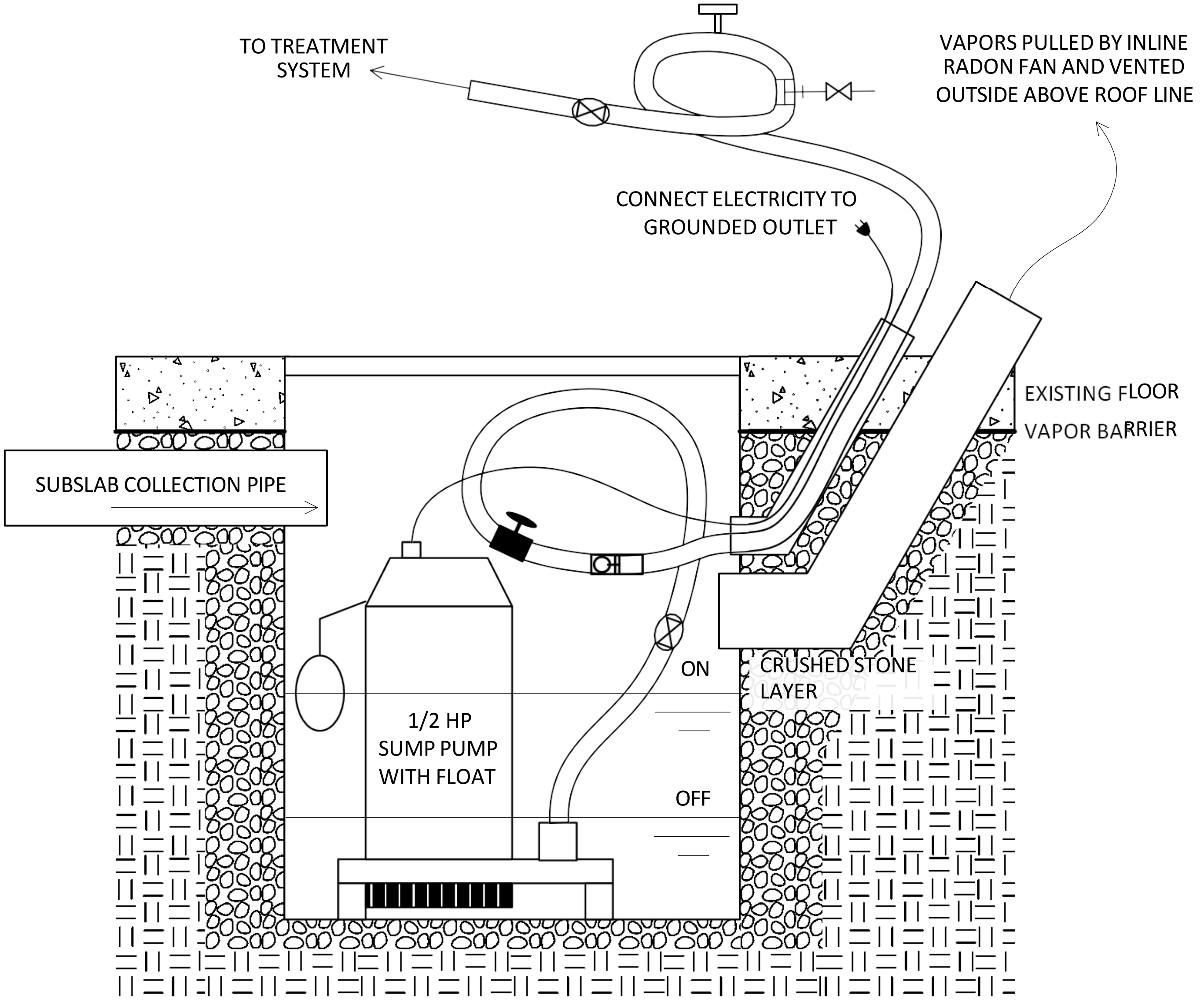
[a] DEP's workplace PID action level (SOP RWM-PS-002 Last Revised 11/26/19) is 10 parts per million (PPM) and with adjustments for a 24 hour/7 day per week residential exposure results in a residential action level of 3 PPM. Actions include avoiding areas, rooms and buildings where PID measurements are sustained above 3 PPM.

[b] Based upon DEP experience with successful clean-ups

DEPARTMENT OF ENVIRONMENTAL PROTECTION · STATE OF MAINE ·

Petroleum Remediation Guidelines SOP 009
Vapor Source Material (VSM) Investigation and Remediation
Appendix A Residential Heating Oil Tank Spill (RHOTS)
FIGURE 1 - ACCESSIBLE, VAPOR TIGHT SUMP

DRAWN BY: LD MEDEP
REVISED 6.2020 BY PME



KEY

- ▀ GATE VALVE
- ⊗ CHECK VALVE
- CAM LOCK DISCONNECT
- ⊤ VACUUM RELIEF VALVE
- SAMPLE PORT

NOTES

Appendix B – Indoor Air Multi Contaminant Risk Calculator for Residential Heating Oil Tank Spill (RHOTS)

Petroleum Remediation Guidelines SOP 009
Vapor Source Material (VSM) Investigation and Remediation
Appendix B
Indoor Air Multi-Contaminant Risk Calculator for Residential Heating Oil Tank Spills

Date June 26, 2020:
Revision No. 01
Page 1 of 2

Indoor Air Multi-Contaminant Risk Calculator for Residential Heating Oil Tank Spills (RHOTS)

1) APPLICABILITY

This guidance document pertains to the use of indoor air multi-contaminant risk calculator assessment tool at home heating oil spills where the spill is promptly reported, thoroughly investigated and the vapor source material is aggressively remediated. This concept allows use of the sub-chronic (7 year) risk scenario to develop targets. This document is a companion to Maine DEP's Excel Program "Home Heating Oil Indoor Air Input Sheet and Summary of Total Incremental Lifetime Cancer Risks and Endpoint-Specific Hazard Indices" dated February 2019.

2) LIMITATION

This guidance is not intended for use with gasoline vapor intrusion or when a significant home heating oil plume remains below a building. Nor is it intended for persistent compounds such us chlorinated solvents. A petroleum spill or a RHOTS with a significant plume still below a building may not be mitigated within a seven year period this guidance is not applicable for the sources and pathways that are complete for more than 7 years. Also, the guidance does not address non-human health endpoints, such as ecological impacts

3) BACKGROUND

The multi-contaminant risk calculator is used to determine the cumulative sub-chronic risk for the total Incremental Lifetime Cancer Risk (ILCR) and the endpoint specific Hazard Index (HI). Action Levels are for volatile chemicals found in #2 fuel oil and kerosene.

The Risk Calculator uses the screening levels (SLs) developed using risk assessment guidance from the EPA Superfund program. The SLs are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data. The Risk Calculator determines the individual risk for each chemical analyzed and the risks are summed to determine if the overall ICLR risk exceeds 1 x 10^{-5} for residential exposure or non-residential exposure. The Risk Calculator also determines the HI risk for each chemical. The individual HI risks are summed to determine if the overall HI risk exceeds 1.

The EPA Screening Levels are determined for residential exposure and indoor worker exposure. The Risk Calculator uses the indoor worker scenario for non-residential exposures where the occupants are only present for part of the day such as schools, businesses, office buildings, and day cares. The residential exposure scenario is used for households nursing homes and hospitals where the occupants are living at the site.

REFERENCES

EPA Regional Screening Levels Calculator, May 2019
"https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search"

The EPA updates the RLS's on a semiannual basis. When the updates are published, the calculator will be updated as well.

4) GUIDELINES AND PROCEDURES

Laboratory canisters should be located in a place to conservatively represent the exposure. A Laboratory Certified in Maine for TO-15, TO-15 SIM and APH analysis should be used. The concentration results are entered into the respective boxes in the Excel Program for each chemical. The individual ICLR and HI results are shown in the cancer and noncancer risk summary. If an individual compound is above the action level, the risk will present as in bold, red font. The Risk Calculator sums the individual risks to determine the cumulative results. Incremental Lifetime Cancer Risk Action Level is a cumulative risk above 1 E-05. 1 E-05 is an increased cancer risk of 1 in 100,000. Hazard Index Action level is any cumulative risk above 1.

The Individual risk summary section reports the results with 3 significant digits. The cumulative results sections report the results with only 1 significant digit. One significant digit is used to determine if the results are above the action levels. Therefore, an ICLR results of 1.49 E-05 and a HI results of 1.49 are both below their respective action levels when rounded and will only be displayed as red and bold when they are above 1.49 E-05 and 1.49 respectively.

In addition to Maine DEP, Maine's Division of Toxicology, within the Environmental Health Unit of CDC, is to be immediately informed when a spill has occurred at a sensitive receptor such as schools, daycares, and/or elderly care facilities as site specific protocols and communications may be necessary.

REFERENCES

EPA Regional Screening Levels Calculator, May 2019
"https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search"

State of Maine – DEP - BRWM
Petroleum Remediation Guidelines SOP 009
Investigating and Remediating Vapor Source Material at
Residential Heating Oil Tank Spills
Appendix B Indoor Air Input Sheet and
Summary of Total ILCR and Hazard Indices

Site:		Sample Date:	
Town		Sample ID	
Spill No.		Lab:	
Risk Calculator for Residential Heating Oil Tank Spills Only		Sample Location:	

CAS Number	Chemical	Indoor Air Concentration (ug/m^3)	Maine Typical Residential Indoor Air (ug/m^3)
106-99-0	1,3-Butadiene		0.38
1634-04-4	Methyl tert-butyl ether		NA
71-43-2	Benzene		2.9
DEP2038	C5-C8 Aliphatics		240
108-88-3	Toluene		34
100-41-4	Ethylbenzene		3.5
1330-20-7	Xylene		19
DEP2039	C9-C12 Aliphatics		230
DEP2040	C9-C10 Aromatics		43
91-20-3	Naphthalene		1.6

RISK SUMMARY

Resident Sub-chronic (7 year)		Non-Resident Sub-chronic (7 year)	
non-cancer	cancer	non-cancer	cancer

Resident	
	Subchronic
Cumulative ILCR	
Cumulative HI	

Non-Resident	
	Subchronic
Cumulative ILCR	
Cumulative HI	

Notes:

ILCR and HIs above the Action Levels are written in red.
Incremental Lifetime Cancer Risk (ICLR) Action Level is anything greater than 1E-05.
1E-05 is an increased risk of cancer of 1 in 100,000.

Hazard Index (HI) Action Levels are any HI levels greater than 1

Sub-Chronic Action levels are based on 7 years of exposure at the same concentration.

The Risk Summary Chart shows the ICLR and HQ for each specific compound by itself.

The Cumulative ILCR shows the combined effect of all the compounds on the ILCR Result.

This version of the risk calculator is not to be used for gasoline sites.

Maine DEP report titled " Typical Concentrations of Petroleum Compounds in Maine Residential Indoor Air, January 2014."
Link to report: https://www.maine.gov/dep/spills/petroleum/documents/typical_compounds4-2012rev2014.pdf

Version: November 18, 2019

Updated from EPA's RSL **May 18, 2020** (no changes made)

Appendix C – Vapor Intrusion (VI) Screening at Sites with Historical Gasoline Contamination

RWM-PP-009 Appendix C

Vapor Intrusion Screening at Historic Gasoline Sites

1) APPLICABILITY

This appendix is applicable to assessing petroleum vapor intrusion potential associated with residual, historic gasoline contamination encountered and/or suspected. It is applicable to property redevelopment, ownership transfer, in any of BRWM programs, including the petroleum program and the VRAP. This appendix is a companion to Maine DEP's "PVI Flow Chart" dated June 2019. This appendix replaces the petroleum vapor intrusion screening process in DEP's 2010 VI Guidance.

2) LIMITATION

This guidance is not intended for use where gasoline vapor intrusion is obvious and or related to a recent discharge. If vapor intrusion is obvious, inform occupants to immediately evacuate and notify emergency fire and response personnel. This guidance is not applicable to home heating oil spills impacting indoor air.

3) BACKGROUND

Complete petroleum vapor intrusion pathways are primarily associated with recent catastrophic underground releases or surface spills that penetrate the surface which is not covered by this SOP. Petroleum Vapor Intrusion (PVI) is rarely detected through investigation of residual impacts from a historical release. Instances of PVI at historical releases involve gross impacts (residual free product on the water table and/or petroleum saturated soil), shallow groundwater (less than 15 feet), buildings located hydraulically downgradient from the gross contamination, and zones of densely developed mixed use buildings with buildings and utilities in close proximity to the residual contamination.

Historic petroleum investigations and clean ups were not designed to assess or address PVI so there is a possibility that vapor source material remains on a property even after the site has been closed by MEDEP. Vapor source material, or gross contamination, may have been identified during the historical clean-up but historic soil removal was limited by structures and or property boundaries. Additionally, new development may encroach upon gross levels of residual gasoline or connect migration pathways between the vapor source material and receptors who were not present at the time of the former investigations.

4) GUIDELINES AND PROCEDURES

This appendix and the accompanying Figure 1 provide a process that define levels of gasoline in soil and groundwater that are considered vapor source material and present vertical and lateral distances between vapor source material and receptors – "PVI inclusion distances". If vapor source material is detected or suspected within the inclusion distances, notify DEP to scope and schedule the follow up investigation. Vapor barriers and sub slab depressurization system infrastructure may be required by local codes and are recommended when developing within 100 feet of historical contamination.

In addition to Maine DEP, Maine’s Division of Toxicology, within the Environmental Health Unit of CDC, is to be immediately informed when sensitive receptors such as schools, daycares, and/or elderly care facilities are within the inclusion distance as site specific protocols and communications may be necessary.

5) REFRENCES

USEPA 2015, Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites, EPA-510-R-15-001, June 2015

GEI, 2012, Summary Report, State of Maine, Vapor Intrusion Study for Petroleum Sites, Prepared for State of Maine DEP, prepared by GEI Consultants, Inc., January 2012

NH-DES, 2013. Revised Vapor Intrusion Screening Levels and TCE Update; Vapor Intrusion Guidance, Waste Management Division Update, State of New Hampshire Department of Environmental Services; February 3, 2013

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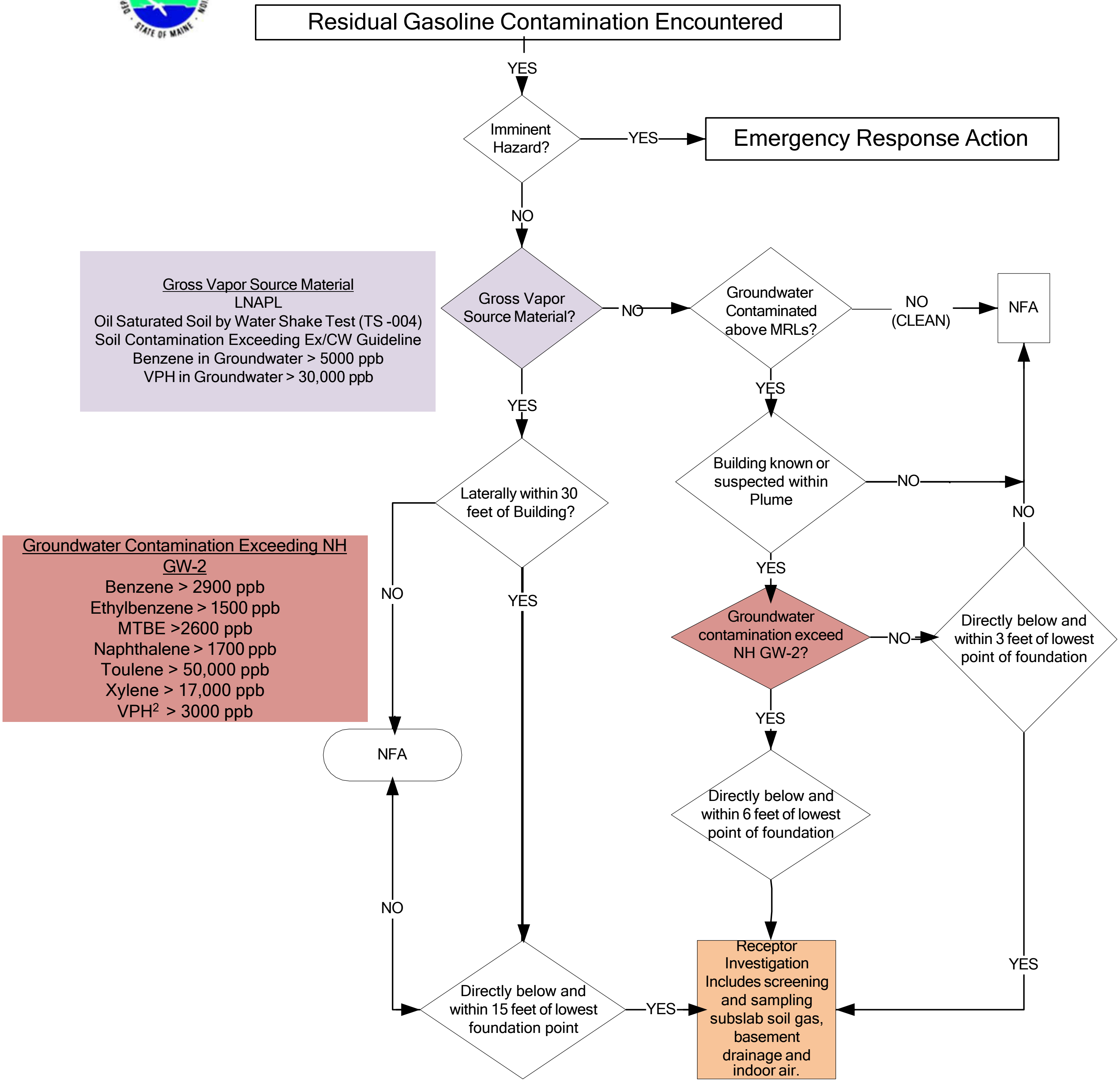
FIGURE 1 - VI Screening at Sites with Historical Gasoline Contamination

Revision No. 01
Interim dated May 30, 2019,



<u>Gross Vapor Source Material</u>
LNAPL
Oil Saturated Soil by Water Shake Test (TS -004)
Soil Contamination Exceeding Ex/CW Guideline
Benzene in Groundwater > 5000 ppb
VPH in Groundwater > 30,000 ppb

<u>Groundwater Contamination Exceeding NH GW-2</u>
Benzene > 2900 ppb
Ethylbenzene > 1500 ppb
MTBE >2600 ppb
Naphthalene > 1700 ppb
Toulene > 50,000 ppb
Xylene > 17,000 ppb
VPH[2] > 3000 ppb

<u>Receptor Subslab Screening/Sampling Criteria for Additional Action</u>
ELEVATED PID > 10 PPM
and/or depressed oxygen < 15%
and/or depressed CO2 < 1%
Or Sub slab APH analysis > 50 times IASL

<u>Receptor Basement Drainage Screening/Sampling Criteria for Additional Action</u>
DRAINAGE HEADSPACE PID > 5 PPM
Or DRAINAGE PIDSOW[3] > 10 PPM
Or DRAINAGE with SHEEN or VPH Analysis > 3 PPM

Note 1: Adapted from NH DES “Vapor Intrusion Guidance”, July 2006
Note 2: VPH GW-2 Standard from Massachussetts DEP
Note 3: PIDSOW = PID screening of oil in water by sampling with a 16 oz bottle, shaking, and PID screening headspace.

RWM-PP-009_VaporSourceInvestigationRemediation

Final Audit Report 2021-09-13

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COVER SHEET
STANDARD OPERATING PROCEDURE

Operation Title: **Water Sampling at Petroleum Release Sites**

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1. APPLICABILITY

This Standard Operating Procedure (SOP) applies to all programs in the Maine Department of Environmental Protection's (MEDEP) Bureau of Remediation and Waste Management (BRWM). It is also applicable to all parties that that may submit petroleum data that will be used by the DEP/BRWM.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2. PURPOSE

The purpose of this document is to describe the MEDEP/BRWM procedure for sampling water for the presence of petroleum-related contaminants and other contaminants that may occur at a petroleum release site. These contaminants include Volatile Petroleum Hydrocarbons (VPH), Extractable Petroleum Hydrocarbons (EPH), Total Extractable Petroleum Hydrocarbons (TEPH), Radon, Arsenic, Lead, Lead scavengers, Methyl tert-butyl ether (MTBE), and Per- and polyfluoroalkyl substances (PFAS). Water samples are collected from monitoring wells and water supply wells to determine extent of groundwater contamination and the impact of groundwater contamination on human health at the exposure point. This standard operating procedure (SOP) is designed to be a guideline for collecting water samples from these wells to assure samples are collected in a consistent, appropriate manner that will provide accurate data for making decisions and meeting the data quality objectives of the task.

3. RESPONSIBILITIES

All MEDEP/BRWM Staff must follow this procedure when performing this task. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/BRWM staff reviewing data by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4. DEFINITIONS

4.1 ARSENIC – A naturally occurring mineral that is used in industrial processes such as pesticide production and can be concentrated as a result of mining and ore smelting. Arsenic occurs naturally in ferric hydroxide minerals present in Maine aquifer materials (soil and bedrock) and can be desorbed from the aquifer and dissolved into groundwater under certain geochemical settings (reduced conditions). Under rare instances the biodegradation of petroleum contaminated groundwater may generate geochemical conditions that results in reductive dissolution and desorption of ferric hydroxide minerals and liberate arsenic from the aquifer.

4.2 EXTRACTABLE PETROLEUM HYDROCARBONS (EPH) - Massachusetts Department of Environmental Protection's Method for the Determination of Extractable Petroleum Hydrocarbons (EPH). https://www.mass.gov/guides/compendium-of-analytical-methods-cam#-petroleum-hydrocarbon-methods-

4.3 HYDROCARBON FRACTIONS- EPH/VPH methods report concentrations for specific carbon ranges that represent the remainder of the TPH mixture after the target compound concentrations have been subtracted. The hydrocarbon fractions analyzed by each analysis includes the following:

Hydrocarbon Fraction	**Analytical Method**
C9-C18 aliphatics	EPH
C19-C36 aliphatics	EPH
C11-C22 aromatics	EPH
C5-C8 aliphatics	VPH
C9-C12 aliphatics	VPH
C9-C10 aromatics	VPH

4.4 HYDROCARBON TARGET COMPOUNDS- EPH/VPH methods report concentrations for specific petroleum target compounds. The specific target compounds include poly aromatic hydrocarbons (PAHs), benzene, toluene, ethyl benzene, xylene, and MTBE. EPH/VPH methods do not analyze for lead or lead scavengers. Lead and lead scavenger compounds must be analyzed using appropriate analyses based on the CSM and Data Quality Objectives.

4.5 LEAD - Lead can be present in groundwater at some petroleum spill sites, high octane racing fuel, aviation gas (AvGas) and at older sites (pre-1986) where leaded motor fuel was stored and spilled.

4.6 LEAD SCAVENGERS - The common Lead Scavenger chemicals are ethylene dibromide (EDB) and 1,2dichloroethane (1,2 DCA).

4.7 METHYL TERT-BUTYL ETHER (MTBE) - An alcohol compound added to gasoline (circa 1979-2006) used to boost octane as a replacement for Lead.

4.8 PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) - Synthetic (man-made) organofluorine chemical compounds that have multiple fluorine atoms attached to an alkyl chain that includes PFOA, PFOS, GenX, and many other chemicals. PFAS have been manufactured and used in a variety of industries since the 1940s, notably fire-fighting foams. There is evidence that exposure to PFAS can lead to adverse human health effects.

4.9 RADON - A colorless and odorless gas present in soils and dissolved in groundwater that is produced from the natural decay of uranium and radium present in Maine bedrock and soils.

4.9 SAMPLE LOCATION: The location where the water sample is collected (i.e. kitchen faucet, outside spigot, pressure tank, before filter, after filter, before softener, well head, etc.) at a given sample point.

4.10 SAMPLE POINT NAME: The unique name assigned to the sample point that is consistent with the sample point name in EGAD and GIS. The sample point name is used to designate the sample point on the Chain of Custody and associated site maps.

4.11 TOTAL EXTRACTABLE PETROLEUM HYDROCARBONS (TEPH) - The fractionation step described in the EPH method can be eliminated to allow for a determination of a Total Petroleum Hydrocarbon (TEPH), and/or to obtain qualitative “fingerprinting” information. While TEPH provides little information on the chemical constituents, toxicity, or environmental fate of petroleum mixtures, it may be a cost-effective screening tool in cases where relatively low concentrations of contamination are suspected.

4.12 VOLATILE PETROLEUM HYDROCARBONS (VPH) - Massachusetts Department of Environmental Protection’s Method for the Determination of Volatile Petroleum Hydrocarbons (VPH) https://www.mass.gov/guides/compendium-of-analytical-methods-cam#-petroleum-hydrocarbon-methods-

5. GUIDELINES AND PROCEDURES

5.1 INTRODUCTION

Correct sampling of groundwater for petroleum and related compounds is essential to the proper investigation of groundwater contamination at petroleum spill sites. Many compounds related to petroleum may be important to add to the Conceptual Site Model (CSM; SOP RWM-PP-006) and Sampling and Analysis Plan (SAP; SOP RWM-PP-007) depending on site-specific criteria. Each well represents a monitoring well for local groundwater and such data must be factored into the groundwater investigation program.

Volatile Petroleum Hydrocarbons (VPH) – Analysis for VPH compounds is important at gasoline and very recent fuel oil, kerosene, or diesel spill sites. VPH analyses should be conducted in accordance with the Massachusetts Department of Environmental Protection's Method for the Determination of Volatile Petroleum Hydrocarbons (VPH) https://www.mass.gov/files/documents/2018/02/23/VPH%20GC%20PIDFID_Revision%202_1_February%202018.pdf

Extractable Petroleum Hydrocarbons (EPH) – Analysis for EPH compounds is important at fuel oil, kerosene, and diesel spill sites. All human health related decisions must be made based on EPH analysis because the list of analytes corresponds to the Department's Petroleum Clean-up Guidelines. EPH analyses should be conducted in accordance with the Massachusetts Department of Environmental Protection's Method for the Determination of Extractable Petroleum Hydrocarbons (EPH). https://www.mass.gov/files/documents/2017/12/21/MassDEP%20EPH%20Method%20-%20May%202004%20v1.1.pdf

Total Extractable Petroleum Hydrocarbons (TEPH) – Analysis for TEPH compounds can be used as a screening tool at fuel oil, kerosene, and diesel spill sites. Human health related decisions cannot be made based on TEPH analysis. All human health related decisions must be made based on the full EPH analysis because the list of analytes corresponds to the Department's Petroleum Clean-up Guidelines.

Radon – When a Water Supply Well is found to be contaminated with petroleum compounds above the Remedial Action Guidelines (RAGs), a Granular Activated Charcoal (GAC) filter system is installed in the drinking water system. Radon is a naturally occurring element present in groundwater and at high concentrations can cause the accumulation of radioactive elements in GAC filter systems to a problematic level. Whenever a GAC filter system is installed, a water sample must be tested for Radon to determine if it may cause problematic accumulation of radionuclides in the GAC system.

Arsenic – When a large petroleum spill occurs, biodegradation of petroleum in groundwater may create geochemical conditions leading to reductive dissolution and desorption of ferric hydroxide minerals that may contain arsenic. BRWM staff should analyze for arsenic at sites where there is a large volume of petroleum released, and petroleum has reached, or is likely to reach, the bedrock and/or groundwater.

Lead – Lead can be present in water samples at some petroleum spill sites, older sites where leaded motor fuel was stored and spilled, and past and present high-octane fuel and aviation gas (AvGas) spill sites. Sample for Lead at gasoline motor fuel sites where the spill pre-dates 1986. Sample at sites where the spill happened between 1986 and 1996 depending on whether the facility stored leaded fuel. Sample sites with discharges after 1996 only if they involve aviation gasoline or high-octane fuel such as racing motor fuel that contain lead or are suspected of containing lead.

Lead Scavengers – Where Lead is likely present as a groundwater contaminant it is important to test for volatile chemicals called Lead Scavengers. These chemicals were added to leaded fuels to prevent lead deposits building up inside internal combustion engines. The common Lead Scavenger chemicals are ethylene dibromide (EDB) and 1,2 dichloroethane (1,2 DCA). Sample for Lead Scavengers at gasoline motor fuel sites where the spill pre-dates 1986. Sample at sites where the spill happened between 1986 and 1996 depending on whether the facility stored leaded fuel. Sample sites with discharges after 1996 only if they involve aviation gasoline or racing motor fuel that contain lead or are suspected of containing lead.

Methyl tert-butyl ether (MTBE) – Beginning in approximately 1979 MTBE was added to gasoline as an octane booster to replace Lead. Its chemical structure causes it to dissolve readily in groundwater after a spill and can travel with groundwater to human health receptors. MTBE is included in a VPH analysis.

Per- and polyfluoroalkyl substances (PFAS) – PFAS compounds are a group of man-made chemicals that includes PFOA, PFOS, GenX, and many other chemicals. They are used in some fire-fighting foams. When a petroleum fire (i.e vehicle fire, structure fire with petroleum) is extinguished with fire-fighting foam some residual foam may enter groundwater along with petroleum spilled from the vehicle.

This procedure includes three attachments, including the following:

- Addendum A- Additional Requirements for the samplings of Per- and Polyfluoroalkyl Substances (PFAS)
- Addendum B - Additional Requirements for the samplings of Radon for the purpose of Managing Groundwater Treatment Systems
- Addendum C - Additional Requirements for Determining the Nature of Arsenic Concentrations in Water Supplies at Petroleum Contamination Sites

5.2 PLANNING

A well-developed CSM (RWM-PP-006) is imperative for effective use of this technique. Prior to conducting any sampling event, a SAP should be developed (SOP RWM-PP-007). During this phase, it is important to identify which petroleum analysis to use and if it is likely that other, non-petroleum, compounds might be present in the groundwater.

5.2.1 EQUIPMENT

A majority of the Petroleum Program monitoring includes private water supply sampling. Below is a list of recommended equipment to have when conducting water supply sampling.

- Bucket (to collect excess water when sampling treatment systems),
- Disposable nitrile gloves (to prevent exposure and/or cross-contamination),
- Flashlight (to enter dark basements/cellars),
- Field Notebook (to record pertinent information),
- Chain of Custody Forms (to document chain-of-custody),
- Label Tags (to label sample points at households with filters),
- Container of clean water (for rinsing),
- Container of Soapy Water (for washing),
- Sample Containers from laboratory
- Fitting and section of hose to attach to spigot

5.2.2 HEALTH AND SAFETY

A site safety plan in accordance with SOP-RWM-PP-071 is required for all site activities, including collecting water samples. Whenever sampling water from any point, at a minimum wear disposable nitrile gloves and safety glasses. Hand and eye protection decrease the chance of dermal exposure and reduces the chance of cross-contamination of samples. Also be aware of physical hazards; treatment systems are usually located in the basement, so make sure to take a flashlight. Watch for overhead hazards such as low ceilings and/or hanging objects. Be especially careful of electrical hazards such as outlets near the sampling area and/or bare wires. Do not purposefully sniff the sample for odors as contaminated water may contain unhealthy levels of volatile compounds. Lastly, try not to splash the water when sampling; splashing contaminated water in the eyes or on exposed skin could be harmful if the water is significantly contaminated. If water supplies are known or suspected to be contaminated, care should be taken to avoid cross-contamination with other water samples being collected as part of the same sampling event.

5.3 PROCEDURE

5.3.1 OVERVIEW

Sampling Water Supplies Without DEP Installed Treatment System

When sampling a water supply well without any treatment system, samples may be obtained from an indoor faucet (kitchen, bathroom, other), or an outside faucet (spigot). If MEDEP has sampled the well previously and conditions have not changed (house renovations, family size, etc.) samples should be obtained from the same location as previously sampled. If MEDEP has not sampled the well before, or if conditions have changed, samplers should inspect the plumbing and select a sample location closest to the pressure tank or pump. Samplers should make sure that the sample point is clean (i.e., no grease, lead soldering, or other possible contaminants) and that no possible sources of cross-contamination (gas cans, solvents, etc.) are nearby. If a water treatment system (such as radon, sediment filters, or water softeners) is present, the sample should be collected prior to these systems. If sampling from a faucet, remove the aerator; if sampling from an outside spigot, remove existing hoses from the spigot. Run the water on cold at full flow for least ten (10) minutes prior to collecting a sample. Running the water will accomplish two goals. First, it will purge the pipes of any stagnant water; second, it will drain the pressure tank and cause the pump to turn on and start pumping water from the well. This should allow the collection of a representative sample from the well.

Record any observations and/or comments about matters pertinent to the sample location or to the site.

After the water has run for approximately 10 minutes, reduce the flow to facilitate sample collection with minimal aeration and begin filling the laboratory containers. Do not adjust flow rate when collecting an EPH sample to avoid false positive detections related to plumbing grease. See Section 6.4.3 below for special procedures when sampling for EPH or VPH.

Sampling Households With Treatment System(s)

For households with a treatment system installed, samplers should collect samples after the treatment system first (post-treatment), between treatment devices second, and before the treatment system (pre-treatment) last to reduce likelihood of cross-contamination. The pre-treatment samples should be collected before any filter, softener, or other device that the landowner or MEDEP has installed. The plumbing system, including any treatment devices should be purged by turning on a faucet located on the downstream end of the devices. This may be a kitchen faucet, bathroom faucet, or outside spigot. When sampling from a faucet, remove the aerator prior to purging and sampling. Sufficient water should be purged to flush the treatment devices as completely as possible (10-20 minutes depending on the number of devices present). In most situations, purging can continue while samples are being collected at the designated sample points. The sample before the filter system is taken last due to its highest probability of being contaminated. If multiple treatment systems are present, sampling should proceed from point of use to point of entry (clean to dirty), in order to reduce potential for cross-contamination. Care should be taken to accurately label the sample containers with the correct sample location designation (after, before, between filters). Each sample port location should be purged for 10 to twenty seconds to remove stagnant water prior to sample collection. When sampling, it may be appropriate to attach polyethylene tubing to the sampling port and collect purge water in a bucket. Properly preserved laboratory containers should be filled using a flow rate that is appropriate for the type of analysis and container type.

If multiple treatment devices are present, it may be necessary to take more samples. Samplers should take care to accurately identify and label sample locations and associated laboratory containers. Filtration devices can often be bypassed with bypass valves included in the plumbing. 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. Be sure to include contingencies for such devices in the sampling plan.

Once all the samples have been collected at a water supply, remove gloves, and return all plumbing to its original position (aerator back on faucet, all sample ports closed, etc.). Record water meter readings if the residence is equipped with a meter. Be sure to properly record the units of the meter(cubic feet or gallons). The water meter reading will give (in conjunction with the previous reading) the amount of water being used, which is useful in predicting/explaining the breakthrough in GAC filters. Place the samples in a cooler on ice for transport to the laboratory.

Sampling from Monitoring Wells

When sampling from monitoring wells, reference MEDEP SOP# RMW-DR-002, and 003. These SOPs describe the procedures for collecting groundwater samples for investigation and assessment monitoring (MEDEP SOP# RWM-DR-002) and long-term groundwater plume monitoring (MEDEP SOP# RWM-DR-003).

Analysis-Specific Considerations

Volatile Petroleum Hydrocarbons (VPH) – When gasoline is a chemical of concern at the site VPH analysis is used to quantify water contamination from a release. The VPH method produces chemical concentration data to compare to PRGs. The lab method used is Massachusetts DEP VPH. Fill the lab-provided 40 ml glassware with water at a slow enough rate to avoid bubbles and agitation. Glassware comes from the lab preserved with Hydrochloric Acid.

Extractable Petroleum Hydrocarbons (EPH) – When fuel oil/diesel/kerosene are chemicals of concern at the site EPH analysis is used to quantify water contamination from a release. The EPH method produces chemical concentration data to compare to PRGs. The lab method used is Massachusetts DEP EPH. Fill the lab-provided one-liter amber glassware. The glassware comes from the lab preserved with Hydrochloric Acid.

Total Extractable Petroleum Hydrocarbons (TEPH) – When fuel oil/diesel/kerosene are chemicals of concern at the site, TEPH analysis is used as a screening test for petroleum in water from a release. This method does not produce data comparable to Petroleum Clean-up Guidelines. The lab method used is Massachusetts DEP EPH. Fill the lab-provided one-liter amber glassware. The glassware comes from the lab preserved with Hydrochloric Acid.

Radon – Samples should be analyzed using EPA laboratory Methods 913.0 or SM 7500-RN B. Fill the laboratory-provided 40 mL glassware with the sample water in accordance with the procedure outlined in Addendum B of this SOP. Also see Addendum B of this SOP for guidance on interpretation of radon results when managing groundwater water treatment and filtration systems.

Arsenic – Samples should be analyzed using test EPA laboratory Methods 200.7 or 200.8. Fill the laboratory-provided 250-mL plastic bottles with the sample water. Bottles come from the laboratory preserved with Nitric Acid. Arsenic samples should be collected and interpreted in accordance with Addendum C of this SOP.

Lead – Use EPA laboratory Methods 200.7, 200.8 or 200.9. Fill the lab-provided 250 ml plastic bottles with water. Bottles come from the lab preserved with Nitric Acid.

Lead scavengers – Use EPA laboratory Method 8260D for 1,2 DCA and EPA Method 8011 for EDB. Fill the lab-provided 40 ml glassware with water at a slow enough rate to avoid bubbles and agitation. Glassware comes from the lab preserved with Hydrochloric Acid.

Methyl tert-butyl ether (MTBE) – MTBE is included in the analyte list for the VPH testing method. Fill the lab-provided 40 ml glassware with water at a slow enough rate to avoid bubbles and agitation. Glassware comes from the lab preserved with Hydrochloric Acid.

Per- and polyfluoroalkyl substances (PFAS) – The method used is Modified EPA Method 537, with isotope dilution or EPA method 533. Additional analyses for Total Oxidizable Precursors (TOP) using TOP Assay may be necessary, depending on the Data Quality Objectives for the sampling event (see SOP RWM-PP-007). Samplers will also follow Addendum A - Additional Requirements for the Sampling of PFAS, PFOA and PFOS. All water samples will be collected using dedicated PFAS-free sampling equipment. Prior to sampling each location, the sample handler must rinse their hands and don nitrile gloves. PFAS contamination during sample collection can occur from common sources, including food packaging and certain foods and beverages. Proper hand rinsing and wearing nitrile gloves will help to minimize this type of accidental contamination of the samples. Samples collected for PFAS analysis do not have to be headspace free.

5.3.2 PROJECT SPECIFIC CONSIDERATIONS

The introduction and procedures for each contaminant of concern discussed above should be addressed during sampling. Additionally, there are certain situations that require unique sampling methods. For example, when sampling for petroleum hydrocarbons by either the VPH or EPH methods, it may be necessary to collect samples from spigots at high flow rates to avoid false positive detections related to the plumbing grease present on the threads or in the shut-off valves (faucets). A section of hose fitted with a "Y"-control valve may be required to assure that grease associated with the moving parts of the fixture or spigot is not introduced into the sample by opening or closing the fixture just prior to sampling.

Another example of a unique situation is when tritium is used to investigate the relative age of the groundwater. Samplers need to remove their watches before collecting samples that will be analyzed for tritium (if the watch is a tritium-illuminated type). Special circumstances should be outlined in the sampling plan.

Samples collected for PFAS must follow procedures in Addendum A to this SOP.

Samples collected for Radon must follow procedures in Addendum B to this SOP.

Samples collected for Arsenic must follow procedures in Addendum C to this SOP.

6. QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

In order to ensure that the samples are representative of the water at a given sampling point, the sampler must pay close attention to QA/QC procedures. At each household the sampler must be aware of four (4) areas which may be sources of cross-contamination of the samples: 1) samplers hands--wear a new pair of gloves at every residence sampled and at each sample point; 2) sampling order--sample at the least contaminated households first, the most contaminated last; and at the least contaminated point in any filtration system first (post-filter) and the most contaminated point last (pre-filter) 3) self-contamination--make sure the sampling area is free of any possible sources of contamination (grease on the tap, solvent bottles near the sample port, etc.), and; 4) piping--look at the plumbing and pipe materials and note the presence of lead soldering or improper lubrication (i.e. WD-40, oil, etc.) on the pipes. Also, ask the resident if any work had recently been done on the well, plumbing, or any other components of the water system.

For all Petroleum Program sites, duplicate samples should be collected in accordance with the Leaking Underground Storage Tank (LUST) Quality Assurance Project Plan (QAPP). Typically, the LUST QAPP specifies collecting a duplicate sample for petroleum compounds in groundwater for one out of every ten samples analyzed. A duplicate sample should not explicitly be identified on the sample container or chain of custody as a duplicate. Instead a duplicate sample can be identified as a made up surname or address. Identify the duplicate sample and its co-located sample in your SAP and field notes or trip report.

A trip blank (prepared from contaminant free water by the laboratory or by MEDEP staff) should be preserved with the same preservative as the actual samples, stored and transported with the other samples collected during the sampling event, and then analyzed (along with the other samples) for the appropriate suspected contaminants by the lab. If a sampling event is completed and the trip blank contains contaminants, this indicates that the containers may not have been clean or other QA/QC procedures have failed. In this case, it may be necessary to re-sample.

Samplers should avoid fueling a vehicle until after the samples have been delivered to the laboratory or after securing them in a cooler. Avoid the use of colognes, perfumes and bug sprays on sampling days. In addition, sampling personnel should avoid any contact with inside surfaces of sample containers and covers or caps.

If sample results indicate that contamination is present at unanticipated levels or between filters re-sampling may be warranted. All sample data should be reviewed for possible sources of error before re-sampling the water supply. Re-check all field documentation from the trip to insure the sample identification or sample numbers were recorded correctly in both the field notebook and on the laboratory analysis request sheet and/or chain of custody. If the documentation check fails, go back to the site and re-sample. When re-sampling, be sure to check the plumbing to make sure all valves are properly opened and closed. An open bypass valve would bypass the filters and supply unfiltered raw water to the house.

7. DOCUMENTATION

Sample point naming should remain consistent through out the project, and any necessary changes should be clearly documented in the project file. Monitoring well names are typically assigned at installation. Addresses are best to use when identifying private water supply sample locations.

All sampling activities must be documented and include the following:

Sample Location Map using the sample point names recorded on the chain of custody
Site Name, Town, Spill Number
Names of Samplers
Date (s) of sample events
Data Quality Objectives
Sample Point Name
Sample Location
Collection Method
Laboratory Analyses
Comments and notes related to the sample locations

Documentation can include Attachment 1 from the SAP (RWM-PP-007), the sample location map from the CSM (RWM-PP-006), and the Chain of Custody for the specific event that provides legible information related to the samplers, sample date(s), and analyses. Alternatively, a Trip Report following SOP RWM-DR-013 that includes the above listed information can also be used to document a sampling event. Sample custody must be followed as outlined in MEDEP/DR SOP# RWM-DR-012 – Chain of Custody Protocol. Any Petroleum Program-specific chain of custody should include the assigned sample point name, sample location, and sample collection method as stated in the SAP.

8. REFERENCES

RWM-DR-001 Water Sample Collection from Water Supply Wells

RWM-DR-002 Groundwater Sample Collection for Site Investigation and Assessment Monitoring

RWM-DR-003 Groundwater Sampling Using Low Flow Purging and Sampling For Long-Term Monitoring

RWM-PP-007 Sampling and Analysis Plan for Petroleum Sites
RWM-PP-006 Conceptual Site Model for Petroleum Sites

ITRC – 2018, Total Petroleum Hydrocarbons Fundamentals.
https://tphrisk-1.itrcweb.org/4-tph-fundamentals/

COVER SHEET
STANDARD OPERATING PROCEDURE-ADDENDUM

OPERATION TITLE: <u>**DEVELOPMENT OF A SAMPLING AND ANALYSIS PLAN-**</u>

ADDENDUM - A – ADDITIONAL REQUIREMENTS FOR THE SAMPLING OF Per- and POLYFLUORALKYL SUBSTANCES (PFAS)

1.0 APPLICABILITY

This Standard Operating Procedure (SOP) ADDENDUM applies to all programs in the Maine Department of Environmental Protection's (MEDEP) Division of Remediation (DR). It is also applicable to all parties that may submit data that will be used by the DEP/DR.

This SOP ADDENDUM is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2.0 PURPOSE

The purpose of this document is to describe the MEDEP/DRs requirements for the development of a Sampling and Analysis Plan (SAP) with specific requirements for the sampling of compounds related to Per- and Polyfluoroalkyl Substances (PFASs), including Perfluorooctanoic acid (PFOA) and Perfluorooctane sulfonate (PFOS).

Prior to conducting any investigative field work, routine monitoring, post closure sampling or any data gathering/sample collection project, a SAP will be developed that outlines the goals of the activity and methodology to achieve that goal. A well-developed SAP that is reviewed by all field team members will assure that the goals are obtainable, the methodology is consistent, and the data generated will meet the Data Quality Objectives (DQOs) for the project.

Given the ubiquitous nature of PFAS compounds, the low detection levels that are generally requested, and the different methodologies for which these compounds are tested, additional requirements regarding sampling methodology, equipment, and analysis for PFAS compounds should be included as part of the sampling plan and during the sampling event. This document outlines those specific requirements to be included in a PFAS sampling plan and during sampling.

3.0 GUIDELINES AND PROCEDURES

3.1 INTRODUCTION

A sampling and analysis plan, regardless of whether sampling for PFAS compounds or other potential contaminants, should include all the elements in SOP RWM-DR-014 – Development of a Sampling and Analysis Plan. Although not required to be included in the SAP, (as outlined in SOP RWM-DR-014), an assessment of the existing data should be conducted, a site reconnaissance completed, a conceptual site model developed, and data quality objectives determined as part of planning to assure the SAP will meet the goals of the sampling.

The SAP itself should include the goal of the sampling, end use of data, data quality objectives, schedule, sampling methodology, sampling locations, media to be sampled, analytical parameters, and QA/QC samples. Additionally, a site specific health and safety plan may be necessary (see SOP-DR-014) depending on the scope of the sampling event. For example, collection of samples in a large or moving water body, or as part of large sampling effort involving drilling rigs and/or excavation equipment would require a health and safety plan; residential well sampling would likely not.

3.2 SAMPLING METHODOLOGY/EQUIPMENT

A description of the sampling methodology will be included in the SAP. Generally, reference to an appropriate SOP for the sample methodology will be sufficient. The Division has developed multiple SOPs for sample collection of most media; please refer to the Division of Remediation's Quality Assurance Plan - Attachment B – Data Collection SOPs for a list of all data collection standard operating procedures.

3.2.1 Sampling Methodology

Sampling for PFAS will follow the standard procedures as outlined in the specific sampling method SOPs. In addition, the following task must be included in the SAP and field staff must perform the task as described below to prevent contamination of the sample:

> "Prior to sampling each location the sample handler must wash their hands and don nitrile gloves. PFAS contamination during sample collection can occur from several common sources, including food packaging and certain foods and beverages. Proper hand washing and wearing nitrile gloves will help to minimize this type of accidental contamination of the samples."

It should be noted that samples collected for PFAS analysis do not have to be headspace free.

3.2.2 Sampling Equipment/Supplies/Personal Protective Equipment (PPE)

The low detection limits required for PFAS water analysis and their common occurrence in frequently used items warrant attention to equipment and PPE used for sampling. A sampling equipment list for PFAS projects should follow the material guidelines in Table 1 of Attachment A, avoiding use of LDPE and any Teflon-lined equipment or tubing. If field decontamination of non-disposable equipment is necessary, washing with an approved soap solution, rinsing with DI water and then a rinse with laboratory-supplied PFAS-free water is recommended. New nitrile gloves should be used between locations and activities. Other recommended clothing and PPE requirements are noted in Table 1 of Attachment A.

3.3 Media Sampled/Analytical Parameters

A chart outlining the media collected and sample analysis methodology will be included in the SAP.

PFOA and PFOS are the typical potential contaminants of concern (COCs) at PFAS sites, although laboratory reporting lists may include 12 to 26 PFAS compounds depending upon method and laboratory. An additional analysis that may be warranted is the sum of all PFAS present, either by total extractable fluorinated compounds (TOP analysis) or evaluation of total fluorine by a method such as proton induced gamma-ray emission (PIGE). Both of these techniques can be followed by analysis of specific compounds, to assess the presence of precursors in environmental media that are not captured by the compound specific methods.

Parameters will be identified by either laboratory analysis methodology number, or generally accepted name of analysis. Given the different methods currently available for sampling PFAS, there must be a clear understanding between the project manager and the laboratory providing the analysis as to what the media sampled, test methodology, and detection levels will be.

Table 1 provides several current methods with their associated media:

TABLE 1
Media/Analytical Methodology

MEDIA	LABORATORY METHOD	HOLD TIME*/ PRESERVATION	ANALYSIS TIME	Reporting List
Drinking Water**	USEPA Method 537	14 days to extraction/Trizma***	28 days after extraction	Method specific
Groundwater	Modified Method 537	14 days to extraction/<6°C	28 days after extraction	DEP Minibid list ****
Surface Water	Modified Method 537	14 days to extraction/<6°C	28 days after extraction	DEP Minibid list ****
Soil/Sediment/sludge	Modified Method 537	14 days to extraction/<6°C	28 days after extraction	DEP Minibid list ****
Other (vegetation…)	Modified Method 537	Lab specific	Lab specific	DEP Minibid list ****
Water or Soil	TOP or other total fluorinated analysis	Lab specific/<6°C	Lab specific	Method specific

* Hold times may vary with contracted laboratory
** USEPA 537 is the only certified method for drinking water
*** Trizma needed for samples that may contain residual chlorine from treated water sources
*** Longer reporting lists may vary between laboratories, generally the DEP mini-bid list can be used for comparison to other selected laboratories

Other methods may be appropriate based on the data quality objectives of the sampling project.

The contracted analytical laboratory must be Maine certified to perform any method for which Maine provides certification. The contract lab must be able to accommodate the sample load and perform the analyses within holding times. The contract lab must be able to achieve PQLs, for all analyses, which are below the associated regulatory guideline value.

Deviations can be made from the laboratory method on a site or event specific basis, based on the goals of the sampling, end use of the data, and the data quality objectives. Rationale for deviations from these methods should be described in the SAP and/or the final report.

As with all parameters, containers, preservation, and holding times will be as recommended by the laboratory providing analytical services. Special or out of the ordinary containers or preservation should be noted in the SAP.

3.4 FIELD QC SAMPLES

Sample collection for PFAS analysis does not require specific field QC samples outside the normal requirements.

General recommendations for all sampling include one aqueous field blank, per field event, to be analyzed for PFASs to determine if water samples have been contaminated by sources unrelated to the project area, and to assess the overall field procedures. An equipment blank may be needed if non-dedicated equipment is used. The field blank is typically one bottle of PFAS-free water supplied by the laboratory, which is uncapped and poured to a second bottle. For multi-day events, one blank per day should be considered. If non-disposable equipment is used a PFAS-free water equipment blank is warranted to check field decontamination procedures.

4.0 PFAS SPECIFIC TEMPLATE

In the instances of a PFAS only sampling event, in which samples are being collected from a project which has a history of sampling for other analytes and a well-developed conceptual site model and/or an SAP already exists, a PFAS sampling specific template has been developed which provides the general requirements of a sampling plan. This template can be found in Attachment A of this Addendum.

5.0 REPORT GENERATION

As stated in SOP RWM-DR-014, A Sampling Event Trip Report (SETR) will be developed for every sampling event (see MEDEP/DR SOP# RWM-DR-013). The staff person responsible for developing the SETR will be stated in the SAP. Data obtained as part of the SAP will be assessed in the final report for which the data has been collected.

ATTACHMENT A
PFOA SAMPLING AND ANALYSIS PLAN FORM TEMPLATE

ATTACHMENT A -
PFAS SAMPLING AND ANALYSIS PLAN FORM TEMPLATE –
04/08/2020

1.1 INTRODUCTION

The introduction will state the objectives of the sampling plan which include:

- Goals of the sampling plan;
- End use of data.

2.0 BACKGROUND INFORMATION

A BRIEF explanation of the background of the Site and/or conceptual site model (CSM) and reason for sampling for PFAS will be presented.

3.0 SITE SPECIFIC HEALTH AND SAFETY PLAN

If determined necessary, a Site-Specific Health and Safety plan (HASP) will be developed and attached.

4.1 SAMPLING METHODOLOGY/ EQUIPMENT

A description of the sampling methodology will be included in the SAP. In instances where a MEDEP/DR SOP is available, reference to SOPs by either name or document number is sufficient.

Prior to sampling each location the sample handler must wash their hands and don nitrile gloves. PFAS contamination during sample collection can occur from a number of common sources, including food packaging and certain foods and beverages. Proper hand washing and wearing nitrile gloves will help to minimize this type of accidental contamination of the samples, particularly when moving pumps, generators or other equipment between sample points.

Some sampling equipment, field supplies, field clothing and personal protective equipment are prohibited when sampling for PFAS. Table 1 outlines the prohibited items. This table must be included in the SOP and field staff informed as to what equipment is allowed.

Table 1: Summary of Prohibited and Acceptable Items for Use in PFAS Sampling

Prohibited Items	Acceptable Items
Field Equipment	
Teflon® containing materials. Aluminum foil.	High-density polyethylene (HDPE) and stainless steel materials
Storage of samples in containers made of LDPE materials	Acetate direct push liners
Teflon® tubing	Silicon or HDPE tubing
Waterproof field books. Water resistant sample bottle labels.	Loose paper (non-waterproof). Paper sample labels covered with clear packing tape, or lab-applied labels.
Plastic clipboards, binders, or spiral hard cover notebooks	Aluminum or Masonite field clipboards
	Sharpies®, pens
Post-It Notes	
Chemical (blue) ice packs	Regular ice
Excel Purity Paste TFW Multipurpose Thread Sealant Vibra-Tite Thread Sealant	Gasoils NT Non-PTFE Thread Sealant Bentonite
Equipment with Viton Components (need to be evaluated on a case by case basis, Viton contains PTFE, but may be acceptable if used in gaskets or O - rings that are sealed away and will not come into contact with sample or sampling equipment.)	
Field Clothing and PPE	
New clothing or water resistant, waterproof, or stain treated clothing, clothing laundered with fabric softeners, clothing containing Gore-Tex™	Well-laundered clothing, defined as clothing that has been washed 6 or more times after purchase, made of synthetic or natural fibers (preferable cotton). Cotton coveralls are one option that reduces the need for specialized personal clothing.
Clothing laundered using fabric softener	No fabric softener
Boots containing Gore-Tex™	Boots made with polyurethane and PVC for wet conditions, or rubber overboots ("chicken boots")
	Reflective safety vests, Tyvek®, Cotton clothing, synthetic under clothing, medical braces

No cosmetics, moisturizers, hand cream, or other related products as part of personal cleaning/showering routine on the morning of sampling	**Sunscreens -** sunscreens that are "free" or "natural", or UV blocking clothing **Insect Repellents -** Sawyer permethrin clothing treatment, Deep Woods Off, Insect Shield pre-treated clothing (1)
Sample Containers	
LDPE, glass containers or passive diffusion bags.	HDPE (any media) or polypropylene (only for EPA Method 537.1 samples)
Teflon®-lined caps	Lined or unlined HDPE or polypropylene caps
Rain Events	
Gore-Tex™ or similar breathable coated waterproof or resistant rain gear	Polyurethane, vinyl, wax or rubber-coated rain gear. Gazebo tent that is only touched or moved prior to and following sampling activities
Equipment Decontamination	
Decon 90	Alconox® and/or Liquinox®
Water from an on-site well	Potable water from municipal drinking water supply (if tested as PFAS-free); Lab-supplied PFAS-free water
Food Considerations	
All food and drink, with exceptions noted on the right	Bottled water and hydration drinks (i.e. Gatorade® and Powerade®) to be brought and consumed only in the staging area

(1) Bartlett SA, Davis KL. Evaluating PFAS cross contamination issues. *Remediation*. 2018;28:53–57.

It is recommended that all water samples will be collected using dedicated or disposable sampling equipment where possible. Any re-usable equipment, such as plumbing fittings, that may be needed in certain cases to obtain a sample from the pressure tank tap, should be deconned using Alconox/Liquinox soap and rinsed with PFAS-free water prior to use and between locations.

5.0 Sample Locations

A map showing planned sampling locations will be included in the sampling plan. If locations are not pre - determined, the method that samples will be chosen and collected (field observations, random, etc.) will be outlined in the SAP. Field or laboratory compositing procedures will also be described, if applicable.

This section should also indicate sampling collection priority and order, to assure that the most important samples are obtained, and that sampling is generally done from low areas of contamination to higher levels of contamination. It is recommended that critical samples be collected in duplicate.

6.0 Media Sampled

A chart outlining the media collected and sample analysis will be included in the SAP. Table 2 provides several current methods with their associated media:

TABLE 2
Media/Analytical Methodology

MEDIA	LABORATORY METHOD	HOLD TIME*/ PRESERVATION	ANALYSIS TIME	Reporting List
Public Drinking Water Supply **	USEPA Method 537.1	14 days to extraction/Trizma***	28 days after extraction	Method specific
Groundwater and Private Water Supplies	Modified Method 537 (Isotope Dilution)	14 days to extraction/<6°C	28 days after extraction	DEP Minibid list ****
Surface Water	Modified Method 537 (Isotope Dilution)	14 days to extraction/<6°C	28 days after extraction	DEP Minibid list ****
Soil/Sediment/sludge	Modified Method 537 (Isotope Dilution)	14 days to extraction/<6°C	28 days after extraction	DEP Minibid list ****
Other (vegetation…)	Modified Method 537 (Isotope Dilution)	Lab specific	Lab specific	DEP Minibid list ****
Water or Soil	TOP or other total fluorinated analysis	Lab specific/<6°C	Lab specific	Method specific

* Hold time of 14 days is specified by DEP

** USEPA 537.1 is currently the only Maine certified method for drinking water, others such as Method 533 will be offered in the future

*** Trizma needed for samples that may contain residual chlorine from treated water sources

**** Longer reporting lists may vary between laboratories, generally the DEP mini-bid list can be used for all projects

Other methods may be appropriate based on the data quality objectives of the sampling project.

The contracted analytical laboratory must be Maine certified to perform any method for which Maine provides certification. The contract lab must be able to accommodate the sample load and perform the analyses within holding times. The contract lab must be able to achieve PQLs, for all analyses, which are below the associated regulatory guideline value.

Containers, preservation, and holding times will be as recommended by the laboratory providing analytical services. Special or out of the ordinary containers or preservation should be noted in the SAP.

7.0 FIELD QC SAMPLES

The specific needs for QC samples for the project will be outlined. General requirements for PFAS sampling events include one aqueous field blank, per field event, to be tested for PFASs to determine if water samples have been contaminated by sources unrelated to the project area, and to assess the overall field procedures. The field blank is typically one bottle of PFAS-free water supplied by the laboratory, which is uncapped and poured to a second bottle. An equipment blank should be collected if non-dedicated equipment is used. For multi-day events, one blank per day should be considered, and for large events one blank per 10 or 20 samples is warranted, depending upon the project requirements. All blanks should be collected with laboratory supplied PFAS-free water. A source-water blank is handled like a trip blank, and assesses the laboratory supplied water and sample containers. This blank may be warranted depending on DEP experience with the laboratory or sensitivity of the project.

Additionally, any QC samples that will be collected in the field that are required as part of laboratory QC requirements and to allow data validation will be outlined.

4.9 REPORT GENERATION

A Sampling Event Trip Report (SETR) will be developed for every sampling event (See MEDEP/DR SOP# RWM-DR-013). Staff person responsible for developing the SETR will be stated.

COVER SHEET
STANDARD OPERATING PROCEDURE

Operation Title: **Water Sampling at Petroleum Release Sites**

ADDENDUM – B – ADDITIONAL REQUIREMENTS FOR THE SAMPLING OF RADON FOR THE PURPOSE OF MANAGING GROUNDWATER TREATMENT SYSTEMS

Originator: **Kelly Perkins**
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APPROVALS:

Division of Technical Services Director:

Print name	*Signature*	*Date*

Bureau of Remediation and Waste Management Director:

Print name	*Signature*	*Date*

QMSC Chair:

Print name	*Signature*	*Date*

Department Commissioner:

Print name	*Signature*	*Date*

DISTRIBUTION;

( ) Division of Technical Services .... By:_______________Date:________

1. APPLICABILITY

This Standard Operating Procedure (SOP) applies to all programs in the Maine Department of Environmental Protection's (MEDEP) BRWM (BRWM). It is also applicable to all parties that provide or oversee the installation or management of granular activated carbon filtration systems at MEDEP remediation sites.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2. PURPOSE

The purpose of this document is to describe the MEDEP/BRWM procedure for sampling water for the presence of radon and interpreting the results for the purposes of managing drinking water treatment systems.

3. RESPONSIBILITIES

All MEDEP/TS Staff must follow this procedure when performing this task. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/TS staff reviewing data by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4. DEFINITIONS AND ACCRONYMS

4.1 GAC – Granular Activated Carbon A filter media used to remove organic and inorganic contaminants dissolved in water and control odors. GAC is a form of processed carbon designed to have small, micropores to increase surface areas available for adsorption or chemical reactions. GAC is made from raw organic carbonaceous materials such as coconut shells, nut shells, peat, wood, or coal.

4.2 Low-level waste – Nuclear water that does not fit into the categorical definitions for intermediate-level waste (ILW), high-level waste (HLW), spent nuclear fuel (SNF), transuranic waste (TRU), or certain byproduct materials known as 11e (2) wastes, such as uranium mill tailings. Low-level waste includes items that have become contaminated with radioactive material or have become radioactive through exposure to neutron radiation.

4.3 pCi/L - Picocurie per Liter

4.4 POET – Point of Entry Treatment- A point of entry treatment system is a whole-house (building) water treatment solution at or before the point the water enters the building.

5. GUIDELINES AND PROCEDURES

5.1 INTRODUCTION

When water supplies become impacted with petroleum compounds, a point of entry treatment (POET) system consisting of GAC filters is often installed to remove petroleum contaminants from the water. GAC filters will also remove radon from water. When POET consisting of GAC is to be installed on a water supply, the concentration of radon in the water supply will need to be determined to ensure appropriate filter system location, and to consider the GAC change-out schedule and whether pre-treatment for radon is required. Additionally, when a replacement water supply well is installed at a site, the concentration of radon in that well will need to be determined.

5.2 PLANNING

Prior to conducting any sampling event, a Sampling and Analysis Plan (SAP) should be developed (see MEDEP/TS SOP# RWM-DR-014 - Development of a Sampling and Analysis Plan).

To complete the sampling activities, staff will need appropriate laboratory-provided sample containers, tubing, a hose adaptor, and a bowl or bucket that is large enough to submerge the sample container. When sampling directly from a wellhead it will be important to ensure that the well has been adequately developed, and a water pump, power source, and associated tubing will be required.

5.3 PROCEDURE

5.3.1 OVERVIEW

Those approved to sample water supplies for radon can collect the sample according a method approved by the Maine Department of Health and Human Services (DHHS) Radon Control Program. MEDEP staff will typically collect radon in drinking water samples using the DHHS-approved method outlined in this SOP.

Sample Collection:
When sampling an active water supply for radon, it is best to sample from the pressure tank faucet if accessible. Otherwise collect the sample from a sample port that is unfiltered being sure to remove the aerator and hoses if present. When sampling from a wellhead,

the discharge piping will need to have a valve installed with a barb to attach tubing. The water supply should be purged for 10 minutes prior to collecting the sample.

When it is time to collect the sample, attach the fitting and tubing to the spigot of the pressure tank (or the tubing to the barb on the piping valve) and start to fill the bowl or bucket. As you are filling the bowl or bucket, adjust the flow to eliminate bubbles or agitation. Fill the bucket enough to be able to submerge the sample container in the water. Once the sample container is submerged, insert the tubing into the mouth of the sample container. Flush the sample container twice, then fill the sample container while it is submerged. Cap the sample container while it is still submerged underwater such that the sample does not contain air bubbles. Do not send samples containing an air bubble to the laboratory.

Interpreting Sample Results:
If the radon concentration in the water supply is less than 10,000pCi/L, the carbon filter media in the GAC POET system can be changed out based on breakthrough of petroleum compounds or bacteria buildup in the filters.

If the radon concentration in the water supply is 10,000 pCi/L or greater, radon concentrations should be entered into the Carbdose calculator, or another EPA-approved calculator. Based on the radon concentration and water supply usage, the Carbdose calculator will provide the time that the GAC will become low-level waste (“waste disposal” output) and the minimum distance recommended to limit gamma radiation in living spaces (“safe distance” output).

Based on the “safe distance” output provided by the Carbdose calculator, ensure that the POET filters are placed in a safe area that avoids potential radiation to site users. Space limitations at sites may require that a protective barrier or shield be installed around the filter system to mitigate gamma radiation.

The GAC changeout schedule may need to be adjusted based on the “waste disposal” output provided by the Carbdose calculator. Even if breakthrough of petroleum compounds or bacteria buildup has not occurred, GAC filter media should be scheduled to be changed out prior to becoming low-level waste. The change out schedule may be so frequent that it is more cost effective to install a pre-treatment system for radon such as an aeration system.

Although the MEDEP’s purpose for analyzing a water supply for radon is to maintain GAC POET systems at homes, radon in water is considered a health risk independent of any potential risk caused by a petroleum discharge. DHHS suggests that radon treatment for health risk purposes should be considered for a water supply if the concentration in the well water is greater than 4,000 pCi/L. If sample results are greater than 4,000 pCi/L, refer the homeowner to DHHS, Maine Radiation Control Program.

5.3.2 PROJECT SPECIFIC CONSIDERATIONS

For some Petroleum Program projects, GAC POET will remain installed as long-term mitigation of petroleum contamination in a water supply. In this case a long-term filter agreement is secured between the property owner and MEDEP. The MEDEP, Division of Resource Administration, Collections, Claims, and Recovery (CCR) Unit will assume monitoring of the water supply and POET system. The CCR Unit will need to be informed of how radon affects the GAC changeout schedule.

If site conditions and levels of petroleum contamination warrant that GAC filters are no longer needed at a site, then the filters should be removed and appropriately disposed. Occasionally, MEDEP staff leave GAC POET at sites even when it is not required for petroleum treatment. If the GAC filters are going to remain installed at a site, and not be maintained by the MEDEP (i.e. the concentrations of petroleum compounds in the water supply do not pose a health risk to the site user), a transfer of ownership agreement will need to be secured between the property owner and MEDEP. The transfer of ownership agreement should address the radon concentration and recommended changeout schedule if the radon concentration is greater than 4,000 pCi/L.

6. QUALITY ASSURANCE/QUALITY CONTROL

Data quality objectives (DQOs) should be stated in the SAP. Quality Assurance/Quality Control (QA/QC) samples may be collected if needed to meet DQOs. All analytical data should be reviewed and assessed to determine if DQOs have been met. If review indicates DQOs have not been met, corrective action will be recommended by the reviewer.

7. REFERENCES

http://www.maine.gov/dhhs/mecdc/environmental-health/rad/radon/hp-radon.htm

COVER SHEET
STANDARD OPERATING PROCEDURE

Operation Title: **Water Sampling at Petroleum Release Sites**

ADDENDUM – C – ADDITIONAL REQUIREMENTS FOR DETERINING THE NATURE OF ARSENIC CONCENTRATIONS IN WATER SUPPLIES AT PETROLEUM CONTAMINATION SITES

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APPROVALS:

Division of Technical Services Director:

Print name	*Signature*	*Date*

Bureau of Remediation and Waste Management Director:

Print name	*Signature*	*Date*

QMSC Chair:

Print name	*Signature*	*Date*

Department Commissioner:

Print name	*Signature*	*Date*

DISTRIBUTION;

( ) Division of Technical Services .... By:________________Date:________

1. APPLICABILITY

This Standard Operating Procedure (SOP) applies at petroleum release sites where there is a large volume of petroleum released, *and* petroleum has reached, or is likely to reach the bedrock and/or groundwater.

This SOP applies to all programs in the Maine Department of Environmental Protection's (MEDEP) Bureau of Remediation and Waste Management (BRWM). It is also applicable to all parties that to all parties that investigate, mitigate, or remediate petroleum releases.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2. PURPOSE

The purpose of this document is to describe the MEDEP/BRWM procedure for determining if arsenic contamination of homeowner wells is attributable to biodegradation of petroleum hydrocarbons in ground water resulting in dissolution and desorption from ferric hydroxides. This document is intended to help MEDEP/BRWM staff determine when to be concerned that a water supply well is at risk of being contaminated with naturally-occurring arsenic that has been mobilized by biodegradation of petroleum hydrocarbons and what parameters to measure to evaluate this condition.

3. RESPONSIBILITIES

All MEDEP/BRWM Staff must follow this procedure when performing this task. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/BRWM staff reviewing data by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4. DEFINITIONS

4.1 ARSENIC CONTAMINATION – Detection of arsenic in groundwater or a water supply above the maximum contaminant level (MCL) of 10 micrograms per liter (ug/l).

4.2 BASELINE WATER QUALITY ANALYSIS: Groundwater or water supply analysis for arsenic, dissolved iron, dissolved manganese, pH, dissolved oxygen (DO), oxidation reduction potential (ORP), and specific conductance.

4.3 SECONDARY WATER QUALITY ANALYSIS: Groundwater or water supply analysis for major ions (calcium, sodium, magnesium, potassium, chlorine, sulfate, and nitrate), alkalinity, total organic carbon, and methane.

5. GUIDELINES AND PROCEDURES

5.1 INTRODUCTION

There are several factors that will control the release of arsenic to the groundwater at a petroleum spill including, but not limited to, the existence of a source of arsenic within the aquifer, the size of the spill, the length of time after the spill, and geologic conditions, such as the depth to bedrock or groundwater.

A small amount of petroleum product is capable of contaminating a nearby water supply well, but a large amount of petroleum product is necessary to drive the redox conditions of the aquifer to the point of iron reducing so that arsenic is mobilized. The amount that is necessary is dependent on the initial redox conditions, the amount of terminal electron acceptors, and the pathway of the petroleum to the groundwater. If the initial redox conditions are very oxidizing and there are abundant electron acceptors, it will take a larger volume of petroleum to feed the microbes required to reduce the electron acceptors. If there is a large volume of soil above the water table, this can store a lot of the petroleum which may not make it to the groundwater, and a larger volume of petroleum is required to influence the conditions of the aquifer. Furthermore, an evaluation on recent spills that are cleaned up quickly and where petroleum does not reach the bedrock groundwater showed that it is unlikely that reducing conditions will be incurred to the point of releasing arsenic to the groundwater.

The methodology presumes that the mechanism for mobilization is reductive dissolution and desorption from ferric hydroxide minerals in the aquifer and that the groundwater sampled retains evidence of the reducing chemical environment.

Arsenic contamination is here defined as a detection above the maximum contaminant level (MCL) of 10 micrograms per liter (ug/l). Elevated iron and manganese are taken as evidence of redox conditions that are reducing enough to mobilize iron, manganese, and arsenic. Iron will be considered elevated if it is measured above 5,000 ug/L, and manganese will be considered elevated if it is measured above 300 ug/l. Where the redox sensitive parameters result in an ambiguous indication of the redox state of the water, BRWM scientists will have to evaluate the weight of the evidence and use professional judgement.

5.2 PLANNING

A well-developed Conceptual Site Model (CSM) is imperative for effective use of this technique (RWM-PP-006). Prior to conducting any sampling event, a Sampling and Analysis Plan (SAP) should be developed (SOP RWM-PP-007). All water supply sampling should be conducted in accordance with MEDEP SOP RWM-PP-014.

5.3 PROCEDURE

5.3.1 OVERVIEW

BRWM staff should analyze for arsenic at sites where there is a large volume of petroleum released, *and* petroleum has reached, or is likely to reach, the bedrock and/or groundwater.

If it is determined that the water supply should be analyzed for arsenic, a Baseline Water Quality Analysis should be completed. At sites where the cause of high arsenic concentrations in a water supply well is not clear, a Secondary Water Quality Analysis including additional groundwater geochemistry parameters should be completed. The parameters to be included in the Baseline and Secondary Analyses are defined below.

Based on the spill scenarios and results of the Baseline Water Quality Analysis, there are several follow-up approaches to consider.

Analyzing for Arsenic Contamination at a Recent Spill
It generally takes a period of months for native microbes to acclimate to petroleum hydrocarbons as a food source and create the reducing conditions that can mobilize arsenic. If BRWM staff are certain that the spill was a discrete event and that it occurred within a few weeks prior to initial sampling, then a Baseline Water Quality Analysis sample may be collected to establish whether the water supply well had elevated arsenic before biodegradation of the petroleum began. Three possible outcomes of these analyses are evaluated below.

1. *The arsenic concentration is below the MCL, iron and manganese are not elevated, DO is greater than 1 milligram/liter (mg/l), and ORP is positive.* This indicates that the biodegradation of the petroleum hydrocarbons has not yet created reducing conditions in the aquifer, or there is insufficient arsenic in the aquifer.
    a. Quarterly monitoring of pH, DO, ORP, and specific conductance should be completed.
    b. The water supply well should be sampled for the Baseline Water Quality Analysis parameters at the end of quarterly sampling to determine if conditions have changed.
    c. If redox conditions decrease and/or arsenic concentrations increase, this may be an indication that the petroleum has impacted water quality, and additional monitoring or a treatment system may be required.
2. *The arsenic concentration is below the MCL, iron and manganese are elevated, DO is less than 1 mg/l, and ORP is negative.* In this case, the water supply and aquifer already provide evidence of reducing conditions that enhance the mobility of arsenic, but there may not be sufficient arsenic in the aquifer materials to mobilize arsenic into the groundwater.
    a. The water supply well should be sampled for the Baseline Water Quality Analysis parameters at the end of quarterly sampling.

   b. If arsenic concentrations are significantly greater than the initial Baseline Water Quality Analysis concentrations, this may be an indication that the petroleum has impacted water quality, and additional monitoring or a treatment system may be required.

3. *The arsenic concentration is above the MCL.* In this case, the water supply will be considered arsenic-contaminated prior to the petroleum discharge. The Department will not be responsible for providing water supply treatment unless the arsenic concentration subsequently increases so much in response to biodegradation of the petroleum that it subsequently increased the cost of appropriate point of use treatment.
   a. Educate the well owner/operator about arsenic health impacts and treatment options and encourage them to address the issue.
   b. The water supply well should be sampled for the Baseline Water Quality Analysis parameters at the end of quarterly sampling.
   c. If arsenic concentrations are significantly greater than the initial Baseline Water Quality Analysis concentrations, this may be an indication that the petroleum has impacted water quality, and additional monitoring or a treatment system may be required.

Analyzing for Arsenic Contamination When the Date of the Release is Unknown

For those petroleum spills where a precise discharge date cannot be determined, and the site meets the criteria contained in the “When to Analyze Water Supply Wells for Arsenic” section of this guidance, collect a Baseline Water Quality Analysis sample upon detection of petroleum contamination in soil or groundwater. Four possible outcomes of these analyses are evaluated below.

1. *The arsenic concentration is below the MCL, iron and manganese are not elevated, DO is greater than 1 milligram/liter (mg/l), and ORP is positive.* This indicates that the biodegradation of the petroleum hydrocarbons has not yet created reducing conditions in the aquifer, or there is insufficient arsenic in the aquifer.
   a. Quarterly monitoring of pH, DO, ORP, and specific conductance should be completed.
   b. The water supply well should be sampled for the Baseline Water Quality Analysis parameters at the end of quarterly sampling to determine if conditions have changed.
   c. If redox conditions decrease and/or arsenic concentrations increase, this may be an indication that the petroleum has impacted water quality, and additional monitoring or a treatment system may be required.
2. *The arsenic concentration is below the MCL, iron and manganese are elevated, DO is less than 1 mg/l, and ORP is negative.* In this case, the water supply and aquifer already provide evidence of reducing conditions that enhance the mobility of arsenic, but there may not be sufficient arsenic in the aquifer materials to mobilize arsenic into the groundwater.

   a. The water supply well should be sampled for the Baseline Water Quality Analysis parameters at the end of quarterly sampling.
   b. If arsenic concentrations are significantly greater than the initial Baseline Water Quality Analysis concentrations, this may be an indication that the petroleum has impacted water quality, and additional monitoring or a treatment system may be required.

3. *The arsenic concentration is above the MCL, iron and manganese are not elevated, and the water contains dissolved oxygen greater than 1 mg/l and/or ORP is positive.* There is no evidence of reducing conditions capable of mobilizing arsenic, so the arsenic can be attributed to natural causes instead of the petroleum contamination. The assumption is that the system has reached equilibrium and no further reduction is occurring.
   a. Educate the well owner/operator about arsenic health impacts and treatment options and encourage them to address the issue.
4. *The arsenic concentration is above the MCL, iron and/or manganese are elevated, DO is less than 1 mg/l, and ORP is negative.* The water composition provides evidence of reductive dissolution of the ferric hydroxide minerals. The Department cannot prove that the arsenic was not mobilized by degradation of the petroleum, but it can obtain more data to assess the situation.
   a. The water supply well should be sampled for Secondary Water Quality Analysis parameters. This will help identify whether the water supply well is located in a recharge or discharge area. Wells located at the end of a flow path in a discharge zone typically have higher specific conductance, higher alkalinity, higher pH, higher sodium concentrations (but low chloride concentrations), as well as reducing conditions and are more likely to have naturally-occurring arsenic. If a well has a chemical signature typical of a recharge area (calcium carbonate-type water, low specific conductance, low pH, low alkalinity), but has reducing conditions, then it is more likely impacted by the presence of petroleum.

5.3.2 PROJECT SPECIFIC CONSIDERATIONS

At some sites where side- or up-gradient monitoring wells and water supply wells are available, it may be practical to evaluate background (side- or up-gradient) water quality to determine prevailing arsenic concentrations before the effects of the petroleum contamination. This type of study should include parameters contained in both the Baseline Water Quality Analysis and Secondary Water Quality Analysis so that the whole water chemistry of the contaminated water supplies can be compared to that of the side- or up-gradient monitoring points, not just the arsenic.

Great caution should be used when drawing conclusions based on neighboring wells. Investigations within Maine have shown that naturally-occurring arsenic concentrations can vary significantly over short distances. A better approach would be to evaluate groundwater downgradient of the plume. If downgradient groundwater does not have high arsenic concentrations, then it is unlikely that the petroleum-contaminated site would.

6. QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Any evaluation of background water quality that is the basis of decisions about water supply treatment must be thorough and convincing enough to withstand external peer review.

Data quality objectives (DQOs) should be stated in the SAP. Quality Assurance/Quality Control (QA/QC) samples may be collected if needed to meet DQOs. Typical types of QA/QC samples that may be collected or prepared at the laboratory include replicate matrix interference spike (MIS) samples to allow determination of an upper confidence limit (UCL) for the decision unit (DU), laboratory control blank spikes, and analysis of reference material containing known concentrations of the target analytes. All analytical data should be reviewed and assessed to determine if DQOs have been met. If review indicates DQOs have not been met, corrective action will be recommended by the reviewer.

7. REFERENCES

RWM-PP-006, Conceptual Site Model for Petroleum Contamination
RWM-PP-007, Development of a Sampling and Analysis Plan
RWM-PP-014, Water Sampling at Petroleum Sites

RWM-PP-014_WaterSamplingatPetroleumReleaseSites

Final Audit Report 2021-10-14

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COVER SHEET
STANDARD OPERATING PROCEDURE

Operation Title: **DEVELOPMENT OF A SITE SAFETY PLAN FOR PETROLEUM REMEDIATION SITES**

Originator: **Kelly Perkins**
Quality Assurance Coordinator
Division of Technical Services
Bureau of Remediation and Waste Management

APPROVALS:

Division of Technical Services Director:

Molly King	Molly King Molly King (Aug 31, 2021 08:24 EDT)	Aug 31, 2021
Print name	*Signature*	*Date*

Bureau of Remediation and Waste Management Director:

Susanne Miller		Sep 7, 2021
Print name	*Signature*	*Date*

QMSC Chair:

Bill Longfellow	Bill Longfellow Bill Longfellow (Sep 7, 2021 16:43 EDT)	Sep 7, 2021
Print name	*Signature*	*Date*

Department Commissioner:

Melanie Loyzim	Melanie	Sep 8, 2021
Print name	*Signature*	*Date*

DISTRIBUTION;

( ) Division of Technical Services .... By:_______________ Date:________

1. APPLICABILITY

This Standard Operating Procedure (SOP) applies to all BRWM staff working on petroleum remediation sites within the Petroleum Program. It is also applicable to all parties that investigate, mitigate, or remediate petroleum releases.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2. PURPOSE

The purpose of this document is to describe the MEDEP BRWM requirements for the development of a Site Safety Plan (SSP). Prior to conducting field work, routine monitoring, post closure sampling or on-site data gathering, a SSP will be developed. The SSP will outline the potential hazards of the site activity, identify control measures to mitigate the risk, and identify PPE needed to complete the control measure. Additionally, the plan will provide the physical address should emergency services be required, directions to the site, weather conditions, and responding emergency services with contact information.

3. RESPONSIBILITIES

All MEDEP/BRWM Staff must follow this procedure when developing a Site Safety Plan. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/BRWM staff reviewing plans by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4.0 DEFINITIONS

4.2 CONTAMINANT OF CONCERN (COC) - A contaminant that has been released at a site and risk evaluation indicates that mitigation or remediation is necessary to prevent exposure to the contaminant.

5. GUIDELINES AND PROCEDURES

5.1 INTRODUCTION

1. A SSP may be developed as a narrative document that contains all the information provided on Attachment 1. Alternatively, Attachment 1 provides a template for completing a site safety plan..

5.2 TITLE SECTION

The title section of an SSP will contain the name and town of project, the MEDEP Spill #, other relevant project numbers (EGAD, Tank Registration, REMO), and the name and title of the person developing the SSP.

5.3 INTRODUCTION

The introduction will state any site specific safety considerations that must be considered at the site. This may include travel and transport situations, such as the location of the site relative to the nearest hospital or EMS. Additionally, it may include site access details that present a potential health and safety component.

5.4 BACKGROUND INFORMATION

At a typical Petroleum Program site, the background information is documented by the Division of Response Services in the spill report file. Reference to the spill number is sufficient for providing background information.

5.5 SITE SPECIFIC HEALTH AND SAFETY PLAN

A SSP will be developed prior to completing any fieldwork. Emergency Responders work under a generic safety plan while the emergency response is taking place. Once the emergency response is completed, field personnel must follow the site specific safety plan. The Site Safety Plan satisfies the requirements for a Site Specific Health and Safety Plan in accordance with the BRWM requirements for sites where work is done in Level C and D PPE. If work tasks require a higher level of protection a full HASP will need to be developed and approved by the BRWM Safety Officer prior to completing the work. If sampling, monitoring, and investigative activities remain the same during the Project Team's involvement, the initial SSP can be applied and remain in effect for the duration of the project. If the Project Team's onsite activities change such that they are outside the scope of a current SSP, a new plan will need to be developed and recorded in the project file.

If below grade sampling is part of the SAP, Dig-Safe and Ok To Dig and/or nonmember utilities must be notified at least 3 working days prior to the sampling event. Sample locations must be marked on the ground prior to calling Dig-Safe and Ok To Dig.

For transportation spills and other incidents that require work within a road right of way, the SSP must include site specific requirements for flagging, vehicle marking and lighting, or other considerations necessary to safely complete the work or access the worksite. This may include work being completed under a subcontractors HASP that is referenced in the SSP.

DEP staff must contact Dig Safe (811 or www.digsafe.com) and OkToDig (1-866-658-6344 or oktodig.com) at least 72-hours prior to advancing any tools below the ground surface (72 hours does not include weekends and holidays). Dig Safe color codes are provided below.

COLOR CODE
FOR MARKING
UNDERGROUND UTILITY LINES

🟥 ELECTRIC

🟨 GAS-OIL-STEAM

🟧 COMMUNICATION CATV

🟦 POTABLE WATER

🟪 RECLAIMED WATER

🟩 SEWER & DRAINAGE

▨ TEMPORARY SURVEY MARKINGS

☐ PROPOSED EXCAVATION

digsafe.com

6. QUALITY ASSURANCE/QUALITY CONTROL

Attachment 1 is acceptable as a SSP for work at petroleum remediation projects being completed in Level C and Level D as long as all the information is entered for the tasks being completed. BRWM staff are responsible for making sure the information is accurate and complete as part of the QA/QC of the SSP, in accordance with Section 3 of this SOP.

7. REFERENCES

ASTM E1689 - 95 (2014), Standard Guide for Developing Conceptual Site Models for Contaminated Sites.

SOP-PP-006 Conceptual Site Model for Petroleum Contamination

ATTACHMENT 1

SITE SAFETY PLAN TEMPLATE

DEP BRWM TECHNICAL SERVICES SITE HEALTH AND SAFETY

SITE INFORMATION

SITE NAME: Click or tap here to enter text. **SPILL NUMBER:** Click or tap here to enter text.

PHYSICAL ADDRESS: Click or tap here to enter text. **TOWN:** Click or tap here to enter text.

DIRECTIONS TO SITE: Click or tap here to enter text.

SITE SPECIFIC SAFETY CONSIDERATIONS: Click or tap here to enter text.

WORK OBJECTIVE: Click or tap here to enter text.

ANTICIPATED WEATHER CONDITIONS:

TEMP	WIND	CLOUD COVER
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

SITE EMERGENCY RESPONSE PLAN

TECHNICAL SERVICES FIELD STAFF WILL EVACAUTE IN THE EVENT OF A SPILL/EMERGENCY

MEDICAL TREATMENT BY DEP STAFF IS LIMITED TO BASIC FIRST AID/CPR

EMERGENCY SERVICES	LOCATION	TELEPHONE #
RESPONDING FIRE DEPARTMENT or AMBULANCE SERVICE	Click or tap here to enter text.	Click or tap here to enter text.
POLICE	Click or tap here to enter text.	Click or tap here to enter text.
NEAREST HOSPITAL	Click or tap here to enter text.	Click or tap here to enter text.
DEP REGIONAL OFFICE -DIVISION OF RESPONSE SERVICES	Click or tap here to enter text.	Click or tap here to enter text.
NATIONAL RESPONSE CENTER	**---**	**1-800-424-8802**
POISON CONTROL CENTER	**---**	**1-800-222-1222**
DEP BRWM ERTC	**Ray Building Augusta**	**(207) 620-4456**

SITE SAFETY COORDINATOR/SITE SUPERVISOR: Click or tap here to enter text.

BASIC SAFETY EQUIPMENT:

First Aid Kit ☐	SAFETY EYEWASH ☐	FIRE BLANKET ☐	Other

SITE MONITORING:

Meter	**Continuous/Periodic**	**Interval**	**Action Level**
PID	Choose an item.		15 PPM
Oxygen	Choose an item.		above/below 20.8%
%LEL	Choose an item.		2%

HAZARD ASSESSMENT

TASK	PHYSICAL HAZARD	CONTROL MEASURE	PPE

TASK	CHEMICAL HAZARD	CONTROL MEASURE	PPE

DECONTAMINATION

PERSONNEL	PROTOCOL
Between tasks:	
Leaving Site:	Use hand sanitizer or soap and water if available
Emergency:	Eyewash, copious amounts of water, remove effective clothing
PROTECTIVE CLOTHING	
Between tasks:	Change nitrile gloves
In field decon:	n/a
Final (back at warehouse) decon:	Throw out used disposable coveralls, overboots and gloves. Launder field clothing. Clean boots in decon room.
EQUIPMENT	
Between tasks:	
In field decon:	
Final (back at warehouse) decon:	Clean all equipment used in decon room with appropriate solution before putting back in supply room
RESPIRATOR (if used)	
Between tasks:	n/a
Field decon:	Remove cartridges and bag for disposal back at warehouse
Final (back at warehouse) decon:	Clean respirator in decon room with approved MSA respirator sanitizer solution, dry thoroughly, check seal before putting away

I have read and understand the contents of this HASP, supporting material referenced and have completed field certification to perform tasks as called for in this plan:

SIGNATURE:	**DATE:**

DEP BRWM TECHNICAL SERVICES SITE HEALTH AND SAFETY

SITE INFORMATION

SITE NAME: Click or tap here to enter text. **SPILL NUMBER:** Click or tap here to enter text.

PHYSICAL ADDRESS: Click or tap here to enter text. **TOWN:** Click or tap here to enter text.

DIRECTIONS TO SITE: Click or tap here to enter text.

SITE SPECIFIC SAFETY CONSIDERATIONS: Click or tap here to enter text.

WORK OBJECTIVE: Click or tap here to enter text.

ANTICIPATED WEATHER CONDITIONS:

TEMP	WIND	CLOUD COVER
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

SITE EMERGENCY RESPONSE PLAN

TECHNICAL SERVICES FIELD STAFF WILL EVACAUTE IN THE EVENT OF A SPILL/EMERGENCY

MEDICAL TREATMENT BY DEP STAFF IS LIMITED TO BASIC FIRST AID/CPR

EMERGENCY SERVICES	LOCATION	TELEPHONE #
RESPONDING FIRE DEPARTMENT or AMBULANCE SERVICE	Click or tap here to enter text.	Click or tap here to enter text.
POLICE	Click or tap here to enter text.	Click or tap here to enter text.
NEAREST HOSPITAL	Click or tap here to enter text.	Click or tap here to enter text.
DEP REGIONAL OFFICE -DIVISION OF RESPONSE SERVICES	Click or tap here to enter text.	Click or tap here to enter text.
NATIONAL RESPONSE CENTER	---	**1-800-424-8802**
POISON CONTROL CENTER	---	**1-800-222-1222**
DEP BRWM ERTC	**Ray Building Augusta**	**(207) 620-4456**

SITE SAFETY COORDINATOR/SITE SUPERVISOR: Click or tap here to enter text.

BASIC SAFETY EQUIPMENT:

First Aid Kit ☐	SAFETY EYEWASH ☐	FIRE BLANKET ☐	Other

SITE MONITORING:

Meter	Continuous/Periodic	Interval	Action Level
PID	Choose an item.		15 PPM
Oxygen	Choose an item.		above/below 20.8%
%LEL	Choose an item.		2%

HAZARD ASSESSMENT

TASK	PHYSICAL HAZARD	CONTROL MEASURE	PPE

TASK	CHEMICAL HAZARD	CONTROL MEASURE	PPE

DECONTAMINATION

PERSONNEL	PROTOCOL
Between tasks:	
Leaving Site:	Use hand sanitizer or soap and water if available
Emergency:	Eyewash, copious amounts of water, remove effective clothing
PROTECTIVE CLOTHING	
Between tasks:	Change nitrile gloves
In field decon:	n/a
Final (back at warehouse) decon:	Throw out used disposable coveralls, overboots and gloves. Launder field clothing. Clean boots in decon room.
EQUIPMENT	
Between tasks:	
In field decon:	
Final (back at warehouse) decon:	Clean all equipment used in decon room with appropriate solution before putting back in supply room
RESPIRATOR (if used)	
Between tasks:	n/a
Field decon:	Remove cartridges and bag for disposal back at warehouse
Final (back at warehouse) decon:	Clean respirator in decon room with approved MSA respirator sanitizer solution, dry thoroughly, check seal before putting away

I have read and understand the contents of this HASP, supporting material referenced and have completed field certification to perform tasks as called for in this plan:

SIGNATURE:	**DATE:**
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________________________________	____________
________________________________	____________
________________________________	____________
________________________________	____________

RWM-PP-071_Site_Safety_Plan

Final Audit Report 2021-09-08

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COVER SHEET
STANDARD OPERATING PROCEDURE

Operation Title: **GROUNDWATER SAMPLING USING LOW FLOW PURGING AND SAMPLING FOR LONG-TERM MONITORING**

Originator: **Becky Blais**
Quality Assurance Coordinator
Division of Remediation
Bureau of Remediation and Waste Management

APPROVALS:

Division of Remediation Director:

Carla J. Hopkins		Dec 17, 2021
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Bureau of Remediation and Waste Management Director:

Susanne Miller		Dec 22, 2021
Print name	*Signature*	*Date*

QMSC Chair:

Kevin Martin		Dec 23, 2021
Print name	*Signature*	*Date*

Department Commissioner:

Melanie Loyzim		Dec 23, 2021
Print name	*Signature*	*Date*

DISTRIBUTION;

( ) Division of Remediation… ....By:_______________Date:________

1.0 APPLICABILITY

This Standard Operating Procedure (SOP) applies to all programs in the Maine Department of Environmental Protection's (MEDEP) Division of Remediation (DR). It is also applicable to all parties that may submit data that will be used by the MEDEP/DR.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2.0 PURPOSE

The purpose of this document is to describe the MEDEP/DR's procedure for collecting groundwater samples from wells utilizing the "Low Flow" purging and sampling procedure. This Standard Operating Procedure (SOP) is similar to MEDEP/DR SOP# RWM-DR-002 - Groundwater Sample Collection for Site Investigation and Assessment Monitoring. RWM-DR-002 is intended to be used at sites where Data Quality Objectives (DQOs) do not require long-term monitoring of concentration trends. The purpose of this SOP (RWM-DR-003) is to outline the procedure for collecting groundwater samples from existing monitoring wells where DQOs require consistently documented procedures for collecting groundwater samples at regular intervals (quarterly, tri-annual, bi-annual, annual, etc.) to monitor data trends over time. Site specific DQOs should be reviewed to ensure the sampling methods are appropriate.

3.0 RESPONSIBLITIES

All MEDEP/DR Staff must follow this procedure when performing this task. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/DR staff reviewing data by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4.0 GUIDELINES AND PROCEDURES

4.1 INTRODUCTION

Low flow sampling (LFS) is an appropriate method for long-term monitoring of groundwater at sites. The goal in any groundwater monitoring activity is to collect groundwater samples that are representative of mobile organic and inorganic loads in the vicinity of the selected open well interval. Current research indicates that LFS is the best available technique for: 1) obtaining the most consistently representative samples of groundwater from the formation surrounding the screened interval of a properly installed monitoring well; 2) eliminating variability introduced by sampling technique; and 3) providing a basis for evaluating appropriateness of long-term groundwater sampling data.

LFS includes both a purge and no-purge option. The purge option for LFS involves pumping the well at a rate that minimizes drawdown in a well to reduce mixing of the riser water and groundwater in the aquifer. Field parameters, such as pH, dissolved oxygen, temperature, turbidity and conductivity are monitored during purging until readings have stabilized; at this point, groundwater entering the pump intake represents formation water and the sample is collected.

In low permeability formations or poorly installed monitoring wells it may not be possible to collect groundwater samples using the specified purge techniques. In such instances, the no-purge option should be evaluated (see Attachment A).

Additionally, this procedure is not designed to collect samples from wells containing light or dense nonaqueous phase liquids (LNAPLs or DNAPLS).

LFS is a skill which requires considerable experience and ongoing education and tuning on the part of those who perform it; therefore, at least one experienced person in LFS should always accompany every sampling team.

4.2 EQUIPMENT

The following list of equipment is necessary when performing LFS. Specific brand names indicate equipment owned by either MEDEP/DR and MEDEP/TS, and is available to staff for use. Equipment with similar performance may be used in place of the specifically identified equipment. (see MEDEP/DR SOP# RWM-DR-014 - Development of a Sampling and Analysis Plan).

4.2.1 PUMP

The pump selected must have capabilities of adjusting the flow rate without the use of flow restrictors. Types of acceptable pumps include: submersible, bladder and peristaltic pumps. Physical limitations on the use of peristaltic pumps also apply to wells with deeper water levels; wells with water levels greater than approximately 24 feet cannot be sampled with a peristaltic pump. In these instances, a submersible or bladder pump should be used.

The Department recommends the use of dedicated equipment, where possible, for long-term monitoring.

4.2.2 TUBING

Low density polyethylene (LDPE) is recommended for most situations. However, site specific DQOs should be reviewed before selecting the appropriate tubing. For example, sites with low concentrations of certain petroleum related contaminants should consider the use of Teflon lined polyethylene tubing. Peristaltic pumps typically use 1/4-inch or 3/8-inch outside diameter (OD) LDPE tubing together with 3/8-inch OD silicone tubing. Submersible pumps typically have barbed fittings that accommodate 3/8-inch or

1/2-inch inner diameter (ID) LDPE tubing, depending on the pump manufacturer. Note that larger diameter tubing (1/4 inch ID or greater) is generally easier to install in monitoring wells equal to or greater than 2 inches in diameter.

As in the case with pumps the use of dedicated tubing, where possible, is recommended for long-term monitoring programs.

4.3 POWER SUPPLY

The power supply options for the pumps include generators, deep cycle batteries, and compressed gas. 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. If the operator of the generator has handled gasoline, then he/she should not risk cross-contamination by handling the sampling equipment or sample containers.

4.4 INDICATOR PARAMETER MONITORING INSTRUMENTS

Site specific Data Quality Objectives (DQOs) should be used to select appropriate field parameters. Field parameter options include, but are not limited to:

- pH (EPA Methods 150.1 or 9040),
- turbidity (EPA Method 180.1),
- specific conductance (EPA Methods 120.1 or 9050),
- temperature (EPA Method 170.1),
- oxidation reduction potential (ORP), and
- dissolved oxygen (EPA Method 360.1).

A flow-through cell is required for dissolved oxygen and ORP measurements.

4.5 WATER LEVEL/FLOW MEASURING TOOLS

Water level and flow measurement are required for LFS. Several different water level meters, including Solinist® and Well Wizard®, are available to staff. A graduated cylinder and stopwatch are used for measuring flow in mL/minute.

4.6 DOCUMENTATION SUPPLIES

This includes a field notebook for taking field notes, and the MEDEP LFS data sheet included in Attachment B.

4.7 WELL DOCUMENTATION

A well's location, well construction, previous sampling data, and the Sampling and Analysis Plan (SAP) should accompany samplers in the field.

4.8 MISCELLANEOUS SUPPLIES

Miscellaneous supplies include decontamination equipment and material, sample bottles, preservation supplies, sample tags and labels.

4.9 LOW FLOW SAMPLING PURGE AND SAMPLE PROCEDURE

4.9.1 PREPARATION

Prior to conducting a low flow sampling(LFS) event, information regarding well construction, development, and water level records for each well to be sampled should be obtained and reviewed to determine the appropriate pump to be used, the depth of 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, length of screen, and a pump test to determine the recharge rate of the well. Additionally, wells that have **not been sampled for two years should be redeveloped** prior to conducting the actual sampling event. Redevelopment of Monitoring wells is outlined in MEDEP/DR SOP RWM-DR-028 – Maintaining and Redevelopment of Inactive Monitoring Wells.

4.9.2 FIELD PROCEDURE

1) Obtain static water level. Measure and record the depth to water (to 0.01 ft) in the well to be sampled before inserting tubing or preparing to purge the well. Monitoring wells should be measured consistently by using the same measuring reference point for each sampling event. If the top of the well riser pipe is the selected reference point, a mark or notch in the well material should indicate where the measurement takes place. If no mark or notch is observed, the measurement should take place on the highest point of the well riser. Care should be taken to minimize suspension of any particulates attached to the sides or at the bottom of the well. If wells to be sampled are arranged in clusters (i.e. shallow/middle/deep), then depth to water readings should be collected from all wells in the cluster before purging.

2) Install sampling pump or tubing. The use of dedicated sample tubing will reduce disturbance and water mixing in the well. In situations where dedicated equipment is not used, field staff will lower equipment (i.e. pump, safety cable, tubing and electrical lines) slowly into the well so that the pump intake is placed at the desired location of the saturated screened interval to avoid disturbing sediments in the bottom of the well.

3) Purge well. Flow rate and water level (drawdown) should stabilize before connecting the flow cell or obtaining any other measurements. Air or gas bubbles trapped in the

sample tube can usually be removed by elevating the discharge tube and pump to allow the air to continue rising until discharged with the water. However, some groundwater has high dissolved gas levels and gas cannot be completely removed from the sample tube. Check previous data sheets to assist in well set up, flow rates, and notes regarding gas presence in the sample tube.

Monitor water level and pumping rate frequently during the first five minutes of purging. If the recharge rate of the well is less than minimum capability of the pump, then the water level will not stabilize. If a constant water level cannot be maintained at a flow rate of 80 to 100 mL/min., then the no-purge option should be evaluated (see Section 4.12 No-Purge Option). Care should be used to avoid dewatering the screen or lowering the water level to the intake depth.

Once the water level has stabilized during purging, monitor field indicator parameters. For field indicator parameter readings collected from a flow-through cell (dissolved oxygen and ORP at a minimum), the pump's flow rate must be able to "turn over" at least one flow-through cell volume between each reading. Depending on the pump rate and flow-through cell volume, these readings are typically collected every three to five minutes. Samples for turbidity measurements should be obtained before water enters the flow-through cell to provide more accurate readings. Purging is complete and sampling may begin when all field indicator parameters are within the following limits after three consecutive readings at the appropriate time interval:

- Turbidity: 10% for values at or above 5 NTU. If three consecutive turbidity readings are less than 5 NTU, the values may be considered stabilized.
- Dissolved Oxygen: 10% for values at or above 0.5 mg/L. If three consecutive dissolved oxygen readings are less than 0.5 mg/L, the values may be considered stabilized.
- Specific Conductance: 3%.
- Temperature: 3%.
- pH: ± 0.1 units
- Oxidation/Reduction Potential: ± 10 millivolts.

<u>4) Collect Samples.</u> Collect samples in appropriate containers as indicated by laboratory conducting the analysis. Samples for laboratory analyses must be collected before the flow cell. This can be done by disconnecting the flow cell after reaching stabilization, using a sample port before the flow cell, or by disconnecting the flow cell once parameters have stabilized.

LFS will help reduce turbidity caused by improper purge and sampling techniques. The need for filtering water samples will be reduced by using this method. However, if turbidity values equilibrate above 20 NTUs, one should consider the need to collect both a filtered and an unfiltered sample. An in-line 0.2-0.45 um particulate filter should be pre-rinsed with approximately 25 - 50 mL of groundwater prior to sample collection, or as per filter manufacturer's instructions. **Note that filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations representative of total mobile loads.**

After collection of the samples, any tubing used may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

4.10 PROCEDURE EVALUATION

The purpose of the LFS purge option is to sample the groundwater from the surrounding aquifer. If the well is not receiving sufficient recharge from the formation, then the water level will drop as pumping continues. This means that the discharge water could contain a significant percentage of stagnant water from the well casing. As the percentage of casing water increases, the representativeness of the sample decreases. If the percentage of casing water is significant, an alternative sampling technique, such as the no–purge option, should be considered (see Section 4.12). A decision process for implementing low flow/no purge sampling can be found in Attachment B.

The second step in evaluating the viability of LFS for a potential no–purge well is to determine the volume of groundwater needed to fill the laboratory containers. Compare this volume to the volume of groundwater in the screened section of the monitoring well. If the volume of water contained in the screened zone is greater than the volume of sample required to fill the sample containers, then the no-purge option is appropriate for this well.

4.10.1 CALCULATING FORMATION/STAGNANT WATER RATIO

The following calculation will determine how much of the water being pumped is coming from the well, and how much is coming from the aquifer. This is done by comparing the total volume being purged to the drawdown volume in the well. If the equilibrium flow rate is 150 mL/min or lower for a given well, the following evaluation should be followed:

- Calculate the total volume of water discharged for a given time interval.
- Measure the total drawdown of the water level in the well during that time interval.
- Calculate the total drawn down volume in the well (see Attachment B for mL/ft conversions of typical monitoring well sizes)

Compare the total volume of water discharged to the total drawdown volume. If the drawdown volume comprises 60% or more of the discharge volume, then any samples collected may not be representative of the surrounding groundwater aquifer and the well construction should be evaluated.

4.10.2 WELL CONSTRUCTION EVALUATION

Evaluate the well construction. Was the appropriate screen slot size selected? Was the appropriate filter sand selected? If the well construction details are not appropriate for the formation, then consideration should be given to installing a replacement well that is properly designed. A poorly designed well will not yield representative samples no matter what purging procedure is utilized.

4.11 PROCEDURE MODIFICATIONS

The LFS procedure can be modified to meet the DQOs for the Sampling Event. In long-term monitoring events it may be possible to reduce the 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 has importance that extends beyond the measurement for equilibrium. If Low-Flow sampling is not appropriate for a particular site, then MEDEP/DR SOP RWM-DR-002 – Groundwater Sample Collection for Site Investigation and Assessment Monitoring should be used for the site.

Cold weather considerations must be factored into a low flow sampling plan.

Monitoring wells with recharge rates below 100 mL/min may not be capable of being pumped at a continuous rate. Therefore, low or no purge options should be considered.

4.12 NO – PURGE OPTION

The theory of no-purge sampling is that the water in the screened zone is in equilibrium with the aquifer and the water in the riser portion of the well is not. The goal is to sample only the water in the screened zone and to minimize any mixing with the water in the riser.

In certain low permeability formations it may not be possible to maintain a constant drawdown at low flow rates (~80-100 mL/min.). In these formations the only option may be to obtain a groundwater sample without purging.

4.12.1 NO-PURGE PROCEDURE

Dedicated equipment is required to properly complete this procedure (to eliminate any additional mixing of the water in the riser with the water in the screen).

The pump intake must be in the screened zone, at or slightly above the midpoint of the screen.

1) Calculate the volume of water standing in the discharge line.

2) Turn on the pump at the lowest possible flow rate.

3) Purge the volume of water that was standing in the discharge line.

4) Immediately begin sample collection after the discharge line is purged.

4.13 DECONTAMINATION

Dedicated equipment will not need decontaminating. However, non-dedicated equipment should be cleaned prior to field work, after each sampling location, and upon return to the office from the field, as outlined in MEDEP/DR SOP# RWM-DR-017 – Equipment Decontamination Protocol, with specific procedures for cleaning submersible pumps outlined below. The pump, including support cable and electrical wires which are in contact with the well will be decontaminated by one of the procedures listed below. Note that if historical data is available for site wells, non-dedicated equipment decontamination in the field can be minimized or even eliminated by sampling monitoring wells in order from cleanest to dirtiest. Non dedicated tubing should be discarded.

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. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is flushed out. The outside of the pump and the electrical wires must be rinsed with the decontaminating solutions as well. The procedure is as follows:

- Flush the equipment/pump with deionized or tap water. Flush pump by allowing pump to run with water for several minutes in basin filled with water.

- Flush with non-phosphate detergent solution for several minutes.
- Flush with deionized water to remove all of the detergent solution. In some instances of high levels of contamination, it may be appropriate to use isopropyl alcohol in this step. The need for this will be determined in the Site Specific Sampling and Analysis Plan (See MEDEP/DR SOP# RWM-DR-014)

- Flush one final time with distilled/deionized water. If required (as determined in Site Specific Sampling and Analysis Plan), collect equipment blank after final flushing.

5.0 QUALITY ASSURANCE/ QUALITY CONTROL

DQOs should be stated in the site Sampling and Analysis Plan (SAP). Quality Assurance/Quality Control (QA/QC) samples may be collected if needed to meet data quality objectives. The following are typical types of QA/QC samples that may be collected as part of the QA/QC program for groundwater samples collected utilizing this

SOP. Other QA/QC samples may be collected as stated in the SAP. For additional information on QA/QC samples, please refer to the MEDEP/DR Quality Assurance Plan, Sections 4 and 8. All analytical data should be reviewed and assessed to determine if DQOs have been met. If review indicates DQOs have not been met, corrective action will be recommended by the reviewer.

5.1 TYPICAL QA/QC SAMPLES

5.1.1 EQUIPMENT BLANKS

If using non dedicated or disposable equipment, equipment blanks should be collected at a rate of 5%, which is equivalent to one equipment blank for every twenty samples collected. The equipment blank will consist of purging de-ionized water through submersible pumps and piping, and/ or rinsing equipment with de-ionized water, and collection for appropriate sample analysis.

5.1.2 DUPLICATE SAMPLES

It is recommended that duplicate samples be collected at a rate of 5% to assess sample location variability.

5.1.3 TRIP BLANK

A trip blank may be necessary when sampling for volatile organic compounds (i.e. EPA 8260). The need for a trip blank will be outlined in the SAP.

5.1.4 BACKGROUND SAMPLES

The need for background groundwater samples will be outlined in the SAP.

6.0 DOCUMENTATION

All site visits, including groundwater sampling events shall be documented as described in the MEDEP/DR SOP# RWM-DR-013 - Documentation of Field Activities and Development of a Trip Report. A field log must be kept each time ground water monitoring activities are conducted in the field; the LFS Data Sheet in Attachment A is the approved form for use by staff. The field log should document the following:

- Well identification, condition of well
- Static water level
- Pumping rate, or flow rate including units
- Time of all measurements
- Water Level at the specified pumping rate
- Indicator parameter values
- Well sampling sequence and time of sample collection.

- Types of sample bottles used and sample identification numbers.
- Preservatives used.
- Parameters requested for analysis.
- Name of sample collector(s).
- Calibration information of meters.

7.0 REFERENCES

Backhus, D.A., Ryan, J.N., Groher, D.M., MacFarlane, J.K., Gschwend, P.M., 1993; Sampling Colloids and Colloid-Associated Contaminats in Ground Water; *Ground Water*, Vol 31, No. 3, pp. 466-479.

Barcelona, M.J., Wehrmann, H.A., Varljen, M.D., 1994. Reproducible Well-Purging Procedures and VOC Stabilization Criteria for Ground-Water Sampling; *Ground Water*, Vol 32, No.1, pp. 12-22.

Garske, E.E., Schock, M.R., An Inexpensive Flow-Through Cell and Measurement System for Monitoring Selected Chemical Parameters in Ground Water. *Groundwater Monitoring & Remediation,* Summer 1986.

Herzog, B.L., Chou, S.J., Valkenburg, J.R., and Griffin R.A., 1988. Changes in Volatile Organic Chemical Concentrations After Purging Slowly Recovering Wells. *Groundwater Monitoring Review*, v.9, no.3, pp 93-99.

Kearl, P.M., Korte, N.E., Cronk, T.A., 1992. Suggested Modifications to Ground Water Sampling Procedures Based on Observations from Colloidal Borescope. *Groundwater Monitoring & Remediation*, Spring 1992, pp 155-161.

Powell, R.M., Puls, R.W., 1993. Passive Sampling of Groundwater Monitoring Wells Without Purging: Mulitlevel Well Chemistry and Tracer Disappearance. *Journal of Contaminant Hydrology*, Volume 12, pp 51-77.

Puls, R.W., Powell, R.M., 1992. Acquisition of Representative Ground Water Quality Samples for Metals. *Groundwater Monitoring Review*, v.12, no.2, pp 167-176.

Puls, R.W., Powell, R.M., 1992. Transport of Inorganic Colloids through Natural Aquifer Material. *Environmental Science Technology*, Vol 26, pp 614-621.

Puls, R.W., Powell, R.M., Clark, D.A., Paul, C.J., 1990. Facilitated Transport of Inorganic Contaminants in Ground Water: Part I, Sampling Considerations. *Environmental Research Brief EPA-600-M-90-023*

Puls, R.W., Powell, R.M., Clark, D.A., Paul, C.J., 1990. Facilitated Transport of Inorganic Contaminants in Ground Water: Part II, Colloidal Transport. *Environmental Research Brief EPA-600-M-90-023*

Puls, R.W., Barcelona, M.J., 1986. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. *USEPA Ground Water Issue* EPA-540-S-95-504.

Shanklin, D.E., Sidle, W.C., Ferguson, 1995. Micro-Purge Low-Flow Sampling of Uranium-Contaminated Ground Water at the Fernald Environmental Management Project. *Groundwater Monitoring Review*, Summer 1995.

USEPA Region 1, 2010. Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, Quality Assurance Unit, 11 Technology Drive North Chelmsford MA, EQASOP-GW001.

ATTACHMENT A
DECISION PROCESS FOR IMPLEMENTING LOW FLOW/NO PURGE SAMPLING

Decision Process for Implementing LFS

1) Obtain well construction, development, and water level records for each well being sampled. Compile total depth, screened interval, water level, and available hydraulic conductivity information for field technician(s).
   Continue to 2

2) Review available equipment. Make sure the pump is capable of variable speeds and can pump water at low rates without the use of mechanical flow restrictions. Reducing flow by altering the diameter of the discharge pipe is not acceptable for purposed of LFS. Make sure the chamber being used to collect field parameters is appropriate for the parameters being measured. For ORP and DO measurements with probes, the chamber must be an enclosed chamber that does not allow water to contact the atmosphere and does not impact the water quality. Additionally, the size of the chamber should be appropriate given the expected flow rates.
   Continue to 3

3) The objectives of the sampling event should be reviewed to determine the important stabilization parameters as well as the important field parameters for geochemical analyses.
   Continue to 4

4) Is the well being used as part of a long-term plan to monitor trends in groundwater chemistry?
   Yes … Go to 5
   No … Go to 6

5) Complete Well Performance Evaluation on Well prior to first sampling event.
   Continue to 6

6) Will water level (under pumping conditions) stabilize above the top of the screen?
   Yes … Go to 11
   No … Go to 7

7) Is the static water level above the top of the screen?
   Yes … Go to 9
   No … Go to 8

8) Will the stabilized water level reduce the volume of water in the well by greater than 10%?
   Yes … Go to 12
   No … Go to 11

9) Is there sufficient water in the well to purge and sample the well given the measured drawdown rate without dewatering any part of the screen?
   Yes … Go to 10
   No … Go to 12

10) Is the volume of water attributable to the change in water level greater than 20% of the volume of water being discharged during the same time period?
    Yes … Go to 12
    No … Go to 11

11) Complete the Standard Low Flow Sampling Procedure and collect groundwater samples once the selected stabilization parameters have equilibrated.

12) Evaluate the appropriate application of Reduced Purge Procedures for this well.
    Continue to 13

13) Is the sampling equipment (pump or sample tube) dedicated to the well and/or has it been installed for more than 2 weeks prior to sampling?
    Yes … Go to 15
    No … Go to 14

14) Install the pump or tubing and purge a volume of water equal to 1.5 times the volume required to fill the laboratory containers. Purging must be completed at the lowest setting possible (must be less than 100 mL/min). Then shut-off the pump and allow the well to recharge until the water level returns to the static water level
    Continue to 15

15) Set the pump rate to the lowest possible setting (must be lower than 100 mL/min) and purge a volume of water equal to the volume of water in the sample tube. Then immediately begin collection of laboratory samples at the same rate. Record the water level at the beginning of sample collection and at the end of sample collection. If field parameters are to be collected, they must be collected after laboratory samples are collected.

ATTACHMENT B
LOW FLOW DATA SHEET

003-Low-Flow-Groundwater-Sampling-Final-2021 - B Blais

Final Audit Report 2021-12-23

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COVERSHEET
STANDARD OPERATING PROCEDURE

Operation Title: **FIELD SCREENING OF SOIL SAMPLES UTILIZING PHOTOIONIZATION AND FLAME-IONIZATION DETECTORS**

Originator: **Becky Blais**
Quality Assurance Coordinator
Division of Remediation
Bureau of Remediation and Waste Management

APPROVALS:

Division of Remediation Director:

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QMSC Chair:

Kevin Martin		Dec 23, 2021
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Department Commissioner:

Melanie Loyzim		Dec 23, 2021
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( ) Division of Remediation….................................By:________________Date:_________

1.0 APPLICABILITY

This Standard Operating Procedure (SOP) applies to all programs in the Maine Department of Environmental Protection's (MEDEP) Division of Remediation (DR). It is also applicable to all parties that may submit data that will be used by the MEDEP/DR.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2.0 PURPOSE

The purpose of this document is to describe the MEDEP/DR procedure for field screening volatile organic content of soils using a closed container and a photoionization detector (PID) or a flame ionization detector (FID). Please note that MEDEP has separate SOPs for the field screening of soils impacted by petroleum products (RWM-PP-004). The investigation and remediation of petroleum related impacts are typically overseen by the MEDEP Division of Petroleum Management or Division of Technical Services. Refer to the most recent version of MEDEP's Petroleum Remediation Guidelines and associated petroleum specific SOPs for additional guidance.

3.0 RESPONSIBILITES

All MEDEP/DR Staff must follow this procedure when performing this task. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/DR staff reviewing data by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4.0 INTRODUCTION

In conducting this procedure, a soil sample is placed in an approved container and sealed. Any volatile compounds in the soil then volatilize into the headspace of the container until a state of equilibrium is reached. The air in the jar headspace is then measured with a calibrated PID or FID, with a result expressed in parts per million (ppm). Due to the different vapor pressures and ionization potentials of the volatile compounds, concentrations of individual compounds cannot be determined. However, this technique provides an effective means of screening soil for the presence of total volatile organic compounds (VOCs). It is also a helpful low-cost field technique that can be used to locate "hot spots", identify the extent of hot-spots, and as a means of screening samples for submittal for laboratory analysis.

This methodology may not be sensitive enough to identify individual VOCs at or near the appropriate guidelines (with the possible exception of petroleum contaminants). The methodology is not a substitute for actual laboratory analysis. The method is a low-cost field screening tool that is most effective when the number of site screening samples is proportional to the size of the area of concern and/or volume of contaminated soil. The methodology effectiveness is also based on the knowledge and experience of the environmental professional and the development of a complete conceptual site model.

5.0 PLANNING

As with any sampling event, a sampling and analysis plan (SAP) and a health and safety plan (HASP) must be developed. Protocol for the development of a Sampling and Analysis Plan (SAP) can be found in MEDEP/DR SOP# RWM-DR-014 – Development of a Sampling and Analysis Plan.

6.0 EQUIPMENT

The following equipment is required for conducting the procedure:

- Soil sampling equipment (e.g., shovel, bucket auger, soil boring tools);
- Approved containers (recommend using a metalized aluminum bag or glass jar, see section 6.1);
- A PID or FID; and
- Calibration equipment, including user's manual, for particular PID or FID to be used.

6.1 SPECIAL CONSIDERATIONS REGARDING CONTAINERS

Currently, the most commonly used (and recommended) containers are one-quart sized metalized aluminum bag (various manufacturers make these types of bags). Also used are wide mouthed, metal screw top 16-oz. glass jars, with a ¼ inch hole drilled through center, and with foil over the top to provide the seal.

7.0 PROCEDURE

1) Warm up and calibrate the PID and FID instrument to be used according to the manufacturers recommended procedure (See Section 8 - Additional Considerations With Use of PID/FID). The PID and/or FID should be ready for use prior to collection of the first sample. The PID/FID should be operated in accordance with MEDEP/DR SOP# RWM-DR-019 – Protocol for the Use of Portable Vapor Monitors.

2) Collect the soil sample, as outlined in the site-specific SAP, utilizing appropriate soil sampling equipment.

3) Place approximately 200 grams of the soil sample into an approved container as stated in the SAP. The same type of container should be consistently used at the site for comparison purposes; do not mix or reuse headspace containers (unless the approved container is reusable and cleaned appropriately between uses). In so far as possible, samples should be mineral soil free of vegetation and stones larger than ½ inches in diameter. The type of soil being screened should be recorded and that description reported with the results. If a duplicate sample is to be submitted to the laboratory for analysis, this sample should **immediately** be containerized and

preserved as appropriate. Care should be taken to co-locate field screening and laboratory samples from the same soils. Laboratory VOC samples should not be taken from the field screening sample after it is screened, unless approved in the SAP and documented in the field notes and subsequent report. If using jars, the jars should be immediately sealed by placing a square of foil over the mouth and screwing on the lid. If using a metalized bag, the gusset at the bottom should be opened to allow development of the headspace within the entire bag.

4) Knead and break-up soil clods and shake the container for 30 seconds to thoroughly mix the contents.

5) Let Sample equilibrate for 10-minutes and shake again. Allow at least ten minutes but not more than 60-minutes for VOCs to reach headspace equilibrium. An attempt should be made to allow the same amount of equilibration time for each sample. When ambient temperatures are greater than 70 ºF, samples should be stored in the shade. When temperatures are below 70 ºF, samples should be warmed in the sunlight or in a running vehicle.

6) Measure and record the samples headspace concentration with the instrument by recording the highest PID/FID response. Collect a sample of the headspace by inserting the PID/FID probe into the appropriate opening for the container you are using. It is important to insert the probe as quickly as possible after the seal to the container has been broken. If the highest reading is related to a spike in the instrument response, then both the spike response and the highest response should be recorded and noted. Documentation of headspace results should be outlined in the SAP.

8.0 ADDITIONAL CONSIDERATIONS WITH USE OF A PID/FID

The protocol for operating a PID/FID can be found in MEDEP/DR SOP# RWM-DR-019 – Protocol for the Use of Portable Vapor Monitors.

There are limitations of PIDs and FIDs. A PID or 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 the PID 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 of the particular instrument that will be conducting this procedure take the time before the sampling event to familiarize themselves with the particular instrument that will be used, if they are not already familiar with that instrument. This includes reviewing the specific user manual, and calibration and practice with the instrument prior to the sampling event. Typically, if petroleum constituents are the primary contaminants of concern then MEDEP petroleum specific SOPs should be followed, as generally described in Section 2 of this SOP, unless otherwise stated in the SAP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

Data quality objectives (DQOs) should be stated in the SAP (See MEDEP/DR SOP# RWM-DR-014). Quality assurance/quality control (QA/QC) samples may be collected, if needed to meet your DQOs. The following are typical QA/QC samples or tasks conducted for PID/FID field screening. Additional sampling or tasks may be added based on the DQO requirements of the project.

9.1 RECALIBRATION DURING USE

During the course of the workday, the PID/FID should be bump tested with the appropriate calibration gas every two hours during the workday, or after screening samples with headspaces greater than 1,000-ppm. If the bump test reading is more than 10% different from the calibration gas, then the instrument should be recalibrated in accordance with the manufacturer’s specifications. All bump test and recalibration readings must be documented in the field notebook.

9.2 DUPLICATE SAMPLES

Field screening duplicate samples may be collected at a rate of 5% to assess sample location variability.

10.0 DOCUMENTATION

Field notes should be collected following the standard procedures outlined in MEDEP/DR SOP# RWM-DR-013 - Documentation of Field Activities and Development of a Trip Report. It is important that documentation include the specific lamp energy rating, calibration standard, and special response factors or curves that may be employed for the particular sampling event. When documenting such a sampling event, one should include enough information so that a person at a later date can easily duplicate the sampling and be able to compare the results.

As this type of screening is done in the field by the sampling team conducting the sampling, no chain of custody is required.

Specialized forms may be developed for recording field screening data. Additionally, some PID/FIDs have software which can record data. Any special method of recording and documenting results must be outlined in the SAP.

011-soil-field-screening-FINAL-2021 - B Blais

Final Audit Report 2021-12-23

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DEPARTMENT OF ENVIRONMENTAL PROTECTION · STATE OF MAINE ·

COVER SHEET
STANDARD OPERATING PROCEDURE

OPERATION TITLE: **DOCUMENTATION OF FIELD ACTIVITIES AND DEVELOPMENT OF A TRIP REPORT**

ORIGINATOR NAME: **Becky Blais**
Quality Assurance Coordinator
Division of Remediation
Bureau of Remediation and Waste Management

APPROVALS:

Division of Remediation Director:

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Print name — *Signature* — *Date*

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Susanne Miller — — Dec 23, 2021
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QMSC Chair:

Kevin Martin — Kevin E Martin — Dec 23, 2021
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Department Commissioner:

Melanie Loyzim — Melanie Loyzim — Dec 23, 2021
Print name — *Signature* — *Date*

DISTRIBUTION;

( ) Division of Remediation…................................By:_______________Date:________

1.0 APPLICABILITY

This Standard Operating Procedure (SOP) applies to all programs in the Maine Department of Environmental Protection's (MEDEP) Division of Remediation (DR). It is also applicable to all parties that may submit data that will be used by the MEDEP/DR.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2.0 PURPOSE

The purpose of this document is to describe the MEDEP/DR procedure for documenting field actions.

3.0 RESPONSIBILITIES

All MEDEP/DR Staff must follow this procedure when performing this task. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/DR staff reviewing data by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4.0 DEFINITIONS

- Field Notebook - Bound books with water resistant pages in which information from field activities is documented.
- Field Notes – Information gathered during a sampling event or other field activity associated with a known or suspected hazardous substance, petroleum, or landfill site.
- Field Log Form – A special use form for obtaining field notes in a standardized format, such as for low flow groundwater well monitoring or landfill inspection form.

5.0 GUIDANCE AND PROCEDURES

5.1 INTRODUCTION

There are several reasons for taking field notes when conducting work at hazardous substance, petroleum, and landfill Sites. These include:

- To provide a record of conditions of a site at a specific time, such as an inspection;
- To document specific activities at a site;
- Noting information in the field for its use, such as recording low flow well field parameters for comparison purposes to determine stabilization;

- To allow the re - creation of an event by persons not at the site (for comparing data of different events or finding sample locations for long term monitoring);
- To provide a means of reviewing the activities at a site if quality concerns with data collected during the site visit are encountered during data review; and
- To document a site visit.

All field notes should be taken with these purposes in mind. Additionally, all field notes must be made available for both internal and external review by assuring a copy is placed in the Sites official file in the MEDEP/BRWM file room. This includes creating an electronic “pdf” copy of field notes and saving in the appropriate MEDEP/DR electronic file using current MEDEP/DR electronic file naming conventions.

5.2.0 PROCEDURE

5.2.1 INITIALIZING FIELD BOOK

Upon Receipt of a Field Notebook, enter your name, DEP address, and phone number on the inside front cover. Staff may dedicate field books to a specific site if it is a long term project, or use one general field book for all of their tasks. Field books should be given a specific designation (site name and book volume number for site specific field books e.g. Joe’s Garage, Volume 1), or project manager/ year/ book number for general field books, (e.g. Frank Zappa, 2008 – 1). If a field book is not paginated, staff must number all pages, in order, prior to its use.

5.2.2 SITE DOCUMENTATION

All field notes, with the stated exceptions (i.e. use of field forms), will be kept in the standard field book issued by MEDEP/DR.

Upon arrival at a site, the following information must be written down in the field notes: 1) Date of field activity; 2) Site or project name and location; 3) names of persons visiting site, including who they represent and their positions or roles; 4) time of arrival; 5) weather conditions.

After completing the header, take field observations as necessary. At the bottom of each page, and at the end of each day or event, sign and date the field book.

The field notebook must be kept organized, legible, and accurate as it may be used as evidence in court proceedings. Do not doodle on pages or document personal comments. Additionally, only blue or black ink should be used. Pencils must never be used.

5.2.3 ITEMS TO BE DOCUMENTED

Given the variety of circumstances that can be found, it is difficult to provide a minimum for documentation. Staff should take field notes with the concept that another person will be able to recreate the activities from the notes taken.

The following list should be considered a guide for documentation:

- Names of personnel present and organization;
- The sample event date and time;
- Weather conditions;
- Field measurements (such as PID readings, pH, temperature, etc);
- Sample station location designations, sample container numbers, etc;
- Specific sample location information, such as description of location, depths of sample, tide conditions, soil conditions, water color/conditions, etc;
- Out of the ordinary events, such as equipment failure, damage to monitoring wells or evidence of tampering, observations of gross contamination, odors, etc; and
- Information the field staff believe may be useful or pertinent at a later date.

For field events with multiple personnel present, it is not necessary for each participant to take field notes. The person(s) responsible for taking field notes and completing the Sampling Event Trip report (SETR) will be stated in the Sampling and Analysis Plan (SAP) or Quality Assurance Project Plan (QAP) for the event (See MEDEP/DR SOP #RWM-DR-014 - Development of a Sampling and Analysis Plan; MEDEP/DR SOP #RWM-DR-016 - Development of a Site Specific Quality Assurance Project Plan (QAPP)).

5.2.4 ERROR CORRECTIONS

Do not scratch out or blacken over error. Place one line through error, initial it, and continue with correct information. Never rip out or otherwise remove a page from a field book.

5.2.5 FIELD LOG FORMS

Some field activities have specific forms for taking notes, or specific projects may require specialized forms to assist in data organization. If sampling for PFAS, field log forms may be used to track sampling events in place of field books due to the composition of the waterproof paper as outlined in MEDEP/DR SOP DR#014-PFAS Addendum. If forms are used in conjunction with a field book, a field book entry must be made with reference to the forms used during that event. At the end of the day, the total number of forms used during that days' activity(s) must be indicated in the field book. If forms are used without a field book, all of the forms for that day must be paginated at the end of the day, and, if multiple forms are used for the same project, attached as a packet to a field event trip report cover sheet (found in Attachment A). If the form has all of the information on the cover sheet, a cover sheet is not required.

MEDEP/DR and Maine Department of Environmental Protection, Bureau of Remediation and Waste Management, Division of Technical Services (MEDEP/TS) have various forms for notes, including but not limited to:

- Low flow purge and sampling of monitoring wells
- Soil boring/test pit logs
- Elevation survey forms
- Residential water supply survey form

- Well development form
- Landfill inspection form
- XRF sample log sheet
- Indoor air and soil vapor form

Site or task specific forms can also be generated on an as needed basis.

6.0 FIELD EVENT TRIP REPORT (FETR)

After each field event, a sampling event trip report (FETR) package must be completed for the event. If the field event has multiple MEDEP/DR staff present, the person responsible for completing the FETR will be stated in the SAP. At a minimum, the FETR will consist of the completed FETR cover sheet form (Attachment A to this SOP), photocopies of all field notes taken by all personnel during the event, and copies of chains of custody for samples. A cover sheet form is not required if only one form is used for a site, and that form has all of the information required on the FETR cover sheet (such as a landfill inspection form). It is also recommended that a summary memo to the file be developed and attached to the FETR form which outlines the field events purpose, activities, and outcomes, and other relevant issues.

Once completed, the original hardcopy of the FETR package will be placed in the Project Site File and a pdf electronic copy will be placed in the electronic file for the site.

ATTACHMENT A
FIELD EVENT TRIP REPORT

DIVISION OF REMEDIATION FIELD TRIP REPORT

DATE: **Weather Conditions:**

SITE NAME and LOCATION:

MEDEP PERSONNEL PRESENT:

OTHER PEOPLE PRESENT:

PURPOSE OF SITE/AREA VISIT:

- ☐ Reconnaissance
- ☐ Residential Water Sampling
- ☐ Sampling Monitoring Wells or Micro Wells
- ☐ Waste Sampling, Drums, Stained Soil, Other ____________________
- ☐ Soil Sampling
- ☐ Surface Water/ Sediment Sampling. Water Body ____________________
- ☐ Geoprobing
- ☐ Contractor Oversight ____________________
- ☐ OTHER____________________

____

FIELD NOTES and SAMPLE NUMBERS RECORDED BY:

ADDITIONAL COMMENTS:

____
____
____
____

Audit of procedures conducted? Yes ☐ No ☐ ____________________
Deficiencies noted? Yes ☐ No ☐ If Yes, explain in written trip report and attach

ATTACHMENTS:

- ☐ Copy of Field Book Pages
- ☐ Copy of Chain-of-Custody
- ☐ Photographs
- ☐ OTHER: ____________________

____

Print Name: **Signature:** **Date:**

013-Field-documentation-and-trip-report-FINAL-2021 - B Blais

Final Audit Report 2021-12-23

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DEPARTMENT OF ENVIRONMENTAL PROTECTION · STATE OF MAINE ·

COVERSHEET
STANDARD OPERATING PROCEDURE

Operation Title: **EQUIPMENT DECONTAMINATION PROTOCOL**

Originator: **Becky Blais**
Quality Assurance Coordinator
Division of Remediation
Bureau of Remediation and Waste Management

APPROVALS:

Division of Remediation Director:

Carla J. Hopkins — Carla J Hopkins — Dec 22, 2021
Print name — *Signature* — *Date*

Bureau of Remediation and Waste Management Director:

Susanne Miller — — Dec 23, 2021
Print name — *Signature* — *Date*

QMSC Chair:

Kevin Martin — Kevin E Martin — Dec 23, 2021
Print name — *Signature* — *Date*

Department Commissioner:

Melanie Loyzim — Melanie Loyzim — Dec 23, 2021
Print name — *Signature* — *Date*

DISTRIBUTION;

( ) Division of Remediation…................................By:_______________Date:________

1.0 APPLICABILITY

This Standard Operating Procedure (SOP) applies to all programs in the Maine Department of Environmental Protection's (MEDEP) Division of Remediation (DR). It is also applicable to all parties that may submit data that will be used by the MEDEP/DR.

This SOP is not a rule and is not intended to have the force of law, nor does it create or affect any legal rights of any individual, all of which are determined by applicable statutes and law. This SOP does not supersede statutes or rules.

2.0 PURPOSE

The purpose of this document is to describe MEDEP/DR procedure for decontamination of equipment.

3.0 RESPONSIBILITIES

All MEDEP/DR Staff must follow this procedure when performing this task. All Managers and Supervisors are responsible for ensuring that their staff are familiar with and adhere to this procedure. MEDEP/DR staff reviewing data by outside parties are responsible for assuring that the procedure (or an equivalent) was utilized appropriately.

4.0 GUIDELINES AND PROCEDURES

4.1 INTRODUCTION

Decontamination is an essential part of a successful field operation. 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.

In addition to this guideline, personnel using a specific piece of equipment for the first time should also review the manufacturer's user manual for any equipment specific decontamination procedures recommended by that manufacturer.

4.2 PLANNING

Prior to conducting any type of sampling or other field work, a sampling and analysis plan (SAP), or in the case of remedial activities, a work plan and a health and safety plan (HASP), must be developed. Protocol for the development of a Sampling and Analysis Plan can be found in MEDEP/DR SOP RWM-DR-014 – Development of a Sampling and Analysis Plan. A conceptual site model (CSM) which includes expected contaminants to be encountered is part of a SAP. Specific chemicals, particularly when sampling containers or tanks, may require the use of neutralizing agents or other specialty decontamination procedures. The need for special decontamination agents for chemicals expected to be found at a site must be outlined in the SAP and HASP.

Decontamination procedures should be completed with an appropriate level of personnel protection. PPE required for staff conducting decontamination must also be indicated in the SAP/ HASP.

4.3 DECONTAMINATION EQUIPMENT

Equipment required for decontamination may include:

- Brushes, scrapers, sponges;
- Spray bottles;
- Water, tap or deionized;
- Soap, such as Liquinox;
- Paper towels;
- Methanol or other solvent wash (as needed).

Other specialty decontamination equipment, such as a powered high-pressure wash, special neutralizing chemicals, or PFAS-free water may be required, and must be described in the SAP.

4.4 PROCEDURES

Decontamination generally involves three steps: 1) gross contamination removal; 2) field decontamination; 3) secondary decontamination. If using a sink (such as in the equipment warehouse after sampling) or washbasin, then cleaning these may be considered a fourth step.

4.4.1 GROSS CONTAMINATION REMOVAL

Gross contamination removal involves the removal of large dirt and mud chunks or clods, and other visible contamination, from the object being decontaminated, and prevents wash water from becoming contaminated by mud and dirt.

If a piece of equipment is grossly contaminated, use appropriate tools/equipment (for example, scraper, bristle brush, sponge, etc.) to remove the excess soil, sludge, and other obvious contamination. While removing the contamination, spray the items of equipment with water or a detergent/water solution. Such spraying (especially from a high pressure sprayer) may loosen the contamination with a minimal amount of effort. Remember that each item (i.e. brush, spray-bottle) used for the decontamination of equipment may also become contaminated and must be appropriately handled, stored, and either decontaminated itself or disposed of. Also be sure to clean your sink, bucket, or wash basin if used.

In addition, the decontamination of equipment generates contaminated rinse liquids, sludges, etc., that potentially may need to be containerized onsite until proper disposal arrangements are made. In many instances, the levels of contamination may be sufficiently low and disposal at a hazardous waste facility may not be necessary. Disposal of wash and rinse fluids will be outlined in the SAP, Work Plan, and/or HASP.

Certain items that become grossly contaminated and cannot be practically decontaminated (i.e. 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 field personnel performing the work activities at the site.

4.4.2 FIELD DECONTAMINATION

Once the gross contamination has been removed from a piece of equipment, a more thorough cleaning involving detergents (such as Liquinox®) and rinses should be done. The primary steps to take when performing field decontamination of equipment are dependent on what item of equipment is being decontaminated; however, these steps will generally be followed:

1) Disassemble the equipment (if applicable), and place in a bucket or suitable sized basin filled with a deionized or tap water and Liquinox® (or other appropriate detergent);
2) Scrub the equipment thoroughly with a suitable sized brush;
3) Rinse the inside and outside of the equipment with deionized or tap water;
3A) Rinse equipment with methanol solvent wash (if determined necessary, see below);
4) Inspect equipment to assure proper decontamination.

In some instances, an additional wash with methanol may be required. The need for a methanol solvent (or other solvent, or chemical neutralizing agent) wash will be determined on a project by project basis, and if required, outlined in the project's SAP. A methanol solvent wash may be necessary in the case of sampling in high levels of contamination, or when sampling particularly difficult to clean contamination such as coal tar.

Instruments such as pH meters, conductivity meters, and other instruments which are immersed in a medium also need field decontamination. In many cases, these instruments do not come into contact with the actual "material" that will be collected for analysis. An example would be collection of groundwater samples using "low flow" methodology (Low flow methodology is outlined in MEDEP/DR SOP# RWM-DR-003). In instances such as this, a thorough rinsing of the instrument probes would suffice, with additional decontamination to follow after the sampling event in a controlled indoor environment, when greater care can be taken so the instrument is not damaged.

If the equipment to be decontaminated is delicate, such as a photoionization detector (PID) or a Combustible Gas Indicator (CGI), care must be taken when decontaminating so the equipment is not damaged. The best way to avoid the need to decontaminate items such as these is to prevent contact with contamination in the first place. 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 affected.

4.4.3 SECONDARY DECONTAMINATION

It is recommended that all field equipment be decontaminated again upon the end of a project in a controlled environment (i.e., indoors, with uninterrupted water delivery) to assure that it as been properly decontaminated and is still working before its next use. Procedures for secondary decontamination would mimic field decontamination, however the availability of uninterrupted water under pressure, plus counter space and being indoors, would allow for greater care taken during decontamination. When doing so, be sure to clean your sink and counters once you finish.

4.4.4 LARGE EQUIPMENT DECONTAMINATION

For site work involving large equipment, such as backhoes, bulldozers, drill rigs, etc., a site specific decontamination procedure will be required in the Site specific work plan. 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.

4.5 DECONTAMINATION ALTERNATIVES

Decontamination is, by its nature, an arduous and painstaking task which is often better to avoid. By eliminating contact with contamination and/or using disposable equipment, decontamination of equipment may be avoided. Such alternatives are:

1) Dedicating specific equipment to a specific sample point (e.g. specific bailers to specific wells) when economically and logistically feasible;
2) Using disposable equipment when applicable (e.g. disposable tubing), and;
3) Wrapping monitoring equipment in plastic bags(or other materials) to protect from contamination.

It is important to keep monitoring equipment such as PIDs or CGIs from contacting soil or liquids at hazardous substance sites. However, if an instrument becomes contaminated it must be decontaminated, regardless as to how protected the equipment was. Additionally, all equipment should be inspected and decontaminated at the end of the project even if protected from contamination.

5.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Data quality objectives (DQOs) must be determined prior to sampling, and outlined in the SAP. **Equipment blanks** are samples obtained from equipment rinsate and may be collected to assure decontamination is effective, and preventing cross contamination. Equipment blanks should be collected at a rate of 5%, or as stated in the SAP to meet DQOs.

5.1 EQUIPMENT BLANK COLLECTION PROCEDURE

1) Procure appropriate water for equipment blank and store in clean area;
2) Decontaminate equipment;
3) Rinse equipment again with blank water, and collect into sample containers for laboratory analysis. Try to drain rinse water directly into containers; however, it may be necessary to utilize a rinsate collection trough, or a funnel. Be sure to decontaminate trough or funnel prior to using for collection of blank.
4) Store/preserve samples with other samples, and submit to laboratory following standard chain of custody protocol.

5.1.1 EQUIPMENT BLANK

Equipment blank water should consist of de-ionized water procured from the laboratory conducting the analysis. However, tap water may be used if metals and trihalomethanes are not contaminants of concern. Source of equipment blank water will be stated in the SAP, and documented in the field notes of the sampling event.

6.0 DOCUMENTATION

Documentation of decontamination activities, including collection of equipment blanks, should be conducted as outlined in MEDEP/DR SOP# RWM-DR-013, Documentation of Field Activities and Development of a Trip Report, and the SAP.

017-Equipment Decontamination Protocol-Final 2021 - B Blais

Final Audit Report 2021-12-23

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Field Quality Control Guidance

Maine Department of Environmental Protection

ME LUST Program

Standard Operating Procedure: Field Quality Control
SOP Number: TS 003
REVISION: 4
DATE: February 28, 2007
Written/Revised by: Deb Stahler
Reviewed by: John Beane

Approval:

George Seel, LUST Program Director date

1.0 APPLICABILITY:

MEDEP LUST Program is responsible for the investigation and remediation of petroleum contaminated sites throughout Maine. Fieldwork for this program may include initial investigation of a reported spill, routine monitoring of an established site, or collecting samples that will be used to support a decision to close a site. The level of quality control needed to meet the needs for the sampling event should be established prior to fieldwork. This SOP is applicable to all phases of LUST Program field sampling.

2.0 PURPOSE

The purpose of this document is to describe the Maine Department of Environmental Protection, LUST Program guidance for collecting and evaluating field quality control samples.

3.0 DEFINITIONS

3.1 GRO: Gasoline Range Organics

3.2 VOC: Volatile Organic compounds

3.3 LUST: Leaking underground storage tanks

3.4 RPD: Relative percent difference, a measure of precision

4.0 RESPONSIBILITIES

All MEDEP LUST Program staff will follow the procedures outlined in this SOP for the collection and evaluation of quality control samples. The project scientist for a site is generally responsible for field quality control, with input from appropriate staff. Their respective supervisors and managers are responsible for ensuring that they are familiar with and adhere to this procedure, and receive the appropriate training and guidance to conduct fieldwork.

5.0 FIELD QUALITY CONTROL GUIDANCE

5.1 Requirements for Quality Control Sample Collection:

Requirements for collection of field quality control samples will depend on the type of site and what data will be used for. Section 5.2 contains general guidelines. Specific requirements should be included in a site work plan as necessary.

For sites that do not require a specific site work plan section 5.2 guidelines should be followed for sampling events that will be used for key project decisions, site closure, and for sampling events used for site monitoring when multiple sample locations are to be sampled.

For occasional sampling including preliminary investigations and routine monitoring of small sites [less than 10 samples] quality control samples are not routinely required. However, if questions of data quality are raised, confirmation sampling should be undertaken that includes the appropriate quality control samples.

5.2 Collection and Evaluation Procedures:

5.2.1 **Trip Blanks** are taken when sampling for GRO or VOC to ensure that routine sample handling procedures including sample bottle contamination issues do not lead to false positive analyses. One trip blank should be taken to each sampling event/ site.

A trip blank is organic free water placed in sample bottles prior to a site visit. Typically laboratories supply the appropriate trip blank. The trip blank is then transported to the site along with sample bottles, and ultimately back to the laboratory for analysis. Trip blanks must be properly labeled, but are not included as samples on the chain of custody form.

Trip blanks are analyzed when field blank samples indicate a problem, or if field blanks are not collected. Analysis of the trip blank in conjunction with a field blank or equipment blank will help determine where a sample contamination problem originates.

Trip blanks should not contain any analytes of interest at or above the quantitation limit of the test. If trip blank contamination is documented, all positive sample results are suspect, and depending on the level of contamination, may require re-sampling.

5.2.2 **Field blanks** are taken when sampling for all analyses to ensure site conditions do not lead to false positive analyses. One field blank should be taken for each batch of up to 20 samples during a sampling event when taken. Often field blanks are not taken for field events that involve samples from a variety of locations since site conditions at one location may be different from other locations. Field blanks should be taken according to the judgement of the project scientist. Generally if solvent odors are present field blanks should be taken for VOC.

To collect field blanks, analyte free water must be transported to the field, and poured into appropriate sampling bottles on-site. Field blanks should be properly labeled, and identified on the chain of custody record. They are analyzed as samples by the analytical laboratory.

Field blanks should not contain any analytes of interest at or above the quantitation limit of the test. If field blank contamination is documented, all positive sample results are suspect, and depending on the level of contamination, may require re-sampling. Field blank contamination also triggers analysis of the trip blank.

5.2.3 **Equipment Blanks**: When sampling equipment, such as bailers, pumps with tubing, hand augers, etc. is used to collect samples, an equipment blank is collected to assess decontamination procedures for the equipment. One equipment blank should be taken for each batch of up to 20 samples during a sampling event.

Equipment blanks are not necessary when using dedicated or disposable equipment unless contamination from the constituent materials is suspected.

Equipment blanks should be properly labeled, and identified on the chain of custody record. They are analyzed as samples by the analytical laboratory.

Equipment blanks should not contain any analytes of interest at or above the quantitation limit of the test. If equipment blank contamination is documented, all positive sample results are suspect, and depending on the level of contamination, may require re-sampling.

5.2.4 **Field Duplicates** are taken to assess precision in the field. One field Duplicate should be taken for each batch of up to 20 samples during a sampling event.

When taking aqueous samples, the field duplicate should be taken directly after the sample using the appropriate sample container.

When taking soil samples, GRO and VOC duplicates should be "co-located" that is taken from soil immediately adjacent to where the sample was taken. Other types of samples can be composited. To take composite samples, place enough soil into a container [plastic for metals, and stainless steel for everything else] for both the sample and the duplicate. Mix thoroughly, and fill the appropriate sample containers.

Samples should be labeled and included on the chain of custody record.

Evaluate results by calculating the RPD between the sample and duplicate.

$\text{RPD} = 100 \times (\lvert S - D \rvert \ / ((S + D)/2))$;

where: S is the sample concentration; and
D is the duplicate concentration.

Water samples should be within 30% RPD and soil samples should be within 50% RPD. If overall precision is outside criteria, laboratory precision should be evaluated to help determine whether this represents a sampling or analysis issue. Sampling precision should be included in an overall analysis of data quality. If sample results are close enough to a site action level, and will be used to make decisions about closing a site, re-sampling may be indicated. Field duplicate precision information should be included in any data evaluation reports.

5.2.5 **Matrix Spikes** and matrix spike duplicates are not required field samples, but are useful to assess matrix interference for the site. Matrix spikes are not used for GRO in groundwater, and are most useful for soil samples. These samples should be collected at the discretion of the project scientist, or according to criteria set up in a site work plan. Note that matrix spike and spike duplicates are required for SW846 solid waste methods such as 8260/ 8270.

For the field sampler matrix spike and matrix spike duplicate collection entails providing enough of the sample so the laboratory can analyze three samples [the sample, a matrix spike, a matrix spike duplicate].

Matrix spike and spike duplicate samples are evaluated by the laboratory for accuracy [percent recovery], and also for precision [RPD]. Criteria used to evaluate these samples are found in the appropriate analytical method.

5.3 Sample Preservation Issues:

5.3.1 All samples should be preserved according to guidelines included in Attachment 1 whenever possible. These guidelines should be strictly met for all sampling events that will be used for key project decisions, site closure, and for sampling events used for site monitoring when multiple sample locations are to be sampled.

5.3.2 It is recognized that due to unforeseen circumstances some samples may need to be taken without proper refrigeration. In these cases, samples should be transported to a lab or an office refrigerator within 4 hours of collection. Sample results that will be most affected by this deviation from guidelines are those for VOC or GRO. In cases where samples are not properly chilled in the field, data quality issues should be evaluated based on sample temperature, time not under refrigeration and use of the data. If data quality does not support project data quality objectives, confirmation sampling may be required.

6.0 REFERENCES

Test Methods for Evaluating Solid Waste, SW 846, third edition, Chapter 1; USEPA, final update III, December 1996

Attachment 1: SAMPLING CRITERIA FOR METALS AND ORGANIC COMPOUNDS

Organics

Test	Method[1]	Sample Size	Type Container	Preservative	Hold Time	Notes
GRO (water)	ME 4.2.17	2-40 ml	G, TLS[3]	cool, 4 C, HCl pH<2	14 Days	trip blank may be needed
GRO (soil)	ME 4.2.17	2-40 ml or 60 ml	G, TLS[3]	Methanol & cool, 4 C **-or-** freeze samples without methanol	14 Days	see GRO in Soil SOP
DRO (water)	ME 4.1.25	1L	Amber G,TLS[3]	cool, 4 C; HCl or sodium bisulfate	7 Days extraction	minimize plumbing grease contamination
DRO (soil)	ME 4.1.25	200g	G,TLS[3]	cool, 4 C	14 Days extraction	
SVOC (water)	3510C or 3520C/ 8270C	1L	Amber G,TLS[3]	cool, 4 C	7 Days extraction	Extra bottles for MS/MDS; minimize phthalate contamination
SVOC (soil)	3540C or 3541/ 8270C	200g	Amber G,TLS[3]	cool, 4 C	14 Days extraction	
PCB in water	3510C or 3520C/ 8082	1L	Amber G,TLS[3]	cool, 4 C	7 Days extraction	Extra bottles for MS/MDS;
PCB in soil	8082	200g	Amber G,TLS[3]	cool, 4 C	14 Days extraction	3550B extraction may be used with caution
Pesticides in water	3510C or 3520C/ 8081A	1L	Amber G,TLS[3]	cool, 4 C	7 Days extraction	Extra bottles for MS/MDS;
Pesticides in soil	3540C or 3541/ 8081A	200g	Amber G,TLS[3]	cool, 4 C	14 Days extraction	3550B extraction may be used with caution
Herbicides in water	8151A	1L	Amber G, TLS[3]	cool, 4 C	7 Days extraction	Extra bottles for MS/MDS;
Herbicides in soil	8151A	200g	Amber G, TLS[3]	cool, 4 C	14 Days extraction	
Volatiles (water)	5030/ 8260B 524.2 [DW]	2-40 ml vials	G, TLS[3]	cool, 4 C [8260 only] cool, 4 C, HCl pH<2	7 Days 14 Days	Extra bottles for MS/MDS; trip blank may be needed dechlorinate as needed prior to addition of HCl
Volatiles (soil)	5035/ 8260B	3 samples	encore sampler	cool, 4 C	48 hours	Extra bottles for MS/MDS; extra sample for % solids
or	5035/ 8260B	3-40 ml vials, 5g in each vial	G, TLS[3]	cool, 4 C; sodium bisulfate soln. in 2 vials and methanol in 1 vial	14 days	Extra bottles for MS/MDS; acetone may be artifact extra sample for % solids
or	8260B	3-40 ml vials	G, TLS[3]	freeze	14 days	Extra bottles for MS/MDS; 5g in each vial extra sample for % solids

Attachment 1: SAMPLING CRITERIA FOR METALS AND ORGANIC COMPOUNDS

Metals

Test	Method[1]	Sample Size	Type Container	Preservative	Holding Time	Notes
Dissolved metals	6010B, 6020 or 7000 series	1 L	cube cont.	HNO3 to pH<2	6 Mos.	Filter on site
Total metals in water	6010B, 6020 or 7000 series 200.7, 200.8, & 200.9 for drinking water	1 L	cube cont.	HNO3 to pH<2	6 Mos.	For RCRA 8 1L includes mercury
Total metals in soil	6010B, 6020 or 7000 series	200g	Whirlpack	none	6 Mos.	
Dissolved Mercury	7470A	1 L	cube cont.	HNO3 to pH<2	28 Days	Filter on site
Total Mercury in water	7470A 245.1 [DW]	1 L	cube cont.	Cool 4 C ; HNO3 to pH<2	28 Days	
Total Mercury in soil	7471A	200g	Whirlpack	Cool 4 C	28 days	

TCLP

Test	SW 846 Method	Sample Size	Type Container	Preservative	Holding Time
TCLP-VOC	1311/ 8260B	4 oz	G, TLS[3]	cool, 4 C	NA
TCLP-Metals	1311/ 6010B or 7000 series	4 oz	G	none	NA
TCLP – herbicides	1311/8151	1 L	G, TLS[3]	cool, 4 C	NA

MISC.

Test	SW 846 Method	Sample Size	Type Container	Preservative	Holding Time
Reactive Sulfide & Reactive Cyanide	SW846 Chapter 8 section 3	2- 4 oz jars	G	none	NA
Flash point	1010, 1020A	4 oz	G, TLS[3]	cool, 4 C	NA
pH[2]	9040A, 9041A, 9045B for soil	4 oz	G	none	NA
Maine Waste Oil Parameters [4]		2 4 oz amber jars	G, TLS[3]	none	NA

Notes:

1. Sw 846 methods, except as noted
2. For situations where the material is very light (e.g. fly ash, feathers, etc.) please provide more material than a 4-oz jar.
3. TLS = Teflon lined cap
4. Maine Waste Oil Parameters include PCBs, flash point, total Halogens, arsenic, cadmium, chromium, and lead

COVERSHEET
STANDARD OPERATING PROCEDURE

Operation Title: Compendium of Field Testing of Soil Samples for Gasoline and Fuel Oil

Originator Name(s): Fred Lavallee, Rob Peale and Troy Smith, Division of Technical Services, Bureau of Remediation & Waste Management

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COVERSHEET
STANDARD OPERATING PROCEDURE

Operation Title: <u>COMPENDIUM OF FIELD TESTING of SOIL SAMPLES for GASOLINE and FUEL OIL</u>

Originators: **Fred Lavallee, Rob Peale, Troy Smith and Deb Stahler**
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Standard Operating Procedure: TS004
REVISION: 2.1
DATE: October 15, 2012

George Seel 10/22/12

George Seel Signature Date
Oil Program Manager

Definition of Acronyms

Acronym	**Definition**
AOC	Area of Concern
AST	Aboveground Storage Tank
BRWM	Bureau of Remediation and Waste Management
CSM	Conceptual Site Model
CSS	Confirmation Screening Sample
DQO	Data Quality Objective
DR	Division of Remediation
EDD	Electronic Data Deliverable
EGAD	Environmental and Geographic Analysis Database
EPS	Expanded Polystyrene
ESA	Environmental Site Assessment
ESS	Excavation Screening Sample
FGS	Feet below Ground Surface
GW	Groundwater
LS	Laboratory Sample
LUST	Leaking Underground Storage Tank
^{o}F	Degrees Fahrenheit
PID	Photo Ionization Detector
PPM	Parts Per Million
PPMV	Parts Per Million by Volume
QAP	Quality Assurance Plan
RAG	Remedial Action Guideline
REC	Recognized Environmental Condition
RS	Response Services
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
TS	Technical Services
UST	Underground Storage Tank

1.0 PURPOSE

The purpose of this document is to describe the Maine Department of Environmental Protection, Bureau of Remediation and Waste Management (BRWM) procedure for petroleum field testing of soils.

2.0 APPLICABILITY

BRWM is responsible for the investigation and remediation of petroleum sites throughout Maine. The procedures described herein are field tests for (1) determining relative levels of gasoline present in soil with a PID instrument and (2) screening soils contaminated with kerosene and fuel oil using an oleophilic dye test. Under certain conditions where soil contact scenarios focus on the excavation-construction worker exposure scenario below two feet, a third screening technique identified as the Water Shake Test can be used as an acceptable substitute for the PID and Oleophilic Dye Test as explained below.

The **PID Bag Headspace Test** is applicable only for soils contaminated with gasoline. It is not applicable for heavier petroleum products such as kerosene or fuel oil.

The **Oleophilic Dye Test** is applicable for fuel oils. It is not applicable for use with heavy crude oils (Bunker C) or bituminous materials like asphalt or waxes. Mineral oil and motor oils may be detected; however, the detergents in some synthetic motor oils may interfere with color development.

Both tests are needed to screen soils for gasoline and fuel oils at sites contaminated with mixed or unknown petroleum products.

When these procedures are strictly followed results may be used to make key field decisions and provide information for site assessments.

The **Water Shake Test** is applicable only when leaching to groundwater is NOT a risk pathway of concern, the direct contact risk is limited to the excavation construction worker, and the soils are deeper than two-feet below the land surface. Under these conditions the Water Shake Test can replace the PID Bag Headspace Test and the Oleophilic Dye Test methods.

3.0 RESPONSIBILITES

All staff must be appropriately trained prior to performing these tests for the investigation of petroleum sites and that training must be documented in accordance with the LUST QAP (http://www.maine.gov/dep/rwm/ust/lustqaplan.htm). Generally, it is the field personnel of BRWM/Technical Services (BRWM/TS), BRWM/Response Services (BRWM/RS) and BRWM/Remediation (BRWM/DR) who will be responsible for performing these tests.

The directors of the Divisions of Response Services, Technical Services and Remediation as well as all supervisors in those divisions are responsible for ensuring that staff understand and adhere to these procedures when used for key field decisions or site assessments.

4.0 INTRODUCTION

This SOP includes three field tests for petroleum along with guidance for their application for site work.

For the **PID Bag Headspace Test**, a soil sample is placed in an approved container and the volatile constituents are allowed to come to equilibrium. The headspace is then measured with an isobutylene calibrated PID, with a result expressed in parts per million by volume (PPMV).

For the **Oleophilic Dye Test**, soil is added to the sample bottle, to which oil-free water is also added and the contents shaken vigorously with a rapidly dissolving red or blue oleophilic dye.

The oleophilic dye stains petroleum products red (or blue). When petroleum is released from the soil it attaches to an expandable polystyrene (EPS) bead and/or attaches to the walls of the container. Where no visible oil layer is present the bead will turn pink or blue down to the limit of detection which is about 500 ppm.

For the **Water Shake Test** soil and water are added to a clear glass container, shaken, and the presence of free petroleum blebs or a petroleum layer can be seen.

5.0 PLANNING

As with any sampling event, a sampling and analysis plan (SAP) and a health and safety plan (HASP) should be developed. Guidance for the development of a Sampling and Analysis Plan can be found in DR SOP #014 – Development of a Sampling and Analysis Plan (http://www.maine.gov/dep/rwm/sops/index.htm).

Processing one headspace sample will take up to 30 minutes from initial sample collection through recording results. It is important to plan for someone to complete the sampling and analysis in a careful and timely fashion for results to be useful. For some projects more than one field person may be needed.

6.0 EQUIPMENT

6.1 The following equipment is required for conducting the PID Bag Headspace Test for gasoline:

- Soil sampling equipment such as shovel, bucket auger, soil borer, scoops; 200g container (6 ounce can), 20g and 5g soil coring devices.
- Approved containers: Bags are made from a double layer of strong metalized polyester and low-density polyethylene (3 mil) with dimensions: 8-1/2" x 12" stand-up zipper pouch with 3-1/2" bottom gusset.

  *Note: Associated Bag Company Item Number 183-52 meets these requirements. Other products may be acceptable. Standard re-sealable plastic bags such as sandwich or freezer bags are **not** acceptable because they do not adequately prevent the loss of gasoline vapors.*
- An approved PID with a lamp energy of 10.2 to 10.6 eV; and
- Calibration equipment, including users' manual, for particular PID to be used.

6.2. The following equipment is required for conducting the Oleophilic Dye Test for fuel oils:

- Soil sampling equipment such as shovel, bucket auger, soil borer, scoops;
- 50 ml plastic sample bottles containing appropriate dyes and EPS bead. Kits from two commercial test kit companies, Oil-In-Soil and OilScreenSoil have been successfully tested

by MEDEP for use according to this SOP. Red dyes are preferred, but Indigo Blue kits are available for use when soil color interferes with interpretation of red dye test kits; and

- Oil-free water

6.3. The following equipment is required for conducting the Water Shake Test:

- Clear container with cover; and
- Oil free water.

7.0 PROCEDURE for PID BAG HEADSPACE

7.1. Instructions for use of a PID can be found in Division of Remediation SOP DR#019 – Protocol for Use of a PID/FID (http://www.maine.gov/dep/rwm/sops/index.htm). It is recommended that the operator that will be conducting this procedure take the time before the sampling event to familiarize themselves with the particular instrument that will be used, if they are not already familiar with that instrument. This includes reviewing the specific user manual, and calibration and practice with the instrument prior to the sampling event.

7.2. The PID must be bump tested prior to each use, at least every two hours during use, and at the end of the day. If the bump test falls outside 100±10 PPM, the lamp should be cleaned and the filter changed. If repeat bump testing remains outside 100±10 PPM the instrument should be re-calibrated. Record all bump test results. The PID must be calibrated to isobutylene according to manufacturer instructions. Check the calibration (“bump test”) against the 100 PPM isobutylene standard and record the results.

Note: No calibration adjustment or correction of instrument readings is made for set points; the response factor should be 1.0 for all instruments.

7.3. Evaluate PID high concentration performance before arriving at the site each day of use. This can be accomplished by measuring the headspace over pure acetone or other suitable substance that normally produces values higher than the Outdoor Commercial Worker/ Excavation-Construction Worker screening number from Table 1. The PID must not be used for site work if performance does not meet the expectation.

7.4. Collect the soil sample with appropriate soil sampling equipment, as outlined in the site specific Sampling and Analysis Plan (SAP)(See SOP DR#014 - Development of a Sampling and Analysis Plan) or the applicable Appendix to this SOP.

- Do test in triplicate (at a minimum), taking co-located samples. True replicates are difficult to collect. It is important to collect at least three samples when using the results to make key field decisions.
- Label and open the bags. Unfold the bottom gusset in each bag to facilitate a uniform headspace volume when the bags are closed. This is particularly important for smaller sample sizes.
- Place appropriate mass of soil in aluminized bag.
    - For Leaching to Groundwater cleanup scenarios use 200 g soil (6 oz can)
    - For Resident or Park User cleanup without regard to groundwater use 20 g soil (20 ml syringe or plug sampler)
    - For Outdoor Commercial Worker/ Excavation-Construction Worker cleanup scenarios use 5 g soil (5 ml syringe or plug sampler)

- Close bag leaving uniform headspace.
- Knead samples (in closed bag) if needed to break up clumps, then shake bags for 30 seconds.
- Thaw sample if frozen.
- Let stand for 10 minutes to develop headspace.
- Knead/shake bags for additional 30 seconds.
- Let stand for 2 minutes. Do not let samples stand for more than a total of 30 minutes before PID measurement. Gasoline vapors can migrate through bags. Testing indicates up to 20% loss after sitting for 60 minutes at 70^{o}F in the metalized bags.
- Open bag carefully and insert probe of calibrated PID one third to half way into bag (approximately 4 inches). Keep bag seal closed as much as possible around probe.
- Allow instrument to read until concentrations start to fall.
- Record highest sustained reading.
- Repeat for additional bags.

7.5. Result Interpretation

- Table 1 presents field cleanup guidelines for the various exposure scenarios. Values in Table 1 are dependent on sample size and PID model. Only approved PID models may be used. Remediation is indicated if the average sample result is at or above the Table 1 value for the site's cleanup scenario.

- Excavation Screening Samples (ESS) and other samples where only one bag per sample is tested: compare results to Table 1 values.

- Confirmation Screening Samples (CSS) and other samples where more than one bag per sample is tested: Average the three (or more) sample results and compare to Table 1 values.

- Alternatively, a PID can be calibrated to a gasoline contaminated site if sufficient laboratory MA VPH sample data are available for comparison. Any alternative calibration must follow a Department approved plan.

8.0 PROCEDURE FOR FUEL OIL OLEOPHILIC DYE TEST

8.1 Collect the soil sample with appropriate soil sampling equipment, as outlined in the site specific Sampling and Analysis Plan (SAP)(See SOP DR#014 - Development of a Sampling and Analysis Plan) or the applicable Appendix to this SOP.

8.2 Perform test as follows:

- Add soil to sample bottle (50 ml plastic sample bottles containing appropriate dyes and EPS bead) according to manufacturer's instructions;
- Label bottle;
- Add oil free water to sample bottle according to manufacturer's instructions;
- Shake vigorously until dye cube dissolves (about 30 seconds);
- Allow sample to sit for 10 minutes for color development on bead;
- Use indigo blue dye when results are inconclusive with red dye.

8.3 Results are reported as saturated, positive, slightly positive and undetected as described below:

- **Saturated** when obvious red (or blue) dye is observed in the soil matrix, or in/on the water (may stain the side of the jar);
- **Positive** when only the EPS bead is dyed dark pink/ red or blue and there is no coloration in the soil or water;
- **Slightly Positive** when only the EPS bead is dyed light pink or blue and there is no coloration in the soil or water; or
- **Undetected** when there is no coloration in the soil or water and the EPS bead remains white.

8.4 Results are interpreted as described below:

- **Undetected** result indicates no cleanup is required unless laboratory results indicate an exceedance of a leaching to groundwater exposure criteria.
- **Positive/ Slightly Positive** result indicates cleanup is needed for leaching to groundwater, excavations less than 200 cubic yards, and resident/park user scenarios.
- **Saturated** results indicate cleanup is needed for leaching to groundwater, resident/park user and outdoor commercial/ excavation-construction worker scenarios.

Note: Testing performed to date indicates that an Undetected result will be protective of leaching to groundwater in most cases. Laboratory analyses may be needed to ensure all guidelines are met. The Department will continue to collect and review results to evaluate whether or not this test may be used to determine when cleanup is needed for leaching to groundwater scenarios.

9.0 PROCEDURE FOR WATER SHAKE TEST

9.1 Collect the soil sample with appropriate soil sampling equipment, as outlined in the site specific Sampling and Analysis Plan (SAP)(See SOP DR#014 - Development of a Sampling and Analysis Plan) or the applicable Appendix to this SOP.

9.2 Perform test as follows:

- Add soil to clear glass container, approximately 1/3 container volume;
- Label bottle;
- Add oil free water to container, to fill approximately 1/2 container volume;
- Shake vigorously for approximately 30 seconds;
- Allow sample to sit for 10 minutes;
- Make observation of any NAPL.

9.3 Results are reported as Observed NAPL (ON) or No Observed NAPL (NON)

- **Observed NAPL** when a NAPL layer or blebs is observed on or below the water surface;
- **No Observed NAPL** when no NAPL is present or only a sheen is observed.

9.4 Results are interpreted as described below:

- **Observed NAPL:** oil or gasoline saturated soil is present;
- **No Observed NAPL:** oil or gasoline saturated soil is not present.

Note: The Water Shake Test is only applicable for sites where leaching to groundwater is not a risk pathway of concern, soils are below two-foot depth, and when resident, park user, or commercial worker scenarios are NOT applicable.

10.0 QUALITY ASSURANCE/QUALITY CONTROL

All field tests must be completed and documented according to these written procedures.

Samples will be collected in accordance with a site specific sampling plan or as outlined in the applicable appendix to this SOP.

PID calibration must be checked at the beginning and end of each day and every two hours while testing is performed. Results must be 100±10 PPM for initial calibration check. If the initial check falls outside 100±10 PPM, the lamp should be cleaned and the filter changed. If repeat bump testing remains outside 100±10 PPM the PID should be recalibrated. All recalibration and calibration checks (bump tests) must be documented on the field sheet or in the field notebook.

PID high concentration performance must be evaluated and documented before each day of use, as described in Section 7.3.

All PID Bag Headspace samples used for key field decisions or assessments performed for compliance to Chapter 691 rules must be taken in triplicate (at a minimum).

Quality control samples will be taken in accordance with the LUST QAP.

Additional quality assurance/quality control tasks may be needed based on the DQO requirements of the project.

11.0 DOCUMENTATION

Field notes should be collected following the standard procedures as outlined in 6.0 of the LUST QAP. When documenting such a sampling event, one should include enough information so that a person at a later date can easily duplicate the sampling and be able to compare the results. Any deviations from these procedures must be documented.

Record results for the PID bag headspace test on the form provided in Attachment 1. Results may alternatively be recorded in the field notebook as long as all information from Attachment 1 is recorded. Additionally, some PIDs have software which can record data. Any special method of recording and documenting results must be outlined in the SAP.

Record results for the oleophilic dye test and/or water shake test on the form provided in Attachment 2. Results may alternatively be recorded in the field notebook as long as all information from Attachment 2 is recorded.

Results for CSS with corresponding laboratory analysis should be submitted to the Department in the Maine DEP electronic data deliverable [EDD] format. Excel spreadsheets (http://www.maine.gov/dep/rwm/ust/sop/EDD_Oil_Field_Sheets_blank.xls) for use specifically with these field tests as well as laboratory EDD spreadsheets (http://www.maine.gov/dep/rwm/egad/ME_DEP_EGAD_EDDv5.1_FINAL_rhd.xls) are available from Maine DEP. The Excel spreadsheets for these field tests follow the format of Attachment 1 and Attachment 2. Note: Submission of EDD should not include ESS field screening results.

Only CSS with the corresponding laboratory results should be submitted for uploading to the Environmental and Geographic Analysis Database [EGAD].

Table 1: Approved PID Field Cleanup and Notification Guidelines

Cleanup Scenario	Soil size [grams]	Ion	Thermo	Passport	Foxboro	MiniRAE	Photon
Leaching to GW/ Notification	200	80	60	60	50	40	40
Resident/ Park User	20	700	275	500	250	350	300
Outdoor Commercial Worker/ Excavation-Construction Worker	5	1200	500	850	375	1500	400

Note: No adjustment is made for set points; the response factor should be 1.0 for all instruments.

Instrument Descriptions

Ion: Ion Science PhoCheck Series

Thermo: Thermo Environmental OVM 580 Series

Passport: MSA Passport PID II OVM

Foxboro PID: Foxboro TVA-1000 PID mode

MiniRAE: RAE Systems MiniRAE 2000 and MiniRAE 3000

Photon: MSA Photon Gas Detector

TS004 Bag Headspace Field EDD Sheet

Site Name:		Spill #	
Town:		Sampler:	
Air Temperature: Date:		Sample Method	
Calibration Gas Concentration:		Soil Heating Method:	
Confirm high end measurement:		PID Instrument:	

Calibration Documentation				**Bump Test Documentation**				Weather:
Time 1:		Reading 1:		Time 1:		Reading 1		
Time 2:		Reading 2:		Time 2:		Reading 2		
Time 3:		Reading 3:		Time 3:		Reading 3		

Calibration Documentation readings above should be post-calibration readings

Sample ID	Depth [FGS]	Sample Size	Collection Time	Analysis Time	Bag-1	Bag-2	Bag-3	Average	Soil Type	CSS Location	Comments

TS004 Oil Shake Test Field/Water Shake Test Field EDD Sheet					
Site Name:				Town:	
Date:			Sample Method:		
Spill #				Sampler:	
Ambient Temperature:			Weather:		
Sample ID	Depth [FGS]	Result	Soil Type	CSS Location	Comments

SA = Saturated- obvious red (or blue) dye is observed in the soil matrix, or in/on the water (may stain the side of the jar)
PO = Positive- the EPS bead is dyed dark pink/ red or blue and there is no coloration in the soil or water
SP = Slightly Positive- the EPS bead is dyed light pink or blue and there is no coloration in the soil or water
U = Undetected - No observations of dye coloration on EPS bead, soil, or water
NON = No Observed NAPL for Water Shake Test
ON = Observed NAPL for Water Shake Test

Field Sampling Procedure for Excavations

Appendix A is to be used at soil removals and excavations where the data quality objective is to meet the Soil Exposure Guidelines in Section 5 of the Remediation Guidelines for Petroleum Contaminated Sites in Maine. Appendix A is not intended for remediating releases under Section 3 of the Remediation Guidelines for Petroleum Contaminated Sites in Maine. The basis of this procedure is that field samples will be used to direct soil excavation and confirm that field screening objectives are met prior to terminating the excavation and collecting laboratory samples. The following procedure should be followed when the objective is to determine excavation limits based on field screening. The following procedure is not intended to override the Conceptual Site Model (CSM) or other site specific objectives for the removal action. If termination of the excavation is not based on field screening procedures, then the reasons should be clearly presented in post removal documentation. A site specific sampling plan that differs from this procedure may be applied if approved in advance by the Department.

This procedure uses three types of samples as defined below. The sample type definitions are provided to help clarify what is meant by terms used in this document.

Excavation Screening Samples (ESS). Use ESS to define soils to be removed. These are field screened samples generally collected to help direct the soil excavation (see Appendices B and C for other uses). These samples may represent soils that are removed during an excavation because they exceed the field screening guidelines, or they may represent soils that remain in place. Triplicate sampling is not required for PID Bag Headspace test of ESS for this application. Documentation of the ESS is at the discretion of the Environmental Professional completing the sampling.

Confirmation Screening Samples (CSS). CSS should identify areas of the excavation where cleanup objectives have been reached or where site limitations prevent further excavation. These field screened samples should represent worst case contaminated soils, if still present, that remain in place. Triplicate samples are required for Bag Headspace test of CSS. CSS must be documented and include all information presented in Attachment B.

Laboratory Samples (LS). These are lab samples that are collected at the termination of the excavation and represent worst case contaminated soils, if still present, that remain in place. They are collected at a rate of 1 - LS per 10 - CSS. Please remember, you can collect as many excavation screening samples as you need to help direct the excavation without collecting any LS. However, once you have reached the limits of the excavation and CSS are collected, then a minimum of one LS will be collected for each ten CSS collected. The LS should be co-located with the corresponding CSS location or locations, and should be collected where the most contaminated soil was present during the excavation process.

CONCEPTUAL SITE MODEL [CSM]

The Appendix A procedure is intended to fit within the context of the CSM when the objective for the site is to complete an excavation based on field screening methods described in this SOP. In cases where the CSM justifies variation from the procedure outlined in Appendix A, the CSM must be presented in written form and included in the post removal document that is available for future investigators. The CSM should also be included in the site specific sampling plan submitted for Department approval when variation from the Appendix A procedure is appropriate. The CSM must include a concise explanation of the sources present at the site and on adjoining properties (surface spill, AST, UST, product piping, loading rack, and fuel dispensers); receptors (on-site and off-site); and the risk scenario (Leaching to Groundwater, Resident/Park User, Outdoor Commercial Worker/Excavation-Construction Worker). Keep in mind that the risk scenario may change if contamination extends onto an adjoining property.

SAMPLING STRATEGIES

During the soil removal various sampling strategies can be utilized to expedite decision making. For example, a large sample (full bag) can be collected from the excavation and brought to a work table for processing. For gasoline contaminated sites, an initial PID screening of the soil (quick bag headspace with a 1-minute headspace equilibration) can be done to determine the relative concentration of gasoline contamination that is present. If the initial screening shows that results are above the termination criteria then no further processing may be necessary and the soil in the bag can be placed in a truck for disposal. If the initial screening determines that the concentrations may be near the termination criteria, then triplicate samples can be prepared. This sampling strategy requires quick processing and handling. Triplicate samples should be prepared within a few minutes of collecting the large sample volume from the excavation.

SAMPLE FREQUENCY

Excavation Screening Sampling (ESS)

The sampling frequency and documentation of ESS is up to the discretion of the environmental professional responsible for directing the excavation. Once the environmental professional determines that sufficient soils have been removed, CSS should be collected to document the decision to terminate excavation.

Confirmation Screening Samples (CSS)

The collection of CSS is separated into specified depth intervals to account for direct contact risks and risks associated with contaminant migration (oil saturated soils, free-product, or leachable to groundwater). The specified depth intervals are based on the definitions of *Accessible, Potentially Accessible,* and *Isolated Soil* included in The Maine Remedial Action Guidelines (RAGs) for Soil Contaminated with Hazardous Substances. The top two feet is defined as *accessible soil* and represents that greatest potential for direct contact and ingestion risk. Therefore, samples are required for determining the risks in the upper two feet. Below two feet the soils are considered *potentially accessible* to a depth of 15-feet unless the soils are covered by a building or other permanent structure that does not have earthen floors. Below 15-feet the soils are considered *isolated* for contact risk, but may represent a groundwater leaching pathway.

Lab Samples (LS)

LS frequency is set at 10% of total CSS analyzed for the excavation. LS should be co-located with a CSS and documentation of the co-located samples should be clear for future investigators.

MINIMUM SAMPLE LOCATIONS

Excavation Wall Sampling

Top Two Feet of Excavation

A minimum of one CSS is required in the top two feet for each twenty-foot section of excavation exposure. The excavation exposure is the total perimeter distance of the excavation.

Two to Fifteen Feet of Excavation Depth

A minimum of one CSS is required for each twenty linear feet of excavation perimeter.

Greater than Fifteen Feet of Excavation Depth

A minimum of one CSS is required for each additional ten feet of depth by 20 linear feet of excavation perimeter.

Floor Sampling

On the floor, a minimum of one CSS sample shall be collected for each 100-square feet of floor exposure (10 x 10). Keep in mind that due to side wall sloping, the floor exposure is likely to be smaller than the foot print of the excavation.

EXAMPLE

An excavation oriented north-south that is 50-feet long, 50-feet wide, and 15-feet deep represents a removal of approximately 1,400 cubic yards (Figure 1). The perimeter measures 200-feet and the walls are vertical to keep things simple.   This excavation would require a minimum of 45 CSS locations as shown below. The 45 CSS included: ten CSSs from 0-2 feet, ten samples from 2-15 feet, and 25 samples from the floor. This example would require a minimum of 5 LS.

Sampling Plan for 50’L x 50’W x 15’D Excavation

North Wall: 50-feet long, 15 feet deep

<table>
<tr><th></th><th>5</th><th>10</th><th>15</th><th>20</th><th>25</th><th>30</th><th>35</th><th>40</th><th>45</th><th>50</th></tr>
<tr><td>1
2</td><td colspan="4">Sample 1</td><td colspan="4">Sample 2</td><td colspan="2">Sample 3</td></tr>
<tr><td>3
4
5
6
7
8
9
10
11
12
13
14
15</td><td colspan="4">Sample 4</td><td colspan="4">Sample 5</td><td colspan="2">Sample 6</td></tr>
</table>

East Wall 50 feet long, 15 feet deep

<table>
<tr><th></th><th>55</th><th>60</th><th>65</th><th>70</th><th>75</th><th>80</th><th>85</th><th>90</th><th>95</th><th>100</th></tr>
<tr><td>1
2</td><td colspan="2">Sample 3</td><td colspan="4">Sample 7</td><td colspan="4">Sample 8</td></tr>
<tr><td>3
4
5
6
7
8
9
10
11
12
13
14
15</td><td colspan="2">Sample 6</td><td colspan="4">Sample 9</td><td colspan="4">Sample10</td></tr>
</table>

South Wall: 50-feet long, 15 feet deep

<table>
<tr><th></th><th>105</th><th>110</th><th>115</th><th>120</th><th>125</th><th>130</th><th>135</th><th>140</th><th>145</th><th>150</th></tr>
<tr><td>1</td><td colspan="4" rowspan="2">Sample 11</td><td colspan="4" rowspan="2">Sample12</td><td colspan="2" rowspan="2">Sample13</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td><td colspan="4" rowspan="13">Sample 14</td><td colspan="4" rowspan="13">Sample 15</td><td colspan="2" rowspan="13">Sample16</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
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<tr><td>12</td></tr>
<tr><td>13</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td></tr>
</table>

West Wall 50 feet long, 15 feet deep

<table>
<tr><th></th><th>155</th><th>160</th><th>165</th><th>170</th><th>175</th><th>180</th><th>185</th><th>190</th><th>195</th><th>200</th></tr>
<tr><td>1</td><td colspan="2" rowspan="2">Sample 13</td><td colspan="4" rowspan="2">Sample 17</td><td colspan="4" rowspan="2">Sample 18</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td><td colspan="2" rowspan="13">Sample 16</td><td colspan="4" rowspan="13">Sample 19</td><td colspan="4" rowspan="13">Sample 20</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td></tr>
</table>

Floor Of Excavation is 50-feet long and 50-feet wide

<table>
<tr><th></th><th>5</th><th>10</th><th>15</th><th>20</th><th>25</th><th>30</th><th>35</th><th>40</th><th>45</th><th>50</th></tr>
<tr><td>5</td><td colspan="2" rowspan="2">Sample 21</td><td colspan="2" rowspan="2">Sample 22</td><td colspan="2" rowspan="2">Sample 23</td><td colspan="2" rowspan="2">Sample 24</td><td colspan="2" rowspan="2">Sample 25</td></tr>
<tr><td>10</td></tr>
<tr><td>15</td><td colspan="2" rowspan="2">Sample 26</td><td colspan="2" rowspan="2">Sample 27</td><td colspan="2" rowspan="2">Sample 28</td><td colspan="2" rowspan="2">Sample 29</td><td colspan="2" rowspan="2">Sample 30</td></tr>
<tr><td>20</td></tr>
<tr><td>25</td><td colspan="2" rowspan="2">Sample 31</td><td colspan="2" rowspan="2">Sample 32</td><td colspan="2" rowspan="2">Sample 33</td><td colspan="2" rowspan="2">Sample 34</td><td colspan="2" rowspan="2">Sample 35</td></tr>
<tr><td>30</td></tr>
<tr><td>35</td><td colspan="2" rowspan="2">Sample 36</td><td colspan="2" rowspan="2">Sample 37</td><td colspan="2" rowspan="2">Sample 38</td><td colspan="2" rowspan="2">Sample 39</td><td colspan="2" rowspan="2">Sample 40</td></tr>
<tr><td>40</td></tr>
<tr><td>45</td><td colspan="2" rowspan="2">Sample 41</td><td colspan="2" rowspan="2">Sample 42</td><td colspan="2" rowspan="2">Sample 43</td><td colspan="2" rowspan="2">Sample 44</td><td colspan="2" rowspan="2">Sample 45</td></tr>
<tr><td>50</td></tr>
</table>

Field Sampling Procedures for Environmental Site Assessment [ESA] Investigations

1. Introduction

The purpose of this appendix is to provide for application of the field procedures to ESAs, which include Phase II assessments, property transactions, or similar environmental investigations. This procedure focuses on analyzing surface and subsurface soil samples. Sample collection methods may include backhoe/excavator, split spoon, direct push, bucket auger, or hand tools.

Results of the field methods can be used for selecting samples for laboratory analyses, determining if DEP notification levels have been exceeded, and for making risk-based decisions for the site.

In situations where the field methods will be used to make risk-based decisions, a site specific sampling plan must be developed prior to completing the field investigation to assure that the appropriate risk-based criteria and field methods are applied to the site.

This procedure specifies methodologies for field screening to make risk-based decisions and DEP notification determinations. This procedure also specifies methodologies for using field screening to select laboratory samples where decisions are based on the laboratory results and not the field results.

This procedure establishes certain documentation requirements for recording the soil sampling method used to obtain samples.

The method or methods selected for field screening will depend on the scope of the investigation and the contaminants of concern. In general the oleophilic dye test is for determining the presence of petroleum saturated soil or for determining the relative concentration of diesel, fuel oil, or kerosene contamination present. The PID bag headspace test is appropriate to determine the relative concentration of gasoline contamination, and may be useful in detecting the presence of fuel oil or kerosene contamination but it cannot be used to determine the absence of fuel oil or kerosene.

2. Sampling Purpose

DEP staff and other environmental professionals using the field methods must understand the purpose for collecting the samples prior to completing the Environmental Site Assessment (ESA). The purpose for sample collection will determine how to apply the procedures at a specific site. It is strongly recommended that historical research be performed and a sampling plan be developed for all ESAs by a qualified environmental professional.

2.1 Field Screening for Laboratory Analyses

The field procedures may be used to select samples for appropriate laboratory analyses (VOC, SVOC, VPH, EPH, lead, etc.). Under this approach, the procedures will be used to determine the relative presence of VOCs detectable with the selected PID and/or the relative presence of middle distillate SVOCs detectable with the oleophilic dye test. However, risk-based decisions will not be based on the field screening methods. Instead risk-based decisions will be based on the laboratory results. PID bag headspace samples collected for this purpose are not required to be completed in triplicate.

Note: the sample volume used for screening should be based on the linear range of the PID selected. Based on the Department's experience the approximate limit of linearity is 10% higher than the Table 1 Outdoor Commercial Worker/ Excavation-Construction Worker Scenario field cleanup guidelines regardless of sample size.

2.2 Field Screening for DEP Notification

The field procedures may be used to determine if the DEP notification level at petroleum sites has been exceeded. Appendix C discusses the application of the field procedures to the UST Site Assessment process. Section 2.2 applies where the screening is not related to an UST site assessment but the ESA is being completed to determine if DEP notification is warranted. For this purpose, PID bag headspace samples will be collected in metalized bags in triplicate with all three samples targeting the same depth (see sample methodology Section 3 for additional discussion). Sample size will be 200 grams as specified on Table 1, page 8 of the SOP.

2.3 Field Screening for Risk-Based Decisions

The field screening procedures may be used as a basis for making risk-based decisions at petroleum sites. DEP staff and other environmental professionals should determine the appropriate exposure scenario (leaching, resident, park user, commercial, excavation) for the project based on the CSM, the appropriate sample depth criteria (accessible, potentially accessible, and isolated), and the applicability of institutional controls to limit future exposure. Select the appropriate PID bag headspace soil sample size(s) for the project given the above criteria. ESSs (as defined in Appendix A) can be used to determine the distribution of contamination within each separate source area (may also be referred to as an area of concern or recognized environmental condition). PID bag headspace CSSs, collected in triplicate, targeting the appropriate depth (based on the CSM, ESS results and exposure scenario) can be used to make risk-based decisions about gasoline contamination within potentially contaminated areas at the site. LS will be based on the number of CSS (1 LS for every 10 CSS).

3. Sampling Methodology

Documentation of the sampling method used must be included with the data in the ESA report. Excavators, backhoes, and hand tools all have the ability to expose relatively large volumes of soil for direct examination and sample collection. However, subsurface soil borings rely on small sample volumes to represent subsurface conditions. Therefore, different sample methodologies are warranted as presented below.

3.1 Hand Tools, Excavator, Backhoe

Triplicate and co-located samples can be selected with more reliability using direct excavation techniques such as test pits than from soil borings. Therefore, the sampling methodology is the same as presented in Appendix A.

3.2 Subsurface Soil Borings

Due to the limitations in sample recovery and direct observation of the subsurface conditions several soil borings may be required to reliably use the field screening procedures to characterize subsurface conditions. The number of soil borings is site specific and depends on the soils present, the size of the area being investigated and the ability of the equipment to recover representative samples. Sample recoveries less than 60% will require alternative methods to use the field screening techniques for making risk-based decisions. Alternative sampling methods may include shortening the sample length to increase soil recovery in a target interval. For example where a 4 foot core barrel is in use, it could be driven and recovered twice to collect 2 two-foot samples over a four-foot interval. Depending on the soil type, this may result in better sample retrieval than attempting to sample all four feet in one run. Another alternative method may include completing multiple borings at a specific location to adequately sample the subsurface when soil recoveries are below 60%. When risk-based decisions or notification level determinations are being based on field methods and soil borings, a minimum of one ESS should be collected for every two feet of boring depth. If significant changes in contaminant concentrations or geologic characteristics are observed over a sampled interval then they should be sampled (field screened) separately. In addition a minimum of one CSS should be collected for each risk-based depth criteria (accessible, potentially accessible, and isolated) in accordance with Appendix A. Lastly at least one boring must be sampled as a CSS per each 500 square feet of potentially contaminated area (AOC, REC, or source area).

4. Documentation

The method of soil sample collection must be documented. Where subsurface soil samples are described on a log (test pit log or boring log) the information must be recorded in a way that documents the stratigraphy and the specific characteristics of the soil sample. For boring logs, the depth interval sampled must be recorded. Additionally, the sample recovery details must be documented, including either the percentage of the target interval actually recovered, or the length of recovery compared to the target length. Collapsed soils recovered in the sample interval must not be included in the percent recovered or in the length of sample recovered. This is often referred to as “wash” from wash and drive drilling methods. Direct push tools that do not utilize dual tube samplers may also experience collapse from coarse grained units.

Field Sampling Procedures for UST Site Assessments at Facility Closure or Tank Abandonment

1.0 Introduction

This section applies to Appendix P of Chapter 691, the Department's Rules for Underground Oil Storage Facilities. Notification levels for the PID Bag Headspace test are given in Table 1 of the SOP. Notification for the Oleophillic Dye Test is any coloration on the ESP bead or if dye is observed in the soil matrix, in/on the water, or staining the side of the jar.

2.0 Underground Piping and Dispenser Island areas

For the purpose of this Appendix, a piping run and associated dispenser(s) island is treated as one area. One ESS is required for each 5-foot section of underground piping, including the associated piping dispenser island. One CSS is required at all ESS locations that exceed the DEP Notification Level specified in this SOP. If no ESS exceeds the notification level, then the three highest ESS readings shall be selected for CSS collection. One LS shall be required for each 10 CSS collected within each underground piping and dispenser area.

3.0 Underground Storage Tank Area

More than one UST may be removed during a tank removal event. If the tanks are located adjacent to one another and the resulting excavation is one continuous excavation, then it can be considered one tank area. If the USTs are not adjacent to one another and the resulting tank excavations have separate excavation side walls, then they shall be treated as separate tank areas.

3.1 Excavation Screening Sampling (ESS)

The ESS are to be collected in accordance with Appendix A in a metalized bag and follow the procedures outlined in this SOP.

3.2 Confirmation Screening Samples (CSS)

CSS are to be collected in accordance with Appendix A. For the tank facility where the tank is to be replaced in the same location, and the surface will be paved, CSS in the top two feet of the tank excavation is not required.

NOTE: The basis for this exclusion is that soil in the upper two feet of a tank excavation is seldom contaminated. CSS are to be taken from the piping runs (including any piping run above the tank footprint) and dispenser island in accordance with Section 2.0 of this Appendix, even when the tank will be replaced and the surface paved.

3.3 Lab Samples (LS)

LS are to be collected in accordance with Appendix A.

Bag Headspace Field EDD Sheet

Site Name:				Spill #	
Town:				Sampler:	
Air Temperature:		Date:		Sample Method	
Calibration Gas Concentration:				Soil Heating Method:	
Confirm high end measurement:				PID Instrument:	

Calibration Documentation				Bumptest Documentation				Weather:
Time 1:		Reading 1:		Time 1:		Reading 1		
Time 2:		Reading 2:		Time 2:		Reading 2		
Time 3:		Reading 3:		Time 3:		Reading 3		

Calibration readings 1,2 and 3 readings are post-calibration checks.

Sample ID	Depth [FGS]	Sample Size	Collection Time	Analysis Time	Bag-1	Bag-2	Bag-3	Average	Soil Type	CSS Location	Comments

FGS = Feet below ground surface

Oil Shake Test Field EDD Sheet

Site Name:				Town:	
Date:			Sample Method:		
Spill #				Sampler:	
Ambient Temperature:			Weather:		
Sample ID	Depth [FGS]	Result	Soil Type	CSS Location	Comments

FGS = Feet below ground surface
SA = Saturated- obvious red/ blue dye is observed in the soil matrix, or in/on the water (may stain the side of the jar)
P = Positive- the EPS bead is dyed dark pink/ red or blue and there is no coloration in the soil or water
SP = Slightly Positive- the EPS bead is dyed light pink or blue and there is no coloration in the soil or water
U = Undetected - No observations of dye coloration on EPS bead, soil, or water

2024 LUST Program Equipment Inventory

Item	Quantity
Hand Tools	
Pickaxes	3
Flat Shovels	7
Spade Shovel	7
Snow Shovels	5
Narrow Shovels	5
Paint Rollers	2
Hoes	5
Auger	6
Push Broom	4
Slam Hammer	3
Jacks	5
Wheelbarrow	1
Garden Cart	1
Field Kits	8
5 Gallon Buckets	20
Miscellaneous Buckets	29
Small Tool Kits	5
Large Tool Kit	2
Garden Hoses	7
Pocket Hoses	2
Air Scrubbers	6
Fire Extinguishers	2 Lrg 2 Sm
Clam Rake	1
Sampling/Remediation Equipment	
Monsoon Pump	1
XRF	1
Water Level Meters	15
Mini Water Level Meters	7
Deep Well Water Lebel Meter	2
Casing Depth Indicator	3
Oil Water Interface Probe	3
Peristaltic Pumps	15
GeoTech Whale Pumps	5
Grundfos Submers. Pumps	7
Pondorff Pumps	5
PID (ppm)	5
PID (ppb)	9
Multi-Gas Meter	3
Well Chlorinating Kit	1
Battery Chargers	4
Moving Carts	2
Deep Cycle Batteries	11

2024 LUST Program Equipment Inventory

Power Inverter	5
GPR	1
Pore Water Samplers	89
Assorted Size Bailers	~100
Lamotte Turbidity Meters	3
Hach Turbidity Meter	1
Hach DO Meters	4
YSI DO Meters	2
Hanna Pens	13
Conductivity Packets	1.5 Boxes
Buffer Packets	1.5 Boxes
Hanna Batteries	3 Boxes
Flow Cells	5
Dish Soap	2 Bottles
Liquinox	4 Bottles
Sampling Bowls	6
Digital Scale	3
Manometer	2
Trailer-able Direct Push Sampler	1
Hand Geoprobe	1
Surface Water Sampler	2
Level Trolls	13
Radon Fans	18
Spill Pads	~50
Spill Socks	33
Bucket Samplers	2
Soil Seives	3 sets
Electric Seive Shaker	1
10 ppm Isobutylene	13
100 ppm Isobutylene	5
Zero Grade Compressed Air	1
.170" ID x 1/4" OD LDPE	250'
1/4" ID x 3/8" OD LDPE	1500'
3/8" ID x 1/2" OD LDPE	400'
1/2" ID x 5/8" OD LDPE	500'
.170" ID x 1/4" OD HDPE	850'
1/4" ID x 3/8" OD HDPE	900'
3/8" ID x 1/2" OD HDPE	600'
1/2" ID x 5/8" OD HDPE	900'
250-Gallon Poly Water Tank	4
Mobile P&T Trailer	2
Groundwater Extraction Trailer	3
Electical Test Kit	1
Survey Tools	

2024 LUST Program Equipment Inventory

Flagging	1 Box
Transit	1
25" Estwing Geo/Paleo Pick	1
3lb Estwing Sledge	1
4lb Estwing Sledge	2
Bolt Cutters	5
Machetes/Brush Cutters	2
Binoculars	1
Hand Saws	3
Survey Wheel	2
Survey Tripod	3
Survey Rod	4
Survey Level	2
Laser Level	2
100' Measuring Tapes	19
Metal Detector	3
Power Tools	
Milwaukee Inspection Scope	1
Milwaukee Hammer Drill	1
Milwaukee Rotary Hammer	1
Cordless Drill	6
Ryobi Circular Saw	1
Ryobi Sawsall	2
Ryobi Flashlight	1
Dremel Tool	1
Extention Cord Spools	6
Power Drill	1
Rigid Angle Grinder	1
Ryobi Angle Grinder	1
Shop Vacuum	5
12v Winch	1
Supplies/Gear	
Flashlights	10
InSitu Powerpack	2
Tablet (For InSitu)	1
Sample Coolers	32
Rite in the Rain Notebooks	6
Rite in the Rain Pens/Pencils	4
Sharpies	1 Box
Duct Tape	11
Packing Tape	3
Electrical Tape	7
Scotch Tape	12
Masterlocks	12

2024 LUST Program Equipment Inventory

Bug Spray Cans	4
Bug Spray Wipes	21
Permethrin Spray (24 fl. oz)	3
Sunscreen (1 fl. oz)	6
Hard Hats	8
Safety Glasses	20
Hand Warmers	8
Ear Plugs	110
Collapsible Traffic Cones	9
Standard Traffic Cones	21
Traffic Signs	2
Traffic Sign Stands	2
Step Stools	4
Saw Horses	4
E-Z Up Canopy	3
Folding Table	4
Folding Chairs	6
Aluminized Bags	>250
Oil N Soil Kits	>250
Assorted Sizes Nitrile Gloves	>500
Polyurathane Bags	3 rolls
PFD	8

Appendix C

METHOD FOR THE DETERMINATION OF EXTRACTABLE PETROLEUM HYDROCARBONS (EPH)

Massachusetts Department of Environmental Protection

Bureau of Waste Site Cleanup

Commonwealth of Massachusetts

Executive Office of Energy and Environmental Affairs
Kathleen A. Theoharides
Secretary

Department of Environmental Protection
Martin Suuberg
Commissioner

December 2019
Revision 2.1

Important Notice!

The purpose of this method is to provide data to help characterize the risks posed by petroleum-contaminated media. Innovative provisions and data adjustment steps are incorporated into the method to ensure that, in most cases, the resultant data will be moderately (but not overly) conservative (i.e., health protective). ***It is essential that all of the provisions and unique procedures in this method are understood and carefully implemented as written.*** Of particular note are the following:

Peak Integration Techniques:

- For individual Target PAH Analytes, the peaks from the FID or GC/MS are individually integrated (valley to valley). This applies to samples and standards.
- For the collective ranges of aliphatic hydrocarbons (i.e., C_9-C_{18} and C_{19}-C_{36}), the chromatogram from the FID or GC/MS is continuously integrated (to baseline) between specified range "marker" compounds (e.g., n-nonane to n-nonadecane for C_9-C_{18} aliphatic hydrocarbons). This applies to samples only; see Calibration Approach for peak integration techniques associated with calibration standards.
- For the collective range of C_{11}-C_{22} Aromatic Hydrocarbons, the chromatogram from the FID or GC/MS is continuously integrated (to baseline) between specified range "marker" compounds (i.e., naphthalene to benzo[g,h,i]perylene). This applies to samples only; see Calibration Approach for peak integration techniques associated with calibration standards.
- For the surrogate standard, the peak is individually integrated (valley-to-valley), so that the area can be subtracted from the collective areas of the hydrocarbon ranges discussed above.

  NOTE: GC/MS analysis is only allowed on fractionated extracts and may not be used as a substitute for fractionation.

Calibration Approach:

- The calibration factors (CFs) for the aliphatic and aromatic hydrocarbon ranges are based on the correlation of collective FID or GC/MS area counts to the collective concentration values of a specified mixture of aliphatic and aromatic hydrocarbon standards, in which the collective FID or GC/MS area count is determined via the summation of individual valley-to-valley peaks for the individual standards.

  As such, the integration procedure for calibration (i.e., valley-to-valley of individual calibration standards) is different from the integration procedure for samples (i.e., integration to baseline across a specified range of the FID or GC/MS chromatogram). This is necessary to ensure a conservative bias (i.e., an integration-to-baseline approach for the calibration standards would incorporate baseline "noise" which could lead to inappropriately elevated CF values resulting in inappropriately lower sample concentration levels which would not be health-protective).

Data Adjustments:

A series of steps are specified to calculate the final sample data results, to ensure that these values are not overly conservative, due to the addition of surrogate standards, and/or the "double counting" of analytes. This involves the subtraction of area counts and/or the subtraction of media concentration values (i.e., µg/L for aqueous samples or µg/kg for soil/sediment samples):

- When determining the collective area count for a specified hydrocarbon range (i.e., C_9-C_{18} or C_{19}-C_{36} Aliphatic Hydrocarbons or C_{11}-C_{22} Aromatic Hydrocarbons), it is necessary to subtract the individual (valley-to-valley) peak area of any surrogate standards that elute within that range, if applicable.
- The individual concentrations of the Target PAH Analytes must be subtracted from the C_{11}-C_{22} Aromatic Hydrocarbon concentration.

Updates/Changes in Method Revision 2.1

This method revision (2.1) replaces revision 1.1 of the MassDEP EPH test method, which was issued in May 2004. These updates and changes are relatively minor in nature, and are summarized below

Technical Revisions:

- Section 7.5: More flexibility was added for the volume of surrogate to be added to aqueous and solid samples.
- Section 8.2: The timeframe for freezing soil/sediment samples was changed from 48 hours to 24 hours from the time of sampling.
- Section 9.7.2.14: A requirement from the existing EPH CAM Protocol was added regarding the evaluation of the low standard when linear regression is used. This is a new requirement to the method but existed in the CAM Protocol.
- Sections 9.7.2.16 and 10.2.2:
    - A requirement from the existing EPH CAM Protocol was added regarding the analysis of an ICV. This is a new requirement to the method but existed in the CAM Protocol.
    - The ICV acceptance criterion of 70-130% for each Target PAH Analyte and hydrocarbon range from the existing EPH CAM Protocol was added.
- Section 9.10.3 and Table 7: Details were added regarding how to evaluate naphthalene and 2-methylnaphthalene in aliphatic extracts analyzed by GC/MS with the associated corrective actions.
- Section 10.2.7: Details were added regarding appropriate corrective actions when the LCS recoveries are outside of the acceptance criteria.
- Section 10.3.1: Details were added regarding appropriate corrective actions when the matrix duplicate RPDs are outside of the acceptance criteria.
- Section 11.3.1.1.6: A new significant modification was added regarding the use of non-linear regression during calibration.
- Table 4: For soil/sediment samples which are frozen, the holding time was changed to require extraction within 14 days of thawing. The footnote in this table was also revised to indicate samples must be frozen within 24 hours from the time of sampling.

Clarifications:

- “Important Notice” added at the beginning of the method to clarify proper peak integration during calibration and sample quantitation and data adjustment steps during sample quantitation.
- Sections 9.7.2.8 – 9.7.2.10: clarified that individual peak areas should be utilized for integration during calibration of the hydrocarbon ranges.
- Section 9.9.2: More details were added regarding the quantitation of the hydrocarbon ranges in samples.
- Section 9.10: Clarification was provided to note that Target PAH Analytes may be quantified from a fractionated or unfractionated extract using GC/MS but aliphatic and aromatic hydrocarbon ranges can only be quantified from a fractionated extract if GC/MS is used.
- Section 10.2.7: Clarification was provided to note that the recoveries of hydrocarbon ranges (not individual aliphatic hydrocarbons) need to be evaluated in the LCS.
- Section 10.3.2: Clarification was provided to note that the recoveries of hydrocarbon ranges (not individual aliphatic hydrocarbons) need to be evaluated in the MS/MSD.
- Section 11.3.2: Clarification on reporting of re-analyses and dilutions was added.
- Appendix 3: MassDEP Analytical Protocol Certification Form was updated to most current version.

LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
CAM	Compendium of Analytical Methods
CCV	Continuing Calibration Verification
CF	Calibration Factor
COD	1-Chlorooctadecane
%D	Percent Difference
DF	Dilution Factor
EPH	Extractable Petroleum Hydrocarbons
FID	Flame Ionization Detector
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
HCl	Hydrochloric Acid
HPLC	High Performance Liquid Chromatography
ICV	Initial Calibration Verification
I.D.	Internal Diameter
IDLC	Initial Demonstration of Laboratory Capability
IS	Internal Standard
K-D	Kuderna-Danish
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LMB	Laboratory Method Blank
MassDEP	Massachusetts Department of Environmental Protection
MCP	Massachusetts Contingency Plan
MDL	Method Detection Limit
NAPL	Non-aqueous Phase Liquids
OSHA	Occupational Safety & Health Administration
OTP	ortho-Terphenyl
PAH	Polynuclear Aromatic Hydrocarbons
QC	Quality Control
%R	Percent Recovery
r	Correlation Coefficient
RL	Reporting Limit
RPD	Relative Percent Difference
%RSD	Percent Relative Standard Deviation
Rt	Retention Time
SIM	Selective Ion Monitoring
SOP	Standard Operating Procedure
SPE	Solid-Phase Extraction
SSB	System Solvent Blank
TPH	Total Petroleum Hydrocarbons

NOTE: Abbreviations of units (e.g., mL, mm, min, ºC, g, µL, ng/µL, cm/sec, psig, µg/Kg, m, µm, µg/L, mg/Kg, oz., L, etc.) are not included.

METHOD FOR THE DETERMINATION OF EXTRACTABLE PETROLEUM HYDROCARBONS (EPH)

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DISCLAIMER

Mention of trade names or commercial products does not constitute endorsement by the Massachusetts Department of Environmental Protection (MassDEP). Trade names and commercial products specified within this method are based upon their use in validation studies conducted by MassDEP. Equipment and materials cited in this method may be replaced by similar products, as long as adequate data exist or have been produced documenting equivalent or superior performance.

METHOD FOR THE DETERMINATION OF EXTRACTABLE PETROLEUM HYDROCARBONS (EPH)

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION (MassDEP)

1.0 SCOPE AND APPLICATION

1.1 This method is designed to measure the collective concentrations of extractable aliphatic and aromatic petroleum hydrocarbons in aqueous and soil/sediment matrices. Extractable aliphatic hydrocarbons are collectively quantitated within two carbon number ranges: C_9 through C_{18} and C_{19} through C_{36}. Extractable aromatic hydrocarbons are collectively quantitated within the C_{11} through C_{22} range. These aliphatic and aromatic hydrocarbon ranges correspond to a boiling point range between approximately 150 °C (n-nonane) and 500 °C (benzo[g,h,i]perylene).

1.2 This method is based on a solvent extraction, silica gel solid-phase extraction (SPE)/fractionation process, and gas chromatography (GC) analysis using a flame ionization detector (FID). Note that gas chromatography/mass spectrometry (GC/MS) analysis is only allowed on fractionated extracts and may not be used as a substitute for fractionation. This procedure should be used by, or under the direct supervision of, analysts experienced in extractable organics analysis. The analysts should be skilled in the interpretation of gas chromatograms and their use as a quantitative tool.

1.3 This method is designed to complement and support the toxicological approach developed by the Massachusetts Department of Environmental Protection (MassDEP) to evaluate human health hazards that may result from exposure to petroleum hydrocarbons (MassDEP, 1994 and MassDEP, 2003). It is intended to produce data in a format suitable for the characterization of risk at sites undergoing evaluation under the Massachusetts Contingency Plan (MCP, 310 CMR 40.0000) using the aforementioned toxicological approach.

1.4 In addition to the quantification of aliphatic and aromatic hydrocarbon ranges, the MassDEP EPH method is also designed to quantify the individual concentrations of Target Polynuclear Aromatic Hydrocarbon (PAH) Analytes, including Diesel PAH Analytes, in aqueous and soil/sediment matrices. Use of this method to identify and quantify these Target PAH analytes is optional. The Reporting Limits (RLs) for some of these PAHs in aqueous samples are greater than the notification and/or cleanup standards specified in the MCP for sites located in groundwater resource areas categorized as RCGW-1 in 310 CMR 40.0362(1)(a). In cases where it is necessary to demonstrate compliance with these criteria, the use of a GC/MS method in the selective ion monitoring (SIM) mode and/or a high performance liquid chromatography (HPLC) method may be necessary.

1.5 The fractionation step described in this method can be eliminated to allow for a determination of Total Petroleum Hydrocarbons (TPH), and/or to obtain qualitative "fingerprinting" information. While TPH provides little information on the chemical constituents, toxicity, or environmental fate of petroleum mixtures, it may be a cost-effective screening tool in cases where relatively low concentrations of contamination are suspected.

1.6 Petroleum products suitable for evaluation by this method include kerosene, fuel oil #2, fuel oil #4, fuel oil #6, diesel fuel, jet fuels, and certain lubricating oils. This method, in and of itself, is not suitable for the evaluation of gasoline, mineral spirits, petroleum naphthas, or other petroleum products which contain a significant percentage of hydrocarbons lighter than C_9 or with boiling points <150 °C. This method, in and of itself, is also not suitable for the evaluation of petroleum products which contain a significant percentage of hydrocarbons heavier than C_{36} or with boiling points >500 °C.

1.7 The RL of this method for each of the Target PAH Analytes is determined by the concentration of the lowest applicable calibration standard. The nominal RL for the individual target analytes is compound-specific, and ranges from approximately 0.2 to 1.0 mg/kg in soil/sediment matrices, and 2 to 5 µg/L in aqueous matrices. The RLs for the collective hydrocarbon ranges are approximately 10 mg/kg in soil/sediment matrices, and approximately 100 µg/L in aqueous matrices. The RL for TPH is approximately 10 mg/kg in soil/sediment matrices and approximately 100 µg/L in aqueous matrices.

1.8 This method includes a data adjustment step to subtract the concentration of Target PAH Analytes from the concentration of C_{11} through C_{22} aromatic hydrocarbons. This data adjustment step may be taken by the laboratory or by the data user .

1.9 Data reports produced using this method must contain all of the information presented in Appendix 3. The format of these reports is left to the discretion of the individual laboratories (but must include the same certification statement presented in the aforementioned Appendix and must be provided in a clear, concise, and succinct manner). However, the format of the MassDEP Analytical Protocol Laboratory Certification Form must follow the format presented in Appendix 3.

1.10 Like all GC procedures, this method is subject to a "false positive" bias in the reporting of Target PAH Analytes, in that non-targeted hydrocarbon compounds eluting or co-eluting within a specified retention time window may be falsely identified and/or quantified as a Target or Diesel PAH Analyte. In addition, this method is subject to a “false negative” bias in the reporting of Target PAH Analytes, in that the ability to identify Target PAH Analytes at low concentrations may be inhibited if a large unresolved complex mixture is present. While cleanup procedures specified in this method to segregate aliphatic and aromatic ranges will serve to mitigate these concerns, confirmatory analysis by dissimilar columns, GC/MS analysis, or other suitable method is recommended in cases where a Target PAH Analyte reported by this method exceeds an applicable reporting or cleanup standard, and/or where co-elution of a non-targeted hydrocarbon compound is suspected.

1.11 The first draft of this method was evaluated by two inter-laboratory “Round Robin” testing programs. In the final evaluation effort, participating laboratories were provided (single-blind) sand samples spiked with a #2 fuel oil, and a “real world” groundwater sample contaminated by a highly weathered fuel oil. Laboratory proficiency was evaluated using a Z-score approach. Data received from 23 laboratories performing the method without significant modifications are summarized below:

Matrix	# Labs Proficient	% Labs Proficient	Data from Proficient Laboratories		
			Fraction	**%RSD**	**% Labs within +/- 40% mean value**
soil	**19**	**83**	**C_9-C_{18} Aliphatics**	**23**	**95**
			C_{19}-C_{36} Aliphatics	**30**	**89**
			C_{11}-C_{22} Aromatics	**19**	**100**
			Total All Fractions (TPH)	**17**	**100**
water	**20**	**87**	**C_9-C_{18} Aliphatics**	**84**	**22**
			C_{19}-C_{36} Aliphatics	**192**	**94**
			C_{11}-C_{22} Aromatics	**47**	**72**
			Total All Fractions (TPH)	**35**	**83**

Laboratory and method performance on the water sample were adversely impacted by the relatively low concentrations of the aliphatic fractions (due to the low solubilities of these hydrocarbons in “real world” samples), and by breakthrough of naphthalenes into the aliphatic extract during fractionation. Improvements incorporated into this final method are expected to mitigate problems of this nature and significantly improve overall method performance.

1.12 This method is one way to quantify collective concentrations of extractable aliphatic and aromatic petroleum hydrocarbons within specified carbon number ranges. It has been designed in a manner that attempts to strike a reasonable balance between analytical method performance and utility. In this manner, assumptions and biases have been incorporated into the method to help ensure protective, though not overly conservative data.

As an example, MassDEP recognizes that branched alkanes have lower boiling points than their n-alkane counterpart, while many of the cycloalkane constituents of diesel range organics have higher boiling points than their n-alkane counterpart. As a consequence:

(1) Depending upon the specific chromatographic column used, most branched C_9 alkanes are expected to elute before n-nonane, the beginning marker compound for the C_9 through C_{18} aliphatic hydrocarbon range, and will therefore not be counted in the C_9 through C_{18} aliphatic hydrocarbon range;

(2) Depending upon the specific chromatographic column used, most branched C_{19} alkanes are expected to elute before n-nonadecane, the beginning marker compound for the C_{19} through C_{36} aliphatic hydrocarbon range, and will be conservatively counted in the more toxic C_9 through C_{18} aliphatic hydrocarbon range; and

(3) Depending upon the specific chromatographic column used, most cycloalkanes within the C_9 through C_{18} and C_{19} through C_{36} aliphatic hydrocarbon ranges will be counted within their proper range.

Based on the nature of petroleum releases encountered in the environment, the collective concentrations of the extractable aliphatic ranges as measured by the EPH Method are considered to be suitable for the evaluation of the risks posed by these releases, consistent with the toxicological approach developed by MassDEP to evaluate human health hazards that may result from exposure to petroleum hydrocarbons (MassDEP, 1994 and MassDEP, 2003).

1.13 There may be better, more accurate, and/or less conservative ways to produce Target PAH Analyte and hydrocarbon range data. MassDEP encourages methodological innovations that (a) better achieve method and/or data quality objectives, (b) increase analytical precision and accuracy, (c) reduce analytical uncertainties and expenses, and/or (d) reduce the use of toxic solvents and generation of hazardous wastes.

All significant modifications to this method, however, must be disclosed and described on the data report form, as detailed in Section 11.3 and the MassDEP Analytical Protocol Certification Form (See Appendix 3, Exhibit 2, Question E). Laboratories that make such modifications, and/or develop and utilize alternative approaches and methods, are further required to demonstrate that:

- Such modifications or methodologies adequately quantify the petroleum hydrocarbon ranges, as defined in Sections 3.4 through 3.6 of this document, ensuring that any methodological uncertainties or biases are addressed in a manner that ensures protective (i.e., conservative) results and data (e.g., over, not under-quantification of the more toxic ranges);
- Such modifications and/or methodologies employ and document initial method demonstration and ongoing quality control (QC) procedures consistent with approaches detailed in the MassDEP Compendium of Analytical Methods (CAM); and
- Such methods and procedural modifications are fully documented in a detailed standard operating procedure (SOP).

1.14 Additional information and details on the MassDEP EPH approach are available at https://www.mass.gov/lists/policies-guidance-technical-support-for-site-cleanup .

1.15 This method should be used in conjunction with the current version of CAM IV B, "Quality Control Requirements and Performance Standards for the Analysis of Extractable Petroleum Hydrocarbons (EPH) in Support of Response Actions Under the Massachusetts Contingency Plan (MCP)". WSC-CAM-IV B was developed by MassDEP to complement this MassDEP EPH Method and to provide more detailed guidance regarding compliance with the QC requirements and performance standards of the MassDEP EPH Method.

2.0 SUMMARY OF METHOD AND DATA QUALITY OBJECTIVES

2.1 Samples submitted for EPH analysis are extracted with methylene chloride, dried over sodium sulfate, solvent exchanged into hexane, and concentrated in a Kuderna-Danish (K-D) apparatus. Sample cleanup and separation into aliphatic and aromatic fractions is accomplished using commercially available silica gel cartridges or prepared silica gel columns. The resulting two individual fraction extracts are re-concentrated to a final volume of 1 mL (i.e., an aliphatic extract and an aromatic extract). The concentrated extracts are then separately analyzed by a capillary column GC equipped with an FID. The resultant chromatogram from the analysis of the aliphatic extracts is used to determine the collective concentrations of aliphatic hydrocarbons within the C_9 through C_{18} and C_{19} through C_{36} ranges. The resultant chromatogram from the analysis of the aromatic extract is used to determine the collective concentration of aromatic hydrocarbons within the C_{11} through C_{22} range, and is (optionally) used to determine the individual concentrations of Target PAH Analytes.

2.2 This method is suitable for the analysis of aqueous samples, soils, sediments, wastes, sludges, and non-aqueous phase liquid (NAPL) samples. However, it should be noted that the method was validated only for soil and aqueous matrices.

2.3 This method is based on (1) USEPA Methods 8000D, 8100, 8270E, 3510C, 3520C, 3540C, 3541, 3545A, 3546, 3580A and 3630C, SW-846, "Test Methods for Evaluating Solid Waste"; (2) Draft *Method for Determination of Diesel Range Organics*, EPA UST Workgroup, November, 1990; and (3) *Modified DRO Method for Determining Diesel Range Organics*, Wisconsin Department of Natural Resources, PUBL-SW-141, 1992.

2.4 Data Quality Objectives should be developed and applied for sampling and analytical efforts involving the use of this method. Key parameters of interest include: (a) the acceptability of RLs achievable by the laboratory for the contaminants of interest and (b) the identification and reporting of target analytes.

3.0 DEFINITIONS

3.1 **Aliphatic Hydrocarbon Standard** is defined as a 14 component mixture of the normal alkanes listed in Table 1. The compounds comprising the Aliphatic Hydrocarbon Standard are used to (a) define and establish retention time windows for the two aliphatic hydrocarbons ranges, and (b) determine average calibration or response factors that can in turn be used to calculate the collective concentration of aliphatic hydrocarbons in environmental samples within those hydrocarbon ranges.

3.2 **Analytical Batch** is defined as a group of field samples with similar matrices which are processed as a unit. For QC purposes, if the number of samples in such a group is greater than 20, then each group of 20 samples or less is defined as a separate analytical batch.

3.3 **Aromatic Hydrocarbon Standard** is defined as a 17 component mixture of the PAHs listed in Table 2. The compounds comprising the Aromatic Hydrocarbon Standard are used to (a) define the individual retention times and determine the average calibration or response factors for each of the PAH analytes listed in Table 2, (b) define and establish the retention time window for the C_{11} through C_{22} Aromatic Hydrocarbon range, and (c) determine an average calibration or response factor that can in turn be used to calculate the collective concentration of aromatic hydrocarbons in environmental samples within the C_{11} through C_{22} hydrocarbon range.

3.4 **C_9 through C_{18} Aliphatic Hydrocarbons** are defined as all aliphatic petroleum hydrocarbon compounds which contain between nine and 18 carbon atoms. In the EPH method, C_9 through C_{18} aliphatic hydrocarbons are defined and quantitated as compounds which elute from n-nonane (C_9) to just before n-nonadecane (C_{19}).

3.5 **C_{19} through C_{36} Aliphatic Hydrocarbons** are defined as all aliphatic petroleum hydrocarbon compounds which contain between 19 and 36 carbon atoms. In the EPH method, C_{19} through C_{36} aliphatic hydrocarbons are defined and quantitated as compounds, which elute from n-nonadecane (C_{19}) to just after hexatriacontane (C_{36}).

3.6 **C_{11} through C_{22} Aromatic Hydrocarbons** are defined as all aromatic petroleum hydrocarbon compounds which contain between 11 and 22 carbon atoms. In the EPH method, C_{11} through C_{22} aromatic hydrocarbons are defined and quantitated as compounds which elute from naphthalene to just after benzo(g,h,i)perylene, excluding Target PAH Analytes.

3.7 **Calibration Standards** are defined as a series of standard solutions prepared from dilutions of a stock standard solution, containing known concentrations of each analyte and surrogate compound of interest.

3.8 **Continuing Calibration Standard** is defined as a calibration standard used to periodically check the calibration state of an instrument. The continuing calibration standard is prepared from the same stock standard solution as initial calibration standards, and is generally one of the mid-level range calibration standard dilutions.

3.9 **Diesel PAH Analytes** are defined as naphthalene, 2-methylnaphthalene, phenanthrene, and acenaphthene, and are a subset of Target PAH Analytes. For most sites known to be contaminated by a release of diesel and/or #2 fuel oil only, Diesel PAH Analytes will be the only Target PAH Analytes of interest.

3.10 **Extractable Petroleum Hydrocarbons (EPH)** are defined as collective fractions of hydrocarbon compounds eluting from n-nonane to n-hexatriacontane, excluding Target PAH Analytes. EPH is comprised of C_9 through C_{18} Aliphatic Hydrocarbons, C_{19} through C_{36} Aliphatic Hydrocarbons, and C_{11} through C_{22} Aromatic Hydrocarbons.

3.11 **Field Duplicates** are defined as two separate samples collected at the same time and place under identical circumstances and managed the same throughout field and laboratory procedures. Analyses of field duplicates give a measure of the precision associated with sample collection, preservation and storage, as well as laboratory procedures.

3.12 **Fractionation Surrogate Standards** are compounds that are added to sample extracts immediately prior to fractionation at known concentrations to evaluate fractionation efficiency.

3.13 **Initial Calibration Verification (ICV) Standard** is defined as a mid-range standard prepared from a separate source than used for the initial and continuing calibration standards. This analysis must be performed every time an initial calibration is performed.

3.14 **Internal Standard (IS)** is a compound added to every calibration standard, blank, laboratory control sample (LCS), matrix spike, sample extract at a known concentration, prior to analysis. ISs are used as the basis for quantitation of the method's target analytes when GC/MS is utilized.

3.15 **Laboratory Control Sample (LCS)** is defined as a reagent water blank (when associated with aqueous samples) or clean sand blank (when associated with soil/sediment samples) fortified with the matrix spiking solution. The LCS is prepared and analyzed in the same manner as the samples and its purpose is to determine the bias of the analytical method.

3.16 **Laboratory Control Sample Duplicate (LCSD)** is defined as a reagent water blank (when associated with aqueous samples) or clean sand blank (when associated with soil/sediment samples) fortified with the matrix spiking solution. The LCSD is prepared separately from the LCS but is prepared and analyzed in the same manner as the LCS. The purpose of LCS duplicates is to determine the bias and precision of the analytical method.

3.17 **Laboratory Method Blank (LMB)** is defined as an aliquot of reagent water (when associated with aqueous samples) or clean sand (when associated with soil/sediment samples) spiked with a surrogate standard. The laboratory method blank is prepared and analyzed in the same manner as the samples, exposed to all glassware, solvents, reagents, and equipment. A laboratory method blank is prepared and analyzed with every batch of samples, to determine if method analytes or other interferences are present in the laboratory environment, reagents, or equipment.

3.18 **Matrix Duplicates** are defined as split samples prepared and analyzed separately with identical procedures. For soil/sediment samples, matrix duplicate samples are taken from the same sampling container. For aqueous samples, a separate container is used for the matrix duplicate sample. The analysis of matrix duplicates gives a measure of the precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.

3.19 **Matrix Spike Sample** is defined as an environmental sample which has been spiked with a matrix spiking solution containing known concentrations of method analytes. The purpose of the matrix spike sample is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined through the separate analyses of an unspiked sample aliquot. The measured values in the matrix spike sample must be corrected for background concentrations when calculating recoveries of spiked analytes.

3.20 **Matrix Spiking Solution** is defined as a solution prepared from a separate source than used for the calibration standards, containing known concentrations of method analytes.

3.21 **System Solvent Blank (SSB)** is defined as an aliquot of a method solvent (e.g., hexane or methylene chloride, pesticide-grade or better) that is directly injected into the GC system. The SSB provides one way of determining the level of noise and baseline rise attributable solely to the analytical system, in the absence of any other analytes or non-analytical related contaminants.

3.22 **Surrogate Standards** are compounds spiked into all samples, blanks, LCSs, and matrix spikes to monitor the efficacy of sample extraction, chromatographic, and calibration systems.

3.23 **Target PAH Analytes** are defined as the 17 PAH compounds listed in Table 2.

3.24 **Total Petroleum Hydrocarbons (TPH)** are defined as the collective concentration of all hydrocarbon compounds eluting from n-nonane to n-hexatriacontane, **excluding Target PAH Analytes**. TPH is equivalent to the summation of C_9 through C_{18} Aliphatic Hydrocarbons, C_{19} through C_{36} Aliphatic Hydrocarbons, and C_{11} through C_{22} Aromatic Hydrocarbons.

3.25 **Unadjusted C_{11} through C_{22} Aromatic Hydrocarbons** are defined as all aromatic hydrocarbon compounds eluting from naphthalene through benzo(g,h,i)perylene.

3.26 **Unadjusted TPH** is defined as the collective concentration of all hydrocarbon compounds eluting from n-nonane to n-hexatriacontane, **including the Target PAH Analytes**.

3.27 All other terms are as defined in the most current version of SW-846, *Test Methods for Evaluating Solid Waste*, USEPA.

4.0 INTERFERENCES AND METHOD LIMITATIONS

4.1 Method interferences are reduced by washing all glassware with hot soapy water and then rinsing with warm tap water, acetone, and methylene chloride.

4.2 High purity reagents must be used to minimize interference problems.

4.3 Cross-contamination can occur whenever a low-concentration sample is analyzed immediately after a high-concentration sample. To reduce carryover, the sample syringe must be rinsed between samples with solvent. Whenever an unusually concentrated sample is encountered, it must be followed by the analysis of an SSB to check for cross-contamination. However, due to the potential for samples to be analyzed using an autosampler, the ability to perform this blank analysis may not always be possible. If the sample analyzed immediately after the unusually concentrated sample is free from contamination, then the assumption can be made that carryover or cross-contamination is not an issue. However, if this sample did detect analytes which were present in the unusually concentrated sample, reanalysis is required for all samples analyzed after this highly concentrated sample which detected similar analytes.

4.4 Matrix interferences may be caused by contaminants that are coextracted from the sample. The extent of matrix interference will vary considerably from one source to another depending upon the nature and complexity of the site being sampled. A silica gel SPE cleanup procedure is used to overcome many of these interferences, but some samples may require additional and more rigorous cleanup procedures which are beyond the scope of this method.

4.5 Other organic contaminants commingled with petroleum product releases, including chlorinated hydrocarbons, phenols, and phthalate esters, will be quantitated as TPH and EPH. If necessary and/or desirable, additional sample cleanup and/or analytical procedures may be employed to minimize or document the presence of such compounds.

4.6 The leaching of plasticizers and other compounds have been observed from commercially available silica gel cartridges used to fractionate EPH sample extracts. Concerns of this nature must be continuously monitored and documented by analysis of LMBs. Section 9.2 provides a procedure to eliminate or minimize this contamination.

4.7 Because of their weakly polar nature, naphthalene and substituted naphthalenes readily mobilize into the aliphatic extract if excessive amounts of hexane are used to elute the silica gel cartridge/column. Because these compounds constitute a significant percentage of the water-soluble fraction of fuel oils, this occurrence is especially problematic in the analysis of water samples. For this reason, the method requires the evaluation of the aliphatic fraction for the presence of naphthalene and 2-methylnaphthalene in the LCS/LCSD pair on a batch basis. The fractionation surrogate, 2-bromonaphthalene, is used to monitor sample-specific fractionation efficiency.

5.0 HEALTH AND SAFETY ISSUES

The toxicity and carcinogenicity of each reagent used in this method have not been precisely defined. However, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. The laboratory is responsible for maintaining a current file of Occupational Safety and Health Administration (OSHA) regulations regarding the safe handling of the chemicals specified in this method. A reference file of safety data sheets should also be made available to all personnel involved in the chemical analysis.

6.0 APPARATUS AND MATERIALS

6.1 Gas Chromatograph System

6.1.1 An analytical system complete with a temperature programmable GC for use with a capillary column is required.

6.1.2 Detector: An FID is required.

6.1.3 Chromatographic Column: The analytical column must adequately resolve the n-C_9 to n-C_{36} aliphatic hydrocarbon standard compounds and the Target PAH Analytes listed in Tables 1 and 2, respectively. The recommended analytical column is an RTX-5 capillary column (30-m x 0.32-mm internal diameter (I.D.), 0.25-µm film thickness [Restek Corp. or equivalent]).

6.1.4 Data Station: A data station is required that is capable of storing and reintegrating chromatographic data and capable of determining peak areas using a forced baseline projection.

6.1.5 Autosampler: An autosampler capable of making 1 to 4 µL injections is recommended.

6.2 The following is a partial list of glassware used for this method:

6.2.1 1-L amber glass bottles.

6.2.2 4 oz. (120 mL) amber wide-mouth glass jars.

6.2.3 Vials:

- autosampler: 2-mL glass vials with Teflon-lined rubber crimp caps
- 10-mL vials with Teflon-lined caps

6.2.4 Glass funnels.

6.2.5 2-L Separatory funnels with Teflon stopcock (aqueous liquid-liquid extraction only).

6.2.6 K-D apparatus including 10-mL graduated concentrator tube, 500-mL Evaporative flask, & 3-ball Snyder column.

6.2.7 250-mL Erlenmeyer flasks.

6.2.8 25-mL graduated cylinder.

6.2.9 1-L graduated cylinder.

6.2.10 100-mL beakers.

6.2.11 Class “A” volumetric flasks: 10, 25, 50 and 100-mL.

6.2.12 Class “A” volumetric pipets: 1, 5 or 10-mL.

6.3 Analytical balance: An analytical balance capable of accurately weighing 0.0001 g must be used for weighing standards, if required. A top-loading balance capable of weighing to the nearest 0.1 g must be used for weighing soil/sediment samples.

6.4 An air or nitrogen blowdown apparatus, or equivalent sample concentration apparatus, is required to concentrate extracts.

6.5 Water bath: heated with a concentric ring cover, capable of temperature control (± 2°C). The bath should be used in a hood.

6.6 Disposable pipets: Pasteur.

6.7 Microsyringes: 10-µL, 100-µL, 250-µL, 500-µL, 1000-µL.

6.8 Boiling chips.

6.9 Soxhlet, Soxtec or alternative extraction apparatus.

6.10 Drying oven.

6.11 Dessicator.

7.0 REAGENTS AND STANDARDS

7.1 Reagents

7.1.1 Reagent Water: organic free water (American Society for Testing and Materials [ASTM] Type I reagent grade water).

7.1.2 Solvents: hexane, methylene chloride, and acetone; pesticide-grade or better. Store away from other solvents.

7.1.3 Sodium sulfate: (ACS) granular, anhydrous. Purify by heating at 400°C for 4 hours in a shallow tray.

7.1.4 Ottawa and/or masonry sand: free of extractable petroleum hydrocarbons.

7.1.5 Silica Gel (5 - 10 grams), either prepared and packed by the laboratory, or purchased in 5 g/15-mL cartridges from a commercial vendor. Silica gel prepared and packed by the laboratory should be activated at 130ºC for at least 16 hours, and heated to 150-160ºC for several hours before use. Refer to Section 9.2.2 for guidance on the use of silica gel.

NOTE: Leaching of plasticizers and other compounds have been observed from commercially prepared silica gel cartridges, and must be monitored and documented by analyses of LMBs. Refer to Section 9.2 for a procedure to eliminate or minimize this contamination.

NOTE: **Silica gel is hygroscopic**. Unused cartridges readily absorb moisture from ambient air if not properly sealed. To preclude moisture adsorption, which adversely effects cartridge performance, unused cartridges must be stored in a properly-maintained desiccator prior to use.

7.2 Stock Standard Solutions

Prepare stock standard solutions at approximately 1000 ng/µL, or purchase as certified solutions.

7.2.1 Aromatic Hydrocarbon Standard: The Aromatic Hydrocarbon Standard consists of the 17 PAH compounds listed in Table 2, a surrogate compound (i.e., ortho-terphenyl [OTP]) and fractionation surrogate compounds. Prepare stock standard solutions by accurately weighing approximately 0.0100 g of pure material. Dissolve the material in methylene chloride and dilute to volume in a 10-mL volumetric flask.

7.2.2 Aliphatic Hydrocarbon Standard: The Aliphatic Hydrocarbon Standard consists of the 14 normal alkanes listed in Table 1, naphthalene, 2-methylnaphthalene, and a surrogate compound (i.e., 1-chloro-octadecane [COD]). Prepare stock standard solutions by accurately weighing approximately 0.0100 g of pure material. Dissolve the material in hexane and dilute to volume in a 10-mL volumetric flask.

7.2.3 Transfer each stock standard into a PTFE-lined screw cap vial. Store the vials (protected from light) at ≤6 °C or as recommended by the standard manufacturer. Stock standard solutions must be replaced after 6 months, or sooner if comparison with check standards indicates a problem.

7.2.4 Calibration standards are prepared by serial dilution of the stock standard as described in Section 7.3.

7.3 EPH Calibration Standards: Prepare Aromatic and Aliphatic Hydrocarbon calibration standards from the stock standard solutions. At a minimum, five different concentrations are required for a valid calibration curve by adding volumes of the stock standard solutions to volumetric flasks and diluting to volume with methylene chloride and hexane, respectively. The surrogate OTP and the fractionation surrogates are included in the Aromatic Hydrocarbon calibration standard; the surrogate COD, naphthalene, and 2-methylnaphthalene are included in the Aliphatic Hydrocarbon calibration standard. The calibration concentrations must be evenly dispersed over the full working range of the detector with the lowest calibration point corresponding to the RL for Target PAH Analytes. The highest concentration defines the maximum upper working range of the calibration curve. Table 3 provides recommended concentrations for each calibration standard for a 5-point initial calibration of hydrocarbon ranges and Target PAH Analytes

7.4 Petroleum Reference Spiking Solution: The Petroleum Reference Spiking Solution consists of an API or commercial diesel fuel standard. Prepare stock standard solutions by accurately weighing approximately 0.02500 g of neat product. Dissolve neat product in acetone and dilute to volume in a 10-mL volumetric flask. An appropriately diluted aliquot of the stock solution may be used to evaluate method performance

7.5 Surrogate Standards

7.5.1 Surrogate standards are used to monitor the efficiency of sample extraction, chromatographic, and calibration systems.

7.5.2 The recommended surrogate standards are COD and OTP. Alternatively, 5-alpha-androstane may also be used as an aliphatic fraction surrogate without qualification.

7.5.3 The surrogate standard COD is prepared by accurately weighing approximately 0.0100 g of pure material in a 10-mL volumetric flask. Dissolve the material in hexane.

7.5.4 The surrogate standard OTP is prepared by accurately weighing approximately 0.0100 g of pure material in a 10-mL volumetric flask. Dissolve the material in methylene chloride.

7.5.5 Surrogate Spiking Solution: The recommended surrogate spiking solution is comprised of a mixture of the COD and OTP surrogate standards. Prepare a surrogate spiking solution which contains the surrogate standards at a concentration of 40 ng/µL in acetone or methanol. Each sample, LMB, LCS, and matrix spike is fortified with a specified volume of the surrogate spiking solution in order to yield a final concentration of 40 ug/mL (on column, prior to correction for preparation factors). The use of higher concentrations is permissible and advisable when spiking highly contaminated samples.

7.6 Fractionation Surrogate Standards

7.6.1 The fractionation surrogate standards are added to the sample (hexane) extract just prior to fractionation. The purpose of the fractionation surrogate standards is to monitor the efficiency of the fractionation process, and ensure that unacceptable quantities of naphthalene and substituted naphthalenes are not being eluted into the aliphatic extract.

7.6.2 The recommended fractionation surrogate standard is 2-Bromonaphthalene. Other alternative fractionation surrogate compounds, including 2-Fluorobiphenyl are permissible, provided that a demonstration is made that such compounds exhibit polarities/fractionation properties similar to naphthalene.

7.6.3 The fractionation surrogate standards are prepared by accurately weighing approximately 0.0100 g of pure material in a 10-mL volumetric flask. Dissolve the material in methylene chloride.

7.6.4 Fractionation Surrogate Spiking Solution: is comprised of 2-Bromonaphthalene and 2-Fluorobiphenyl (optional) prepared in hexane at concentrations of 40 ng/µL. An aliquot of 1 mL of the fractionation surrogate spiking solution is added to the 1 mL EPH sample extract prepared in accordance with the provisions of Sections 9.1.1 and 9.1.2. Alternative concentrations/volumes of the fractionation surrogate spiking solution are permissible.

7.7 Internal Standards (ISs)

7.7.1 ISs are compounds with similar physical and chemical properties, and chromatographic compatibility with an analytical method's target analytes. ISs are added to all samples, both for analysis and quality control, at a known concentration and carried through the entire analytical process. ISs are used as the basis for quantification of Target PAH Analytes (and hydrocarbon ranges) for the applied analytical method. For the EPH method, ISs are only utilized when GC/MS is utilized for quantification.

7.7.2 The recommended IS for the EPH Method is 5-alpha-androstane when a modified SW-846 8270E is used to quantify the Target PAH Analytes and the fractionated aliphatic and/or aromatic hydrocarbon range concentrations using GC/MS.

7.7.3 The IS is prepared by accurately weighing approximately 0.0500 grams of pure material in a 10-mL volumetric flask. Dissolve the material in methylene chloride or hexane.

7.7.4 An aliquot of 10 µL of the IS stock standard is added to each 1 mL EPH sample extract prepared in accordance with Section 9.3. Alternative concentrations/volumes of the IS spiking solution are permissible.

7.8 Matrix Spiking Solution

7.8.1 The matrix spiking solution, consisting of all normal alkanes in Table 1 and all PAHs in Table 2, is prepared in methanol or acetone at concentrations between 50 - 150 ng/µL (The concentration should be between the mid and upper level of calibration).

7.8.2 The samples selected as the matrix spike are fortified with a specified volume of the matrix spiking solution in order to yield a final concentration of 50-150 ug/mL (on column, prior to correction for preparation factors).

<u>Analytical Note</u>: The matrix spiking solution should always be brought to room temperature before use to promote dissolution of the highest boiling (marginal solubility) hydrocarbon standards.

7.9 Fractionation Check Solution

7.9.1 The Fractionation Check Solution is used to monitor the fractionation efficiency of the silica gel cartridge/column, and establish the optimum hexane volume required to efficiently elute aliphatic hydrocarbons while not allowing significant aromatic hydrocarbon breakthrough.

7.9.2 Prepare a Fractionation Check Solution in hexane containing 200 ng/µL of the Aliphatic Hydrocarbon standard (C_9-C_{36} alkanes) and 200 ng/µL of the Aromatic Hydrocarbon standard (Target PAH Analytes). The final solution will contain 14 alkanes and 17 PAHs at concentrations of 200 ng/µL each. Alternative concentrations are permissible.

8.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

8.1 Aqueous Samples

8.1.1 It is good practice to instruct field personnel to collect aqueous samples in duplicate. Samples must be collected in 1-liter amber glass bottles with Teflon-lined screw caps.

8.1.2 Aqueous samples must be preserved at the time of sampling by the addition of a suitable acid to reduce the pH of the sample to less than 2.0. This may be accomplished by the addition of 5 mL of 1:1 hydrochloric acid (HCl) to a 1 liter sample. The uses of alternative acids are permissible. Following collection and addition of acid, the sample must be cooled to 0-6° C.

8.1.3 A chain-of-custody form must accompany all sample bottles and must document the date and time of sample collection and preservation method used. The laboratory must determine the pH of all water samples as soon as possible after sample receipt and prior to sample extraction. Any sample found to contain a pH above 2 must be so noted on the laboratory/data report sheet and the pH must be adjusted as soon as possible.

8.1.4 Any sample received by the laboratory that is not packed in ice or cooled to 0-6° C must be so noted on the laboratory/data report sheet. The temperature of the cooler must be recorded by the laboratory upon receipt.

8.1.5 Aqueous samples must be extracted within 14 days of collection, and analyzed within 40 days of extraction.

8.2 Soil/Sediment Samples

8.2.1 Soil and sediment samples are collected in 4-oz. (120-mL) amber wide-mouth glass jars with Teflon-lined screw caps.

8.2.2 Soil and sediment samples must be cooled to 0-6° C immediately after collection.

8.2.3 A chain-of-custody form must accompany all sample bottles and must document the date and time of sample collection and preservation method used.

8.2.4 Any sample received by the laboratory that is not packed in ice or cooled to 0-6° C must be so noted on the laboratory/data report sheet. The temperature of the cooler must be recorded by the laboratory upon receipt.

8.2.5 Soil and sediment samples must be extracted within 14 days of collection, and analyzed within 40 days of extraction.

8.2.6 Alternatively, samples may be frozen (- 10°C) in the field or in the laboratory. Samples frozen in the laboratory must be preserved at 0-6° C from the time of sampling and frozen within 24 hours of the time of collection.

8.3 A summary of sample collection containers, preservation, and holding times is provided in Table 4.

9.0 EXTRACTION AND ANALYTICAL PROCEDURES

9.1 Overview of Sample Extraction Procedures

Samples are extracted using methylene chloride and solvent-exchanged into hexane. EPH extraction may be accomplished manually or by automated methods. In this section a detailed description of manual separatory funnel liquid-liquid extraction for aqueous samples (SW-846 Method 3510) and the Soxhlet extraction procedure (SW-846 Method 3540) for soils and/or sediments are presented to demonstrate general extraction concepts for petroleum products. The applicable SW-846 Method should be consulted for specific details for the other approved EPH extraction procedures.

NOTE: For optimum performance, the sample volumes/weights, solvent volumes, and final extract volumes cited in Sections 9.1.1 and 9.1.2 are recommended. Alternate volumes can be used as long as comparable RLs are achieved.

The complete list of approved EPH extraction procedures for aqueous and soil/sediment samples is presented in Table 5. Alternative extraction procedures other than those listed are acceptable, provided that the laboratory can document acceptable matrix- and petroleum product-specific performance. However, use of an alternative extraction procedure is considered a “significant modification” of the EPH method pursuant to Section 11.3.1.1 and as such would preclude obtaining “Presumptive Certainty” status for any analytical data produced using an alternative EPH extraction procedure

9.1.1 Aqueous Extraction by Separatory Funnel Liquid-Liquid Extraction

9.1.1.1 Mark the meniscus on the 1-liter sample bottle (for later volume determination) and transfer the contents to a 2-liter separatory funnel. For LMBs, LCSs, and LCSDs, pour 1 liter of reagent water into the separatory funnel. For all samples, LMBs, LCSs, LCSDs and matrix spikes add the specified volume of the surrogate spiking solution (see Section 7.5) directly to the separatory funnel. For samples selected for matrix spikes, also add the specified volume of the matrix spiking solution (see Section 7.8).

9.1.1.2 Check the pH of the sample with wide-range pH paper. Note the pH in the laboratory notebook. The pH of the sample must be adjusted to pH <2.

9.1.1.3 Add 60 mL methylene chloride to the sample bottle to rinse the inner walls of the container, then add this solvent to the separatory funnel.

9.1.1.4 Seal and shake the separatory funnel vigorously for at least three (3) minutes with periodic venting to release excess pressure.

NOTE: Methylene chloride creates excessive pressure very rapidly; therefore, venting should be done immediately after the separatory funnel has been sealed and shaken once.

9.1.1.5 Allow the organic layer to separate from the water phase for a minimum of 5 minutes. If the emulsion interface between layers is more than one-third the size of the solvent layer, the analyst must employ mechanical techniques to complete the phase separation. The optimum technique depends upon the sample and may include stirring, filtration of the emulsion through glass wool, centrifugation, or other physical methods. Collect the solvent extract in an Erlenmeyer flask.

9.1.1.6 Repeat the extraction two more times using additional 60 mL portions of solvent. Combine the three solvent extracts in a 250-mL Erlenmeyer flask. (Steps 9.1.1.3 to 9.1.1.5)

9.1.1.7 For sample volume determination add water to the sample bottle to the level of the meniscus previously marked and transfer this water to a graduated cylinder.

9.1.1.8 Assemble a K-D concentrator by attaching a 10-mL concentrator tube to a 500-mL evaporation flask.

9.1.1.9 Dry the extract by passing it through a glass powder funnel containing anhydrous sodium sulfate or other suitable drying agent. Collect the dried extract in the K-D concentrator. Rinse the Erlenmeyer flask, which contained the solvent extract, with 20 to 30 mL of methylene chloride and add it to the funnel to complete the quantitative transfer.

9.1.1.10 Add one or two clean boiling chips to the K-D flask and attach a three-ball Snyder column. Pre-wet the Snyder column by adding about 1 mL of methylene chloride to the top of the column. Place the K-D apparatus on a hot water bath (80-90°C) so that the concentrator tube is partially immersed in the hot water and the entire lower rounded surface of the flask is bathed with hot vapor. Adjust the vertical position of the apparatus and the water temperature, as required, to complete the concentration in 10 to 20 minutes. At the proper rate of distillation, the balls of the column will actively chatter, but the chambers will not flood. When the apparent volume of liquid reaches 1 mL, remove the K-D apparatus from the water bath and allow it to drain and cool for at least 10 minutes.

9.1.1.11 Exchange the methylene chloride with hexane by adding 50 mL of hexane to the top of the Snyder column. Concentrate the extract to less than 10 mL, as described in Section 9.1.1.10, raising the temperature of the water bath, if necessary, to maintain proper distillation.

9.1.1.12 Remove the Snyder column and evaporation flask from the 10-mL concentrator tube. Place the concentrator tube containing the hexane extract onto an air blowdown apparatus. Adjust the extract volume to 1 mL under a gentle stream of nitrogen or air. If the extract is highly colored, forms a precipitate, or stops evaporating, the final volume should be higher. If a TPH analysis is to be conducted, without fractionation, proceed to Section 9.3.3.

Analytical Note: Due caution must be exercised during blowdown to avoid losses of the more volatile (C_9 through C_{12}) EPH components. The fractionation extract (or any extract) volume should never be reduced below 1 mL in this or any other step to minimize volatilization losses.

9.1.1.13 Add 1 mL of the concentrated fractionation surrogate spiking solution (see Section 7.6) to the 1 mL hexane extract. Alternatively, add 20-50 ng each of the fractionation surrogate standards using a microliter syringe (up to 10 uL volume).

Analytical Note: If the latter alternative is exercised, only a single extract will be available for fractionation unless the spiked extract is further diluted. Such dilution may not be advisable for samples with Target PAH Analytes or hydrocarbon ranges at or near the method's RL.

9.1.1.14 Record the sample preparation information for the extraction and concentration steps. At a minimum, record the date, sample laboratory number, sample volume, volume and concentration of added surrogates and matrix spike solutions, the original pH, final extract volume, and any deviations or problems associated with the extraction of the samples.

9.1.1.15 The 2 mL extract (1 mL extract + 1 mL fractionation surrogate) is now ready to be cleaned and fractionated using silica gel SPE cartridges. If cleanup will not be performed immediately, transfer the extract to a Teflon-lined screw-cap vial, label, and refrigerate.

9.1.1.16 For cleanup and fractionation, refer to Section 9.2.

9.1.2 Soil and/or Sediment Extraction using Soxhlet Extraction

9.1.2.1 Blend 10 g of the solid sample with 10 g anhydrous sodium sulfate and place in an extraction thimble. The extraction thimble must drain freely for the duration of the extraction period. Add the specified volume of the surrogate spiking solution (see Section

7.5) to all samples, LMBs, LCSs, LCSDs and matrix spikes. Thoroughly mix the surrogate spiking solution into the sample. For samples selected for matrix spikes, also add the specified volume of the matrix spiking solution (see Section 7.8). Thoroughly mix the matrix spiking solution(s) into the sample.

9.1.2.2 Place 300 mL of methylene chloride into a 500-mL round-bottom flask containing one or two clean boiling chips. Attach the flask to the extractor and extract the sample for 16-24 hours. The volume of methylene chloride should be adjusted to accommodate the size of the round-bottom flask utilized.

9.1.2.3 Allow the extract to cool after the extraction is completed.

9.1.2.4 Assemble a K-D concentrator by attaching a 10-mL concentrator tube to a 500-mL evaporation flask.

9.1.2.5 Dry the extract by passing it through a glass powder funnel containing anhydrous sodium sulfate or other suitable drying agent. Collect the dried extract in the K-D concentrator. Rinse the extractor flask with 100 to 125 mL of methylene chloride and add it to the funnel to complete the quantitative transfer.

9.1.2.6 Add one or two clean boiling chips to the K-D flask and attach a three-ball Snyder column. Pre-wet the Snyder column by adding about 1 mL of methylene chloride to the top of the column. Place the K-D apparatus on a hot water bath (80-90°C) so that the concentrator tube is partially immersed in the hot water and the entire lower rounded surface of the flask is bathed with hot vapor. Adjust the vertical position of the apparatus and the water temperature, as required, to complete the concentration in 10 to 20 minutes. At the proper rate of distillation, the balls of the column will actively chatter, but the chambers will not flood. When the apparent volume of liquid reaches 1 mL, remove the K-D apparatus from the water bath and allow it to drain and cool for at least 10 minutes.

9.1.2.7 Exchange the methylene chloride with hexane by adding 50 mL of hexane to the top of the Snyder column. Concentrate the extract to less than 10 mL, as described in Section 9.1.2.6, raising the temperature of the water bath, if necessary, to maintain proper distillation.

9.1.2.8 Remove the Snyder column and evaporation flask from the 10-mL concentrator tube. Place the concentrator tube containing the hexane extract onto an air blowdown apparatus. Adjust the extract volume to 1 mL under a gentle stream of nitrogen or air. If the extract is highly colored, forms a precipitate, or stops evaporating, the final volume should be higher. If a TPH analysis is to be conducted without fractionation, proceed to Section 9.3.3.

<u>Analytical Note</u>: Due caution must be exercised during blowdown to avoid losses of the more volatile (C_9 through C_{12}) EPH components. <u>The fractionation extract (or any extract) volume should never be reduced below 1 mL in this or any other step to minimize volatilization losses.</u>

9.1.2.9 Add 1 mL of the concentrated fractionation surrogate spiking solution (see Section 7.6) to the 1 mL hexane extract. Alternatively, add 20-50 ng each of the fractionation surrogate standards using a microliter syringe (up to 10 uL volume).

<u>Analytical Note</u>: If the latter alternative is exercised, only a single extract will be available for fractionation unless the spiked extract is further diluted. Such dilution may not be advisable for samples with Target PAH Analytes or hydrocarbon ranges at or near the method's RL.

9.1.2.10 Record the sample preparation information for the extraction and concentration steps. At a minimum, record the date, sample laboratory number, sample weight, volume and concentration of added surrogates and matrix spike solutions, extraction start and stop times, final extract volume and any deviations or problems associated with the extraction of the samples.

9.1.2.11 The 2 mL extract (1 mL extract + 1 mL fractionation surrogate) is now ready to be cleaned and fractionated using silica gel SPE cartridges. If cleanup will not be performed immediately, transfer the extract to a Teflon-lined screw-cap vial, label, and refrigerate.

9.1.2.12 For cleanup and fractionation, refer to Section 9.2.

9.2 Silica Gel Cleanup and Fractionation

NOTE: The Silica Gel Cleanup and Fractionation step is a critical and highly sensitive procedure. Small changes in the volumes of eluting solvents, fractionation equipment, and/or fractionation techniques can significantly impact the proportion of hydrocarbons segregated in either the aliphatic or aromatic fractions. Considerable care and attention is required to ensure satisfactory results.

9.2.1 Each sample fractionation requires 1 mL of sample extract. Because 2 mL of sample extract are available, two fractionations may be undertaken for each sample. Refractionation would be necessary if problems are experienced during the initial fractionation effort, if unacceptable breakthrough is noted for naphthalene and 2-methylnaphthalene in the LCS and/or LCSD, and/or if unacceptable recoveries are noted for the fractionation surrogate standard(s). The extra volume of sample extract is also provided to facilitate initial (unfractionated) TPH screening of a sample, to obtain a GC/FID “fingerprint”, and/or to determine whether sufficient total hydrocarbons are present to warrant fractionation and comparison to risk-based cleanup standards.

9.2.2 Silica gel is a regenerative adsorbent of amorphous silica with weakly acidic properties. It is produced from sodium silicate and sulfuric acid. Silica gel can be used for column chromatography and is used for separating analytes from interfering compounds of a different chemical polarity. Silica gel is also used to separate petroleum distillates into aliphatic and aromatic fractions.

A 5 g/15-mL SPE silica gel cartridge is commercially available. Alternatively, the use of self-packed columns of activated silica gel may also be used. The use of activated silica gel for general column chromatographic applications is described in detail in SW-846 Method 3630C.

To ensure satisfactory fractionation, silica gel/cartridges must not be overloaded. It is recommended that loading be limited to no more than 5 mg total hydrocarbons/gram silica gel; for a 1 mL extract fractionated on a 5 gram silica gel cartridge, this would equate to a hydrocarbon extract loading of no greater than 25,000 µg/mL. It should be noted that overloading the column may result in a premature breakthrough of the C_{11}-C_{22} aromatic hydrocarbon range. If overloading is encountered, the sample must be re-fractionated at a dilution appropriate for the column’s maximum loading capacity.

Unsealed silica gel/cartridges must be stored in a properly-maintained desiccator to avoid inadvertent adsorption of ambient moisture. Silica gel that has been exposed to moisture may perform erratically resulting in poor performance manifested by naphthalene/2-methylnaphthalene and fractionation surrogate breakthrough.

Analytical Note: **Air-drying of the cartridges may adversely affect silica gel performance and is not advised.**

9.2.3 If concerns exist over the presence of contaminants in the silica gel/cartridge, pre-rinse the column with 30 mL of methylene chloride.

9.2.3.1 Rinse the column with 30 mL of hexane, or 60 mL if pre-rinsed with methylene chloride per Section 9.2.3. Let the hexane flow through the column until the head of the liquid in the column is just above the column frit. Close the stopcock to stop solvent flow. Discard the collected hexane.

9.2.3.2 Load 1.0 mL of the combined sample extract and fractionation surrogate solution onto the column. Open the stopcock, and start collecting elutant immediately in a 25-mL volumetric flask labeled “aliphatics”.

9.2.3.3 Just prior to exposure of the column frit to the air, elute the column with an additional 19 mL of hexane, so that a total of approximately 20 mL of hexane is passed through the column.

It is essential that “plug flow” of the sample extract be achieved through the silica gel cartridge/column. Hexane should be added in 1-2 mL increments or dropwise using a pipet, with additions occurring when the level of solvent drops to the point just prior to exposing the column frit to air. The use of a stopcock is mandatory. Care must be taken to ensure that the silica gel is uniformly packed in the column. The analyst must be cognizant of any channeling, streaking, or changes in the silica gel matrix during fractionation; if any of these occur, the procedure must be repeated with another 1 mL volume of sample extract.

The amount of hexane used during fractionation is critical. Excessive hexane - as little as 0.5 mL - can cause significant elution of lighter aromatics into the aliphatic fraction. Insufficient hexane will cause low recoveries of the aliphatic fraction. The volume of the hexane fractionation elutriate should not exceed 20 mL.

9.2.3.4 The Fractionation Check Solution described in Section 7.9 <u>must be used to evaluate each new lot of silica gel /cartridges</u> to re-establish the optimum volume of hexane elutriate. See Appendix 5, Section 5.0 for optimization specifications.

It is not uncommon to encounter inconsistent cartridge weights, mesh sizes and/or variable fractionation performance within the same lot of silica gel cartridges. It may be advisable to perform additional intra-lot fractionation performance checks particularly for larger lot sizes (500) of silica gel cartridges.

9.2.3.5 Following recovery of the aliphatic fraction, elute the column with 20 mL of <u>methylene chloride</u> and collect the eluant in a 25 mL volumetric flask. Label this fraction "aromatics".

9.3 Final Sample Extract Concentration

9.3.1 Transfer the contents of the 25.0 mL “aliphatics” (in hexane) and “aromatics” (in methylene chloride) volumetric flasks into separate labeled graduated concentrator tubes. Concentrate each of the extracts to a final volume of 1 mL under a gentle stream of air or nitrogen.

<u>Analytical Note</u>: Due caution must be exercised during blowdown to avoid losses of the more volatile (C_9 through C_{12}) EPH components. <u>The fractionation extract (or any extract) volume should never be reduced below 1 mL in this or any other step to minimize volatilization losses.</u>

9.3.2 Transfer the final 1 mL extracts from each concentrator tube to labeled 2-mL glass autosampler vials with Teflon-lined rubber crimp caps. If appropriate, add an IS at the appropriate concentration.

9.3.3 Proceed with the analysis in accordance with Section 9.8. Analyze all QC samples under the same conditions as that used for samples.

9.4 Determination of Percent Moisture

9.4.1 Soil and sediment results must be reported on a dry-weight basis.

9.4.2 Transfer 5 to 10 g of sample into a tared (± 0.1 g) crucible and determine “wet weight”. Dry this 5 to 10 g sample overnight at 105°C. Allow the crucible to cool in a desiccator and reweigh (± 0.1 g). Re-desiccate and verify “dry weight”. Calculate the percent moisture of the sample using the equation provided in Section 9.9.3 (Equation 10). Refer to ASTM Method D2216, *Determination of Moisture Content of Soils and Sediments*, for more detailed analytical and equipment specifications.

9.5 Analytical Conditions

9.5.1 Recommended analytical conditions are presented below. A chromatographic column with equivalent chromatographic properties, as described in Section 6.1.3, or alternative chromatographic conditions may be substituted to improve resolution of extractable petroleum hydrocarbons.

Chromatographic Column:	30 m x 0.32 mm I.D., 0.25 μm film thickness Restek RTX-5
Oven Temperature Program	Initial oven temperature 60°C, hold time 1 min; to 290 °C @ 8°C/min, hold time 6.75 min
Total Run Time:	36.5 min
Sample/autosampler Injection	1-4 uL
Gas Flow Rates:	Carrier gas – Helium @ 2 to 3 mL/ min Oxidizer – Air @ 400 mL/min Fuel – Hydrogen @ 35 mL/min Make up – Air @ 30.0 mL/min
Injection Port Temperature:	285°C
Column Inlet Pressure:	15 p.s.i.g.
Detector Temperature:	315°C (FID)
Linear Velocity	50 cm/sec

9.5.2 GC Maintenance

9.5.2.1 Capillary columns: Clean and deactivate the glass injection port insert or replace with a cleaned and deactivated insert.

9.5.2.2 Break off the first few inches, up to one foot, of the injection port side of the column.

9.5.2.3 Remove the column and solvent backflush according to the manufacturer's instructions.

9.5.2.4 Bake out the column at the maximum temperature of the temperature program. If these procedures fail to eliminate a column degradation problem, it may be necessary to replace the column.

9.6 Retention Time Windows

9.6.1 Before establishing retention time (Rt) windows, optimize the GC system’s operating conditions. Make three injections of the Aromatic Hydrocarbon and Aliphatic Hydrocarbon Standard mixtures over the course of a 72-hr period. Serial injections over less than a 72-hr period may result in Rt windows that are too restrictive.

9.6.2 Calculate the standard deviation of the three absolute Rts for each individual compound in the Aromatic Hydrocarbon Standard, the Aliphatic Hydrocarbon Standard, and all surrogates and internal standards.

9.6.3 The Rt window is defined as plus or minus three times the standard deviation of the absolute Rt for each compound in the Aliphatic and Aromatic Hydrocarbon Standards. However, the experience of the analyst should weigh heavily in the interpretation of chromatograms.

9.6.4 In those cases where the standard deviation for a particular standard is close to zero, the default value of 0.1 minutes should be used. Alternatively, the laboratory may substitute the standard deviation of a closely eluting structurally similar compound to develop a representative statistically-derived Rt window.

9.6.5 The laboratory must calculate Rt windows for each compound in the Aliphatic and Aromatic Hydrocarbon Standards on each GC column and whenever a new GC column is installed. These data must be retained by the laboratory.

9.6.6 EPH Rt windows are defined as beginning 0.1 minutes before the Rt of the beginning marker compound and ending 0.1 minutes after the Rt of the ending marker compound, except for n-C_{19}, which is both a beginning and ending marker compound for two different ranges.

The C_9 - C_{18} Aliphatic Hydrocarbon range ends immediately (0.1 min) before the elution of the n-C_{19} peak. The C_{19} - C_{36} Aliphatic Hydrocarbon range begins 0.1 min before the elution of the n-C_{19} peak; therefore there is no overlap of the two ranges and the n-C_{19} peak is only included in the C_{19} - C_{36} Aliphatic Hydrocarbon range.

EPH marker compounds and windows are summarized in Table 6.

9.6.7 If a TPH analysis is done without fractionation, TPH Rt windows are defined as beginning 0.1 minutes before the Rt of n-Nonane and ending 0.1 minutes after the Rt of n-Hexatriacontane.

9.7 Calibration

9.7.1 The EPH calibration standards are used to calibrate the GC/FID system. Two distinct calibration operations are necessary.

9.7.1.1 Target PAH Analytes and Surrogates: Calibration Factors (CFs) are calculated for the Target PAH Analytes and surrogate standards, based upon a correlation between the concentration of analyte/surrogate and FID area counts for the analyte/surrogate peaks. This allows for the individual identification and quantitation of these specific compounds. It is not necessary to develop CFs for any other individual EPH Components.

9.7.1.2 Collective Aliphatic/Aromatic Hydrocarbon Ranges: CFs are calculated for C_9-C_{19} aliphatic hydrocarbons and C_{19}-C_{36} aliphatic hydrocarbons based upon a correlation between the TOTAL concentration of aliphatic EPH Components eluting within the range of interest and the total FID area count of the applicable EPH component peaks. A CF is calculated for C_{11}-C_{22} aromatic hydrocarbons based upon a correlation between the concentration of the Target PAH Analytes used to calibrate this range and the total FID area count of the Target PAH Analytes. Specified EPH Components are designated marker compounds to define the beginning and end of the hydrocarbon ranges (see Table 6). A listing of the hydrocarbon range compounds used to establish CFs for each hydrocarbon range of interest and their individual component concentration (µg/L) is provided in Tables 1 through 3.

9.7.2 Initial Calibration

9.7.2.1 Initial calibration is performed at instrument set-up and at any time recalibration is required or performed.

9.7.2.2 An internal standard calibration procedure is not recommended for this method except when GC/MS is used to quantify Target PAH Analytes and hydrocarbon ranges (see Section 9.10).

9.7.2.3 The use of CFs is the preferred approach to determine the relationship between the detector response and the Target PAH Analyte and hydrocarbon range concentrations. It is also permissible to utilize linear regression (see Sections 9.7.2.13 and 9.7.2.14). The linear regression approach for Target PAH Analytes and hydrocarbon ranges is described in Appendix 4. The use of non-linear regression is not allowed in this method and is considered a significant modification as discussed in Section 11.3.1.1.

9.7.2.4 An initial calibration is performed using a minimum of five different concentrations of EPH calibration standards as per Section 7.3. Recommended Target PAH Analyte and hydrocarbon range calibration standard concentrations are provided in Table 3. The calibration concentrations must be evenly dispersed over the full working range of the detector with the lowest calibration point corresponding to the target RL for the Target PAH Analytes (see Section 12.0).

9.7.2.5 Introduce each calibration standard into the gas chromatograph using the injection volume (e.g., 1 to 4 µL) that will be used to introduce the "actual" samples and according to the procedures specified in Section 9.8.

9.7.2.6 Target PAH Analytes and Surrogates - Tabulate the FID area response against the concentration for each Target PAH Analyte and surrogate, and calculate a CF for each compound using Equation 1. Perform this calculation for each Target PAH Analyte and surrogate.

Equation 1: Calibration Factor for Target PAH Analytes and Surrogates

$$\boxed{\text{Calibration Factor (CF)} = \frac{\text{area of peak}}{\text{concentration injected } (ng/uL)}}$$

9.7.2.7 Hydrocarbon Ranges - Establish retention time windows for the hydrocarbon ranges using the EPH component marker compounds shown in Table 6.

9.7.2.8 Calculate a CF for the C_9-C_{18} aliphatic hydrocarbon range using the following steps.

Sum the individual FID peak areas of the six EPH Components that are used to establish an average range CF for C_9-C_{18} aliphatic hydrocarbons. It is important to note that these integrations must be performed using a valley-to-valley approach for each of the individual peaks that comprise this range. The sum of each of these areas is used in the subsequent calculation. Note: Do not include the areas of any surrogate standard or naphthalene and 2-methylnaphthalene in calculating a hydrocarbon range CF.

Using this total area, calculate the C_9-C_{18} aliphatic hydrocarbon range CF using Equation 2.

Equation 2: Calibration Factor for Hydrocarbon Range

$$\boxed{Range\ CF = \frac{Area\ summation\ of\ range\ components}{Total\ concentration\ injected\ (ng\ /uL)}}$$

9.7.2.9 Calculate a CF for the C_{19}-C_{36} aliphatic hydrocarbon range using the following steps.

Sum the individual FID peak areas of the eight EPH Components that are used to establish an average range CF for C_{19}-C_{36} aliphatic hydrocarbons. It is important to note that these integrations must be performed using a valley-to-valley approach for each of the individual peaks that comprise this range. The sum of each of these areas is used in the subsequent calculation. Note: Do not include the area of any surrogate standard in calculating a hydrocarbon range CF.

Using this total area, calculate the C_{19}-C_{36} hydrocarbon range CF using Equation 2.

9.7.2.10 Calculate a CF for the C_{11}-C_{22} aromatic hydrocarbon range using the following steps.

Use the individual FID peak areas of the 17 Target PAH Analytes which are used to establish an average range CF for C_{11}-C_{22} aromatic hydrocarbons. It is important to note that integration must be performed using a valley-to-valley approach for each of the individual peaks that comprise this range. The sum of each of these areas is used in the subsequent calculation. Note: Do not include the area of any surrogate standard in calculating a hydrocarbon range CF.

Using this area, calculate the C_{11}-C_{22} aromatic range CF using Equation 2.

9.7.2.11 Calculate the average CF for each of the Target PAH Analytes, the surrogates, and each hydrocarbon range.

9.7.2.12 Calculate the percent relative standard deviation (%RSD) of the CFs over the working range of the curve for each of the Target PAH Analytes, the surrogates, and each hydrocarbon range using Equation 3.

Equation 3: Percent Relative Standard Deviation

$$\boxed{\%RSD = [(SD_{n-1})/(AVG_{X})]*100}$$

where:

%RSD =	percent relative standard deviation
SD_{n-1} =	standard deviation (n-1 degrees of freedom)
AVG_x =	average CF from the initial calibration curve

9.7.2.13 If the %RSD is ≤25 for Target PAH Analytes, the surrogates, and hydrocarbon ranges, linearity can be assumed and the average CF can be used for quantitation in lieu of a calibration curve.

If, under **extenuating** analytical circumstances (e.g., extending the RL beyond the expected linear range of the detector), the %RSD criteria cannot be achieved, then a linear (least squares) regression may be used to generate a calibration curve consistent with the guidance provided in SW-846 Method 8000D, Section 11.5.2. For the linear regression calculations, the origin (0,0) cannot be included as a calibration point.

NOTE: Use of non-linear calibration is not allowed and is considered a Significant Modification as per Section 11.3.1.1.

9.7.2.14 In order for the linear regression model to be used for quantitative purposes, the correlation coefficient (r) must be ≥0.99. In addition, the resulting calibration curve from the linear regression must be verified by recalculating concentrations of the Target PAH Analytes and hydrocarbon ranges in the lowest calibration standard using the final calibration curve. Recoveries must be 70-130%.

If recalculated concentrations from the lowest calibration standard are outside the 70-130% recovery range, raise the RL to the concentration of the next highest calibration standard that exhibits acceptable recoveries when recalculated using the final calibration curve.

9.7.2.15 For any calibration model, the concentration of the lowest initial calibration standard used in an acceptable initial calibration (i.e., %RSDs and r within method criteria), adjusted for sample size, dilution, etc., establishes the method RL.

9.7.2.16 The initial calibration must be verified through the analysis of an ICV. This analysis must be performed every time an initial calibration is performed. The ICV must be prepared from a different stock standard than that used to prepare the calibration standards and must be analyzed immediately following the initial calibration. The ICV should be prepared at a mid-range calibration curve concentration.

Calculate the percent recovery (%R) of each Target PAH Analyte and hydrocarbon range using Equation 4. Percent recoveries must be between 70-130%. Recalibrate if >10% of all analytes are outside of criteria.

Equation 4: Percent Recovery

$$\boxed{\%R = [(C_{found})/(C_{true})] * 100}$$

where:

%R = Percent Recovery
C_{found} = Concentration of the Target PAH Analyte or hydrocarbon range detected in the ICV (µg/L)
C_{true} = True concentration of the Target PAH Analyte or hydrocarbon range in the ICV (µg/L)

9.7.3 Continuing Calibration

9.7.3.1 A Continuing Calibration Standard must be analyzed daily prior to sample analysis, after every 20 samples or every 24 hours (whichever is more frequent), and at the end of the analytical sequence. It should be noted that the Percent Differences (%Ds) are calculated (Equation 5) when CFs are used for the initial calibration and Percent Drifts (Equation 4-5, Appendix 4) are calculated when calibration curves using linear regression are used for the initial calibration.

9.7.3.2 The concentration of the EPH Continuing Calibration Standard must be near the midpoint of the calibration curve.

9.7.3.3 Calculate the CF for each Target PAH Analyte, surrogate, and hydrocarbon range from the Continuing Calibration Standard using Equations 1 and 2.

9.7.3.4 Calculate the %D of the Continuing Calibration Standard CF from the initial calibration average CF using Equation 5.

Equation 5: Percent Difference

$$\boxed{\%D = [(CFc) - (CFI)]/[(CFI)]}$$

where:

%D = Percent Difference
CFc = CF from the EPH Continuing Calibration Standard
CF_I = average CF from the initial calibration curve

9.7.3.5 The %D or Percent Drift for each Target PAH Analyte, surrogate, and hydrocarbon range must be $\leq$25. If more than one Target PAH Analyte or hydrocarbon range fails to meet the applicable criterion, the instrument must be recalibrated. Otherwise, sample analysis may proceed. For the closing continuing calibration standard (analyzed after every 20 samples, every 24 hours, or at end of analytical sequence), four compounds may exhibit %Ds or Percent Drifts greater than 25% but less than 40%.

9.7.4 For TPH analysis without fractionation, CFs are developed based upon the response of all 14 aliphatic components using Equation 2.

9.7.5 Daily Rt Windows: The range Rt windows must be established daily based upon the Rt of the marker compounds in the EPH Continuing Calibration Standard. Use the absolute Rt for each analyte in the Continuing Calibration Standard as the midpoint of the window for that day. The daily Rt window equals the midpoint $\pm$ 3 times the standard deviation determined in Section 9.6. Alternatively, the default value of 0.1 minutes may be used for the daily Rt window. The marker compounds used for each hydrocarbon range are defined in Table 6.

9.8 GC Analysis

9.8.1 Samples are analyzed in a group referred to as an analytical batch. For methods that require extraction prior to analysis, such as EPH, the number of samples that comprise an analytical batch is generally limited to 20 samples plus the requisite QC samples processed concurrently with the extraction batch. The analytical sequence begins with instrument calibration (initial or continuing) followed by up to 20 samples interspersed with blanks and other QC samples and closed with a mid-range Continuing Calibration Standard. The analytical sequence ends when one or more analytical batches have been processed or when any required qualitative and/or quantitative QC criteria are exceeded, whichever comes first.

9.8.2 Aliphatic and aromatic extracts are introduced into the gas chromatograph by direct injection.

9.8.3 Inject 1 to 4 µL of the sample extract using the solvent flush technique. Smaller volumes may be injected if automatic devices are employed. Record the volume injected to the nearest 0.05 µL and the resulting peak size in area units. It is required that the sample and calibration standard injection volume be consistent.

9.8.4 Identification of Target PAH Analytes

- Tentative identification of a Target PAH Analyte occurs when a peak from a sample chromatogram falls within the daily Rt window. Confirmation on a second GC column or by GC/MS analysis may be necessary, if warranted by the project's data quality objectives.
- Validation of GC system qualitative performance must be accomplished by the analysis of mid-level standards within the analysis sequence. If the Rts of the Target PAH Analytes fall outside their daily Rt window in the standards, the system is out of control. In such cases, the cause of the non-conformance must be identified and corrected.

9.8.5 Aliphatic and aromatic hydrocarbon ranges of interest in samples are determined by the collective integration of all peaks that elute between specified range "marker" compounds. Due to the variability in software approaches and applications to collective peak area integration, it is recommended that a manual verification be initially performed to document accurate integration.

9.8.6 **In samples, collective peak area integration for the hydrocarbon ranges, or TPH, must be <u>from baseline</u> (i.e., must include the unresolved complex mixture "hump" areas).** For the integration of individual Target PAH Analytes, surrogate compounds, and internal standards, a valley-to-valley approach should typically be used, though this approach may be modified on a case-by-case basis by an experienced analyst. In any case, the unresolved complex mixture "hump" areas must <u>not</u> be included in the integration of individual Target PAH Analytes, surrogate compounds, and internal standards.

9.8.7 Baseline correction using a SSB is **only** permissible for the calculation of aliphatic and aromatic hydrocarbon range concentrations when conducted in accordance with the procedures and requirements specified in Section 11.2.5.

9.8.8 If the Target or Diesel PAH Analytes are to be quantitated using this method, and the response for an individual Target PAH analyte exceeds the linear range of the system, dilute the extract and reanalyze. The samples/extracts must be diluted so that all peaks fall within the linear range of the detector.

9.8.9 For non-target analytes eluting in the aliphatic, aromatic or TPH ranges, the upper linear range of the system should be defined by peak height measurement, based upon the maximum peak height documented for an aliphatic or aromatic component within the hydrocarbon range that is shown to be within the linear range of the detector.

9.8.10 Under circumstances that sample dilution is required because the concentration of one or more of the Target PAH Analytes exceeds the concentration of their respective highest calibration standard, any non-target peak eluting within any aliphatic or aromatic hydrocarbon range exceeds the peak height documented for the highest range-specific calibration standard, or anytime a saturated chromatographic peak (flat-topped peak) is encountered, the RL for each Target PAH Analyte and/or hydrocarbon range must be adjusted (increased) in direct proportion to the Dilution Factor (D).

Where:

$$D = \frac{\text{Sample Aliquot Volume (mL) + Diluent Volume (mL)}}{\text{Sample Aliquot Volume (mL)}}$$

And the revised RL for the diluted sample, RL_d:

RL_d = D * Lowest Calibration Standard for Target PAH Analyte

It should be understood that samples with elevated RLs as a result of a dilution may not be able to satisfy "MCP program" RLs in some cases if the RL_d is greater than the applicable MCP standard or criterion to which the concentration is being compared. Such increases in RLs are the unavoidable but acceptable consequence of sample dilution that enable quantification of target analytes which exceed the calibration range. All dilutions must be fully documented in the laboratory narrative.

Analytical Note: Over dilution is an unacceptable laboratory practice. The post-dilution concentration of the highest concentration target analyte must be at least 60 - 80% of its highest calibration standard. This will avoid unnecessarily high RLs for other target analytes, which did not require dilution.

9.9 Calculations

The concentrations of Target PAH Analytes and hydrocarbon ranges in a sample may be determined from the peak area response, using the CFs determined in Section 9.7.2. If linear regression was used for calibration, refer to Appendix 4 for sample concentration calculations.

9.9.1 Individual Target PAH Analytes and Surrogate: The average CF from the initial calibration is used to calculate the concentration of an analyte or surrogate detected in the sample. Equations 6 and 7 are used to calculate the concentrations of Target PAH Analytes and the surrogate in aqueous and non-aqueous samples, respectively.

Equation 6: Aqueous Samples (Target PAH Analytes and Surrogates)

$$\boxed{Conc\ Analyte\ (\mu g/L) = \frac{(A_x)(D)(V_t)}{(CF)(V_s)}}$$

where:

Ax = Area count for the Target PAH Analyte or surrogate
D = Dilution factor (see Section 9.8.10)
CF = Average CF for Target PAH Analyte or surrogate
V_t = Volume of total extract, µL (including fractionation surrogate volume)
V_s = Volume of sample extracted, mL.

Equation 7: Non-Aqueous Samples (Target PAH Analytes and Surrogates)

$$\boxed{Conc\ Analyte\ (ug/kg) = \frac{(A_x)(V_t)(D)}{(W_d)(CF)}}$$

where:

W_d = Dry weight of sample, g (see Equations 10 through 12)
A_x, V_t, D, and CF have the same definition as described above for Equation 6.

The integration of Target PAH Analytes and surrogates must be performed from valley-to-valley.

9.9.2 Hydrocarbon Ranges

When calculating the aliphatic and aromatic hydrocarbon range concentrations, the laboratory **must** include the area of **all** peaks eluting within the Rt windows specified for these ranges, excluding surrogates, as described below in Sections 9.9.2.1 and 9.9.2.2.

The average hydrocarbon range CF from the initial calibration is used to calculate the concentration of hydrocarbon ranges in samples**. Collective peak area integration for the hydrocarbon ranges must be from baseline (i.e., must include the unresolved complex mixture).**

9.9.2.1 C_9-C_{18} Aliphatic Hydrocarbons and C_{19}-C_{36} Aliphatic Hydrocarbons

- Sum all peaks in the appropriate Rt window, as specified in Section 9.6 and Table 6 (using baseline integration).
- From this sum, subtract the area counts of any surrogates which elute in this range (using valley-to-valley integration).
- Equations 8 and 9 are used to calculate the concentrations of C_9-C_{18} aliphatic hydrocarbons and C_{19}-C_{36} aliphatic hydrocarbons in aqueous and non-aqueous samples, respectively.

Equation 8: Aqueous Samples (Hydrocarbon Ranges and TPH)

$$\boxed{Conc\ HC\ Range\ or\ TPH\ (\mu g/L) = \frac{(A_x)(D)(V_t)}{(Range\ CF)(V_s)}}$$

where:
Ax = Area count for hydrocarbon range of interest
D = Dilution factor (see Section 9.8.10)
Range CF = Average CF for hydrocarbon range
V_t = Volume of total extract, µL (including fractionation surrogate volume)
V_s = Volume of sample extracted, mL.

Equation 9: Non-Aqueous Samples (Hydrocarbon Ranges and TPH)

$$\boxed{Conc\ HC\ Range\ or\ TPH\ (ug/kg) = \frac{(A_x)(V_t)(D)}{(W_d)(Range\ CF)}}$$

where:

W_d = Dry weight of sample, g (see Equations 10 through 12)
A_x, V_t, D, and Range CF have the same definition as described above for Equations 8 and 9.

9.9.2.2 C_{11}-C_{22} Aromatic Hydrocarbons

- Sum all peaks in the appropriate Rt window, as specified in Section 9.6 and Table 6 (using baseline integration).

- From this sum, subtract the area counts of any surrogates which elute in this range (using valley-to-valley integration).

- Calculate the concentrations in aqueous and non-aqueous samples using Equations 8 and 9, respectively.

  NOTE: These values are reported as the "Unadjusted C_{11}-C_{22} aromatics" as shown in Appendix 3, Exhibit 1.

- From the Unadjusted concentration (µg/L or µg/kg), calculate the concentration of C_{11}-C_{22} aromatic hydrocarbons by subtracting the concentrations of the Target PAH Analytes (which are quantified using the FID or GC/MS). This is the final concentration reported as the "C_{11}-C_{22} Aromatic Hydrocarbons" on the data report form in Appendix 3, Exhibit 1.

9.9.3 Calculation of Dry Weight of Sample

In order to calculate the dry weight of sample extracted (W_d), it is necessary to determine the moisture content of the soil/sediment sample, using the procedure outlined in Section 9.4. Using the data obtained from Section 9.4, W_d is calculated using Equations 10 through 12.

Equation 10: Percent Moisture

$$\boxed{\%\ Moisture = \frac{g\ wet\ sample - g\ dry\ sample}{g\ wet\ sample}\ X\ 100}$$

Equation 11: Percent Solids

$$\boxed{\%\ Dry\ Solids\ =\ (100)\ -\ (\%\ Moisture)}$$

Equation 12: Dry Weight of Sample

$$\boxed{W_d\ (g)\ =\ (\%\ Dry\ Solids / 100)(g\ of\ extracted\ sample)}$$

9.10 Determination of Target PAH Analytes and EPH Aliphatic and Aromatic Hydrocarbon Range Concentrations by Gas Chromatography/Mass Spectrometry (GC/MS)

Target PAH Analytes may be quantified from a fractionated or unfractionated extract using GC/MS and must satisfy the requirements listed below. Aliphatic and aromatic hydrocarbon ranges may only be quantified **after fractionation** using GC/MS under the MassDEP EPH Method and not be considered a "Significant Modification", as described in Section 11.3.1.1, by satisfying the following requirements:

9.10.1 Target PAH Analytes in the aromatic hydrocarbon range must be identified, quantified and satisfy the QC requirements and performance standards of SW-846 Method 8270E as described in WSC-CAM-II B with the modifications listed below. For quantification of the EPH aliphatic and aromatic ranges, the MS detector must be operated in the Total Ion Current mode.

9.10.2 Modified SW-846 Method 8270E QC Requirements for EPH Analysis*

* All referenced Section numbers refer to SW-846 Method 8270E.

9.10.2.1 DFTPP must be used as a tuning standard (Section 7.6).

9.10.2.2 5-alpha-androstane (using m/z 245 as primary quantitation ion) is the recommended internal standard; other internal standards may be used, as appropriate.

9.10.2.3 OTP is the recommended analytical surrogate to evaluate %R of the Target PAH analytes contained in the aromatic fraction; other surrogates (i.e., d_8-Naphthalene) may be used, as appropriate.

9.10.2.4 Evaluation of DDT breakdown, and pentachlorophenol and benzidine tailing is not required (Section 11.3.1.3).

9.10.2.5 All Target PAH Analytes described in Table 2 must meet the initial and continuing calibration requirements for the SW-846 Method 8270E described in WSC-CAM-II B unless specifically excepted in this section.

9.10.2.6 Hydrocarbon range response factors must be based on all individual aliphatic or aromatic calibration standards described in Tables 1 and 2, that are included within the specified range as defined by the EPH marker compounds described in Table 6. Hydrocarbon range response factors are determined using the summation of the peak areas (Total Ion Current) for all individual calibration standard components that elute within a specified range (i.e., C_9–C_{18} Aliphatic Hydrocarbons, 6 components) and the total concentration injected.

9.10.2.7 All Target PAH Analytes and hydrocarbon ranges must be evaluated in the initial calibration and continuing calibration verifications (CCVs) and meet the performance standards described in Table 7.

9.10.2.8 Evaluation of Continuing Calibration Standards (equivalent to the CCV described in SW-846 Method 8270E) is required at the beginning and end of each analytical sequence.

9.10.2.9 The analytical batch for EPH analyses may include the analysis of up to 20 samples completed within 12 hours of the batch's tune.

9.10.2.10 The performance standards for the EPH aliphatic and aromatic hydrocarbon ranges and comparable performance standards for the Target PAH Analytes are presented in Table 7. In addition to these performance standards, the performance standards for the Target PAH Analytes must also meet the requirements of SW-846 Method 8270E as described in WSC-CAM-II B, Table II B-1.

9.10.3 If the aliphatic hydrocarbon range concentrations are quantified by GC/MS, naphthalene and 2-methylnaphthalene must be identified and quantified in the aliphatic hydrocarbon fraction of each sample using SW-846 Method 8270E, using an internal standard. **If either the concentration of naphthalene or 2-methylnaphthalene in the aliphatic fraction exceeds 5% of the total concentration for naphthalene or 2-methylnaphthalene in the sample, fractionation must be repeated on the archived sample extract. NOTE: The total concentration of naphthalene or 2-methylnaphthalene in the sample includes the summation of the concentration detected in the aliphatic fraction and the concentration detected in the aromatic fraction.**

9.10.4 The QC requirements and performance standards for SW-846 Method 8270E described in WSC-CAM-II B must also be satisfied.

9.10.5 The sample must be extracted using the procedures described in Section 9.1 and the resultant concentrated extract fractionated as described in Section 9.2.

9.10.6 WSC-CAM-II B must be identified as the "Method for Target Analytes" and "Method for Ranges", as applicable, on the Required EPH Data Report Information form described in Appendix 3.

9.10.7 Any other modifications to the WSC-CAM-II B Method must be described in detail in the laboratory narrative.

10.0 QUALITY CONTROL

10.1 General Requirements and Recommendations

10.1.1 Each laboratory that uses this method is required to operate a formal quality control program. The minimum requirements of this program consist of an Initial Demonstration of Laboratory Capability (IDLC) and an ongoing analysis of prepared QC samples to evaluate and document the quality of data. The laboratory must maintain records to document the quality of the data produced. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance standards for the method.

10.1.2 An SSB must be run after all highly contaminated samples to minimize the potential for sample carryover.

10.1.3 Batch Analytical QC Samples

10.1.3.1 At a minimum, for each analytical batch (up to 20 samples) or every 24 hours, whichever comes first, a beginning and ending Continuing Calibration Standard must be analyzed. For analytical batches with more than 10 samples, the analysis of an additional mid-range Continuing Calibration Standard should also be considered. However, it should be noted that the analysis of the Continuing Calibration Standard is required prior to sample analysis, after every 20 samples or every 24 hours, whichever comes first, and at the end of an analytical sequence, at a minimum.

10.1.3.2 At a minimum, for each extraction batch (up to 20 samples of similar matrix), an LMB, LCS, and an LCS Duplicate must also be prepared and results analyzed as part of the laboratory's continuing QC program. The blank and QC samples fortified with known concentrations and volumes of analytical standards should be carried through the complete sample preparation and measurement processes.

10.1.4 The recommended sequence of analysis is as follows:

(1) Analytical batch Calibration Standards (initial) or mid-range Continuing Calibration Standard (daily check of initial calibration). **[REQUIRED]**
(2) Initial Calibration Verification. **[REQUIRED only after initial calibration]**
(3) Extraction batch LCS. **[REQUIRED]**
(4) Extraction batch LCS Duplicate. **[REQUIRED]**
(5) Extraction batch LMB. **[REQUIRED]**
(6) Batch samples. (up to 20 samples or 24 hours, whichever comes first)
(7) Matrix duplicate. [**As requested by data user**]
(8) Matrix Spike/Matrix Spike Duplicate. [**As requested by data user**]
(9) Optional mid-range Continuing Calibration Standard. (consider after 10 samples)
(10) Closing mid-range Continuing Calibration Standard[a] after 20 samples or 24 hours, whichever comes first, and at end of analytical batch. **[REQUIRED]**

[a] May be used as analytical batch opening Continuing Calibration Standard for the next analytical batch if batches are processed continuously.

All analytical sequences and data must be recorded in a daily run log.

10.2 Minimum Instrument QC

10.2.1 The instrument must be able to achieve adequate separation and resolution of peaks and analytes of interest.

10.2.1.1 The n-nonane (n-C_9) peak must be adequately resolved from the solvent front of the chromatographic run.

10.2.1.2 The surrogates COD and OTP must be adequately resolved from any individual components in the Aliphatic Hydrocarbon and Aromatic Hydrocarbon standards.

10.2.1.3 All peaks of interest in the Aliphatic Hydrocarbon standard must be adequately resolved to baseline. In the Aromatic Hydrocarbon standard, baseline separation is expected for phenanthrene and anthracene. Benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene are not expected to be chromatographically separated to baseline and may be reported as an un-resolved mixture, unless adequate resolution is obtained.

10.2.1.4 Due care must be exercised to assure that the peaks for naphthalene and n-dodecane in the aliphatic hydrocarbon fraction are adequately resolved to allow for an accurate determination of the naphthalene concentration in the LCS/LCSD pair.

Note: For the purposes of this method, adequate resolution is assumed to be achieved if the height of the valley between two peaks is less than 25% of the average height of the two peaks.

10.2.2 **Initial Calibration Verification:** An ICV standard, prepared from a separate source standard than used for initial and continuing calibrations must be analyzed immediately following the initial calibration. The recoveries of all Target PAH Analytes and hydrocarbon ranges must be between 70-130%. A new five-point calibration must be performed if >10% of all analytes are outside of criteria.

10.2.3 **System Solvent Blank:** If baseline correction will be employed, as specified in Section 11.2.5, a SSB, air blank, and/or system run must be undertaken with every batch, and after the analysis of a sample that is suspected to be highly contaminated. Baseline correction for EPH aliphatic and aromatic hydrocarbon area data may not be used for any sample for which the area count associated with the baseline correction is greater than 10% of the uncorrected area count for the sample’s corresponding collective range. For purposes of this analytical requirement, any sample with an on-column concentration greater than the highest calibration standard is considered “highly contaminated” (see Section 4.3).

10.2.4 **Laboratory Method Blank:** A water or soil LMB is prepared by fortifying a reagent water blank (for aqueous samples) or clean sand blank (for soil/sediment samples) with the surrogate spiking solution (using the same volume of surrogate as samples). Peaks must not be detected above the RL within the Rt window of any analyte of interest. The hydrocarbon ranges must not be detected at a concentration greater than 10% of the most stringent applicable MCP cleanup standard for soil/sediment samples and 50% of the most stringent applicable MCP cleanup standards for aqueous samples. Peaks detected within the Rt window of any analyte or range of interest above the RL must be noted on the data report form. Re-extraction of all associated samples may be warranted

10.2.5 **Retention Times Windows:** must be established for each Target PAH Analyte and hydrocarbon range of interest each time a new GC column is installed and must be verified and/or adjusted on a daily basis. (See Sections 9.6 and 9.7.5).

10.2.6 **Calibration**

10.2.6.1 **Initial Calibration**: CFs must be calculated for each Target PAH Analyte, surrogate, and hydrocarbon range based upon the analysis of a minimum of 5 calibration standards. The linearity of CFs may be assumed if the %RSD over the working range of the calibration curve is $\leq$25. (See Section 9.7.2). For linear regression, r must be $\geq$0.99.

10.2.6.2 **Continuing Calibration Standard**: The Continuing Calibration Standard must be analyzed daily prior to sample analysis, every 20 samples or every 24 hours (whichever comes first), and at the end of an analytical sequence to verify the accuracy of the calibration of the instrument. For Target PAH Analytes, surrogates, and hydrocarbon ranges, the %D or Percent Drift must be ≤25. If more than one Target PAH Analyte or hydrocarbon range fails to meet this criterion, the instrument must be recalibrated. Otherwise, sample analysis may proceed. For the closing continuing calibration standard (analyzed after every 20 samples, every 24 hours, or at end of analytical sequence), four compounds may exhibit %Ds or Percent Drifts greater than 25% but less than 40%.

10.2.7 **Laboratory Control Sample:** An LCS is prepared by fortifying a reagent water blank (for aqueous samples) or clean sand blank (for soil/sediment samples) with the matrix spiking solution. The spike recoveries for the Target PAH Analytes and the hydrocarbon ranges must be between 40% and 140%.

- If the recoveries are low and outside of the acceptance limits, re-extract and reanalyze the LCS and associated samples. If still outside of the acceptance limits, recalibrate.

- If the recoveries are high and outside of the acceptance limits and the affected compound was detected in the associated samples, re-extract and reanalyze the LCS and the associated samples. If recoveries are still outside of the acceptance limits, recalibrate.

- If the recoveries are high and sample results were nondetect, data can be reported without qualification; however, the high recoveries should be noted in the laboratory narrative.

10.2.8 **LCS Duplicate:** The LCSD is prepared separately from the LCS but prepared and analyzed in the same manner as the LCS and is used as the data quality indicator of precision. The analytical batch precision is determined from the relative percent difference (RPD) of the concentrations (not recoveries) of the LCS/LCSD pair. The RPD for Target PAH Analytes and aliphatic and aromatic hydrocarbon range concentrations must be ≤25. See Section 10.2.7 for corrective actions associated with recoveries outside of acceptance limits.

10.2.9 **Surrogate Spike Recoveries**

Each sample, LMB, LCS, LCSD, matrix spike, and matrix duplicate must be fortified with the surrogate spiking solution. Required surrogate recovery is 40% to 140%. At a minimum, when surrogate recovery from a sample, blank, or QC sample is less than 40% or more than 140%, check calculations to locate possible errors, check the fortifying solution for degradation, and check for changes in instrument performance. If the cause cannot be determined, reextract and reanalyze the sample if the recovery of one surrogate is less than 40% or the recoveries of both surrogates are outside the acceptance limits. The laboratory may first reanalyze the archived portion (prior to fractionation) to see if the surrogate recoveries were possibly affected by fractionation. If surrogate recoveries are acceptable in the archived portion, refractionation and reanalysis of the archived extract must be performed. Reextraction and reanalysis are not required if one of the following exceptions applies:

(1) Obvious interference is present on the chromatogram (e.g., unresolved complex mixture); and
(2) The surrogate exhibits high recovery and associated target analytes or hydrocarbon ranges are not detected in the sample.

If a sample with a surrogate recovery outside of the acceptable range is not reextracted or reanalyzed based on any of these aforementioned exceptions, this information must be noted on the data report form and discussed in the laboratory narrative.

Analysis of the sample on dilution may diminish matrix-related surrogate recovery problems. This approach can be used as long as the RL for the applicable MCP standards will still be achieved with the dilution. If not, reanalysis without dilution must be performed unless the concentrations of target analytes do not allow an undiluted run. Recoveries of surrogates outside of the acceptable range after reanalysis must also be noted on the data report form and discussed in the laboratory narrative.

10.2.10 In order to demonstrate the absence of aliphatic mass discrimination, the response ratio of C_{28} to C_{20} must be at least 0.85. If <0.85, this nonconformance must be noted in the laboratory narrative. The chromatograms of Continuing Calibration Standards for aromatics must be reviewed to ensure that there are no obvious signs of mass discrimination.

10.2.11 Each sample (field and QC sample) must be evaluated for potential breakthrough on a sample-specific basis by evaluating the %R of the fractionation surrogate (2-bromonaphthalene) and on a batch basis by quantifying naphthalene and 2-methylnaphthalene in both the aliphatic and aromatic fractions of the LCS and LCSD. **If either the concentration of naphthalene or 2-methylnaphthalene in the aliphatic fraction exceeds 5% of the total concentration for naphthalene or 2-methylnaphthalene in the LCS or LCSD, fractionation must be repeated on all archived batch extracts.** If the fractionation surrogate recovery is outside the 40 – 140% limits, then fractionation must be repeated on the archived extract of the affected sample. **NOTE: The total concentration of naphthalene or 2-methylnaphthalene in the LCS/LCSD pair includes the summation of the concentration detected in the aliphatic fraction and the concentration detected in the aromatic fraction.**

Analytical Note: Due care must be exercised to assure that the peaks for naphthalene and n-dodecane in the aliphatic hydrocarbon fraction are adequately resolved to allow for an accurate determination of the naphthalene concentration in the LCS/LCSD pair.

Example Naphthalene* % Breakthrough Calculation

Naphthalene in Aromatic Fraction (N_{ar}): 48 µg/L
Naphthalene in Aliphatic Fraction (N_{al}): 1.5 µg/L
Total Naphthalene Concentration (NT_r): 49.5 µg/L

$$\text{\% Naphthalene Breakthrough} = \frac{N_{al}}{NT_r} \times 100$$

$$\text{\% Naphthalene Breakthrough} = \frac{1.5}{49.5} \times 100$$

% Naphthalene Breakthrough = 3.0

* may be applied to 2-methylnaphthalene breakthrough calculation also

10.2.12 **Fractionation Check Solution:** A fractionation check solution is prepared containing 14 alkanes and 17 PAHs at a nominal concentration of 200 ng/µl of each constituent. The Fractionation Check Solution must be used to evaluate the fractionation efficiency of each new lot of silica gel / cartridges as described in Appendix 5, Section 5.0, and establish the optimum hexane volume required to efficiently elute aliphatic hydrocarbons while not allowing significant aromatic hydrocarbon breakthrough. For each analyte contained in the fractionation check solution, excluding n-nonane, the %R (see Appendix 5, Equation 5-4) must be between 40 and 140%. A recovery of 30% is acceptable for n-nonane.

10.3 At the request of the data user, and in consideration of sample matrices and data quality objectives, matrix spikes and matrix duplicates may be analyzed with every batch of 20 samples or less per matrix.

10.3.1 **Matrix Duplicate:** Matrix duplicates are prepared by extracting and analyzing one sample in duplicate. The purpose of the matrix duplicates is to determine the homogeneity of the sample matrix as well as analytical precision. The RPD of detected results in the matrix duplicate samples must not exceed 50 when the results are greater than 5x the RL. Refer to Equation 13 for the RPD calculation. If the RPD exceeds 50 and both results are > 5x the RL, the sample analysis must be repeated.

- If an analyte is detected in one analysis at > 5x the RL and not detected in the duplicate analysis, the analysis must be repeated.
- If an analyte is detected in one analysis at $\leq$ 5x the RL and not detected in the duplicate analysis, the RPD is not calculable and the analysis does not have to be repeated.
- If an analyte is not detected in both the original and duplicate analyses, the RPD is not calculable. No further action is required.

Equation 13. Relative Percent Difference Calculation

$$\boxed{RPD = [(C_s - C_d)/[(C_s + C_d)/2]]*100}$$

where:

C_s = concentration in original sample analysis
C_d = concentration in duplicate sample analysis

10.3.2 **Matrix Spike/Matrix Spike Duplicate** - The aqueous or soil/sediment matrix spike is prepared by fortifying an actual aqueous or soil/sediment sample with a specified volume of the matrix spiking solution (See Section 7.8). The desired spiking level is 50% of the highest calibration standard. However, the total concentration in the matrix spike (including the matrix spike and native concentration in the unspiked sample) should not exceed 75% of the highest calibration standard in order for a proper evaluation to be performed. The purpose of the matrix spike is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate unspiked aliquot and the measured values in the matrix spike corrected for the background concentrations. The corrected concentrations of the Target PAH Analytes and the hydrocarbon ranges within the matrix spiking sample must be within 40 - 140% of the true value. RPDs between MS and MSD results must be $\leq$50.

10.4 If any of the performance standards specified in Section 10.2 are not met, the cause of the non-conformance must be identified and corrected before any additional samples may be analyzed. Any samples run between the last QC samples that met the criteria and those that are fallen out must be re-extracted and/or re-analyzed, as noted in Section 10.2. These QC samples include the opening and closing Continuing Calibration Standards, LMB, LCS, and LCSD. If this is not possible, that data must be reported as suspect.

10.5 Initial and Periodic Method Demonstrations of Laboratory Capability (IDLC)

The QC procedures described in Appendix 5 and described in SW-846 Method 8000D, Section 9.3 must be conducted, successfully completed and documented as an IDLC, prior to the analysis of any samples by the EPH Method. Subsequent to this initial demonstration, additional evaluations of this nature should be conducted on a periodic basis, in response to changes in instrumentation or operations, training new analysts and/or in response to confirmed or suspected systems, method, or operational problems. Elements of the IDLC include:

- Demonstration of Acceptable System Background, see Appendix 5, Section 2.0 (Optional);
- Initial Demonstration of Accuracy, see Appendix 5, Section 3.0;
- Initial Demonstration of Precision, see Appendix 5, Section 4.0;
- Initial Demonstration of Fractionation Efficiency, see Appendix 5, Section 5.0; and
- Method Detection Limit (MDL) Determination, see Appendix 5, Section 6.0 (Optional).

11.0 DATA PRODUCTION AND REPORTING

11.1 Calibration

Using the external standard calibration procedure (9.7.2) calibrate the GC as follows:

11.1.1 Calculate an average CF or linear regression calibration curve for each Target PAH Analyte that comprises the Aromatic Hydrocarbon standard. This step is not necessary if the Target or Diesel PAH Analytes will not be individually identified and quantitated by the EPH method (i.e., if unadjusted values only will be reported for the C_{11}- C_{22} aromatic hydrocarbon range or TPH or if reporting concentrations of Target PAH Analytes via another method).

11.1.2 Calculate an average CF or linear regression calibration curve for the surrogates OTP, COD, and the fractionation surrogates.

11.1.3 Calculate an average collective CF or linear regression calibration curve for the total concentration of the C_9-C_{18} Aliphatic Hydrocarbons. Tabulate the collective peak area response of the 6 components against the collective concentration injected. Do not include the area responses of the internal standard, naphthalene, and 2-methylnaphthalene.

11.1.4 Calculate an average CF or linear regression calibration curve for naphthalene and 2-methylnaphthalene from the Aliphatic Hydrocarbon standard. This is not required if the same instrument is calibrated, separately, for all aliphatic and aromatic compounds using the same internal standard and resolution of naphthalene from n-C_{12} is demonstrated.

11.1.5 Calculate an average collective CF or linear regression calibration curve for the total concentration of the C_{19}-C_{36} Aliphatic Hydrocarbons. Tabulate the collective peak area response of the 8 components against the collective concentration injected. Do not include the area response of the surrogate COD.

11.1.6 Calculate an average collective CF or linear regression calibration curve for the total concentration of the C_{11}-C_{22} Aromatic Hydrocarbons. Tabulate the collective peak area response of the 17 components against the collective concentration injected. Do not include the area responses of the surrogates OTP, 2-bromonaphthalene, or 2-fluorobiphenyl.

11.1.7 For TPH analyses without fractionation, calculate an average collective CF or linear regression calibration curve. Tabulate the collective peak area response of the 14 aliphatic components against the collective concentration injected. Do not include the area responses of surrogates or naphthalene and 2-methylnaphthalene in the Aliphatic Hydrocarbon standard.

11.2 Sample Analysis

11.2.1 Aliphatic Fraction

11.2.1.1 Determine the total area count for all peaks eluting 0.1 minutes before the Rt for n-C_9 and 0.1 minutes before the Rt for n-C_{19}. It is not necessary to identify or quantitate individual aliphatic compounds within this range.

11.2.1.2 Determine the total area count for all peaks eluting 0.1 minutes before the Rt for n-C_{19} and 0.1 minutes after the Rt for n-C_{36}. It is not necessary to identify or quantitate individual aliphatic compounds within this range.

11.2.1.3 Determine the peak area count for the extraction surrogate COD. Subtract this value from the collective area count value within the C_{19} through C_{36} aliphatic hydrocarbon range.

11.2.1.4 Using the equations contained in Section 9.9, calculate the concentrations of C_9 through C_{18} Aliphatic Hydrocarbons, C_{19} through C_{36} Aliphatic Hydrocarbons, and the surrogate COD.

11.2.2 Aromatic Fraction

11.2.2.1 Determine the total area count for all peaks eluting 0.1 minutes before the Rt for naphthalene and 0.1 minutes after the Rt for benzo(g,h,i)perylene.

11.2.2.2 Determine the peak area count for the extraction surrogate OTP and fractionation surrogate(s). Subtract these values from the collective area count value.

11.2.2.3 Optionally, determine the peak area count for the individual Target or Diesel PAH Analytes.

11.2.2.4 Using the equations contained in Section 9.9, calculate the concentrations of Unadjusted C_{11} through C_{22} Aromatic Hydrocarbons, the surrogate standard OTP, fractionation surrogate standard(s) and optionally, the Target or Diesel PAH Analytes.

11.2.3 Total Petroleum Hydrocarbons

11.2.3.1 Determine the total area count for all peaks eluting 0.1 minutes before the Rt for n-C_9 and 0.1 minutes after the Rt for n-C_{36}. It is not necessary to identify or quantitate individual aliphatic compounds within this range.

11.2.3.2 Determine the peak area count for any surrogate and internal standards used. Subtract these values from the collective area count value.

11.2.3.3 Using the equations contained in Section 9.9, calculate the concentration of Unadjusted TPH.

11.2.4 Data Adjustments

11.2.4.1 By definition, the collective concentration of the aromatic fraction (and/or TPH) **excludes** the individual concentrations of the Target PAH Analytes. Accordingly, a data adjustment step is necessary to adjust the collective hydrocarbon range concentration calculated in Sections 11.2.2.4 and 11.2.3.3 to eliminate "double counting" of analytes.

11.2.4.2 The necessary data adjustment step may be taken by the laboratory reporting the hydrocarbon range/TPH concentration data, or by the data user. The extent of data adjustments taken by the laboratory must be noted on the data report form.

11.2.4.3 Subtract the individual concentrations of the Target or Diesel PAH Analytes from the collective concentration of Unadjusted C_{11} through C_{22} Aromatic Hydrocarbons. Do not subtract any Target or Diesel PAH Analyte concentration if this concentration is less than the RL. If the individual concentrations of Target PAH Analytes have been quantified using another method (e.g., by using an MS detector), note this on the data report form. It should be noted that the reported Target PAH Analyte results must be the results used to adjust the C_{11}-C_{22} Aromatic Hydrocarbon results. If the individual concentrations of Target PAH Analytes have not been quantitated, report the value as Unadjusted C_{11} through C_{22} Aromatic Hydrocarbons, and indicate "Not Determined" for C_{11} through C_{22} Aromatic Hydrocarbons.

11.2.4.4 Subtract the individual concentrations of the Target or Diesel PAH Analytes from the collective concentration of Unadjusted TPH only if the concentrations of the Target or Diesel PAH Analytes were determined using a GC/MS method. If the concentration of Target or Diesel PAH Analytes were not determined using a GC/MS method, report a value for Unadjusted TPH, and indicate "Not Determined" for TPH.

11.2.4.5 For purposes of compliance with the reporting and cleanup standards specified in the MCP, the concentration of Unadjusted C_{11} through C_{22} Aromatic Hydrocarbons and/or Unadjusted TPH may be conservatively deemed to be equivalent to the concentration of C_{11} through C_{22} Aromatic Hydrocarbons and/or TPH.

11.2.5 Baseline Correction for Instrument Noise Level

11.2.5.1 EPH aliphatic and aromatic hydrocarbon range area data determined by the collective integration of all eluting peaks between the specified EPH range marker compounds (see Table 6) may be corrected by the manual or automatic subtraction of the baseline established by the injection of a SSB. Correction in this manner is not recommended or preferred, but is permissible in cases where all reasonable steps have been taken to eliminate or minimize excessive baseline bias associated with analytical system noise.

11.2.5.2 The instrument baseline must be established by the direct injection of a SSB. The injection of an air blank or activation of a temperature programmed chromatographic run without the injection of any material should be used to verify that the system noise is not attributable to solvent contamination. All system operational elements and parameters must be identical to those of a typical sample run.

If baseline correction is used, the baseline must be re-established for every analytical batch by the analysis of a SSB. Baseline correction for EPH aliphatic and aromatic hydrocarbon area data may not be used for any sample for which the area count associated with the baseline correction is greater than 10% of the uncorrected area count for the sample's corresponding collective range.

11.2.6 Contamination of SPE Cartridges

11.2.6.1 Hydrocarbon range integration areas may be affected by peaks identified during the injection of a LMB, and determined to be attributable to the leaching of plasticizers or other contaminants from silica gel SPE cartridges. In general, this contamination affects the C_{11}-C_{22} Aromatic Hydrocarbons. Blank correction is not permissible.

11.2.6.2 The laboratory must report the presence of this contamination in the associated range. Optionally, the laboratory may perform GC/MS analysis of the LMB extract to demonstrate that the contaminant in question is not a C_{11}-C_{22} aromatic hydrocarbon compound. Analysis of only the LMB is acceptable as long as the associated samples exhibit the same contaminant peak at the same Rt. If demonstrated not to be a C_{11}-C_{22} aromatic hydrocarbon compound, the contaminant does not need to be included in the calculation of the C_{11}-C_{22} aromatic hydrocarbon range concentration. The laboratory must provide a discussion in the laboratory narrative if this approach is used.

11.3 Data Reporting Content

11.3.1 The required content for EPH Method data is presented in Appendix 3. This information provides data users with a succinct and complete summary of pertinent information and data, as well as a clear affirmation that the QC procedures and standards specified in this method were evaluated and achieved. Any significant modification to the MassDEP EPH Method, as described in Section 11.3.1.1, and indicated by a negative response to Question E on the MassDEP Analytical Protocol Certification Form (also included in Appendix 3) precludes the affected data from achieving "Presumptive Certainty" status. If a significant modification to the EPH Method is utilized, an attachment to the analytical report must be included to demonstrate compliance with the method performance requirements of Section 1.13 on a matrix- and petroleum product-specific basis.

While it is permissible to modify the reporting format, all of the data and information specified in Appendix 3 for these reports must be provided in a clear, concise, and succinct manner.

11.3.1.1 "Significant Modifications" to this method are defined as any deviations from "required," "shall," or "must" provisions of this document, or any change or modification that will or could substantively change the accuracy or precision of analytical results. Such modifications include, but are not limited to, any of the following:

11.3.1.1.1 The use of other than a silica-gel fractionation technique;

11.3.1.1.2 The use of an extraction procedure other than those presented in Table 5;

11.3.1.1.3 The use of solvents other than those recommended in this method or approved extraction methods listed in Table 5;

11.3.1.1.4 The use of a detector other than an FID to quantitate range/TPH concentrations (See Notes 1 and 2 below);

11.3.1.1.5 The use of aliphatic or aromatic surrogate compounds with Rts not within ± 2 minutes of the Rts of the recommended compounds or the use of inappropriate surrogates to represent the aliphatic and aromatic ranges;

11.3.1.1.6 The use of non-linear regression (i.e., quadratic equations) for the calibration of Target PAH Analytes, hydrocarbon ranges, and/or TPH; or

11.3.1.1.7 Failure to provide all of the data and information presented in Appendix 3 as well as the required method deliverables discussed in Section 11.3.2.

<u>NOTE 1</u>: Use of a GC/MS detector operated in the Total Ion Current mode to quantify the EPH Method's aliphatic and aromatic hydrocarbon ranges is not considered a significant modification provided that (1) the sample extract has been fractionated; (2) the GC/MS system was also used to identify and quantify the Target PAH Analytes in the sample's aromatic fraction; and (3) the QC requirements and performance standards specified in Section 9.10 are satisfied.

<u>NOTE 2</u>: If alternate detectors are used with or without fractionation, other than noted above, the laboratory must demonstrate that the performance standards listed in Section 1.13 were achieved. Use of an alternate detector, other than noted above, is considered a "significant modification". Any EPH data produced using a "significant modification" cannot achieve Presumptive Certainty status.

11.3.1.2 Positive affirmation that all required QC procedures and performance standards were followed and achieved means that all of the required steps and procedures detailed in Sections 9.0 and 10.0 have been followed, and that all data obtained from these steps and procedures were within the acceptance limits specified for these steps and procedures.

11.3.2 In addition to sample results, the EPH data report must contain the following items:

- LMB results
- LCS results
- LCSD results
- Matrix spike and/or matrix spike duplicate results (only if requested by data user)
- Matrix duplicate results (only if requested by data user)
- Fractionation check standard results
- Surrogate spike recoveries (for all field samples and QC samples), including fractionation and extraction surrogates
- Percentage of total naphthalene and 2-methylnaphthalene concentrations detected in the aliphatic fractions of the LCS and LCS Duplicate (see Section 10.2.11)
- Percentage of total naphthalene and 2-methylnaphthalene concentrations detected in the aliphatic fractions of samples when GC/MS is utilized (see Section 9.10.3)
- Results of reanalyses or dilutions, reported as follows:
  - If reextraction or reanalysis due to surrogate issues yields similar non-conformances, the laboratory must report results of both analyses.
  - If rextraction or reanalysis due to surrogate issues is performed outside of holding time and yields acceptable surrogate recoveries, the laboratory must report results of both analyses.
  - If sample is not reanalyzed or reextracted for surrogate issues due to obvious interference, the laboratory must provide the chromatogram in the data report.
  - If diluted and undiluted analyses are performed, the laboratory must report results for the lowest dilution within the valid calibration range for each analyte. The associated QC (e.g., LMBs, LCS, etc.) for each analysis must be reported. This may result in more than one analysis per sample being reported.

- Demonstration of compliance with analytical performance standards specified in Section 1.13 on a matrix- and petroleum product-specific basis (only if a "significant modification" is utilized)

11.3.3 General laboratory reporting requirements are outlined in WSC-CAM-VII A, *Quality Assurance and Quality Control Guidelines for the Acquisition and Reporting of Analytical Data*. A copy of the required MassDEP Analytical Protocol Certification Form is included in Appendix 3 of this method.

12.0 REPORTING LIMITS

The RLs for Target PAH Analytes shall be based upon the concentration of the lowest calibration standard for the analyte of interest. The RL must be greater than or equal to the concentration of the lowest calibration standard. **Target PAH Analytes with calculated concentrations below the RL should be reported as < the specific Target Analyte's RL (i.e., < 2.0 ug/L).** For GC/MS analysis only, calculated concentrations of Target PAH Analytes below the RL (lowest calibration standard) may be reported as a "J Value", or equivalent.

The RLs for hydrocarbon ranges shall be based upon the concentration of the lowest calibration standard for an individual analyte within the range of interest. The range RL will be set at 50x the concentration of the lowest calibration standard for the associated analyte. Calculated collective concentrations for EPH aliphatic and aromatic hydrocarbon ranges below the RL should be reported as < Range RL (i.e., < 100 ug/L).

Based on the on-column concentration of 1 ηg/µL for the lowest calibration standard for all analytes, the following RLs would be generated for the hydrocarbon ranges:

Aqueous Samples:	Hydrocarbon range RLs would be equivalent to 100 µg/L based on the extraction of 1 liter of sample, a final fractionation extract volume of 2 mL, and a sample injection volume of 1 µL.
Soil/Sediment Samples:	Hydrocarbon range RLs would be equivalent to 10 mg/kg (dry weight basis) based on the extraction of 10 grams of soil, a final fractionation extract volume of 2 mL, and a sample injection volume of 1 µL.

13.0 METHOD PERFORMANCE

Single laboratory accuracy, precision and MDL data for method analytes are provided in Tables 1-1 through 1-4 in Appendix 1. Chromatograms are provided in Appendix 2.

14.0 REFERENCES

1. ASTM Method D2216-92, *Determination of Moisture Content of Soils and Sediments.*

2. MassDEP, 1994: Interim *Final Petroleum Report: Development of Health-Based Alternative to the Total Petroleum Hydrocarbon (TPH) Parameter*, Massachusetts Department of Environmental Protection, August 1994.

3. MassDEP, 1998: *Report on Results of the Fall 1997 VPH/EPH Round Robin Testing Program*, Massachusetts Department of Environmental Protection, January 12, 1998.

4. MassDEP, 2002: *Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MADEP VPH/EPH Approach*, Massachusetts Department of Environmental Protection, WSC Policy # 02-411, October 31, 2002.

5. MassDEP, 2003: *Updated Petroleum Hydrocarbon Fraction Toxicity Values For VPH/EPH/APH Methodology*, Massachusetts Department of Environmental Protection, November 2003.

6. USEPA, *Measurements of Petroleum Hydrocarbons: Report on Activities to Develop a Manual*; Prepared by Midwest Research Institute, Falls Church, VA under EPA Contract No. 68-WO-0015, WA No. 4; Submitted to USEPA Office of Underground Storage Tanks; Washington, DC; November 20, 1990.

7. USEPA UST Workgroup, Draft *Method for Determination of Diesel Range Organics*, November, 1990.

8. USEPA Federal Register 40 CFR Part 136, Appendix B, *Guidelines Establishing Test Procedures for the Analysis of Pollutants*, July 1992.

9. USEPA, *Guidance on Evaluation, Resolution, and Documentation of Analytical Problems Associated with Compliance Monitoring*, EPA 821-B-93-001; U.S. Government Printing Office, Washington D.C., June, 1993.

10. USEPA: SW-846 Test Methods for Evaluating Solid Waste, 3rd Edition; Methods 3510C, 3520C, 3540C, 3541, 3545A, 3546, 3580A, 3630C, 8000D, 8100, and 8270E.

11. Wisconsin DNR, *Modified DRO Method for Determining Diesel Range Organics*, PUBL-SW-141, 1992.

TABLES

Table 1. Aliphatic Hydrocarbon Standard

Carbon Number	Compound	Retention Time (min.)[1]
9	n-Nonane	3.14
10	n-Decane	4.55
12	n-Dodecane	7.86
14	n-Tetradecane	11.10
16	n-Hexadecane	14.05
18	n-Octadecane	16.71
19	n-Nonadecane	17.95
20	n-Eicosane	19.14
NA	1-Chloro-octadecane (surrogate)	20.13
22	n-Docosane	21.35
24	n-Tetracosane	23.40
26	n-Hexacosane	25.29
28	n-Octacosane	27.04
30	n-Triacontane	28.69
36	n-Hexatriacontane	34.82

[1] Results obtained using the column and chromatographic conditions described in Sections 6.1 and 9.5, respectively.

NA = Not applicable

Table 2. Aromatic Hydrocarbon Standard/Target PAH Analytes

Compound	Retention Time (min.)[1]
Naphthalene	7.66
2-Methylnaphthalene	9.49
Acenaphthylene	11.93
Acenaphthene	12.46
Fluorene	13.89
Phenanthrene	16.54
Anthracene	16.66
Ortho-Terphenyl (surrogate)	17.95
Fluoranthene	19.92
Pyrene	20.51
Benzo(a)anthracene	24.08
Chrysene	24.21
Benzo(b)fluoranthene	26.94
Benzo(k)fluoranthene	27.02
Benzo(a)pyrene	27.66
Indeno(1,2,3-cd)pyrene[2]	30.25
Dibenz(a,h)anthracene[2]	30.36
Benzo(g,h,i)perylene	30.76

[1] Results obtained using the column and chromatographic conditions described in Sections 6.1 and 9.5, respectively.

[2] Indeno(1,2,3-cd)pyrene and Dibenz(a,h)anthracene may co-elute under the column and chromatographic conditions described in Sections 6.1 and 9.5, respectively.

Table 3. Recommended Calibration Standard Concentrations (1 µL Injection)

	Conc. of standard analytes (ng/µL)				
Concentration of Individual Target PAH Analytes	1	10	50	100	200
Total Concentration C_9 - C_{18} Aliphatic Hydrocarbons (6 components)*	6	60	300	600	1200
Total Concentration C_{19} - C_{36} Aliphatic Hydrocarbons (8 components)*	8	80	400	800	1600
Total Concentration C_{11} - C_{22} Aromatic Hydrocarbons (17 components)	17	170	850	1700	3400

*Assumes concentration of individual aliphatic components equivalent to concentration of individual Target PAH Analytes.

Table 4. Holding Times and Preservatives for EPH Samples

Matrix	Container	Preservation	Holding Time
Aqueous Samples	1-Liter amber glass bottle with Teflon-lined screw cap	Add 5 mL of 1:1 HCl to pH <2; cool to 0-6° C	Samples must be extracted within 14 days and extracts must be analyzed within 40 days of extraction.
Soil/Sediment Samples	4-oz. (120-mL) wide-mouth amber glass jar with Teflon-lined screw cap	Cool to 0-6° C	Samples must be extracted within 14 days and extracts must be analyzed within 40 days of extraction.
	4-oz. (120-mL) wide-mouth amber glass jar with Teflon-lined screw cap. Jar should be filled to only 2/3 capacity to avoid breakage if expansion occurs during freezing.	Freeze at - 10°C in the field or in the laboratory[1]	Samples must be extracted within 14 days of thawing and extracts must be analyzed within 40 days of extraction.[2]

[1] Samples processed in the laboratory must be preserved at 0-6° C and frozen within 24 hours of the time of collection. Frozen samples may be held for up to one year prior to analysis and must be extracted within 14 days of thawing.

[2] Once the thawing process begins, samples must be kept at 0-6° C until extraction.

Table 5. Approved EPH Extraction Methods

SW-846 Method	Matrix	Description
3510C	Aqueous	Separatory Funnel Liquid-Liquid Extraction
3520C	Aqueous	Continuous Liquid-Liquid Extraction
3511	Aqueous	Organic Compounds in Water by Microextraction
3535A	Aqueous	Solid Phase Extraction (SPE)
3540C	Soil/Sediment	Soxhlet Extraction
3541	Soil/Sediment	Automated Soxhlet Extraction
3545A	Soil/Sediment	Pressurized Fluid Extraction (PFE)
3546	Soil/Sediment	Microwave Extraction
3570	Soil/Sediment	Microscale Solvent Extraction (MSE)
3550C	Contaminated Solids[1]	Ultrasonic Extraction
3580A	NAPL	Waste Dilution

[1] Ultrasonic extraction may only be used for the extraction of highly contaminated (free product) non-soil/sediments (debris). Any other use of ultrasonic extraction is considered a **"significant modification"** of the EPH Method.

Table 6. EPH Marker Compounds

Hydrocarbon Range	**Beginning Marker**	**Ending Marker**
C_9-C_{18} Aliphatic Hydrocarbons	0.1 min before n-Nonane	0.1 min before n-Nonadecane
C_{19}-C_{36} Aliphatic Hydrocarbons	0.1 min before n-Nonadecane	0.1 min after n-Hexatriacontane
C_{11}-C_{22} Aromatic Hydrocarbons	0.1 min before Naphthalene	0.1 min after Benzo(g,h,i)perylene

Table 7. Modified SW-846 Method 8270E Analytical QC Requirements and Performance Standards for Target PAH Analyte and EPH Aliphatic and Aromatic Hydrocarbon Range Analyses

QC ELEMENT	**PERFORMANCE STANDARD**	
	Target PAH Data	**EPH Range Data**
Initial Calibration (% RSD)	≤ 20	≤ 25
Opening CCV (% drift)	≤ 20	≤ 25
Closing CCV (% drift)	≤ 20	≤ 25
Method Blanks	< RL	< RL
Internal Standard (IS)	Area Count of IS must be within 50 and 200% of associated Opening CCV	Area Count of IS must be within 50 and 200% of associated Opening CCV
Surrogate Recovery	40 – 140%	40 – 140%
Fractionation Surrogate Recovery	Not Required	40 – 140%
Laboratory Control Sample (LCS)	40 –140%	40 –140%
LCS Duplicate (RPD)	≤20 for water, ≤30 for soil/sediment	≤25
Matrix Spike (MS)/MS Duplicate[1]	40 –140%; RPD ≤50	40 –140%; RPD ≤50
LCS/LCSD and Sample Naphthalene or 2-Methylnaphthalene Breakthrough	≤ 5% of total for either constituent in EPH aliphatic fraction[2]	≤ 5% of total for either constituent in EPH aliphatic fraction[2]

1. At discretion of data user
2. Naphthalene and 2-Methylnaphthalene must be measured in EPH aliphatic fraction of each sample for GC/MS analysis. Sample must be re-fractionated if concentration of either compound in the aliphatic fraction is >5% of the total measured in the aliphatic and aromatic extracts.

APPENDIX 1

SINGLE LABORATORY ACCURACY, PRECISION, AND METHOD DETECTION LIMIT (MDL) DATA

Table 1-1. Single Laboratory Accuracy, Precision, and Method Detection Limits (MDLs) for Alkanes Spiked Into Reagent Water and Analyzed by the EPH Method

Compound[a]	Compound Conc. Measured (µg/L)		Mean Accuracy (Mean % Recovery[b])	Method Precision (RSD[c] - %)	MDL (µg/L)
	Mean	Std. Dev.			
C_9	1.79	0.13	72	7.3	0.41
C_{10}	2.65	0.02	106	0.7	0.06
C_{12}	2.46	0.03	98	1.2	0.09
C_{14}	2.51	0.05	100	1.9	0.15
C_{16}	2.54	0.05	102	1.8	0.14
C_{18}	2.53	0.05	101	2.1	0.17
C_{19}	2.52	0.05	101	2.0	0.16
C_{20}	2.50	0.06	100	2.4	0.19
COD	2.39	0.06	96	2.3	0.18
C_{22}	2.45	0.08	98	3.2	0.25
C_{24}	2.41	0.10	96	4.0	0.30
C_{26}	2.40	0.13	96	5.4	0.41
C_{28}	2.43	0.16	97	6.6	0.50
C_{30}	2.46	0.16	98	6.5	0.50
C_{36}	2.63	0.46	105	17.5	1.44

[a] Compounds were spiked into 7 samples at a concentration of 2.5 µg/L.
[b] Recovery (%) of spiked concentration.
[c] RSD = relative standard deviation (%) of mean concentration measured.

Table 1-2. Single Laboratory Accuracy, Precision, and Method Detection Limits (MDLs) for Polynuclear Aromatic Hydrocarbons (PAHs) Spiked Into Reagent Water and Analyzed by the EPH Method

Compound[a]	Compound Conc. Measured (µg/L)		Mean Accuracy (Mean % Recovery[b])	Method Precision (RSD[c] - %)	MDL (µg/L)
	Mean	Std. Dev.			
Naphthalene	2.36	0.04	94	1.9	0.14
2-Methylnaphthalene	2.36	0.06	94	2.4	0.18
Acenaphthylene	2.37	0.04	95	1.9	0.14
Acenaphthene	2.39	0.05	96	2.2	0.16
Fluorene	2.35	0.08	94	3.4	0.25
Phenanthrene	2.29	0.10	91	4.3	0.31
Anthracene	2.02	0.10	81	4.8	0.30
OTP	2.36	0.10	94	4.2	0.31
Fluoranthene	2.26	0.15	90	6.6	0.47
Pyrene	2.27	0.15	91	6.6	0.47
Benzo(a)Anthracene	2.27	0.19	91	8.3	0.60
Chrysene	2.30	0.19	92	8.3	0.60
Benzo(b)Fluoranthene	2.47	0.19	99	7.7	0.60
Benzo(k)Fluoranthene	2.49	0.21	99	8.4	0.66
Benzo(a)Pyrene	2.29	0.15	92	6.6	0.50
Indeno(123 cd)Pyrene	2.00	0.13	80	6.5	0.41
Dibenz(ah)Anthracene	1.99	0.14	80	7.0	0.44
Benzo(ghi)Perylene	2.11	0.18	84	8.5	0.57

[a] Compounds were spiked into 7 samples at a concentration of 2.5 µg/L.
[b] Recovery (%) of spiked concentration.
[c] RSD = relative standard deviation (%) of mean concentration measured.

Table 1-3. Single Laboratory Accuracy, Precision, and Method Detection Limits (MDLs) for Alkanes Spiked Into EPH-Free Sand and Analyzed by the EPH Method

Compound[a]	Compound Conc. Measured (mg/Kg)		Mean Accuracy (Mean % Recovery[b])	Method Precision (RSD[c] - %)	MDL (mg/Kg)
	Mean	Std. Dev.			
C_9	0.49	0.02	98	3.7	0.06
C_{10}	0.46	0.02	92	3.9	0.06
C_{12}	0.44	0.02	88	4.5	0.06
C_{14}	0.46	0.03	92	6.5	0.09
C_{16}	0.48	0.03	96	6.2	0.09
C_{18}	0.51	0.03	102	5.8	0.09
C_{19}	0.52	0.03	104	5.8	0.09
C_{20}	0.53	0.03	106	5.7	0.09
COD	0.53	0.03	106	5.7	0.09
C_{22}	0.55	0.03	110	5.5	0.09
C_{24}	0.56	0.04	112	7.1	0.13
C_{26}	0.57	0.05	114	8.8	0.16
C_{28}	0.57	0.06	114	10.5	0.19
C_{30}	0.58	0.07	116	12.1	0.22
C_{36}	0.62	0.02	124	3.2	0.06

[a] Compounds were spiked into 7 samples at a concentration of 0.5 mg/Kg.
[b] Recovery (%) of spiked concentration.
[c] RSD = relative standard deviation (%) of mean concentration measured.

Table 1-4. Single Laboratory Accuracy, Precision, and Method Detection Limits (MDLs) for Polynuclear Aromatic Hydrocarbons (PAHs) Spiked Into EPH-Free Sand and Analyzed by the EPH Method

Compound[a]	Compound Conc. Measured (mg/Kg)		Mean Accuracy (Mean % Recovery[b])	Method Precision (RSD[c] - %)	MDL (mg/Kg)
	Mean	Std. Dev.			
Naphthalene	0.48	0.03	96	6.3	0.09
2-Methylnaphthalene	0.48	0.03	96	6.3	0.09
Acenaphthylene	0.50	0.03	100	6.0	0.09
Acenaphthene	0.51	0.03	102	5.9	0.09
Fluorene	0.51	0.03	102	5.9	0.09
Phenanthrene	0.53	0.05	106	9.4	0.16
Anthracene	0.52	0/05	104	9.6	0.16
OTP	0.54	0.04	108	7.4	0.13
Fluoranthene	0.55	0.05	110	9.1	0.16
Pyrene	0.55	0.05	110	9.1	0.16
Benzo(a)Anthracene	0.59	0.06	118	10.2	0.19
Chrysene	0.59	0.06	118	10.2	0.19
Benzo(b)Fluoranthene	0.64	0.06	128	9.3	0.19
Benzo(k)Fluoranthene	0.63	0.05	126	7.9	0.16
Benzo(a)Pyrene	0.62	0.05	124	8.0	0.16
Indeno(123 cd)Pyrene	0.59	0.04	118	6.7	0.13
Dibenz(ah)Anthracene	0.55	0.04	110	7.3	0.13
Benzo(ghi)Perylene	0.58	0.04	116	6.9	0.13

[a] Compounds were spiked into 7 samples at a concentration of 0.5 mg/Kg.
[b] Recovery (%) of spiked concentration.
[c] RSD = relative standard deviation (%) of mean concentration measured.

APPENDIX 2

CHROMATOGRAMS

Figure 1 Gas Chromatogram (FID) of the EPH Alkane Component Standard (20 µg/L)

Figure 2 Gas Chromatogram (FID) of the EPH PAH Component Standard (20 µg/L)

Figure 3 Gas Chromatogram (FID) of a Diesel Standard (Aliphatic Fractions)

Figure 4 Gas Chromatogram (FID) of a Diesel Standard (Aromatic Fraction)

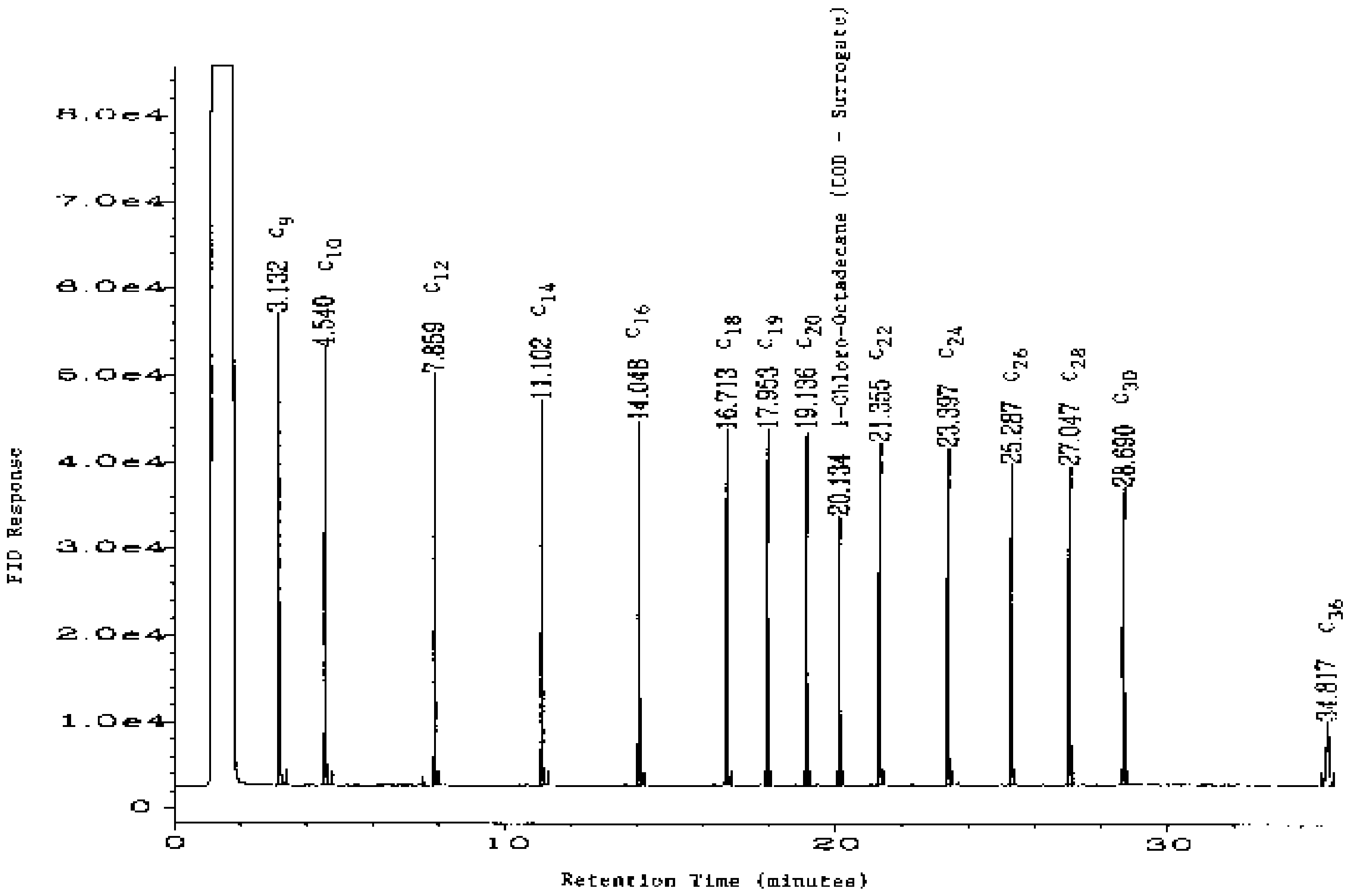

Figure 1. **Gas Chromatogram of the Alkane Diesel Component Standard (20 µg/mL).**

RTX-5 capillary column (30-m x 0.32-mm i.d., 0.25-µm film thickness); FID at 315°C; splitless injection of 2 µL at 285°C; oven programming, 60°C (hold 1 min) to 290°C at 8°C/min (hold 6.75 min); helium column flow, 2-3 mL/min; helium makeup flow, 30 mL/min; air flow 400 mL/min; hydrogen flow 35 mL/min; electronic pressure control of 15 psi at 60°C

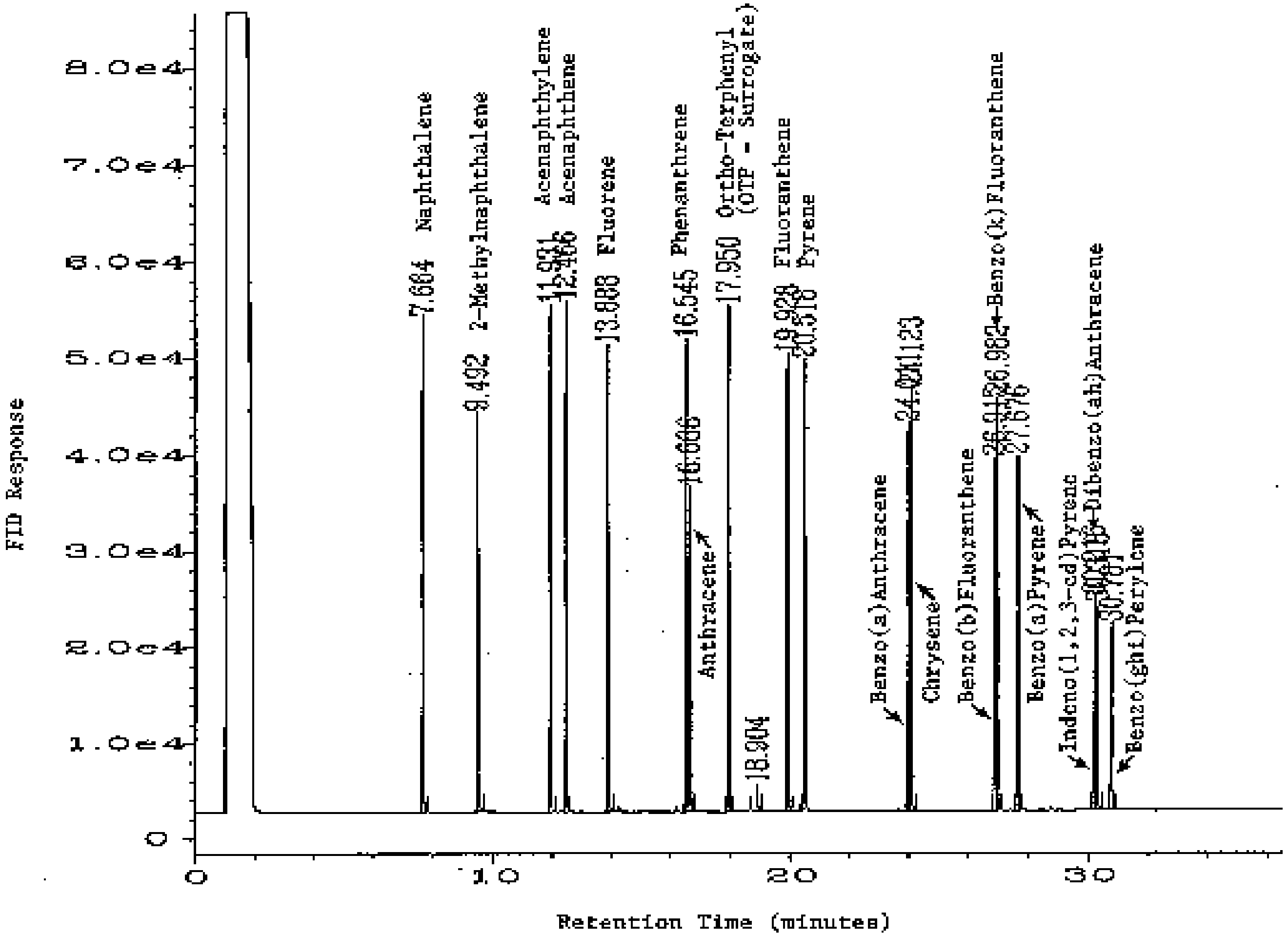

Figure 2. **Gas Chromatogram of the PAH Component Standard (20 μg/mL).**

All operating conditions same as specified for Figure 1.

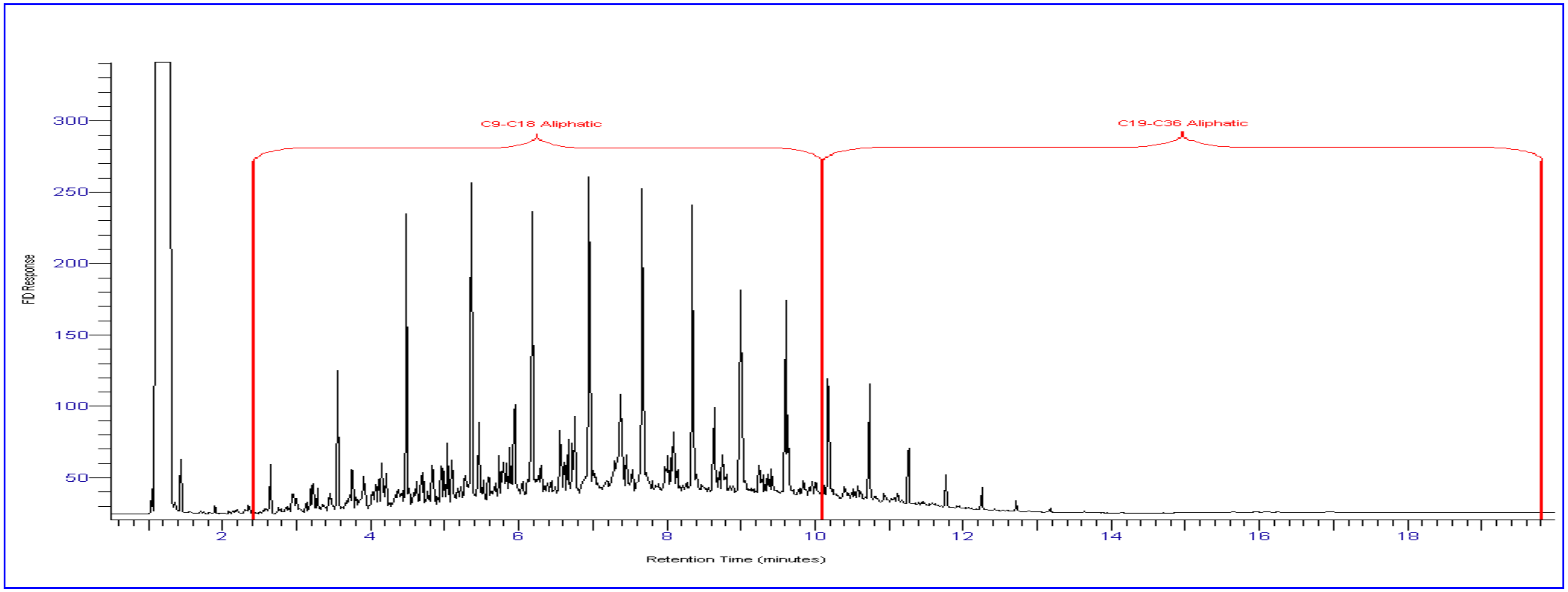

Figure 3 Gas Chromatogram (FID) of a Diesel Standard (Aliphatic Fractions)

Restek RTX-5 SIL-MS capillary column (30 meters, 0.32mm I.D., 0.25 microns film thickness); FID detector on a HP 5890 Series II.

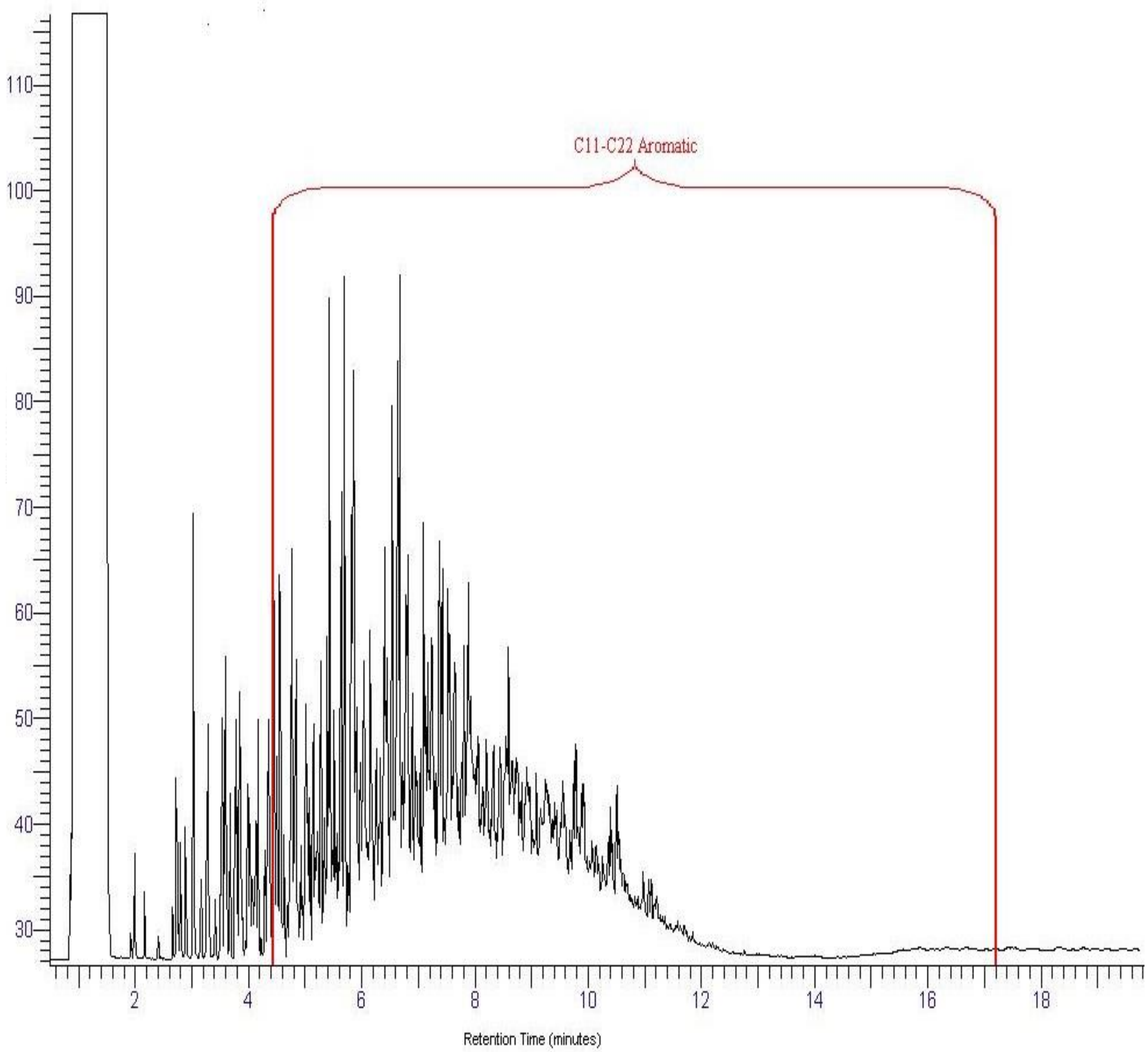

Figure 4 Gas Chromatogram (FID) of a Diesel Standard (Aromatic Fraction)

All operating conditions same as specified on Figure 3

APPENDIX 3

REQUIRED EPH and TPH DATA REPORT INFORMATION

Exhibit 1. Required EPH and TPH Data Report Information

Exhibit 2. MassDEP Analytical Protocol Certification Form

APPENDIX 3

Exhibit 1: Required EPH Data Report Information

SAMPLE INFORMATION

Matrix	☐ Aqueous ☐ Soil ☐ Sediment ☐ Other:
Containers	☐ Satisfactory ☐ Broken ☐ Leaking:
Aqueous Preservatives	☐ N/A ☐ pH≤2 ☐ pH>2 Comment:
Temperature	☐ Received on Ice ☐ Received at 4 ± 2 °C ☐ Other: °C
Extraction Method	Water: Soil/Sediment:

EPH ANALYTICAL RESULTS

Method for Ranges:		**Client ID**						
Method for Target Analytes:		**Lab ID**						
EPH Surrogate Standards: **Aliphatic:** **Aromatic:**		**Date Collected**						
		Date Received						
		Date Thawed						
		Date Extracted						
EPH Fractionation Surrogates: **(1)** **(2)**		**Date Analyzed**						
		Time Analyzed						
		Dilution Factor						
		% Moisture (soil/sediment)						
RANGE/TARGET ANALYTE		**RL**	**Units**					
Unadjusted C11-C22 Aromatics[1]								
Diesel PAH Analytes	**Naphthalene**							
	2-Methylnaphthalene							
	Phenanthrene							
	Acenaphthene							
Other Target PAH Analytes								
C9-C18 Aliphatic Hydrocarbons[1]								
C19-C36 Aliphatic Hydrocarbons[1]								
C11-C22 Aromatic Hydrocarbons[1,2]								
Aliphatic Surrogate % Recovery								
Aromatic Surrogate % Recovery								
Sample Surrogate Acceptance Range				**40-140%**	**40-140%**	**40-140%**	**40-140%**	**40-140%**
Fractionation Surrogate (1) % Recovery								
Fractionation Surrogate (2) % Recovery								
Fractionation Surrogate Acceptance Range				**40-140%**	**40-140%**	**40-140%**	**40-140%**	**40-140%**

[1] **Hydrocarbon Range data exclude area counts of any surrogate(s) and/or internal standards eluting in that range**

[2] **C_{11}-C_{22} Aromatic Hydrocarbons exclude the concentrations of Target PAH Analytes**

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APPENDIX 3
Exhibit 1: Required TPH Data Report Information

SAMPLE INFORMATION

Matrix	☐ Aqueous ☐ Soil ☐ Sediment ☐ Other:
Containers	☐ Satisfactory ☐ Broken ☐ Leaking:
Aqueous Preservatives	☐ N/A ☐ pH≤2 ☐ pH>2 Comment:
Temperature	☐ Received on Ice ☐ Received at 4 ± 2 °C ☐ Other: °C
Extraction Method	Water: Soil/Sediment:

TPH ANALYTICAL RESULTS

Method for Ranges:		**Client ID**						
Method for Target Analytes:		**Lab ID**						
TPH Surrogate Standards:		**Date Collected**						
		Date Received						
		Date Thawed						
		Date Extracted						
		Date Analyzed						
		Time Analyzed						
		Dilution Factor						
		% Moisture (soil/sediment)						
Range/Target Analyte		**RL**	**Units**					
Unadjusted Total Petroleum Hydrocarbons[1]								
Diesel PAH Analytes	**Naphthalene**							
	2-Methylnaphthalene							
	Phenanthrene							
	Acenaphthene							
Other PAH Target Analytes								
Total Petroleum Hydrocarbons[2]								
Sample Surrogate % Recovery								
Sample Surrogate % Recovery								
Sample Surrogate Acceptance Range				**40-140%**	**40-140%**	**40-140%**	**40-140%**	**40-140%**

[1] Hydrocarbon Range data exclude area counts of any surrogate(s) and/or internal standards eluting in that range

[2] Total Petroleum Hydrocarbons exclude the concentration of PAH Target Analytes only if determined by GC/MS

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APPENDIX 3
Exhibit 2: MassDEP Analytical Protocol Certification Form

MassDEP Analytical Protocol Certification Form

Laboratory Name: Project #:

Project Location: RTN:

This Form provides certifications for the following data set: list Laboratory Sample ID Number(s):

Matrices: ☐ Groundwater/Surface Water ☐ Soil/Sediment ☐ Drinking Water ☐ Air ☐ Other:

CAM Protocol (check all that apply below):

8260 VOC CAM II A ☐	7470/7471 Hg CAM III B ☐	MassDEP VPH (GC/PID/FID) CAM IV A ☐	8082 PCB CAM V A ☐	9014 Total Cyanide/PAC CAM VI A ☐	6860 Perchlorate CAM VIII B ☐
8270 SVOC CAM II B ☐	7010 Metals CAM III C ☐	MassDEP VPH (GC/MS) CAM IV C ☐	8081 Pesticides CAM V B ☐	7196 Hex Cr CAM VI B ☐	MassDEP APH CAM IX A ☐
6010 Metals CAM III A ☐	6020 Metals CAM III D ☐	MassDEP EPH CAM IV B ☐	8151 Herbicides CAM V C ☐	8330 Explosives CAM VIII A ☐	TO-15 VOC CAM IX B ☐

Affirmative Responses to Questions A through F are required for "Presumptive Certainty" status

A	Were all samples received in a condition consistent with those described on the Chain-of-Custody, properly preserved (including temperature) in the field or laboratory, and prepared/analyzed within method holding times?	☐ Yes ☐ No
B	Were the analytical method(s) and all associated QC requirements specified in the selected CAM protocol(s) followed?	☐ Yes ☐ No
C	Were all required corrective actions and analytical response actions specified in the selected CAM protocol(s) implemented for all identified performance standard non-conformances?	☐ Yes ☐ No
D	Does the laboratory report comply with all the reporting requirements specified in CAM VII A, "Quality Assurance and Quality Control Guidelines for the Acquisition and Reporting of Analytical Data"?	☐ Yes ☐ No
E	VPH, EPH, APH, and TO-15 only a. VPH, EPH, and APH Methods only: Was each method conducted without significant modification(s)? (Refer to the individual method(s) for a list of significant modifications). b. APH and TO-15 Methods only: Was the complete analyte list reported for each method?	☐ Yes ☐ No ☐ Yes ☐ No
F	Were all applicable CAM protocol QC and performance standard non-conformances identified and evaluated in a laboratory narrative (including all "No" responses to Questions A through E)?	☐ Yes ☐ No

Responses to Questions G, H and I below are required for "Presumptive Certainty" status

G	Were the reporting limits at or below all CAM reporting limits specified in the selected CAM protocol(s)?	☐ Yes ☐ No[1]

<u>Data User Note</u>: Data that achieve "Presumptive Certainty" status may not necessarily meet the data usability and representativeness requirements described in 310 CMR 40. 1056 (2)(k) and WSC-07-350.

H	Were **all** QC performance standards specified in the CAM protocol(s) achieved?	☐ Yes ☐ No[1]
I	Were results reported for the complete analyte list specified in the selected CAM protocol(s)?	☐ Yes ☐ No[1]

[1] *All negative responses must be addressed in an attached laboratory narrative.*

I, the undersigned, attest under the pains and penalties of perjury that, based upon my personal inquiry of those responsible for obtaining the information, the material contained in this analytical report is, to the best of my knowledge and belief, is accurate and complete.

Signature:______________________________ **Position:**________________________

Printed Name:____________________________ **Date:**____________________________

APPENDIX 4

EPH METHOD CALIBRATION AND ANALYSIS USING LINEAR REGRESSION

APPENDIX 4
EPH Method Calibration and Analysis Using Linear Regression

Use of linear regression is permissible to calculate the slope and y-intercept that best describes the linear relationship between Target PAH Analyte and hydrocarbon range concentrations and instrument responses.

1.0 Prepare EPH Calibration Standards as described in Table 3 in the method at a minimum of five concentration levels in accordance with the procedures and specifications contained in Section 7.0. The EPH marker compounds for the C_9-C_{18} aliphatic, C_{19}-C_{36} aliphatic and C_{11}-C_{22} aromatic hydrocarbon ranges are presented in Table 6 in the method.

Analyze each EPH Calibration Standard following the procedures outlined in Section 9.7. Tabulate area responses against the injected concentration. These data are used to calculate a calibration curve for each Target PAH Analyte (Equation 4-1). The correlation coefficient (r) of the resultant calibration curve must be ≥0.99.

Equation 4-1: Linear Regression: Target PAH Analytes

$$\boxed{Area\ \ of\ peak\ = a \times concentration\ injected\ (\mu g/L\ )\ +\ b}$$

where:

a = the calculated slope of the line
b = the calculated y intercept of the "best fit" line

A calibration curve may also be established for each aliphatic and aromatic hydrocarbon range of interest. Calculate the calibration curve for C_9-C_{18} and C_{19}-C_{36} Aliphatic Hydrocarbons and C_{11}-C_{22} Aromatic Hydrocarbons using the FID chromatogram of the appropriate fraction. Tabulate the summation of the peak areas of all components in that hydrocarbon range (i.e., C_9-C_{18} Aliphatic Hydrocarbons, 6 components) against the total concentration injected. These data are used to calculate a calibration curve for each EPH hydrocarbon range (Equation 4-2). The correlation coefficient (r) of the resultant calibration curve must be ≥0.99.

Note: Do not include the area of any surrogates or internal standard when determining the calibration curve for the hydrocarbon ranges. Do not include the area of naphthalene or 2-methylnaphthalene when determining the calibration curve for C_9 – C_{18} Aliphatic Hydrocarbons.

Equation 4-2: Linear Regression: EPH Aliphatic and Aromatic Hydrocarbon Ranges

$$\boxed{Area\ summation\ of\ \ range\ components\ = a \times total\ concentration\ injected\ (\mu g/L\ )\ +\ b}$$

where:

a = the calculated slope of the line
b = the calculated y intercept of the "best fit" line

2.0 The concentration of a specific Target PAH Analyte or hydrocarbon range in aqueous samples may be calculated using linear regression analysis by applying Equation 4-3.

Equation 4-3: Determination of Target PAH Analytes and Hydrocarbon Range Concentrations in Aqueous Samples using Linear Regression

$$\boxed{Conc\ Analyte\ or\ HC\ Range(\mu g/L) = \left(\frac{Ax - b}{a}\right) x\ D\ x\ \frac{Vt}{Vs}}$$

where:

A_x = Response for the Target PAH Analyte or hydrocarbon range in the sample. Units are in area counts for Target PAH Analytes and the hydrocarbon ranges.
D = Dilution factor; if no dilution was made, D = 1, dimensionless.
a = Slope of the line for Target PAH Analyte or hydrocarbon range.
b = Intercept of the line for Target PAH Analyte or hydrocarbon range.
V_t = Volume of total extract, µL (including fractionation surrogate volume)
V_s = Volume of sample extracted, mL.

Note: Do not include the area of any surrogates or internal standard in Ax when calculating a hydrocarbon range concentration.

3.0 The concentration of a specific Target PAH Analyte or hydrocarbon range in a soil/sediment sample may be calculated using linear regression analysis by applying Equation 4-4.

Equation 4-4: Determination of Target PAH Analytes and Hydrocarbon Range Concentrations in Soil/Sediment Samples using Linear Regression

$$\boxed{Conc\ Analyte\ or\ HC\ Range\ (\mu g/kg) = \left(\frac{Ax - b}{a}\right)\ x\ D\ x\ \frac{(Vt)(D)}{W_d}}$$

where: A_x, a, b, V_t, and D have the same definition as for aqueous samples in Equation 4-3, and
W_d = Dry weight of sample, g (see Section 9.9.3)

Note: Do not include the area of any surrogates or internal standard in Ax when calculating a hydrocarbon range concentration.

4.0 At a minimum, the working calibration factor must be verified on each working day, after every 20 samples or every 24 hours (whichever comes first), and at the end of the analytical sequence to verify instrument performance and linearity. The Percent Drift is determined using Equation 4-5. The Percent Drift for each Target PAH Analyte, surrogate, and hydrocarbon range must be ≤25. A greater Percent Drift is permissible for n-nonane. If the Percent Drift for n-nonane is >30, note the nonconformance in the laboratory narrative. If more than one Target PAH Analyte or hydrocarbon range fails to meet the criteria, the instrument must be recalibrated. Otherwise, sample analysis may proceed.

For the closing continuing calibration standard (analyzed after every 20 samples, every 24 hours, or at end of analytical sequence), four compounds may exhibit Percent Drifts >25 but <40.

Equation 4-5: Percent Drift

$$\boxed{\%\ Drift = \frac{Calculated\ concentration\ -\ Theoretical\ concentration}{Theoretical\ concentration}\ x\ 100}$$

APPENDIX 5

INITIAL DEMONSTRATION OF LABORATORY CAPABILITY (IDLC) FOR THE MassDEP EPH METHOD

1.0 Overview of the Initial Demonstration of Laboratory Capability (IDLC) Approach

2.0 Demonstration of Acceptable System Background

3.0 Initial Demonstration of Accuracy (IDA)

4.0 Initial Demonstration of Precision (IDP)

5.0 Initial Demonstration of Fractionation Efficiency

6.0 Method Detection Limit (MDL) Determination

Appendix 5
INITIAL DEMONSTRATION OF LABORATORY CAPABILITY (IDLC) for MassDEP EPH Method

For purposes of the IDLC accuracy and precision determinations (***and only this application***) the calibration mixture presented in Tables 1 and 2 of the method is considered to be representative of Extractable Petroleum Hydrocarbon (EPH) Target PAH Analytes and hydrocarbon ranges (cumulative sum of the concentrations of the range calibration standards). Other reference materials or combinations of reference materials with an individual assay for individual Target PAH Analytes and the C_9 through C_{18} aliphatic, C_{19} through C_{36} aliphatic and C_{11} through C_{22} aromatic hydrocarbon ranges are also suitable for this determination.

1.0 Overview of the Initial Demonstration of Laboratory Capability (IDLC) Approach

An IDLC must be conducted to characterize instrument and laboratory performance prior to performing analyses using the EPH Method. A laboratory may not report data to be used in support of MCP decisions unless the IDLC QC requirements and performance standards described below and compiled in Table 5-1 of this Appendix are satisfied.

2.0 Demonstration of Acceptable System Background

Demonstration of acceptable system background is optional. To determine system background, a Laboratory Method Blank (LMB) must be prepared and treated exactly as a typical field sample submitted for analysis, including fractionation and exposure to all glassware, equipment, solvents and reagents. An LMB for aqueous sample analyses is prepared by adding a specified volume of surrogate spiking solution to 1-liter of organic-free water (ASTM Type I reagent grade). An LMB for soil/sediment sample analyses is prepared by adding a specified volume of surrogate spiking solution to 10 g of certified organic contaminant-free soil. The volume of surrogate added should be the same as used for samples.

At least seven (7) replicate matrix-specific LMBs should be extracted, fractionated and analyzed, and the mean concentration of Target PAH Analytes and hydrocarbon ranges determined, as appropriate. Data produced (mean Target PAH Analyte and hydrocarbon range concentrations detected related to background noise) are used to assess instrument performance of a blank sample and evaluate potential contamination from the laboratory environment, in the absence of any other analytes or system contaminants. Calculate the measured concentration of C_{mean} of the replicate values as follows.

Equation 5-1: Calculation of C_{mean} LMB

$$C_{mean} = \frac{(C_1 + C_2 + C_3 + ...C_n)}{n}$$

where,

C_{mean} = Mean recovered concentration of the replicate LMB analysis.
C_1, C_2, ...C_n = Recovered concentrations of the replicate 1,2...n.
n = at least 7

Any concentration of C_{mean} that exceeds one half of the RL (lowest Target PAH Analyte calibration or collective hydrocarbon range calibration standard) for either a Target PAH Analyte or hydrocarbon range is considered unacceptable, and indicates that laboratory and/or LMB contamination is present. The source of the non-conformance must be identified and corrected prior to conducting any sample analysis. For purposes of acceptable system background demonstration, concentrations are determined using Equations 6 through 9 in Section 9.9 of the method for Target PAH Analytes and collective hydrocarbon ranges. Calculated concentrations below the lowest calibration standard, including zero (zero area), may be used in these calculations.

3.0 Initial Demonstration of Accuracy (IDA)

Prepare and analyze seven (7) replicate Laboratory Control Samples (LCSs) fortified at a concentration of 50% of the highest calibration curve standard concentrations. An LCS must be prepared and treated exactly as a typical field sample submitted for analysis, including fractionation and exposure to all glassware, equipment, solvents and reagents. See Section 10.2.7 of the method for how to prepare the LCS.

Calculate the mean measured concentration (C_{mean}) of the replicate LCSs for Target PAH Analytes and hydrocarbon ranges as follows.

Equation 5-2: Calculation of C_{mean}

$$C_{mean} = \frac{(C_1 + C_2 + C_3 + \text{....}C_n)}{n}$$

where,

C_{mean} = Mean recovered concentration of the replicate LCS analysis.
C_1, C_2, ...C_n = Recovered concentrations of the replicate 1,2...n.
$n = 7$

The value derived for C_{mean} must be within 40-140% of the true value.

4.0 Initial Demonstration of Precision (IDP)

Using the results calculated from Section 3.0 above, calculate the percent relative standard deviation (%RSD) of the seven (7) replicate LCS analyses for Target PAH Analytes and hydrocarbon ranges, as indicated below. The %RSD must be ≤25 for both aqueous and soil/sediment samples.

Equation 5-3: Calculation of % RSD

$$\% \text{ RSD} = \frac{S_{n-1}}{C_{mean}} \text{ X } 100$$

where,

S_{n-1}= sample standard deviation (n-1) of the replicate analyses.
C_{mean} = mean recovered concentration of the replicate analyses.

Appendix 5
INITIAL DEMONSTRATION OF LABORATORY CAPABILITY (IDLC) for MassDEP EPH Method

5.0 Initial Demonstration of Fractionation Efficiency

A mixed aliphatic and aromatic hydrocarbon fractionation check solution (FCS) is used to evaluate the separation efficiency of the silica gel cartridge/column and to establish the optimum hexane volume to efficiently elute aliphatic hydrocarbons while not allowing significant aromatic hydrocarbon breakthrough. The FCS is prepared as per Section 7.9 of the method.

5.1 To demonstrate the capability of properly fractionating aliphatic and aromatic hydrocarbons, at least four (4) replicate FCSs (see Section 7.9) should be fractionated (using the fractionation procedures detailed in Section 9.2) and analyzed, and the mean measured concentration ($C_{x\ mean}$) of the individual fractionation check compounds determined (see below).

5.2 For each analyte included in the FCS, excluding n-nonane, the mean percent recovery for four (4) replicate samples, expressed as a percentage of the true value, must be between 40% and 140%. Lower recoveries are permissible for n-nonane. If recovery of n-nonane is <30%, the source of the problem should be found and the fractionation check repeated.

Equation 5-4: Calculation of Mean Percent Recovery

$$\text{Mean Percent Recovery} = \frac{C_{x\ mean}\,*}{\text{True Concentration}} \text{ X } 100$$

$$*\ C_{x\ mean} = \frac{C_1 + C_2 + C_3 \ldots\ldots C_n}{n}$$

5.3 Subsequent to the IDLC, it is recommended that a FCS be analyzed for each new lot of silica gel/cartridges, to re-establish the optimum volume of hexane elution. **NOTE: Within the same lot of cartridges, different mesh sizes and cartridge weights could exist. It is advisable to evaluate fractionation efficiency on a more frequent basis for large lots (> 500 units) to ensure consistent performance.**

6.0 Method Detection Limit (MDL) Determination

The determination of MDL for the MassDEP EPH Method is optional. The RL for the method is defined as the lowest calibration standard. Determination of the lowest detectable concentration of Target PAH Analytes and hydrocarbon ranges is verified on a continuing basis by analysis of the lowest concentration calibration standard and recovery of method surrogates. The recommended RL concentrations for the EPH Method do not approach (are considerably higher than) the sensitivity limits of the EPH Method for either Target PAH Analytes or hydrocarbon ranges and are generally more than adequate to meet the most stringent regulatory requirements of the MCP (exception may be for select PAHs compared to GW-1 standards).

An MDL may be established for Target PAH Analytes and hydrocarbon ranges either analytically using the 40 CFR 136 approach or by the statistical evaluation of analytical system noise as a good laboratory practice component of an overall quality control program for the EPH Method.

6.1 Determination of MDL, 40 CFR 136, Appendix B Approach

To determine MDL values, take seven (7) replicate aliquots of reagent water fortified at the estimated or “calculated” MDL concentration or the concentration of the lowest calibration standard, and process through the entire analytical method over a three day period. These seven MDL replicate analyses may be performed gradually over a three day period or may represent data that have been collected, at a consistent MDL “calculated” concentration, over a series of more than three days. Perform all calculations defined in the method and report the concentration values in the appropriate units. Calculate the MDL as follows:

Equation 5-5: Calculation of MDL based on Laboratory Analysis

$$\boxed{MDL = (t_{n-1}) \times (S_{n-1})}$$

where,

t_{n-1} = Student's t value for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom [t_{n-1} = 3.14 for seven replicates]
S_{n-1} = Sample standard deviation (n-1) of 7 replicate MDL analyses

Appendix 5

INITIAL DEMONSTRATION OF LABORATORY CAPABILITY (IDLC) for MassDEP EPH Method

Table 5-1 Initial Demonstration of Laboratory Capability QC Requirements for EPH Analyses

Reference Section	Requirement	Specification & Frequency	Acceptance Criteria
2.0	Initial Demonstration of Acceptable System Background (Optional)	Analyze at least 4 replicate Laboratory Method Blanks (LMB) fortified with surrogate spiking solution. Calculate the mean recovered concentration for each Target PAH analyte and hydrocarbon range. See Equation 5-1 in Section 2.0.	The mean LMB concentrations must be <½ of the RL (lowest point on calibration curve or lowest cumulative range calibration standard).
3.0	Initial Demonstration of Accuracy (IDA)	Analyze seven (7) replicate LCSs fortified with EPH calibration standards at 50% of the highest calibration standard concentration. Calculate the mean recovered concentration $C_{mean.}$ for each Target PAH analyte and hydrocarbon range. See Equation 5-2 in Section 3.0.	The C_{mean} must be 40-140% of the true value of the aliphatic and aromatic hydrocarbon ranges and Target PAH Analytes for both aqueous and soil/sediment samples.
4.0	Initial Demonstration of Precision (IDP)	Calculate the percent relative standard deviation (%RSD) of LCS replicates for each Target PAH analyte and hydrocarbon range. See Equation 5-3 in Section 4.0.	The %RSD must be ≤25 for both aqueous and soil/sediment samples.
5.0	Initial Demonstration of Fractionation Efficiency	Fractionate and analyze four (4) replicate FCSs at a concentration of 200 µg/L. A mixed aliphatic and aromatic hydrocarbon FCS is used to evaluate the separation efficiency of the silica gel cartridge/column.	The mean percent recovery for four (4) replicate samples, expressed as a percentage of the true value, must be between 40% and 140%. Lower recoveries (30%) are permissible for n-nonane.
6.0	Method Detection Limit (MDL) Determination (Optional)	Select a fortifying level at the estimated or "calculated" MDL or RL for the LCS. Analyze these 7 replicate low-level LCSs over multiple days and calculate the MDL using Equation 5-5 in Section 6.1. Do not subtract any blank contribution to this value.	See 40 CFR 136, Appendix B The MDL must be < ½ of the RL for individual Target PAH Analytes and < ½ of the RL for collective EPH hydrocarbon ranges.
Continuing QC for each Analytical Batch (up to 20 samples of a similar matrix analyzed contemporaneously)			

METHOD FOR THE DETERMINATION OF

VOLATILE PETROLEUM HYDROCARBONS (VPH) BY GAS CHROMATOGRAPHY/PHOTOIONIZATION DETECTOR/FLAME IONIZATION DETECTOR

Massachusetts Department of Environmental Protection

Bureau of Waste Site Cleanup

Commonwealth of Massachusetts

Executive Office of Energy and Environmental Affairs
Matthew A. Beaton
Secretary

Department of Environmental Protection
Martin Suuberg
Commissioner

February 2018
Revision 2.1

Important Notice!

The purpose of this method is to provide data to help characterize the risks posed by petroleum-contaminated media. Innovative provisions and data adjustment steps are incorporated into the method to ensure that, in most cases, the resultant data will be moderately (but not overly) conservative (i.e., health protective). ***It is essential that all of the provisions and unique procedures in this method are understood and carefully implemented as written.*** Of particular note are the following:

Peak Integration Techniques:

- For individual Target VPH Analytes, the peaks from the PID are individually integrated (valley to valley). This applies to samples and standards.
- For the collective ranges of aliphatic hydrocarbons (i.e., C_5-C_8 and C_9-C_{12}), the chromatogram from the FID is continuously integrated (to baseline) between specified range "marker" compounds (e.g., n-pentane to n-nonane for C_5-C_8 aliphatic hydrocarbons). This applies to samples only; see Calibration Approach for peak integration techniques associated with calibration standards.
- For the collective range of C_9-C_{10} Aromatic Hydrocarbons, the chromatogram from the PID is continuously integrated (to baseline) between specified range "marker" compounds (i.e., o-xylene to naphthalene). This applies to samples only; see Calibration Approach for peak integration techniques associated with calibration standards.
- For the surrogate standard, the peak is individually integrated (valley to valley), so that the area can be subtracted from the collective areas of the hydrocarbon ranges discussed above. NOTE: if the method recommended surrogate (2,5-dibromotoluene) is utilized, this subtraction will not be required since this surrogate elutes after all aliphatic and aromatic compounds of interest.

Calibration Approach:

- The calibration factors (CFs) for the aliphatic hydrocarbon ranges are based on the correlation of collective FID area counts to the collective concentration values of a specified mixture of aliphatic hydrocarbon standards, in which the collective FID area count is determined via the summation of individual valley-to-valley peaks for the individual standards.
- For the aromatic range (i.e., C_9-C_{10} Aromatic Hydrocarbons), the CF is based on the correlation of the PID area count of one compound (1,2,4-trimethylbenzene) to the concentration value of this compound, in which the area count is determined via the individual valley-to-valley peak for this one compound.

  As such, the integration procedure for calibration (i.e., valley-to-valley of individual calibration standards) is different from the integration procedure for samples (i.e., integration to baseline across a specified range of the FID or PID chromatogram). This is necessary to ensure a conservative bias (i.e., an integration-to-baseline approach for the calibration standards would incorporate baseline "noise" which could lead to inappropriately elevated CF values resulting in inappropriately lower sample concentration levels which would not be health-protective).

Data Adjustments:

A series of steps are specified to calculate the final sample data results, to ensure that these values are not overly conservative, due to the addition of surrogate standards, and/or the "double counting" of analytes. This involves the subtraction of area counts and/or the subtraction of media concentration values (i.e., µg/L for aqueous samples or µg/kg for soil/sediment samples):

- When determining the collective area count for a specified hydrocarbon range (i.e., C_5-C_8 or C_9-C_{12} Aliphatic Hydrocarbons or C_9-C_{10} Aromatic Hydrocarbons), it is necessary to subtract the individual (valley-to-valley) peak area of any surrogate standards that elute within that range, if applicable.

- The individual PID concentrations of the Target VPH Analytes must be subtracted from the C_5 to C_8 and C_9 to C_{12} Aliphatic Hydrocarbon FID concentrations, and the PID concentration of C_9-C_{10} Aromatic Hydrocarbons must be subtracted from the FID concentration of C_9-C_{12} Aliphatic Hydrocarbons.

Significant Updates/Changes in Method Revision 2.1

This method revision (2.1) replaces revision 1.1 of the MassDEP VPH by GC/PID/FID test method, which was issued in May 2004. These updates and changes are relatively minor in nature, and are summarized below

Technical Revisions:

- Section 6.1.1.2: Recommended traps are provided and a requirement has been added to specify the trap used in the data package. If a different trap is used, the laboratory must perform a trap desorption efficiency study using a neat gasoline standard and the RPDs of each hydrocarbon range and Target VPH Analyte between the recommended trap and the trap utilized must be ≤25.
- Section 7.5.1: More flexibility was added for the volume of surrogate to be added to aqueous and solid samples.
- Section 9.1.2: MassDEP has added in a preference for the use of purge-and-trap autosamplers over manual load purge-and trap systems.
- Section 9.1.2.2: Details regarding the procedures for spiking of surrogates and matrix spike solutions in aqueous and solid samples prior to purge-and-trap have been added to the method.
- Section 9.1.3.7: A caution from the VPH PID/FID CAM Protocol (2010, et seq.) was added to the method regarding the amount of methanol extract to be added to reagent water. Section 9.3.6 and Table 5: The retention time windows were updated slightly to be consistent with the new VPH by GC/MS method and the APH method.
    - The ending marker for C_5-C_8 aliphatics is 0.01 minutes before nonane instead of 0.1 minutes.
    - The beginning marker for C_9-C_{12} aliphatics is 0.01 minutes before nonane instead of 0.1 minutes.
- Section 9.4.2.12: The %RSD for Target VPH Analytes and the surrogate in the initial calibration must be ≤20 (previously was ≤25).
- Section 9.4.2.13: A requirement from the VPH PID/FID CAM Protocol (2010, et seq.) was added to the method regarding the evaluation of the low standard when linear regression is used.
- Sections 9.4.2.15 and 10.2.2:
    - A requirement from the VPH PID/FID CAM Protocol (2010, et seq.) was added to the method regarding the analysis of an ICV.
    - The ICV acceptance criteria are 70-130% for each Target VPH Analyte and hydrocarbon range (was 80-120% in the 2010 CAM protocol).
- Section 9.4.3.5: The %D for Target VPH Analytes and the surrogate in the continuing calibration must be ≤20 (previously was ≤25).
- Section 10.2.6: Details were added regarding appropriate corrective actions when the LCS recoveries are outside of the acceptance criteria.
- Section 10.3.1: Details were added regarding appropriate corrective actions when the matrix duplicate RPDs are outside of the acceptance criteria.
- Section 11.3.1.4: A new significant modification was added regarding the use of non-linear regression during calibration.
- Section 11.3.3: The laboratory is required to include information on the column and trap used in the CAM deliverable.

Clarifications:

- "Important Notice" added at the beginning of the method to clarify proper peak integration during calibration and sample quantitation and data adjustment steps during sample quantitation.
- Sections 9.4.2.7 – 9.4.2.9: clarified that individual peak areas should be utilized for integration during calibration of the hydrocarbon ranges.
- Section 9.6.2: More details were added regarding the quantitation of the hydrocarbon ranges in samples.
- Section 11.3.3: Clarification on reporting of re-analyses and dilutions was added.

- Appendix 2: Updated chromatograms were added.
- Appendix 3:
    - Required VPH Data Report form updated to include prompts for the column and trap information.
    - MassDEP Analytical Protocol Certification Form updated to include both VPH method options (GC/MS and PID/FID).

MassDEP VPH by GC/MS

MassDEP has developed and published two analytical testing methods to quantify the concentrations of Volatile Petroleum Hydrocarbons (VPH) in aqueous and solid matrices. The first VPH method was issued in 1998 and involves the use of in-series photoionization and flame ionization detectors (PID and FID). This document constitutes the second revision of that method, which is now referred to as the "VPH by GC/PID/FID" method.

In January 2017, MassDEP issued a second VPH method that involves the use of a mass spectrometer, which s referred to as the "VPH by GC/MS" method. It is available at https://www.mass.gov/guides/compendium-of-analytical-methods-cam-massdep-bwsc

For additional information and insights on the origin and implications of the various requirements and biases within these methods, see "Evaluation of MassDEP Volatile Petroleum Hydrocarbon (VPH) Methods" at http://www.mass.gov/eea/docs/dep/cleanup/evaluation-of-vph-methods-june-2016.pdf.

LIST OF ACRONYMS

APH	Air-Phase Petroleum Hydrocarbons
ASTM	American Society for Testing and Materials
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CAM	Compendium of Analytical Methods
CF	Calibration Factor
%D	Percent Difference
DF	Dilution Factor
FID	Flame Ionization Detector
GC	Gas Chromatography
GC/MS	Gas Chromatography / Mass Spectrometry
HCl	Hydrochloric Acid
ICV	Initial Calibration Verification
I.D.	Internal Diameter
IDLC	Initial Demonstration of Laboratory Capability
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LMB	Laboratory Method Blank
MassDEP	Massachusetts Department of Environmental Protection
MCP	Massachusetts Contingency Plan
MDL	Method Detection Limit
MTBE	Methyl tertiary butyl ether
NAPL	Non-aqueous Phase Liquid
OSHA	Occupational Safety & Health Administration
PID	Photoionization Detector
QC	Quality Control
%R	Percent Recovery
r	Correlation Coefficient
RL	Reporting Limit
RPD	Relative Percent Difference
%RSD	Percent Relative Standard Deviation
Rt	Retention Time
SOP	Standard Operating Procedure
SSB	System Solvent Blank
TSP	Trisodium Phosphate Dodecahydrate
VOC	Volatile Organic Compound
VPH	Volatile Petroleum Hydrocarbons

NOTE: Abbreviations of units (e.g., mL, mm, min, ºC, g, µL, µg/mL, µg/Kg, m, µm, µg/L, mg/Kg, ng, etc.) are not included.

METHOD FOR THE DETERMINATION OF VOLATILE PETROLEUM HYDROCARBONS (VPH) BY GAS CHROMATOGRAPHY/PHOTOIONIZATION DETECTOR/FLAME IONIZATION DETECTOR

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DISCLAIMER

Mention of trade names or commercial products does not constitute endorsement by the Massachusetts Department of Environmental Protection (MassDEP). Trade names and commercial products specified within this method are based upon their use in validation studies conducted by MassDEP. Equipment and materials cited in this method may be replaced by similar products, as long as adequate data exist or have been produced documenting equivalent or superior performance.

METHOD FOR THE DETERMINATION OF VOLATILE PETROLEUM HYDROCARBONS (VPH) BY GAS CHROMATOGRAPHY/PHOTOIONIZATION DETECTOR/FLAME IONIZATION DETECTOR

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION (MassDEP)

1.0 SCOPE AND APPLICATION

1.1 This method is designed to measure the collective concentrations of volatile aliphatic and aromatic petroleum hydrocarbons in water and soil/sediment matrices. Volatile aliphatic hydrocarbons are collectively quantitated within two carbon number ranges: C_5 through C_8 and C_9 through C_{12}. Volatile aromatic hydrocarbons are collectively quantitated within the C_9 to C_{10} range. These aliphatic and aromatic hydrocarbon ranges correspond to a boiling point range between approximately 36°C (n-pentane) and 220°C (naphthalene).

1.2 This method is based on a purge-and-trap, gas chromatography (GC) procedure using a photoionization and flame ionization detector (PID/FID) in-series. This method should be used by, or under the direct supervision of, analysts experienced in the use of purge-and-trap systems and gas chromatographs. The analysts should be skilled in the interpretation of gas chromatograms and their use as a quantitative tool.

1.3 This method is designed to complement and support the toxicological approach developed by the Massachusetts Department of Environmental Protection (MassDEP) to evaluate human health hazards that may result from exposure to petroleum hydrocarbons (MassDEP, 1994 and MassDEP, 2003). It is intended to produce data in a format suitable for the characterization of risk at sites undergoing evaluation under the Massachusetts Contingency Plan (MCP, 310 CMR 40.0000) using the aforementioned toxicological approach.

1.4 This method is one of two analytical options provided by MassDEP to collectively quantitate ranges of volatile aliphatic and aromatic hydrocarbons in aqueous and soil/sediment matrices. The other option was issued by the agency in January 2017, and involves the use of a mass spectrometer. The method detailed in this document is identified as "MassDEP VPH by GC/PID/FID." The other option is identified as "MassDEP VPH by GC/MS." MassDEP has also issued the "Method for the Determination of Air-Phase Petroleum Hydrocarbons (APH)" which enables the quantification of aliphatic and aromatic ranges of petroleum hydrocarbons and target analytes in air and vapor samples by gas chromatography/mass spectrometry (GC/MS).

1.5 In addition to the quantification of aliphatic and aromatic hydrocarbon ranges, the MassDEP VPH by PID/FID method is also designed to quantify the individual concentrations of the Target VPH Analytes benzene, toluene, ethylbenzene, xylenes (BTEX), naphthalene, and methyl tertiary butyl ether (MTBE) in aqueous and soil/sediment matrices. Use of this method to identify and quantify these Target VPH Analytes is optional.

1.6 Petroleum products suitable for evaluation by this method include gasoline, as well as the volatile fractions of mineral spirits, kerosene, #2 diesel fuel oil, jet fuels, and certain petroleum naphthas. This method, in and of itself, is not suitable for the evaluation of kerosene, jet fuel, heating oils, lubricating oils, and/or other petroleum products which contain a significant percentage of hydrocarbons heavier than C_{12} or with boiling points > 220°C.

1.7 The Reporting Limit (RL) of this method for each of the Target VPH Analytes is determined by the concentration of the lowest applicable calibration standard. The nominal RL for the individual target analytes is compound-specific, and ranges from approximately 0.050 to 0.25 mg/kg in soil/sediment matrices and 1 to 5 µg/L in aqueous matrices. The RLs for the collective hydrocarbon ranges are approximately 5-10 mg/kg in soil/sediment matrices and approximately 100-150 µg/L in aqueous matrices.

1.8 This method includes a series of data adjustment steps to determine the concentrations of the collective aliphatic and aromatic hydrocarbon ranges of interest. These steps may be taken by the laboratory or by the data user.

1.9 Data reports produced using this method must contain all of the information presented in Appendix 3. The format of these reports is left to the discretion of the individual laboratories (but must include the same certification statement presented in the aforementioned Appendix and must be provided in a clear, concise, and succinct manner). However, the format of the Laboratory Certification must follow the format presented in Appendix 3.

1.10 Like all GC procedures, this method is subject to a "false positive" bias in the reporting of Target VPH Analytes, in that non-targeted hydrocarbon compounds eluting or co-eluting within a specified retention time window may be falsely identified and/or quantified as a Target VPH Analyte. Confirmatory analysis by a GC/MS procedure or other suitable method is recommended in cases where a Target VPH Analyte reported by this method exceeds an applicable reporting or cleanup standard, and/or where co-elution of a non-targeted hydrocarbon compound is suspected.

1.11 The first draft of this method was evaluated by two inter-laboratory "Round Robin" testing programs. In the final evaluation effort, participating laboratories were provided (single-blind) sand samples spiked with gasoline, and a "real world" groundwater sample contaminated by gasoline. Laboratory proficiency was evaluated using a Z-score approach. Data received from 21 laboratories performing this method without significant modifications are summarized below:

			Data from Proficient Laboratories		
Matrix	**# Labs Proficient**	**% Labs Proficient**	**Fraction**	**%RSD**	**% labs within +/- 30% mean value**
soil	**20**	**95**	**C_5-C_8 Aliphatics**	**28**	**80**
			C_9-C_{12} Aliphatics	**52**	**50**
			Total GC/FID	**31**	**70**
			C_9-C_{10} Aromatics	**24**	**80**
water	**17**	**81**	**C_5-C_8 Aliphatics**	**31**	**71**
			C_9-C_{12} Aliphatics	**44**	**47**
			Total GC/FID	**24**	**76**
			C_9-C_{10} Aromatics	**20**	**82**

Laboratory and method performance were believed to have been adversely impacted by the use of multiple chromatographic columns, which may have significantly altered the placement of aliphatic hydrocarbons into either the C_5-C_8 or C_9-C_{12} Aliphatic Hydrocarbon ranges. Better performance was noted for the aromatic fraction and total GC/FID data. Improvements incorporated into this final method are expected to significantly improve overall method performance.

1.12 The VPH by GC/PID/FID and VPH by GC/MS methods are two ways to quantify collective concentrations of volatile aliphatic and aromatic petroleum hydrocarbons within specified carbon number ranges. Both have been designed in a manner that attempts to strike a reasonable balance between analytical method performance and utility. In this manner, assumptions and biases have been structured into the methods to help ensure protective, though not overly conservative data.

As an example, MassDEP recognizes that branched alkanes have lower boiling points than their n-alkane counterpart, while many of the cycloalkane constituents of gasoline range volatile organics have higher boiling points than their n-alkane counterpart. As a consequence:

(1) Depending upon the specific chromatographic column used, most branched C_9 alkanes are expected to elute before n-nonane, the beginning marker compound for the C_9 through C_{12} aliphatic hydrocarbon range, and will be conservatively counted in the more toxic C_5 through C_8 aliphatic hydrocarbon range;

(2) Depending upon the specific chromatographic column used, most branched C_5 alkanes will elute before n-pentane, the beginning marker compound for the C_5 through C_8 aliphatic hydrocarbon range, and will therefore not be counted in the C_5 through C_8 aliphatic hydrocarbon range; and

(3) Depending upon the specific chromatographic column used, most cycloalkanes within the C_5 through C_8 and C_9 through C_{12} aliphatic hydrocarbon ranges will be counted within their proper range with the exception of some C_{12} cycloalkanes which will elute after naphthalene, the end marker compound for the C_9 through C_{12} aliphatic hydrocarbon range.

Based on the nature of petroleum releases encountered in the environment, the collective concentrations of the volatile aliphatic ranges as measured by the VPH Methods are considered to be suitable for the evaluation of the risks posed by these releases, consistent with the toxicological approach developed by MassDEP to evaluate human health hazards that may result from exposure to petroleum hydrocarbons (MassDEP, 1994 and MassDEP, 2003).

1.13 There may be better, more accurate, and/or less conservative ways to produce Target VPH Analyte and hydrocarbon range data. MassDEP encourages methodological innovations that (a) better achieve method and/or data quality objectives, (b) increase analytical precision and accuracy, (c) reduce analytical uncertainties and expenses, and/or (d) reduce the use of toxic solvents and generation of hazardous wastes.

All significant modifications to this method, however, must be disclosed and described on the data report form, as detailed in Section 11.3 and the MassDEP Analytical Protocol Certification Form (See Appendix 3, Exhibit 2, Question E). Laboratories that make such modifications, and/or develop and utilize alternative approaches and methods, are further required to demonstrate that:

- Such modifications or methodologies adequately quantify the petroleum hydrocarbon ranges, as defined in Sections 3.6 through 3.8 of this document, ensuring that any methodological uncertainties or biases are addressed in a manner that ensures protective (i.e., conservative) results and data (e.g., over, not under-quantification of the more toxic ranges);

- Such modifications and/or methodologies employ and document initial method demonstration and ongoing quality control (QC) procedures consistent with approaches detailed in the MassDEP Compendium of Analytical Methods (CAM); and

- Such methods and procedural modifications are fully documented in a detailed standard operating procedure (SOP).

1.14 Additional information and details on the MassDEP VPH approach are available at http://www.mass.gov/dep/cleanup/laws/policies.htm#vph.

1.15 This method should be used in conjunction with the current version of CAM IV A, “Quality Control Requirements and Performance Standards for the Analysis of Volatile Petroleum Hydrocarbons (VPH) by Gas Chromatography/Photoionization Detector/Flame Ionization Detector in Support of Response Actions Under the Massachusetts Contingency Plan (MCP)”. WSC-CAM-IV A was developed by MassDEP to complement this MassDEP VPH by GC/PID/FID Method and to provide more detailed guidance regarding compliance with the QC requirements and performance standards of the MassDEP VPH by GC/PID/FID Method.

2.0 SUMMARY OF METHOD AND DATA QUALITY OBJECTIVES

2.1 Samples are analyzed using purge-and-trap sample concentration. The GC is temperature programmed to facilitate separation of the individual compounds and hydrocarbon ranges of interest on a capillary column. All compounds are detected using a PID and FID in series. Quantitation is based on comparing the PID and FID response of a sample to a standard comprised of aromatic and aliphatic hydrocarbons. The PID chromatogram is used to determine the individual concentrations of Target VPH Analytes (BTEX/MTBE/naphthalene) and collective concentration of aromatic hydrocarbons within the C_9 through C_{10} range. The FID chromatogram is used to determine the collective concentration of aliphatic hydrocarbons within the C_5 through C_8 and C_9 through C_{12} ranges.

2.2 This method is suitable for the analysis of aqueous samples, soils, sediments, wastes, sludges, and non-aqueous phase liquid (NAPL) samples. However, it should be noted that the method was validated only for soil and aqueous matrices. Aqueous samples may be analyzed directly for VPH by purge-and-trap concentration and GC/PID/FID. Soil/sediment samples are dispersed in methanol to dissolve the volatile organic constituents. An aliquot of the methanol extract is then analyzed by purge-and-trap concentration and GC/PID/FID.

2.3 This method is based on (1) USEPA Methods 5030B, 5035A, 8000D, 8015C, and 8021B, SW-846, "Test Methods for Evaluating Solid Wastes," (2) Draft "Method for Determination of Gasoline Range Organics," EPA UST Workgroup, November, 1990; and (3) "Modified GRO Method for Determining Gasoline Range Organics," Wisconsin Department of Natural Resources, PUBL-SW-140, 1992.

2.4 Data Quality Objectives should be developed and applied for sampling and analytical efforts involving the use of this method. Key parameters of interest include: (a) the acceptability of RLs achievable by the laboratory for the contaminants of interest and (b) the identification and reporting of target analytes.

3.0 DEFINITIONS

3.1 **Aliphatic Hydrocarbons** are defined as acyclic or cyclic, saturated or unsaturated compounds that contain only carbon and hydrogen atoms, excluding aromatic compounds.

3.2 **Aromatic Hydrocarbons** are defined as compounds whose structures include a cyclic structure and a closed conjugated system of double bonds containing only carbon and hydrogen atoms.

3.3 **Analytical Batch** is defined as a group of field samples with similar matrices which are processed as a unit. For QC purposes, if the number of samples in such a group is greater than 20, then each group of 20 samples or less is defined as a separate analytical batch.

3.4 **Calibration Standards** are defined as a series of standard solutions prepared from dilutions of a stock standard solution, containing known concentrations of each analyte and surrogate compound of interest.

3.5 **Continuing Calibration Standard** is defined as a calibration standard used to periodically check the calibration state of an instrument. The continuing calibration standard is prepared from the same stock solution as calibration standards, and is generally one of the mid-level range calibration standard dilutions.

3.6 **C_5 through C_8 Aliphatic Hydrocarbons** are defined as all aliphatic petroleum hydrocarbon compounds that elute from just before n-pentane (C_5) to just before n-nonane (C_9). C_5 through C_8 aliphatic hydrocarbons are determined using the FID.

3.7 **C_9 through C_{12} Aliphatic Hydrocarbons** are defined as all aliphatic petroleum hydrocarbon compounds that elute from just before n-nonane (C_9) to just before naphthalene. C_9 through C_{12} aliphatic hydrocarbons are determined using the FID.

3.8 **C_9 through C_{10} Aromatic Hydrocarbons** are defined as all aromatic petroleum hydrocarbon compounds that elute from just after o-xylene to just before naphthalene; therefore this range will include any unsaturated hydrocarbons (e.g., alkenes, alkynes, carbonyls, ethers, etc.). Although naphthalene is an aromatic compound with 10 carbon atoms, it is excluded from this range because it is evaluated as a separate Target VPH Analyte. C_9 through C_{10} aromatic hydrocarbons are determined using the PID.

3.9 **Field Duplicates** are defined as two separate samples collected at the same time and place under identical circumstances and managed the same throughout field and laboratory procedures. Analyses of field duplicates give a measure of the precision associated with sample collection, preservation, and storage, as well as laboratory procedures.

3.10 **Laboratory Control Sample (LCS)** is defined as a reagent water blank (when associated with aqueous samples) or clean methanol blank (when associated with soil/sediment samples) fortified with the matrix spiking solution. The LCS is prepared and analyzed in the same manner as a sample and its purpose is to determine the bias of the analytical method.

3.11 **Laboratory Control Sample Duplicate (LCSD)** is defined as a reagent water blank (when associated with aqueous samples) or clean methanol blank (when associated with soil/sediment samples) fortified with the matrix spiking solution. The LCSD is prepared separately from the LCS but is prepared and analyzed in the same manner as the LCS. The purpose of LCS duplicates is to determine the bias and precision of the analytical method.

3.12 **Laboratory Method Blank (LMB)** is defined as an aliquot of reagent water (when associated with aqueous samples) or clean methanol (when associated with soil/sediment samples) spiked with a surrogate standard. The laboratory method blank is prepared and analyzed in the same manner as a sample, exposed to all glassware, solvents, reagents, and equipment. A laboratory method blank is analyzed with every batch of samples, to determine if method analytes or other interferences are present in the laboratory environment, reagents, or equipment.

3.13 **Matrix Duplicates** are defined as split samples prepared and analyzed separately with identical procedures. For soil/sediment samples, matrix duplicate samples are taken from the same sampling container. For aqueous samples, a separate container is used for the matrix duplicate sample. The analysis of matrix duplicates gives a measure of the precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.

3.14 **Matrix Spike Sample** is defined as an environmental sample which has been spiked with a matrix spiking solution containing known concentrations of method analytes. The purpose of the matrix spike sample is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined through the separate analysis of an unspiked sample aliquot. The measured values in the matrix spike sample must be corrected for background concentrations when calculating recoveries of spiked analytes.

3.15 **Matrix Spiking Solution** is defined as a solution prepared from a separate source than used for the calibration standards, containing known concentrations of method analytes.

3.16 **System Solvent Blank (SSB)** is defined as an aliquot of organic-free water (American Society for Testing and Materials [ASTM] Type I reagent grade) and purge-and-trap grade, or equivalent, methanol. For aqueous samples 4.0 uL of methanol is mixed with 5.0 mL of water and for soil/sediment samples 100 uL of methanol is mixed with 4.9 mL of water. The SSB is analyzed in the same manner as a sample, exposed to all glassware, solvents, reagents, and equipment. <u>Surrogates must not be spiked into SSBs</u>. An SSB provides one way of determining the level of noise and baseline rise attributable solely to the analytical system, in the absence of any other analytes or non-analytical related contaminants.

3.17 **Target VPH Analytes** are defined as benzene, toluene, ethylbenzene, m-xylene, p-xylene, o-xylene, naphthalene, and MTBE.

3.18 **Unadjusted C_5 through C_8 Aliphatic Hydrocarbons** are defined as all petroleum hydrocarbon compounds which elute on the FID chromatogram from n-pentane (C_5) to just before n-nonane (C_9).

3.19 **Unadjusted C_9 through C_{12} Aliphatic Hydrocarbons** are defined as all petroleum hydrocarbon compounds which elute on the FID chromatogram from just before n-nonane (C_9) to just before naphthalene.

3.20 **Volatile Petroleum Hydrocarbons (VPH)** are defined as collective fractions of hydrocarbon compounds eluting from n-pentane to just before naphthalene, excluding Target VPH Analytes. VPH is comprised of C_5 through C_8 Aliphatic Hydrocarbons, C_9 through C_{12} Aliphatic Hydrocarbons, and C_9 through C_{10} Aromatic Hydrocarbons.

3.21 **Volatile Petroleum Hydrocarbon (VPH) Component Standard** is defined as a 15 component mixture of the aliphatic and aromatic compounds and one surrogate listed in Table 1. The compounds comprising the VPH Component Standard are used to (a) define the individual retention times and calibration factors for each of the Target VPH Analytes, (b) define and establish the retention time windows for the collective aliphatic and aromatic hydrocarbon ranges of interest, and (c) determine average calibration factors or generate calibration curves that can in turn be used to calculate the collective concentrations of hydrocarbons within these ranges.

3.22 All other terms are as defined in the most current version of SW-846, "Test Method for Evaluating Solid Waste," USEPA.

4.0 INTERFERENCES AND METHOD LIMITATIONS

4.1 Samples can become contaminated by diffusion of volatile organics through the sample container septum during shipment and storage or by dissolution of volatiles into the methanol used for preservation. Trip blanks prepared from both reagent water (when associated with aqueous samples) and methanol (when associated with soil/sediment samples) should be carried through sampling and subsequent storage and handling to serve as a check on such contamination.

4.2 Cross-contamination can occur whenever a low-concentration sample is analyzed immediately after a high-concentration sample. To reduce carryover, the sample syringe and/or purging device must be rinsed between samples with reagent water or solvent. For volatile samples containing high concentrations of water-soluble materials, suspended solids, high boiling-point compounds or organohalides, it may be necessary to wash the syringe or purging device with a detergent solution, rinse with distilled water, and then dry in an oven at 105°C between analyses. The trap and other parts of the system are also subject to contamination; therefore, frequent bake-out and purging of the entire system may be required. A screening step is recommended to protect analytical instrumentation. Whenever an unusually concentrated sample is encountered, it must be followed by the analysis of an SSB or LMB to check for cross-contamination. However, due to the potential for samples to be analyzed using an autosampler, the ability to perform this blank analysis may not always be possible. If the sample analyzed immediately after the unusually concentrated sample is free from contamination, then the assumption can be made that carryover or cross-contamination is not an issue. However, if this sample did detect analytes which were present in the unusually concentrated sample, reanalysis is required for all samples analyzed after this highly concentrated sample which detected similar analytes.

4.3 The response selectivity of a PID is used in this method to differentiate aromatic hydrocarbons from aliphatic hydrocarbons. All compounds eluting on the PID chromatogram after o-xylene are identified by the method as aromatic hydrocarbons. This will lead to an overestimation of aromatic hydrocarbons within samples, as certain aliphatic compounds will elicit a response on the PID, particularly unsaturated compounds such as alkenes. The significance and implications of this overestimation will vary from sample to sample; where less conservative data are desired, additional actions should be considered to minimize the detection of non-aromatic compounds, including the use of a lower energy PID lamp and/or an alternative chromatographic column.

4.4 Certain organic compounds not associated with the release of petroleum products including chlorinated solvents, ketones, and ethers may be detected by this method and may contribute to the collective response quantified within an aliphatic or aromatic hydrocarbon range.

5.0 HEALTH AND SAFETY ISSUES

The toxicity and carcinogenicity of each reagent used in this method have not been precisely defined. However, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. The laboratory is responsible for maintaining a current file of Occupational Safety & Health Administration (OSHA) regulations regarding the safe handling of the chemicals specified in this method. A reference file of safety data sheets should also be made available to all personnel involved in the chemical analysis.

6.0 APPARATUS AND MATERIALS

6.1 Purge-and-Trap System

6.1.1 The purge-and-trap system consists of a sample purging chamber, a concentrating trap, and a thermal desorber. Complete systems are available commercially.

6.1.1.1 The purging chamber must be designed to accept 5 mL samples with a water column at least 3 cm deep. Purging devices larger than 5 mL have a reduced purging efficiency and should not be used. The gaseous headspace between the water column and the trap must have a total volume of less than 15 mL. The purge gas must pass through the water column as finely divided bubbles with a diameter of less than 3 mm at the origin. Fritted glass or needle sparge cells may be used. If needle sparge cells are used, the purge gas must be introduced no more than 5 mm from the base of the water column. Alternate sample purging devices may be used, provided an equivalent performance is demonstrated.

6.1.1.2 The recommended trap should be at least 25 cm long and have an inside diameter of at least 0.105 inches. The trap should be packed with 400 mg of Carbopack B (Supelco Cat. No. 2-0273). Alternative trap packing materials include: 7.6 cm Carbopack B and 1.3 cm Carbosieve S-III (Supelco Cat No. 2-0321); or 7.7 cm Carbopack C and 1.2 cm Carbopack B (Supelco Cat No. 2-1064). In general, Carbopack trap packing materials are recommended because they have less of a tendency to retain methanol, which could interfere with the elution of pentane and quench the FID flame. The recommended trap length and packing materials may be varied as long as equivalent performance (i.e., meeting QC criteria of method) has been verified.

NOTE: Based upon data obtained from the MassDEP VPH by GC/MS Method Round Robin testing program, the choice of traps may have a significant impact on the quantification of aliphatic and aromatic compounds within the collective hydrocarbon ranges specified in the method, specifically the heavier boiling point components. It must be demonstrated that the selected trap has equivalent properties for the efficient desorption of the aliphatic and aromatic compounds and ranges of interest. In all cases, the laboratory must specify the trap used in the data package (see Appendix 3).

To demonstrate equivalency of trap desorption efficiency, a neat gasoline standard must be analyzed using a trap with the recommended packing materials and the proposed substitute trap, with all other run and system parameters held constant. The concentrations of C_5-C_8 and C_9-C_{12} aliphatic hydrocarbons, C_9-C_{10} aromatic hydrocarbon ranges, and Target VPH Analytes must be determined for each trap. The relative percent differences (RPDs) between the concentrations of each hydrocarbon range and Target VPH Analyte obtained from each trap must be $\leq$ 25.

6.1.1.3 The traps should be conditioned and desorbed according to the manufacturer's guidelines. The trap may be vented to the analytical column during daily conditioning; however, the column must be run through the temperature program prior to analysis of samples.

6.1.1.4 The desorber should be capable of rapidly heating the trap to the temperature recommended by the trap manufacturer prior to the beginning of the flow of desorption gas.

6.2 Gas Chromatograph System

6.2.1 An analytical system complete with a temperature programmable GC for use with a capillary column is required.

6.2.2 Chromatographic Column: The required column is: 105 m x 0.53 mm internal diameter (I.D.) Restek RTX-502.2 with 3 micron film thickness, or column with equivalent chromatographic properties.

NOTE: Based upon data obtained from the MassDEP VPH by GC/PID/FID Method Round Robin testing programs, the choice of chromatographic column may have a significant impact on the apportionment and quantitation of aliphatic and aromatic compounds within the collective hydrocarbon ranges specified in this method. Substitution of the required column is not allowed, unless it can be demonstrated that the selected column has equivalent chromatographic properties and elution order for the aliphatic and aromatic compounds and ranges of interest. In all cases the laboratory must specify the column used in the data package (see Appendix 3).

To demonstrate equivalency of column chromatography, a neat gasoline standard must be analyzed on both the required column and the proposed substitute column, with all other run and system parameters held constant. The concentrations of C_5-C_8 and C_9-C_{12} aliphatic hydrocarbons, C_9-C_{10} aromatic hydrocarbons, and Target VPH Analytes must be determined for each column (in which the PID concentrations of the Target VPH Analytes have been subtracted from the FID concentrations of the aliphatic hydrocarbon ranges). The RPDs between the concentrations of each hydrocarbon range and Target VPH Analyte obtained from each column must be $\leq$ 25. The elution order of VPH components on the proposed substitute column must be equivalent to the elution order on the required column.

6.3 Detectors

6.3.1 The method requires the use of a PID in series with a FID; the PID first in the series. The method is based upon the use of a 10.0 +/- eV PID lamp, although lower energy lamps are permissible in order to minimize PID response to aliphatic compounds. In lieu of an in-series arrangement, in-parallel PID and FID units may be also used if the RL for the method is not adversely affected.

6.3.2 A data station is required that is capable of storing and reintegrating chromatographic data and capable of determining peak areas using a forced baseline projection.

6.4 The following glassware is used in this method:

6.4.1 VOC Vials: Wide mouth 60-mL VOC vials or 40-mL VOC vials with Teflon/silicone septa for soil/sediment matrices; 40-mL VOC vials with Teflon/silicone septa for aqueous matrices.

6.4.2 Class “A” Volumetric flasks: 10-mL, 50-mL, 100-mL, and 1,000-mL with ground-glass stoppers.

6.5 Analytical balance: An analytical balance capable of accurately weighing 0.0001 g must be used for weighing standards, if required. A top-loading balance capable of weighing to the nearest 0.1 g must be used for weighing soil/sediment samples.

6.6 Ultrasonic bath.

6.7 Disposable pipets: Pasteur.

6.8 Syringes: 5-mL Luerlock glass hypodermic and 5-mL gas-tight syringe with shutoff valve.

6.9 Syringe valve: Two-way, with luer-lock connections.

6.10 Microsyringes: 1-µL, 5-µL, 10-µL, 25-µL, 100-µL, 250-µL, 500-µL, and 1,000-µL.

6.11 Spatula: Stainless steel.

6.12 Drying oven.

6.13 Dessicator.

7.0 REAGENTS AND STANDARDS

7.1 Reagents

7.1.1 Reagent Water: organic-free water (ASTM Type I reagent grade water).

7.1.2 Solvent: methanol; purge-and-trap grade or equivalent. Store away from other solvents.

7.2 Stock Standard Solution

Prepare stock standard solutions in methanol at approximately 10 micrograms per microliter (µg/µL), or purchase certified solutions. Preparation of stock standards and component standards should be done using volumetric glassware. The stock standard solution consists of the aliphatic and aromatic range calibration compounds and Target VPH Analytes listed in Table 1. A separate stock standard solution containing only the surrogate must be prepared. Transfer the stock standard solution into a Teflon-lined screw-cap or crimp cap bottle. Store, with minimal headspace, at -10°C to -20°C and protect from light. Stock standard solutions must be replaced after 6 months, or sooner if comparison with check standards indicates a problem.

7.3 Primary Dilution Standard

Using the stock standard solutions, prepare primary dilution standards in methanol, as needed. The primary dilution standards should be prepared at 100 µg/mL. These standards should be stored with minimal headspace, at -10°C to -20°, and should be checked frequently for signs of degradation or evaporation. The primary dilution standards should be replaced at least monthly.

7.4 VPH Calibration Standards

Prepare VPH Calibration standards in reagent water from the primary dilution standards (in methanol). At a minimum, five different concentrations are required for a valid calibration curve. The calibration concentrations must be evenly dispersed over the full working range of the detector with the lowest calibration point corresponding to the RL. The highest concentration defines the maximum upper working range of the calibration curve. Target VPH analytes may not be reported above this concentration without sample dilution. Tables 2a and 2b provide recommended concentrations for each calibration standard for a 5-point initial calibration of hydrocarbon ranges, Target VPH Analytes, and the surrogate.

<u>Aqueous standards are not stable and should be discarded after one hour.</u>

7.5 Surrogate Standard

The analyst must monitor both the performance of the analytical system and the effectiveness of the method in dealing with sample matrices by spiking each sample, LMB, LCS, LCSD, and matrix spike with a surrogate standard. The surrogate standard is included in the VPH calibration standards. The recommended surrogate standard is 2,5-dibromotoluene, which elutes after all aliphatic and aromatic compounds of interest.

However, other surrogates may be used as long as they are adequately resolved from the components of interest.

7.5.1 Recommended Surrogate Spiking Solution: From a stock standard solution, prepare a surrogate spiking solution in methanol. Add a specified volume (recommended 5-10 µl) of this surrogate spiking solution directly into the 5-mL syringe with every aqueous sample, LMB, LCS, LCSD, and matrix spike in order to yield a final concentration of 50 µg/L. Add a specified volume (recommended not to exceed 1.0 mL) of the surrogate spiking solution to soil/sediment samples during the extraction step (See Section 9.1.3.2) in order to yield a final concentration of 2.5 mg/kg (or 50 µg/L on column). The use of higher concentrations is permissible and advisable when spiking highly contaminated samples.

7.6 Matrix Spiking Solution

The recommended matrix spiking solution, consisting of the full analyte list (VPH Component Standard), is prepared in methanol at a nominal concentration of 50 µg/mL.

7.7 Petroleum Reference Standard (To demonstrate equivalency of column chromatography and trap desorption efficiency)

The Petroleum Reference Standard consists of an API or commercial gasoline standard. Prepare Petroleum Reference Standard spiking solutions by accurately weighing approximately 0.0100 g of neat product. Dissolve the neat product in methanol and dilute to volume in a 100-mL volumetric flask.

8.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

8.1 Aqueous Samples

8.1.1 Aqueous samples should be collected in triplicate (or the number of vials directed by the laboratory) without agitation and without headspace in contaminant-free 40 mL glass VOC vials with Teflon-lined septa screw caps. The Teflon liner must contact the sample. All samples must be chemically preserved as follows (based on the laboratory's purge-and-trap system setup).

a. Samples analyzed with ambient purge temperature: Samples must be acidified to a pH of 2.0 or less at the time of collection. This can generally be accomplished by adding 3 or 4 drops (0.1 to 0.2 mL) of 1:1 hydrochloric acid (HCl) (1 part reagent water and 1 part concentrated HCl) to a 40-mL sample vial prior to collection. Samples must be cooled to 0-6°C immediately after collection.

b. Samples analyzed with heated purge temperature: Samples must be treated to a pH of 11.0 or greater at the time of collection. This can be accomplished by adding 0.40 to 0.44 grams of trisodium phosphate dodecahydrate (TSP) to a 40-mL sample vial prior to collection. Samples must be cooled to 0-6°C immediately after collection.

8.1.2 A chain-of-custody form must accompany all sampling vials and must document the date and time of sample collection and preservation method used. The pH of all water samples must be determined by the laboratory after sample analysis has been completed. The pH measurement may be performed on leftover sample. Any acid-preserved sample found to contain a pH above 2 must be so noted on the laboratory/data report sheet. Any TSP-preserved sample found to contain a pH <11 must be so noted on the laboratory data report sheet. Additional details and recommendations on aqueous sample preservation are provided in Appendix 4.

8.1.3 A reagent water trip blank, preserved in the same manner as the samples, should accompany each batch of water samples. Refer to WSC-CAM-VII A for the **required** frequency of trip blanks.

8.1.4 Any sample received by the laboratory that is not packed in ice or cooled to 0-6°C must be so noted on the laboratory/data report sheet. The temperature of the cooler must be recorded by the laboratory upon receipt.

8.1.5 Aqueous samples must be analyzed within 14 days of collection.

8.2 Soil/Sediment Samples

8.2.1 Soil/sediment samples must be collected in a manner that minimizes sample handling, environmental exposure and/or aeration. The use of specially designed air-tight collection samplers or a 30-mL plastic syringe with the end sliced off is recommended. All soil/sediment must be removed from the glass threads of the vial to ensure an adequate seal. Samples must be cooled to 0-6°C immediately after collection.

8.2.2 **Methanol preservation of soil/sediment samples is mandatory.** Methanol (purge-and-trap grade) must be added to the sample vial before or immediately after sample collection. In lieu of the in-field preservation of samples with methanol, soil samples may be obtained in specially-designed air tight sampling devices, provided that the samples are extruded and preserved in methanol within 48 hours of collection. Additional details and recommendations on soil/sediment sampling are provided in Appendix 4.

8.2.3 The desired ratio of methanol-to-soil/sediment is 1 mL methanol/1 gram soil/sediment, +/- 25%. The exact weight of the soil/sediment sample and volume of methanol must be known or ascertained by the laboratory when calculating and reporting soil/sediment concentration data. A recommended practice is for a laboratory to provide labeled, pre-weighed sampling vials with the measured volume of methanol clearly indicated to the field sampling technician. The laboratory “fill line” indicating the height of the methanol meniscus should be permanently marked on the side of the sampling container. After the soil/sediment sample is added to the methanol in the sampling container, the sample “fill line” indicating the height of the sample-displaced (increased) methanol level should also be marked by the field sampling technician. **In all cases, the soil/sediment sample in the vial must be completely covered by methanol.**

8.2.4 Samples for VPH analysis should be collected in duplicate 60-mL or 40-mL VOC vials with Teflon-lined septa screw caps. An additional sample of the soil/sediment must also be obtained (without methanol) to allow for a determination of moisture content and VPH dry weight correction factors. Refer to Appendix 5 for details on shipping methanol-preserved samples.

8.2.5 A methanol trip blank should accompany each batch of soil/sediment samples.

8.2.6 A chain-of-custody form must accompany all sampling vials and must document the date and time of sample collection and, where appropriate, the volume of methanol added. Observations of vial leakage must be so noted on the laboratory/data report sheet.

8.2.7 Any sample received by the laboratory that is not packed in ice or cooled to 0-6°C must be so noted on the laboratory/data report sheet. The temperature of the cooler must be recorded by the laboratory upon receipt.

8.2.8 Soil/sediment samples must be analyzed within 28 days of collection.

8.3 A summary of sample collection containers, preservation, and holding times is provided in Table 3.

9.0 ANALYTICAL PROCEDURE

9.1 Sample Preparation and Purging

9.1.1 It is highly recommended that all samples be screened prior to analysis. This screening step may be analysis of a soil/sediment sample's methanol extract (diluted), the headspace method (SW-846 method 3815), or the hexadecane extraction and screening method (SW-846 Method 3820). For soil/sediment samples, headspace screening of the unpreserved vial (obtained for the purposes of determining soil/sediment moisture content) is also an option.

9.1.2 Aqueous Samples

Introduce volatile compounds into the GC using a purge-and-trap concentrator.

Note: Although procedures for manual purge-and-trap load systems are provided below, MassDEP prefers the use of purge-and-trap autosamplers to reduce variability and to minimize the handling of samples for VPH analysis.

9.1.2.1 For a manual load system, remove the plunger from a 5-mL syringe and attach a closed syringe valve. Open the sample or standard bottle, which has been allowed to come to ambient temperature, and carefully pour the sample into the syringe barrel to just short of overflowing. Replace the syringe plunger and compress the sample. Open the syringe valve and vent any residual air while adjusting the sample volume to 5.0 mL. This process of taking an aliquot destroys the validity of the liquid sample for future analysis; therefore, if there is only one 40-mL vial, the analyst should fill a second syringe at this time to protect against possible loss of sample integrity. This second sample is maintained only until such time when the analyst has determined that the first sample has been analyzed properly. Filling one 20-mL syringe would allow the use of only one syringe. If a second analysis is needed from a syringe, it must be analyzed within 24 hours. Care must be taken to prevent air from leaking into the syringe.

Alternatively, commercially-available autosamplers may be used to automatically introduce a 5.0 mL sample aliquot directly from a 40 mL sampling vial to the system for purging. The addition of surrogates may also be performed automatically by the autosampler. Follow manufacturer's instructions for operation. In some cases, concentrations of surrogates and/or matrix spikes may need to be modified to accommodate the fixed injection volumes associated with automated sample introduction systems.

If necessary, samples should be diluted prior to injection into the purge chamber. In such cases, all steps must be performed without delay. If using an autosampler, sufficient volume of the diluted sample should be prepared to fill a 40 mL sampling vial. Analyze the diluted sample as described above.

9.1.2.2 Spiking Samples.

If the purge-and-trap manual load system is utilized:

- Add a specified volume (recommended 5-10 µL) of the surrogate spiking solution through the valve bore of the syringe to yield a final concentration of 50 µg/L. Close the valve.
- If matrix spike analysis is to be performed, add a specified volume (recommended 5-10 µL) of the matrix spiking solution through the valve bore of the syringe to yield a nominal concentration of 50 µg/L. Close the valve.
- Attach the syringe valve assembly to the syringe valve on the purging device. Open the syringe valve and inject the sample into the purging chamber. Close the valve.

If the purge-and trap autosampler is utilized:

- The addition of surrogates may be performed automatically by the autosampler.
- If matrix spike analysis is to be performed, add a specified volume (recommended 5-10 µL) of the matrix spiking solution through the Teflon-lined septa screw cap of the VOC vial.

9.1.2.3 Regardless if manual load or autosampler is used, purge the sample for 11 minutes. Recommended purge-and-trap operating parameters are provided in Table 4. At the conclusion of the purge time, attach the trap to the GC (if necessary), adjust the device to the desorb mode, and begin the GC temperature program and GC data acquisition. Concurrently, introduce the trapped materials to the GC column by rapidly heating the trap to 260°C (desorb temperature) and backflushing the trap with inert gas between 15 and 20 mL/min for 4 minutes.

9.1.2.4 While the trap is desorbing into the GC, empty the purging chamber. Wash the chamber with a minimum of two 5 mL flushes of reagent water (or methanol followed by reagent water) to avoid carryover of compounds into subsequent analyses.

9.1.2.5 After desorbing the sample, recondition the trap by returning the purge-and-trap device to the purge mode. Wait 15 seconds, then close the syringe valve on the purging device to begin gas flow through the trap. The trap temperature should be maintained at 260°C. After approximately 7 to 15 min, turn off the trap heater and open the syringe valve to stop the gas flow through the trap. After a highly concentrated sample, a longer baking time may be necessary. When cool, the trap is ready for the next sample.

9.1.2.6 Following sample analysis, measure and record the pH of the remaining sample.

9.1.3 Soil/Sediment/Samples

Soil and sediment samples are extracted with methanol. An aliquot of the methanol extract is added to reagent water and volatile compounds are introduced into the GC using a purge-and-trap concentrator.

9.1.3.1 Weigh the sample vial to 0.1 g on a top-loading balance and determine the weight of the soil/sediment sample; this determination requires knowledge of the empty/tared weight of the sample vial and volume/weight of methanol preservative that was added to the sample vial.

9.1.3.2 Add a specified volume (recommended not to exceed 1.0 mL) of the surrogate spiking solution through the septum of the sample vial. The concentration and/or volume of the surrogate spiking solution may need to be increased for samples that are highly contaminated (based upon screening and/or field notes), to prevent dilution to below detectable limits. The amount of surrogate added should yield a final concentration of 2.5 mg/kg.

9.1.3.3 If matrix spike analysis is to be performed, add a specified volume (recommended not to exceed 1.0 mL) of the matrix spiking solution through the septum of a separate sample vial to yield a nominal concentration of 2.5 mg/kg.

9.1.3.4 Agitate sample to facilitate adequate mixing of spiking solution(s).

9.1.3.5 Allow soil/sediment to settle until a layer of methanol is apparent.

9.1.3.6 Using a microliter syringe, withdraw an appropriate aliquot of the methanol extract for sparging through the septum of the container. Sample screening data can be used to determine the volume of methanol extract to add to the 5 mL of reagent water for analysis.

9.1.3.7 Remove the plunger from one 5.0-mL Luerlock type syringe equipped with a syringe valve and fill until overflowing with reagent water. Replace the plunger and compress the water to vent trapped air. Adjust the volume to allow for addition of the extract (e.g., for 100 µL of extract adjust to 4.9 mL). Pull the plunger to 5.0 mL for addition of the sample extract. Add the volume of methanol extract determined from screening (recommended 100 µL if dilution not required). **Be advised that the volume of methanol aliquot added to the**

reagent water should not exceed 200 µL to preclude adverse solvent front and trap breakthrough difficulties. Alternatively, the addition of methanol extracts to reagent water can be performed in 40 mL VOC vials when an autosampler is used keeping similar methanol to water ratios.

9.1.3.8 If using a manual load purge-and-trap system, attach the syringe valve assembly to the syringe valve on the purging device. Open the syringe valve and inject the sample into the purging chamber. Close the valve.

9.1.3.9 Complete operations as specified in Sections 9.1.2.3 through 9.1.2.5.

9.1.4 Determination of Percent Moisture

9.1.4.1 Soil and sediment results must be reported on a dry-weight basis.

Transfer 5 to 10 g of sample into a tared (± 0.1 g) crucible. This sample must be obtained from a vial or container that does not contain methanol. Dry this 5 to 10 g sample overnight at 105°C, and reweigh (± 0.1 g). Allow to cool in a desiccator before reweighing. Calculate the percent moisture of the sample using the equation provided in Section 9.6.3 (Equation 10). Refer to ASTM Method D2216, Determination of Moisture Content of Soils and Sediments, for more detailed analytical and equipment specifications.

9.2 Analytical Conditions

GC/PID/FID Conditions:

Chromatographic Column: 105 m x 0.53 mm I.D., 3.0 µm Restek Rtx- 502.2

Oven Temperature Program Initial oven temperature 45°C, hold time 1 min;
to 100 °C @ 3°C/min, hold time 0 min
to 160°C @ 8 °C/min, hold time 0 min
to 230 °C @ 20°C/min, hold time 7.5 min

Gas Flow Rates: Carrier gas - Helium @ 12.5 mL/ min
Oxidizer - Air @ 350 mL/min
Fuel - Hydrogen @ 30 mL/min
Make up - Air @ 17.5 mL/min
Injection Port Temperature: 250°C
Column Inlet Pressure: 20 p.s.i.g.
Detector Temperature: 230°C (PID)
230°C (FID)

9.3 Retention Time Windows

9.3.1 Before establishing retention time (Rt) windows, optimize the GC system's operating conditions. Make three injections of the VPH Component Standard over the course of a 72-hr period. Serial injections over less than a 72-hr period may result in Rt windows that are too restrictive.

9.3.2 Calculate the standard deviation of the three absolute Rts for each individual compound in the VPH Component Standard.

9.3.3 The Rt window is defined as plus or minus three times the standard deviation of the absolute Rt for each compound in the VPH Component Standard. However, the experience of the analyst should weigh heavily in the interpretation of chromatograms.

9.3.4 In those cases where the standard deviation for a particular standard is zero, the laboratory should substitute the standard deviation of a closely eluting structurally similar compound to develop a representative statistically-derived Rt window.

9.3.5 The laboratory must calculate Rt windows for each compound in the VPH Component Standard on each GC column and whenever a new GC column is installed. These data must be retained by the lab.

9.3.6 The Rt window of the C_5-C_8 aliphatic hydrocarbons is defined as beginning 0.1 minutes before the elution of n-pentane and ending 0.01 minutes before the elution of nonane. The C_9-C_{12} aliphatic hydrocarbon range begins 0.01 minutes before the elution of nonane; therefore there is no overlap of the two ranges and the nonane peak is only included in the C_9-C_{12} aliphatic hydrocarbon range. The C_9-C_{12} aliphatic hydrocarbon range ends 0.1 minutes before the elution of naphthalene.

The Rt window for the C_9-C_{10} aromatic hydrocarbons is defined as beginning 0.1 minutes **after** the elution of o-xylene and ending 0.1 before the elution of naphthalene.

VPH marker compounds and windows are summarized in Table 5.

9.4 Calibration

9.4.1 The VPH calibration standards are used to calibrate the GC/PID/FID system. Two distinct calibration operations are necessary.

9.4.1.1 Target VPH Analytes and Surrogate: Calibration Factors (CFs) are calculated for the Target VPH Analytes and surrogate standard, based upon a correlation between the concentration of analyte/surrogate and PID area counts for the analyte/surrogate peaks. This allows for the individual identification and quantitation of these specific compounds. It is not necessary to develop CFs for any other individual VPH Components.

9.4.1.2 Collective Aliphatic/Aromatic Hydrocarbon Ranges: CFs are calculated for C_5-C_8 aliphatic hydrocarbons and C_9-C_{12} aliphatic hydrocarbons based upon a correlation between the TOTAL concentration of aliphatic VPH Components eluting within the range of interest and the total FID area count of the applicable VPH component peaks. A CF is calculated for C_9-C_{10} aromatic hydrocarbons based upon a correlation between the concentration of the one aromatic VPH Component used to calibrate this range and the PID area count of this VPH component. Specified VPH Components are designated marker compounds to define the beginning and end of the hydrocarbon ranges (see Table 5). A listing of the hydrocarbon range compounds used to establish CFs for each hydrocarbon range of interest and their individual component concentration (µg/L) is provided in Table 2b.

9.4.2 Initial Calibration

9.4.2.1 Initial calibration is performed at instrument set-up and at any time recalibration is required or performed.

9.4.2.2 The use of CFs is the preferred approach to determine the relationship between the detector response and the Target VPH Analyte and hydrocarbon range concentrations. It is also permissible to utilize linear regression (see Sections 9.4.2.12 and 9.4.2.13). The linear regression approach for Target VPH Analytes and hydrocarbon ranges is described in Appendix 6. The use of non-linear regression is not allowed in this method and is considered a significant modification as discussed in Section 11.3.1.

9.4.2.3 An initial calibration is performed using a minimum of five different concentrations of VPH calibration standards as per Section 7.4. Recommended Target VPH Analyte and hydrocarbon range calibration standard concentrations are provided in Tables 2a and 2b, respectively. The calibration concentrations must be evenly dispersed over the full working range of the detector with the lowest calibration point corresponding to the target

RL for the Target VPH Analytes (see Section 12.0). NOTE: If an autosampler is used to spike the surrogate in calibration standards, five standards with the same concentration of surrogate are acceptable for determination of a CF for the surrogate.

9.4.2.4 Analyze each VPH Calibration standard according to the procedures specified in Sections 9.1 and 9.2.

9.4.2.5 Target VPH Analytes and Surrogate - Tabulate the PID area response against the concentration for each Target VPH Analyte and surrogate, and calculate a CF for each compound using Equation 1. Perform this calculation for each Target VPH Analyte and the surrogate.

Equation 1: Calibration Factor for Target VPH Analytes and Surrogate

$$\boxed{Calibration\ Factor(CF) = \frac{area\ of\ peak}{concentration\ purged(\mu g/L)}}$$

9.4.2.6 Hydrocarbon Ranges - Establish retention time windows for the hydrocarbon ranges using the VPH Component marker compounds shown in Table 5.

9.4.2.7 Calculate a CF for the C_5-C_8 aliphatic hydrocarbon range using the following steps.

Sum the **individual FID peak areas** of the three VPH Components that are used to establish an average range CF for C_5-C_8 aliphatic hydrocarbons, as designated in Table 2b. It is important to note that these integrations must be performed using a valley-to-valley approach for each of the individual peaks that comprise this range. The sum of each of these areas is used in the subsequent calculation. Note: Do not include the area of any surrogate standard in calculating a hydrocarbon range CF.

Using this total area, calculate the C_5-C_8 aliphatic hydrocarbon range CF using Equation 2.

Equation 2: Calibration Factor for Hydrocarbon Range

$$\boxed{Range\ CF = \frac{Area\ summation\ of\ range\ components}{Total\ concentration\ purged(\mu g/L)}}$$

9.4.2.8 Calculate a CF for the C_9-C_{12} aliphatic hydrocarbon range using the following steps.

Sum the **individual FID peak areas** of the three VPH Components that are used to establish an average range CF for C_9-C_{12} aliphatic hydrocarbons, as designated in Table 2b. Note that erratic performance has been noted for n-nonane; calibration of C_9-C_{12} aliphatic hydrocarbons using only two VPH Components (n-decane and n-butylyclohexane) is allowed. It is important to note that these integrations must be performed using a valley-to-valley approach for each of the individual peaks that comprise this range. The sum of each of these areas is used in the subsequent calculation. Note: Do not include the area of any surrogate standard in calculating a hydrocarbon range CF.

Using this total area, calculate the C_9-C_{12} hydrocarbon range CF using Equation 2.

9.4.2.9 Calculate a CF for the C_9-C_{10} aromatic hydrocarbon range using the following steps.

Use the individual PID peak area of the one VPH component that is used to establish an average range CF for C_9-C_{10} aromatic hydrocarbons, as designated in Table 2b. It is important to note that integration must be performed using a valley-to-valley approach for the one peak that comprises this range. This area is used in the subsequent calculation. Note: Do not include the area of any surrogate standard in calculating a hydrocarbon range CF. Do not include the area of naphthalene when determining the CF for C_9-C_{10} aromatic hydrocarbons

Using this area, calculate the C_9-C_{10} aromatic range CF using Equation 2.

9.4.2.10 Calculate the average CF for each of the Target VPH Analytes, the surrogate, and each hydrocarbon range.

9.4.2.11 Calculate the percent relative standard deviation (%RSD) of the CFs over the working range of the curve for each of the Target VPH Analytes, the surrogate, and each hydrocarbon range using Equation 3.

Equation 3: Percent Relative Standard Deviation

$$\boxed{\%RSD = [(SD_{n-1})/(AVG_x)]*100}$$

where:

%RSD = percent relative standard deviation
SD_{n-1} = standard deviation (n-1 degrees of freedom)
AVG_x = average CF from the initial calibration curve

9.4.2.12 If the %RSD is ≤20 for Target VPH Analytes and the surrogate and ≤25 for hydrocarbon ranges, linearity can be assumed and the average CF can be used for quantitation in lieu of a calibration curve.

If, under **extenuating** analytical circumstances (e.g., extending the RL beyond the expected linear range of the detector), the %RSD criteria cannot be achieved, then a linear (least squares) regression may be used to generate a calibration curve consistent with the guidance provided in SW-846 Method 8000D, Section 11.5.2. For the linear regression calculations, the origin (0,0) cannot be included as a calibration point.

NOTE: Use of non-linear calibration is not allowed and is considered a Significant Modification as per Section 11.3.1.

9.4.2.13 In order for the linear regression model to be used for quantitative purposes, r (correlation coefficient) must be ≥0.99. In addition, the resulting calibration curve from the linear regression must be verified by recalculating concentrations of the Target VPH Analytes and hydrocarbon ranges in the lowest calibration standard using the final calibration curve. Recoveries must be 70-130%.

If recalculated concentrations from the lowest calibration standard are outside the 70-130% recovery range, raise the RL to the concentration of the next highest calibration standard that exhibits acceptable recoveries when recalculated using the final calibration curve.

9.4.2.14 For any calibration model, the concentration of the lowest initial calibration standard used in an acceptable initial calibration (i.e., %RSDs and r within method criteria), adjusted for sample size, dilution, etc., establishes the method RL.

9.4.2.15 The initial calibration must be verified through the analysis of an initial calibration verification (ICV). This analysis must be performed every time an initial calibration is performed. The ICV must be prepared from a different stock standard than that used to prepare the calibration standard and must be analyzed immediately following the initial calibration. The ICV should be prepared at a mid-range calibration curve concentration.

Calculate the percent recovery (%R) of each Target VPH Analyte and hydrocarbon range using Equation 4. Percent recoveries must be between 70-130%. Recalibrate if >10% of all analytes are outside of criteria.

Equation 4: Percent Recovery

$$\boxed{\%R = [(C_{found})/(C_{true})]*100}$$

where:

%R = Percent Recovery
C_{found} = Concentration of the Target VPH Analyte or hydrocarbon range detected in the ICV (µg/L)
C_{true} = True concentration of the Target VPH Analyte or hydrocarbon range in the ICV (µg/L)

9.4.3 Continuing Calibration

9.4.3.1 A Continuing Calibration Standard must be analyzed daily prior to sample analysis, after every 20 samples, and at the end of the analytical sequence. It should be noted that the Percent Differences (%Ds) are calculated (Equation 5) when CFs are used for the initial calibration and Percent Drifts (Equation 6-4, Appendix 6) are calculated when calibration curves using linear regression are used for the initial calibration.

9.4.3.2 The concentration of the VPH Continuing Calibration Standard must be near the midpoint of the calibration curve.

9.4.3.3 Calculate the CF for each Target VPH Analyte, surrogate, and hydrocarbon range from the Continuing Calibration Standard using Equations 1 and 2.

9.4.3.4 Calculate the %D of the Continuing Calibration Standard CF from the initial calibration average CF using Equation 5.

Equation 5: Percent Difference

$$\boxed{\%D = [(CFc) - (CF_I)]/[(CF_I)]*100}$$

where:

%D = Percent Difference
CFc = CF from the VPH Continuing Calibration Standard
CF_I = average CF from the initial calibration curve

9.4.3.5 The %D or Percent Drift for each Target VPH Analyte and surrogate must be $\leq$ 20. The %D or Percent Drift for each hydrocarbon range must be $\leq$25. Greater %Ds are permissible for n-nonane. If the %D for n-nonane is > 30, note the nonconformance in the case narrative. If more than one Target VPH Analyte or hydrocarbon range fails to meet the applicable criterion, the instrument must be recalibrated. Otherwise, sample analysis may proceed.

9.4.4 Daily Retention Time Windows

The range retention time windows must be established daily based upon the retention time of the marker compounds in the VPH Continuing Calibration Standard. Use the absolute retention time for each analyte in the continuing calibration standard as the midpoint of the window for that day. The daily retention time window equals the midpoint ± 3 times the standard deviation determined in Section 9.3. The marker compounds used for each range are defined in Table 5.

9.4.5 Target VPH Analytes, C_9 to C_{10} Aromatic Hydrocarbons, and the surrogate are quantitated on the PID chromatogram

9.4.6 C_5 through C_8 and C_9 through C_{12} Aliphatic Hydrocarbons and the surrogate are quantitated on the FID chromatogram.

9.5 GC Analysis

9.5.1 Samples are analyzed in a group referred to as an analytical batch. The analytical sequence begins with instrument calibration (initial or continuing) followed by up to 20 samples interspersed with blanks and QC samples and closed with a mid-range continuing calibration standard. The analytical sequence ends when one or more analytical batches have been processed or when any required qualitative and/or quantitative QC criteria are exceeded, whichever comes first.

9.5.2 Identification of Target VPH Analytes

- Tentative identification of a Target VPH Analyte occurs when a peak from a sample chromatogram falls within the daily retention time window. Confirmation on a second GC column or by GC/MS analysis may be necessary, if warranted by the project's data quality objectives.

- Co-elution of the p- and m- xylene isomers may occur.

- Validation of GC system qualitative performance must be accomplished by the analysis of mid-level standards within the analysis sequence. If the retention times of the Target VPH Analytes fall outside their daily retention time window in the standards, the system is out of control. In such cases, the cause of the nonconformance must be identified and corrected.

9.5.3 Aliphatic and aromatic hydrocarbon ranges of interest are determined by the collective integration of all peaks that elute between specified range "marker" compounds. Due to the variability in software approaches and applications to collective peak area integration, it is recommended that a manual verification be initially performed to document accurate integration.

9.5.4 **Collective peak area integration for the hydrocarbon ranges must be <u>from baseline</u> (i.e., must include the unresolved complex mixture "hump" areas).** For the integration of individual Target VPH Analytes and surrogate compounds, a valley-to-valley approach should typically be used, though this approach may be modified on a case-by-case basis by an experienced analyst. In any case, the unresolved complex mixture "hump" areas must <u>not</u> be included in the integration of individual Target VPH Analytes and surrogate compounds.

9.5.5 If the response for an individual Target VPH Analyte exceeds the linear range of the system, dilute the sample and reanalyze. The samples must be diluted so that all peaks fall within the linear range of the detector.

9.5.6 For non-target analytes eluting in the aliphatic or aromatic hydrocarbon ranges, the upper linear range of the system should be defined by peak height measurement, based upon the maximum peak height documented for an aliphatic or aromatic standard within the hydrocarbon range that is shown to be within the linear range of the detector.

9.5.7 Under circumstances that sample dilution is required because either the concentration of one or more of the Target VPH Analytes exceed the concentration of their respective highest calibration standard or any non-target peak eluting within any aliphatic or aromatic range exceeds the peak height documented for the highest range-specific calibration standard, the RL for each Target VPH

Analyte and/or hydrocarbon range must be adjusted (increased) in direct proportion to the Dilution Factor (DF).
Where:

$$DF = \frac{\text{Sample Aliquot Volume (mL) + Diluent Volume (mL)}}{\text{Sample Aliquot Volume (mL)}}$$

And the revised RL for the diluted sample, RL_d:

RL_d = DF X Lowest Calibration Standard for Target VPH Analyte

It should be understood that samples with elevated RLs as a result of a dilution may not be able to satisfy "MCP program" reporting limits in some cases if the RL_d is greater than the applicable MCP standard or criterion to which the concentration is being compared. Such increases in RLs are the unavoidable but acceptable consequence of sample dilution that enable quantification of target analytes which exceed the calibration range. All dilutions must be fully documented in the laboratory narrative.

Analytical Note: Over dilution is an unacceptable laboratory practice. The post-dilution concentration of the highest concentration target analyte must be at least 60 - 80% of its highest calibration standard. This will avoid unnecessarily high RLs for other target analytes, which did not require dilution.

9.6 Calculations

The concentrations of Target VPH Analytes and hydrocarbon ranges in a sample may be determined from the peak area response, using the CFs determined in Section 9.4. If linear regression was used for calibration, refer to Appendix 6 for sample concentration calculations.

9.6.1 Individual Target VPH Analytes and Surrogate: The average CF from the initial calibration is used to calculate the concentration of an analyte or surrogate detected in the sample. Equation 6 is used to calculate the concentration of Target VPH Analytes and the surrogate in µg/L.

Equation 6: Aqueous Samples: Calculation of Sample Concentration (µg/L)

$$\boxed{Conc\ Analyte\,(\mu g/L) = \frac{(A_x)(DF)}{(CF)}}$$

where

Ax = Area count for the Target VPH Analyte or surrogate
DF = Dilution factor (see Section 9.5.7)
CF = Average CF for Target VPH Analyte or surrogate

For soil/sediment samples, convert the µg/L value to µg/kg using Equation 7.

Equation 7: Soil/Sediment Samples: Conversion of µg/L to µg/kg

$$\boxed{Conc\,Analyte(\mu g/kg) = \frac{(Cx)(V_t)(V_w)}{(V_i)(W_d)}}$$

where:

Cx = Concentration from Equation 6 (µg/L)

V_t = Total volume of methanol extract, mL

Analytical Note: This volume must also include the volume of surrogate spiking solution added to soil/sediment samples (if $\geq$ 100 µL) and the volume of water added due to % moisture correction. See Section 9.6.4.

V_i = Volume of methanol extract added to reagent water for purge-and-trap analysis, µL.
V_w = Volume of reagent water used for purge-and-trap analysis, µL.
W_d = Dry weight of sample, g (see Equations 10 through 12)

The integration of Target VPH Analytes and surrogates must be performed from valley to valley.

9.6.2 Hydrocarbon Ranges

When calculating the VPH by GC/PID/FID method aliphatic and aromatic hydrocarbon range concentrations, the laboratory **must** include the area of **all** peaks eluting within the retention time windows specified for these ranges, excluding surrogates, as described below in Sections 9.6.2.1, 9.6.2.2, and 9.6.2.3.

The average hydrocarbon range CF from the initial calibration is used to calculate the concentration (µg/L) of hydrocarbon ranges in samples**. Collective peak area integration for the hydrocarbon ranges must be from baseline (i.e., must include the unresolved complex mixture).**

9.6.2.1 C_5-C_8 Aliphatic Hydrocarbons: FID

- Sum all peaks in the appropriate retention time window, as specified in Section 9.3 and Table 5 (using baseline integration).
- From this sum, subtract the area counts of any surrogates which elute in this range (using valley-to-valley integration).
- Calculate a preliminary concentration (Unadjusted C_5-C_8 aliphatic hydrocarbons) in µg/L using Equation 8.

Equation 8: Aqueous Samples: Calculation of Preliminary (Unadjusted) Sample Concentration of C_5-C_8 Aliphatic Hydrocarbons (µg/L)

$$\boxed{Conc\ HC\ Range(\mu g/L) = \frac{(A_x)(DF)}{(CF)}}$$

where:

A_x = total area count of all peaks eluting within hydrocarbon range window (excluding the surrogates)
CF_{avg} = average CF for hydrocarbon range
DF = dilution factor (see Section 9.5.7)

For soil/sediment samples, convert the µg/L value to µg/kg using Equation 9.

Equation 9: Soil/Sediment Samples: Conversion of µg/L to µg/kg

$$\boxed{Conc\ Analyte(\mu g/kg) = \frac{(Cx)(V_t)(V_w)}{(V_i)(W_d)}}$$

where:

Cx = Concentration from Equation 8 (µg/L)
V_t = Total volume of methanol extract, mL

Analytical Note: This volume must also include the volume of surrogate spiking solution added to soil/sediment samples (if ≥ 100 µL) and the volume of water added due to % moisture correction. See Section 9.6.4.

V_i = Volume of methanol extract added to reagent water for purge-and-trap analysis, µL
V_w = Volume of reagent water used for purge-and-trap analysis, µL
W_d = Dry weight of sample, g (see Equations 10 through 12)

NOTE: These values are reported as the "Unadjusted C_5-C_8 aliphatics" as shown in Appendix 3, Exhibit 1.

- From the Unadjusted concentration (µg/L or µg/kg), calculate the concentration of C_5-C_8 aliphatic hydrocarbons by subtracting the concentrations of Target VPH Analytes (which are quantified using the PID) which elute in this range (typically MTBE, benzene, and toluene for the C_5-C_8 aliphatic hydrocarbons). This is the final concentration reported as the "C_5-C_8 Aliphatic Hydrocarbons" on the data report form in Appendix 3, Exhibit 1.

9.6.2.2 C_9-C_{10} Aromatic Hydrocarbons: PID

- Sum all peaks in the appropriate retention time window, as specified in Section 9.3 and Table 5 (using baseline integration).

- From this sum, subtract the area counts of any surrogates which elute in this range (using valley-to-valley integration).

- Calculate the concentration in µg/L using Equation 8.

For soil/sediment samples, convert the µg/L value to µg/kg using Equation 9.

9.6.2.3 C_9-C_{12} Aliphatic Hydrocarbons: FID

- Sum all peaks in the appropriate retention time window, as specified in Section 9.3 and Table 5 (using baseline integration).

- From this sum, subtract the area counts of any surrogates which elute in this range (using valley-to-valley integration).

- Calculate a preliminary concentration (Unadjusted C_9-C_{12} aliphatic hydrocarbons) in µg/L using Equation 8.

  For soil/sediment samples, convert the µg/L value to µg/kg using Equation 9.

  NOTE: These values are reported as the "Unadjusted C_9-C_{12} aliphatics" as shown in Appendix 3, Exhibit 1.

- From the Unadjusted concentration (µg/L or µg/kg), calculate the concentration of C_9-C_{12} aliphatic hydrocarbons by subtracting the concentrations of C_9-C_{10} aromatic hydrocarbons (from the PID) and the Target VPH Analytes (which are quantified using the PID) which elute in this range (typically ethylbenzene, m & p-xylenes, and o-xylene for the C_9-C_{12} aliphatic hydrocarbons). This is the final concentration reported as the "C_9-C_{12} Aliphatic Hydrocarbons" on the data report form in Appendix 3, Exhibit 1.

9.6.3 Calculation of Dry Weight of Sample

In order to calculate the dry weight of sample purged (W_d), it is necessary to determine the moisture content of the soil/sediment sample, using the procedure outlined in Section 9.1.4. Using the data obtained from Section 9.1.4, W_d is calculated using Equations 10 through 12.

Equation 10: Percent Moisture

$$\boxed{\%\ Moisture = \frac{g\ wet\ sample - g\ dry\ sample}{g\ wet\ sample}\ X\ 100}$$

Equation 11: Percent Solids

$$\boxed{\%\ Dry\ Solids\ =\ (100)\ -\ (\%\ Moisture)}$$

Equation 12: Dry Weight of Sample

$$\boxed{W_d\,(g) = (\%\ \text{Dry Solids}/100)(\text{g of extracted sample})}$$

9.6.4 Data Correction for Target VPH Analyte and Range Calculations for Methanol Preservation Dilution Effect

Based on the requirements of SW-846 Method 8000D, Section 11.10.5, VPH analytical results for soil/sediment samples must be corrected for the Methanol Preservation Dilution Effect. The potential for under reporting Target VPH Analyte and hydrocarbon range concentrations is more pronounced as the "as-received" % moisture content of the soil/sediment sample increases, if this correction is neglected.

Target VPH Analyte and hydrocarbon range concentrations in soil/sediment samples preserved with methanol are subject to a systematic negative bias if the potential increase of the total solvent volume during the methanol extraction process is not considered. This increase in extraction solvent volume is a direct result of the solubility of the entrained sample moisture (water) in the methanol. The total solvent volume is the additive sum of the volume of methanol and the entrained sample moisture that partitions into the methanol during extraction. The volume of water partitioned is estimated from the % moisture determination (and the assumption that 1 g of water occupies a volume of 1 mL). This is a conservative correction regarding calculated VPH concentrations because some fraction of the sample's % moisture may not partition into the methanol, due to various physiochemical binding forces. The total solvent/water volume (Vt) is calculated as follows:

<u>Equation 13: Calculation of Solvent/Water Volume</u>

$$\boxed{\text{mL solvent/water (Vt)} \;=\; \text{mL of methanol} + ((\%\ \text{moisture}/100) \times \text{g of sample})}$$

This "corrected" Vt value should be substituted directly for the Vt value shown in Section 9.6, Equations 7 and 9. <u>It should be noted</u> that the Vt value used in Equations 7 or 9 to calculate VPH concentrations must also include the volume of surrogate spiking solution added to soil/sediment samples (if $\geq$ 100 µl).

10.0 QUALITY CONTROL

10.1 General Requirements and Recommendations

10.1.1 Each laboratory that uses this method is required to operate a formal quality control program. The minimum requirements of this program consist of an Initial Demonstration of Laboratory Capability (IDLC) and an ongoing analysis of prepared QC samples to evaluate and document the quality of data. The laboratory must maintain records to document the quality of the data produced. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance standards for the method.

10.1.2 At a minimum, for each analytical batch (up to 20 samples of similar matrix), a beginning Initial Calibration or Opening mid-range Continuing Calibration Standard, Closing mid-range Continuing Calibration Standard, LMB, LCS and LCSD must be analyzed. The Initial Calibration or Continuing Calibration Standard, LMB, and LCS must be analyzed prior to samples. Matrix duplicates, matrix spike and/or matrix spike duplicates should be analyzed, at the request of the data user, based upon the nature of the sample. For analytical batches with more than 10 samples, the analysis of an additional mid-range Continuing Calibration Standard should also be considered. However, it should be noted that the analysis of the Continuing Calibration Standard is required prior to sample analysis, after every 20 samples, and at the end of an analytical sequence, at a minimum.

10.1.3 The recommended sequence of analysis is as follows:

(1) Analytical Batch Calibration Standards (initial) or mid-range Continuing Calibration Standard (daily check of initial calibration). **[REQUIRED]**

(2) Initial Calibration Verification. **[REQUIRED only after initial calibration]**

(3) Analytical batch LCS. **[REQUIRED]**

(4) Analytical batch LCSD. **[REQUIRED; can instead be analyzed at end of sequence]**

(5) Analytical batch LMB. **[REQUIRED]**

(6) Batch samples. (up to 20 samples).

(7) Matrix duplicate. **[As requested by data user]**

(8) Matrix Spike/Matrix Spike Duplicate. **[As requested by data user]**

(9) <u>Optional</u> mid-range Continuing Calibration Standard. (consider after 10 samples)

(10) Analytical Batch LCS Duplicate. [a] **[REQUIRED]**

(11) Closing mid-range Continuing Calibration Standard [b] after 20 samples and at end of analytical batch. **[REQUIRED]**

[a] May be used as the analytical batch LCS for the next analytical batch if batches are processed continuously.

[b] May be used as analytical batch opening Continuing Calibration Standard for the next analytical batch if batches are processed continuously.

All analytical sequences and data must be recorded in a daily run log.

10.2 Minimum Instrument QC

10.2.1 The n-pentane (C_5) and MTBE peaks must be adequately resolved from any solvent front that may be present on the FID and PID chromatograms, respectively. This is achievable using the recommended chromatographic column and purge-and-trap procedures. Coelution of the m- and p-xylene isomers is permissible. All surrogates must be adequately resolved from individual Target VPH Analytes included in the VPH Component Standard. For the purposes of this method, adequate resolution is assumed to be achieved if the height of the valley between two peaks is less than 25% of the average height of the two peaks.

10.2.2 **Initial Calibration Verification** – An ICV standard, prepared from a separate source standard than used for initial and continuing calibrations must be analyzed immediately following the initial calibration. The recoveries of all Target VPH Analytes and hydrocarbon ranges must be between 70-130%. A new five-point calibration must be performed if >10% of all analytes are outside of criteria.

10.2.3 **Laboratory Method Blank** – A water or soil LMB is prepared by fortifying a reagent water blank (for aqueous samples), or 25 ml of methanol (for soil/sediment samples) with the surrogate spiking solution (using same volume of surrogate as samples). Peaks must not be detected above the RL within the retention time window of any analyte of interest. The hydrocarbon ranges must not be detected at a concentration greater than 10% of the most stringent applicable MCP cleanup standard for soil/sediment samples and 50% of the most stringent applicable MCP cleanup standard for aqueous samples.

10.2.4 **Relative Retention Times** must be established for each Target VPH Analyte and hydrocarbon range of interest each time a new GC column is installed and must be verified and/or adjusted on a daily basis. (See Sections 9.3 and 9.4.4).

10.2.5 **Calibration**

10.2.5.1 **Initial Calibration:** CFs must be calculated for each Target VPH Analyte and hydrocarbon range based upon the analysis of a minimum of 5 calibration standards. The linearity of CFs may be assumed if the %RSD over the working range of the calibration curve is ≤20 for Target VPH Analytes and the surrogate and ≤25 for hydrocarbon ranges. (See Section 9.4). For linear regression, r must be ≥ 0.99.

10.2.5.2 **Continuing Calibration Standard:** The Continuing Calibration Standard must be analyzed daily prior to sample analysis, every 20 samples, and at the end of an analytical sequence to verify the accuracy of the calibration of the instrument. For Target VPH Analytes and the surrogate, the %D or Percent Drift must be ≤20. For hydrocarbon ranges, the %D or Percent Drift must be ≤ 25. Greater %Ds or Percent Drifts are permissible for n-nonane (if included in the calibration of the C_9 – C_{12} aliphatic range). If the %D or Percent Drift is > 30 for n-nonane, note the nonconformance in the laboratory narrative. If more than one Target VPH Analyte or hydrocarbon range fails to meet this criterion, the instrument must be recalibrated. Otherwise, sample analysis may proceed.

10.2.6 **Laboratory Control Sample** – An LCS is prepared by fortifying a reagent water blank (for aqueous samples) or 25 mL of methanol (for soil/sediment samples) with the matrix spiking solution for a final concentration of 50 µg/L (2.5 mg/kg). The spike recoveries for the Target VPH Analytes and the hydrocarbon ranges must be between 70% and 130%.

- If the recoveries are low and outside of the acceptance limits, reanalyze the LCS and associated samples. If still outside of the acceptance limits, recalibrate.

- If the recoveries are high and outside of the acceptance limits and the affected compound was detected in the associated samples, reanalyze the LCS and the associated samples. If recoveries are still outside of the acceptance limits, recalibrate.

- If the recoveries are high and sample results were nondetect, data can be reported without qualification; however, the high recoveries should be noted in the laboratory narrative.

10.2.7 **LCS Duplicate** – The LCSD is prepared separately from the LCS but prepared and analyzed in the same manner as the LCS and is used as the data quality indicator of precision. The analytical batch precision is determined from the RPD of the concentrations (not recoveries) of the LCS/LCSD pair. The RPD for Target VPH Analytes and aliphatic and aromatic hydrocarbon range concentrations must be $\leq$ 25. See Section 10.2.6 for corrective actions associated with recoveries outside of acceptance limits.

10.2.8 **Surrogate Spike Recoveries**

10.2.8.1 Each sample, LMB, LCS, LCSD, matrix spike, and matrix duplicate must be fortified with the surrogate spiking solution. Required surrogate recovery is 70% to 130% from each detector. At a minimum, when surrogate recovery from a sample, blank, or QC sample is less than 70% or more than 130%, check calculations to locate possible errors, check the fortifying solution for degradation, and check for changes in instrument performance. If the cause cannot be determined, reanalyze the sample unless one of the following exceptions applies:

(1) Obvious interference is present on the chromatogram (e.g., unresolved complex mixture);
(2) Percent moisture of associated soil/sediment sample is > 25% and surrogate recovery is > 10%; or
(3) The surrogate exhibits high recovery and associated target analytes or hydrocarbon ranges are not detected in sample.

If a sample with a surrogate recovery outside of the acceptable range is not reanalyzed based on any of these aforementioned exceptions, this information must be noted on the data report form and discussed in the laboratory narrative.

Analysis of the sample on dilution may diminish matrix-related surrogate recovery problems. This approach can be used as long as the RL for the applicable MCP standards will still be achieved with the dilution. If not, reanalysis without dilution must be performed unless the concentrations of target analytes do not allow an undiluted run. Recoveries of surrogates outside of the acceptable range after reanalysis must also be noted on the data report form and discussed in the laboratory narrative.

10.3 At the request of the data user, and in consideration of sample matrices and data quality objectives, matrix spikes and matrix duplicates may be analyzed with every batch of 20 samples or less per matrix.

10.3.1 **Matrix Duplicate** – Matrix duplicates are prepared by analyzing one sample in duplicate. The purpose of the matrix duplicates is to determine the homogeneity of the sample matrix as well as analytical precision. The RPD of detected results in the matrix duplicate samples must not exceed 50 when the results are greater than 5x the RL. Refer to Equation 14 for the RPD calculation. If the RPD exceeds 50 and both results are > 5x the RL, the sample analysis must be repeated.

- If an analyte is detected in one analysis at > 5x the RL and not detected in the duplicate analysis, the analysis must be repeated.
- If an analyte is detected in one analysis at $\leq$ 5x the RL and not detected in the duplicate analysis, the RPD is not calculable and the analysis does not have to be repeated.
- If an analyte is not detected in both the original and duplicate analyses, the RPD is not calculable. No further action is required.

Equation 14. Relative Percent Difference Calculation

$$\boxed{RPD = [(C_s - C_d)/[(C_s + C_d)/2]]*100}$$

where:

C_s = concentration in original sample analysis
C_d = concentration in duplicate sample analysis

10.3.2 **Matrix Spike/Matrix Spike Duplicate** – The aqueous or soil/sediment matrix spike is prepared by fortifying an actual aqueous sample or soil/sediment sample with a specified volume (5-10 µl for aqueous samples and not to exceed 1.0 ml for soil/sediment samples) of the matrix spiking solution (see Section 7.6). The desired spiking level is 50% of the highest calibration standard. However, the total concentration in the matrix spike (including the matrix spike and native concentration in the unspiked sample) should not exceed 75% of the highest calibration standard in order for a proper evaluation to be performed. The purpose of the matrix spike is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate unspiked aliquot and the measured values in the matrix spike corrected for background concentrations. The corrected concentrations of each analyte within the matrix spiking solution must be within 70-130% of the true value.

10.4 If any of the performance standards specified in Section 10.2 are not met, the cause of the non-conformance must be identified and corrected before any additional samples may be analyzed. Any samples run between the last QC samples that met the criteria and those that are fallen out must be reanalyzed, as noted in Section 10.2. These QC samples include the Continuing Calibration Standard, LMB, LCS, and LCSD. If this is not possible, the data must be reported as suspect.

10.5 Initial and Periodic Method Demonstration of Laboratory Capability (IDLC)

The QC procedures described in Appendix 7 and described in SW-846 Method 8000D, Section 9.3 must be conducted, successfully completed, and documented as an initial demonstration of laboratory capability, prior to the analysis of any samples by the VPH by GC/PID/FID Method. Subsequent to this initial demonstration, additional evaluations of this nature should be conducted on a periodic basis, in response to changes in instrumentation or operations, training new analysts and/or in response to confirmed or suspected systems, method, or operational problems. Elements of the IDLC include:

- Demonstration of Acceptable System Background, see Appendix 7, Section 2.0 (Optional);
- Initial Demonstration of Accuracy, see Appendix 7, Section 3.0;
- Initial Demonstration of Precision, see Appendix 7, Section 4.0; and
- Method Detection Limit (MDL), see Appendix 7, Section 5.0 (Optional).

11.0 DATA PRODUCTION AND REPORTING

11.1 Calibration

Using the external calibration procedure (See Section 9.4.2) calibrate the GC/PID/FID as follows:

11.1.1 Using the PID chromatogram, calculate an average CF or linear regression calibration curve for the Target VPH Analytes (benzene, toluene, ethylbenzene, m,p,o-xylenes, naphthalene, and MTBE). This step is not necessary if these Target VPH Analytes will not be individually identified and quantitated by the VPH method (i.e., if unadjusted values only will be reported for the hydrocarbon ranges or if reporting concentrations of Target VPH Analytes via another method).

11.1.2 Using both the FID and PID chromatograms, calculate an average CF for the surrogate 2,5-dibromotoluene.

11.1.3 Using the FID chromatogram, calculate an average collective CF for the total concentration of the C_5-C_8 Aliphatic Hydrocarbons. Tabulate the collective peak area response of the 3 components (n-pentane, 2-methylpentane, 2,2,4-trimethylpentane) against the collective concentration injected.

11.1.4 Using the FID chromatogram, calculate an average collective CF for the total concentration of C_9-C_{12} Aliphatic Hydrocarbons. Tabulate the collective peak area response of the 2 components (n-decane and n-butylcyclohexane) against the collective concentration injected. Alternatively, the CF for C_9-C_{12} Aliphatic Hydrocarbons can be calculated using the collective area response of 3 components (n-nonane, n-decane and n-butylcyclohexane).

11.1.5 Using the PID chromatogram, calculate an average collective CF for the total concentration of C_9-C_{10} Aromatic Hydrocarbons. This value is the value for 1,2,4-trimethylbenzene, the only aromatic standard within this range.

11.2 Sample Analysis

11.2.1 PID Chromatogram

11.2.1.1 If desired, determine the peak area counts for the Target VPH Analytes (using valley-to-valley integration).

11.2.1.2 Determine the peak area count for the surrogate 2,5-dibromotoluene (using valley-to-valley integration).

11.2.1.3 Determine the total area count for all peaks eluting 0.1 minutes after the Rt for o-xylene and 0.1 minutes before the Rt for naphthalene (using baseline integration).

11.2.1.4 Using the equations contained in Section 9.6, calculate the concentrations of the surrogate standard 2,5-dibromotoluene and C_9 through C_{10} Aromatic Hydrocarbons. Optionally, calculate the concentrations of the individual Target VPH Analytes.

11.2.2 FID Chromatogram

11.2.2.1 Determine the total area count for all peaks eluting 0.1 minutes before the Rt for n-pentane and 0.01 minutes before the Rt for n-nonane (using baseline integration). It is not necessary to identify or quantitate individual aliphatic compounds within this range.

11.2.2.2 Determine the total area count for all peaks eluting 0.01 minutes before the Rt for n-nonane and 0.1 before the Rt for naphthalene (using baseline integration). It is not necessary to identify or quantitate individual aliphatic compounds within this range.

11.2.2.3 Determine the peak area count for the surrogate standard 2,5-dibromotoluene (using valley-to-valley integration).

11.2.2.4 Using the equations contained in Section 9.6, calculate the concentrations of C_5 through C_8 Aliphatic Hydrocarbons, C_9 through C_{12} Aliphatic Hydrocarbons, and the surrogate standard 2,5-dibromotoluene.

11.2.3 Data Adjustments

11.2.3.1 By definition, the collective concentrations of aliphatic and aromatic fractions of interest **exclude** the individual concentrations of Target VPH Analytes. Accordingly, a series of data adjustment steps are necessary to adjust the collective hydrocarbon range concentrations calculated in Section 11.2.2.4, to eliminate “double counting” of analytes.

11.2.3.2 The necessary data adjustment steps may be taken by the laboratory reporting the range concentration data, or by the data user. The extent of data adjustments taken by the laboratory must be noted on the data report form.

11.2.3.2.1 Subtract the area counts of the surrogate compound(s) from the collective area count of any range in which they elute. If the recommended surrogate 2,5-dibromotoluene is used, no correction is necessary, as this compound elutes after all ranges of interest.

11.2.3.2.2 Subtract the collective concentration of C_9-C_{10} Aromatic Hydrocarbons from the collective concentration of C_9-C_{12} Aliphatic Hydrocarbons. Do not subtract the C_9-C_{10} Aromatic Hydrocarbon concentration if this concentration is less than the RL. If the resulting C_9–C_{12} Aliphatic Hydrocarbon value is less than the RL, report "< RL" or "RL U", with a specific value replacing "RL" (e.g., "< 10" or "10 U").

11.2.3.2.3 Subtract the individual concentrations of the Target VPH Analytes from the appropriate aliphatic range (i.e., C_5-C_8 or C_9-C_{12} Aliphatic Hydrocarbons) in which they elute. Do not subtract any Target VPH Analyte concentration if this concentration is less than the RL (lowest calibration standard). If the individual concentrations of Target VPH Analytes have been quantitated using another method (e.g., by using an MS detector), note this on the data report form. If the individual concentrations of Target VPH Analytes have not been quantitated, report the values as Unadjusted C_5-C_8 Aliphatic Hydrocarbons and Unadjusted C_9-C_{12} Aliphatic Hydrocarbons, and indicate "Not Determined" for C_5-C_8 Aliphatic Hydrocarbons and C_9-C_{12} Aliphatic Hydrocarbons.

11.2.3.3 For purposes of compliance with the reporting and cleanup standards specified in the MCP, the concentration of Unadjusted C_5-C_8 Aliphatic Hydrocarbons and Unadjusted C_9-C_{12} Aliphatic Hydrocarbons may be conservatively deemed to be equivalent to the concentration of C_5-C_8 Aliphatic Hydrocarbons and C_9-C_{12} Aliphatic Hydrocarbons.

11.3 Data Reporting Content

The required content for VPH Method by GC/PID/FID data is presented in Appendix 3. This information provides data users with a succinct and complete summary of pertinent information and data, as well as a clear affirmation that the QC procedures and standards specified in this method were evaluated and achieved. Any significant modification to the MassDEP VPH by GC/PID/FID Method, as described in Section 11.3.1, and indicated by a negative response to Question E on the MassDEP Analytical Protocol Certification Form (also included in Appendix 3) precludes the affected data from achieving "Presumptive Certainty" status. If a significant modification to the VPH by GC/PID/FID Method is utilized, an attachment to the analytical report must be included to demonstrate compliance with the method performance requirements of Section 1.13 on a matrix- and petroleum product-specific basis.

While it is permissible to modify the reporting format, all of the data and information specified in Appendix 3 for these reports must be provided in a clear, concise, and succinct manner.

11.3.1 "Significant Modifications" to this method are defined as any deviations from "required," "shall," or "must" provisions of this document, or any change or modification that will or could substantively change the accuracy or precision of analytical results. Such modifications include, but are not limited to, any of the following:

11.3.1.1 The use of alternative detectors other than GC/PID/FID to quantitate hydrocarbon range concentrations;
11.3.1.2 The use of other than a purge-and-trap sample preparation procedure;
11.3.1.3 The use of a heated purge;

11.3.1.4 The use of non-linear repression (i.e., quadratic equations) for the calculation of Target VPH Analytes and/or hydrocarbon ranges; or

11.3.1.5 Failure to provide all of the data and information presented in Appendix 3 as well as the required method deliverables discussed in Section 11.3.3.

11.3.2 Positive affirmation that all required QC procedures and performance standards were followed and achieved means that all of the required steps and procedures detailed in Sections 9.0 and 10.0 have been followed, and that all data obtained from these steps and procedures were within the acceptance limits specified for these steps and procedures.

11.3.3 In addition to sample results, the VPH data report must contain the following items:

- LMB Results
- LCS Results
- LCSD Results
- Matrix spike and/or matrix spike duplicate results (only if requested by data user)
- Matrix duplicate results (only if requested by data user)
- Surrogate spike recoveries (for all field samples and QC samples from each detector)
- Summary of column used (manufacturer, column name, length, ID, film thickness)
- Summary of trap used (manufacturer, trap contents)
- Results of reanalyses or dilutions, reported as follows:
    1. If reanalysis due to surrogate issues yields similar non-conformances, the laboratory must report results of both analyses.
    2. If reanalysis due to surrogate issues is performed outside of holding time and yields acceptable surrogate recoveries, the laboratory must report results of both analyses.
    3. If sample is not reanalyzed for surrogate issues due to obvious interference, the laboratory must provide the chromatogram in the data report.
    4. If diluted and undiluted analyses are performed, the laboratory must report results for the lowest dilution within the valid calibration range for each analyte. The associated QC (e.g., LMBs, LCS, etc.) for each analysis must be reported. This may result in more than one analysis per sample being reported.

11.3.4 General laboratory reporting requirements are outlined in WSC-CAM-VII A, *Quality Assurance and Quality Control Guidelines for the Acquisition and Reporting of Analytical Data*. A copy of the required MassDEP MCP Analytical Protocol Certification Form is included in Appendix 3 of this method.

12.0 REPORTING LIMITS

The RLs for Target VPH Analytes shall be based upon the concentration of the lowest calibration standard for the analyte of interest. The RL must be greater than or equal to the concentration of the lowest calibration standard.

The RLs for hydrocarbon ranges shall be based upon the concentration of the lowest calibration standard for an individual analyte within the range of interest. The RL will be set at 100x the concentration of the lowest calibration standard for the associated analyte.

Based on a concentration of 1 µg/L for the lowest calibration standard for all analytes, the following RLs would be generated for the hydrocarbon ranges:

<u>Aqueous Samples:</u> Hydrocarbon range RLs would be equivalent to 100 µg/L.

Soil/Sediment Samples: Hydrocarbon range RLs would be equivalent to 5 mg/kg based on a 1:1 ratio of methanol: soil and analysis of a 100 µL aliquot of the methanol extract in 5 mL water.

13.0 METHOD PERFORMANCE

Single laboratory accuracy, precision and MDL data for method analytes are provided in Tables 1-1 through 1-2 in Appendix 1. Chromatograms are provided in Appendix 2. For an evaluation of method performance, refer to *Evaluation of MassDEP Volatile Petroleum Hydrocarbon (VPH) Methods*, Massachusetts Department of Environmental Protection, June 2016.

14.0 REFERENCES

1. American Petroleum Institute *Laboratory Study on Solubilities of Petroleum Hydrocarbons in Groundwater*, August 1985, API Publ. 4395.

2. ASTM *Standard Practice for Sampling Waste and Soils for Volatile Organics* Draft #1, 2/16/87.

3. ASTM Method D2216-92, *Determination of Moisture Content of Soils and Sediments.*

4. Fitzgerald, John *Onsite Analytical Screening of Gasoline Contaminated Media Using a Jar Headspace Procedure* in Petroleum Contaminated Soils, Vol. 2, 1989.

5. Hughes, B. M., D. E. McKenzie, C. K. Trang, L. S. R. Minor, *Examples of the Use of an Advances Mass Spectrometric Data Processing Environment for the Determination of Sources of Wastes* in Fifth Annual Waste Testing and Quality Assurance Symposium; USEPA, July 24-28, 1989.

6. *Leaking Underground Fuel Tank (LUFT) Field Manual*, State Water Resources Control Board, State of California, Sacramento, CA, May 1988.

7. MassDEP, 1994: Interim *Final Petroleum Report: Development of Health-Based Alternative to the Total Petroleum Hydrocarbon (TPH) Parameter*, Massachusetts Department of Environmental Protection, August 1994.

8. MassDEP, 1998: *Report on Results of the Fall 1997 VPH/EPH Round Robin Testing Program*, Massachusetts Department of Environmental Protection, January 12, 1998.

9. MassDEP, 2002: *Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MADEP VPH/EPH Approach*, Massachusetts Department of Environmental Protection, WSC Policy # 02-411, October 31, 2002.

10. MassDEP, 2003: *Updated Petroleum Hydrocarbon Fraction Toxicity Values For VPH/EPH/APH Methodology*, Massachusetts Department of Environmental Protection, November 2003.

11. MassDEP, 2016: *Evaluation of MassDEP Volatile Petroleum Hydrocarbon (VPH) Methods*, Massachusetts Department of Environmental Protection, June 2016.

12. Parr, J. L., G. Walters, and M. Hoffman, *Sampling and Analysis of Soils for Gasoline Range Organics* presented at First Annual West Coast Conference Hydrocarbon Contaminated Soils and Groundwater, 2/21/90.

13. Senn, R. B., and M. S. Johnson, *Interpretation of Gas Chromatographic Data in Subsurface Hydrocarbon Investigations*, Ground Water Monitoring Review, 1987.

14. Siegrist, R. L. and P.D. Jenssen, *Evaluation of Sampling Method Effects on Volatile Organic Compound Measurements in Contaminated Soils*, Environmental Science and Technology, Vol. 24, November 9, 1990.

15. Urban, M. J., J. S. Smith, E. K/ Schultz, R. K. Dickson, *Volatile Organic Analysis for a Soil Sediment or Waste Sample* in Fifth Annual Waste Testing and Quality Assurance Symposium; USEPA, July 24-28, 1989.

16. USEPA UST Workgroup, Draft *Method for Determination of Gasoline Range Organics*, November, 1990.

17. USEPA, *Measurements of Petroleum Hydrocarbons: Report on Activities to Develop a Manual*; Prepared by Midwest Research Institute, Falls Church, VA under EPA Contract No. 68-WO-0015, WA No. 4; Submitted to USEPA Office of Underground Storage Tanks; Washington, DC; November 20, 1990.

18. USEPA, *Guidance on Evaluation, Resolution, and Documentation of Analytical Problems Associated with Compliance Monitoring*, EPA 821-B-93-001; U.S. Government Printing Office, Washington D.C., June, 1993.

19. USEPA: SW-846 Test Methods for Evaluating Solid Waste, 3rd Edition; Methods 5030B, 5035A, 8000D, 8015C, and 8021B.

20. Wisconsin DNR, *Modified GRO Method for Determining Gasoline Range Organics*, PUBL-SW-140, 1992.

TABLES

Table 1. Volatile Petroleum Hydrocarbon (VPH) Component Standard

Compound	Retention Time (minutes)[1]	
	PID	FID
n-Pentane	N/A	5.11
2-Methylpentane	N/A	6.68
Methyl-tert-butylether	7.26	7.26
2,2,4-Trimethylpentane	N/A	11.25
Benzene	12.24	12.24
Toluene	18.06	18.06
n-Nonane	N/A	22.59
n-Decane	N/A	26.98
Ethylbenzene	23.12	23.12
m- & p- Xylene	23.37	23.37
o-Xylene	24.78	24.78
1,2,4-Trimethylbenzene	28.34	28.34
n-Butylcyclohexane	N/A	28.52
Naphthalene	32.03	N/A
2,5-Dibromotoluene (surrogate)	33.78	33.78

[1] Results obtained using an RTX-502.2 column and chromatographic conditions described in Appendix 2

Table 2a. Recommended VPH Calibration Standard Concentrations

Component	Nominal Concentration (µg/L)				
Pentane	1	5	25	100	200
2-Methylpentane	1	5	25	100	200
Methyl-t-butyl ether	1	5	25	100	200
2,2,4-Trimethylpentane	1	5	25	100	200
Benzene	1	5	25	100	200
Toluene	1	5	25	100	200
n-Nonane[1]	1	5	25	100	200
n-Decane	1	5	25	100	200
Ethylbenzene	1	5	25	100	200
m-Xylene	1	5	25	100	200
p-Xylene	1	5	25	100	200
o-Xylene	1	5	25	100	200
1,2,4-Trimethylbenzene	1	5	25	100	200
n-Butylcyclohexane	1	5	25	100	200
Naphthalene	1	5	25	100	200
2,5-Dibromotoluene (surrogate)	1	5	25	100	200

[1] Erratic performance has been noted for n-nonane; calibration of C_9-C_{12} aliphatics with n-decane and n-butylcyclohexane only is allowed. However, n-nonane must be retained in the calibration standard for use as a range marker compound (see Table 5).

Table 2b. Initial Calibration of VPH Hydrocarbon Range Components

Hydrocarbon Range	Hydrocarbon Range Compounds Used to Establish Range Calibration Factor	Calib. Level	Component Standard Calibration Concentration	
			Individual Range Component Concentration (µg/L)	Hydrocarbon Range Total Concentration (µg/L)
C_5-C_8 Aliphatic	n-Pentane 2-Methylpentane 2,2,4-Trimethylpentane	1	1	3
		2	5	15
		3	25	75
		4	100	300
		5	200	600
C_9-C_{12} Aliphatic	n-Nonane[1] n-Decane n-Butylcyclohexane	1	1	3
		2	5	15
		3	25	75
		4	100	300
		5	200	600
C_9-C_{10} Aromatic	1,2,4-Trimethylbenzene	1	1	1
		2	5	5
		3	25	25
		4	100	100
		5	200	200

[1] Erratic performance has been noted for n-nonane; calibration of C_9-C_{12} aliphatics with n-decane and n-butylcyclohexane only is allowed. However, n-nonane must be retained in the calibration standard for use as a range marker compound (see Table 5). Hydrocarbon range total concentrations provided above assume n-nonane is included in the calibration of this range.

Table 3. Holding Times and Preservatives for VPH Samples

Matrix	Container	Preservation	Holding Time
Aqueous Samples (using ambient temperature purge)	40-mL VOC vials w/ Teflon-lined septa screw caps	Add 3 to 4 drops of 1:1 HCl to pH <2; cool to 0-6°C	14 days
Aqueous Samples (using heated purge)[1]	40-mL VOC vials w/ Teflon-lined septa screw caps	Add 0.40 to 0.44 grams of trisodium phosphate dodecahydrate to pH >11; cool to 0-6°C	14 days
Soil/Sediment Samples[2]	VOC vials w/ Teflon-lined septa screw caps. 60-mL vials: add 25 g soil/sediment 40-mL vials: add 15 g soil/sediment	1 mL methanol for every g soil/sediment; add before or at time of sampling; cool to 0-6°C	28 days

[1] Heated purge is considered a significant modification to the method, as per Section 11.3.1.
[2] Refer to Appendix 4 for details on sample collection or optional collection/storage devices.

Table 4. Recommended Purge-and-Trap Operating Parameters

Purge gas	Helium
Purge gas flow rate (mL/min)	40
Purge time (min)	11.0 ± 0.1
Purge temperature	Ambient*
Desorb temperature °C	260
Desorb time (min)	4.0
Backflush inert gas flow during desorb (mL/min)	15-20
Bake temperature (°C)	260
Bake time (min)	7-15

* If heated purge temperature is used, different preservation procedures apply; see Table 3. Heated purge is considered a significant modification to the method, as per Section 11.3.1.

Table 5. VPH Marker Compounds and Range Retention Time Windows

Hydrocarbon Range	**Beginning Marker**	**Ending Marker**
C_5-C_8 Aliphatic Hydrocarbons (FID)	0.1 min before n-Pentane	0.01 min before n-Nonane
C_9-C_{12} Aliphatic Hydrocarbons (FID)	0.01 min before n-Nonane	0.1 min before Naphthalene[1]
C_9-C_{10} Aromatic Hydrocarbons (PID)	0.1 min after o-xylene	0.1 min before Naphthalene

[1] The retention time for Dodecane (C_{12}) is approximately 2 minutes less than the retention time for naphthalene, using the column and chromatographic conditions recommended for this method. For simplicity, naphthalene is used as the ending marker for the C_9-C_{12} Aliphatic Hydrocarbon range.

APPENDIX 1

SINGLE LABORATORY ACCURACY, PRECISION, AND METHOD DETECTION LIMITS (MDL) DATA

Table 1-1. Single Laboratory Accuracy, Precision, and Method Detection Limits (MDLs) for Compounds in Component Standard Spiked Into Reagent Water and Analyzed by the VPH Method

Compound	Spiked Conc. (µg/L)	Method Accuracy[a] (Mean % Recovery[b])		Method Precision[a] (RSD[c] - %)		MDL[a] (µg/L)	
		PID[d]	FID[e]	PID	FID	PID	FID
n-Pentane	6.0		91		6.3		1.1
2-Methylpentane	8.0		100		8.6		2.2
Methyl-tert-butylether	3.0	95		5.2		0.47	
2,2,4-Trimethylpentane	4.0		98		11.9		1.5
Benzene	1.0	91		7.5		0.21	
Toluene	3.0	93		6.2		0.55	
n-Nonane	2.0		98		7.2		0.44
Ethylbenzene	1.0	92		5.6		0.16	
m- & p-Xylene	4.0	95		5.2		0.62	
o-Xylene	2.0	86		14.8		0.81	
1,2,4-Trimethylbenzene	2.0	89		6.1		0.34	
Naphthalene	4.0	113		11.1		1.57	
2,5-Dibromotoluene (surrogate)	40	90	90	10.9	13.3		

[a] Based on analysis of seven samples spiked with component standard.
[b] Recovery (%) of spiked concentration.
[c] RSD = relative standard deviation (%) of mean concentration measured.
[d] PID = photoionization detector.
[e] FID = flame ionization detector.

Table 1-2. Single Laboratory Accuracy, Precision, and Method Detection Limits (MDLs) for Compounds in Component Standard Spiked Into VPH-Free Sand and Analyzed by the VPH Method

Compound	Spiked Conc. (µg/g)	Method Accuracy[a] (Mean % Recovery[b])		Method Precision[a] (RSD[c] - %)		MDL[a] (µg/g)	
		PID[d]	FID[e]	PID	FID	PID	FID
n-Pentane	2		96		4.7		0.28
2-Methylpentane	3		99		5.1		0.47
Methyl-tert-butylether	3	89		4.7		0.39	
2,2,4-Trimethylpentane	3		110		2.1		0.22
Benzene	1	100		4.5		0.14	
Toluene	3	104		4.3		0.42	
n-Nonane	2		108		3.6		0.25
Ethylbenzene	1	103		5.0		0.16	
m- & p-Xylene	4	101		4.0		0.51	
o-Xylene	2	106		4.3		0.28	
1,2,4-Trimethylbenzene	2	103		3.8		0.25	
Naphthalene	2	86		2.8		0.15	
2,5-Dibromotoluene (surrogate)	2	95		11.4		0.68	

[a] Based on analysis of seven samples spiked with component standard.
[b] Recovery (%) of spiked concentration.
[c] RSD = relative standard deviation (%) of mean concentration measured.
[d] PID = photoionization detector.
[e] FID = flame ionization detector.

APPENDIX 2

VPH BY GC/PID/FID METHOD CHROMATOGRAMS

Gas Chromatograms of the VPH Component Standard

Restek RTX-502.2 capillary column (105 m x 0.53 mm i.d., 3-µm film thickness); PID (10.2 eV) in series with FID; GC operating conditions: 45°C for 2 min/ 3°C/min to 90°C for 0 min/ 5°C/min to 140°C for 0 min/ 45°C/min to 230°C for 6.5 min.

Figure 1. FID Chromatogram

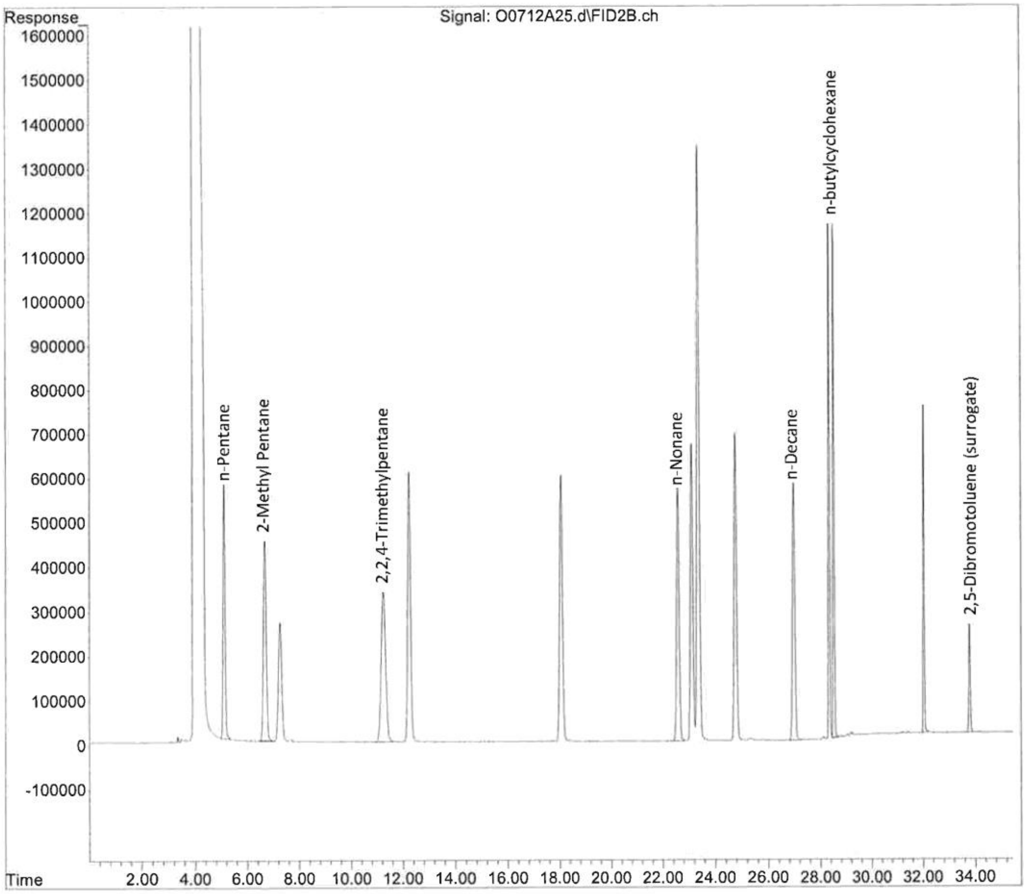
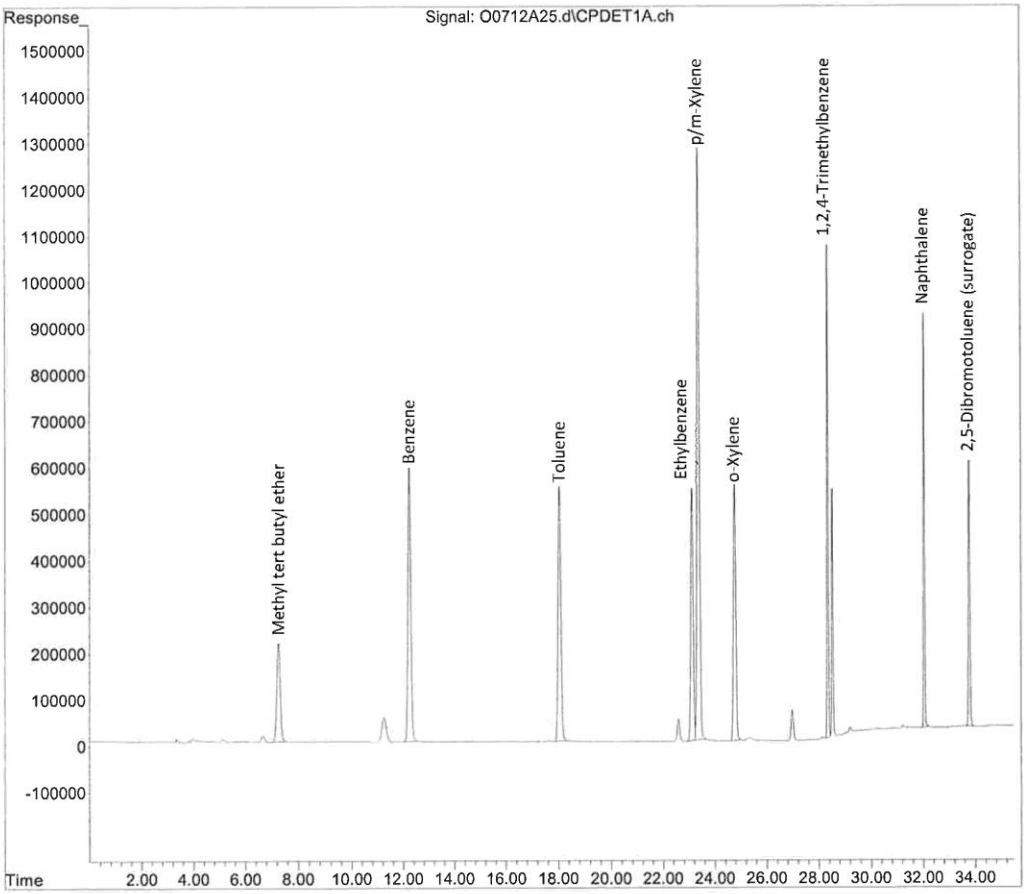


Figure 2. PID Chromatogram



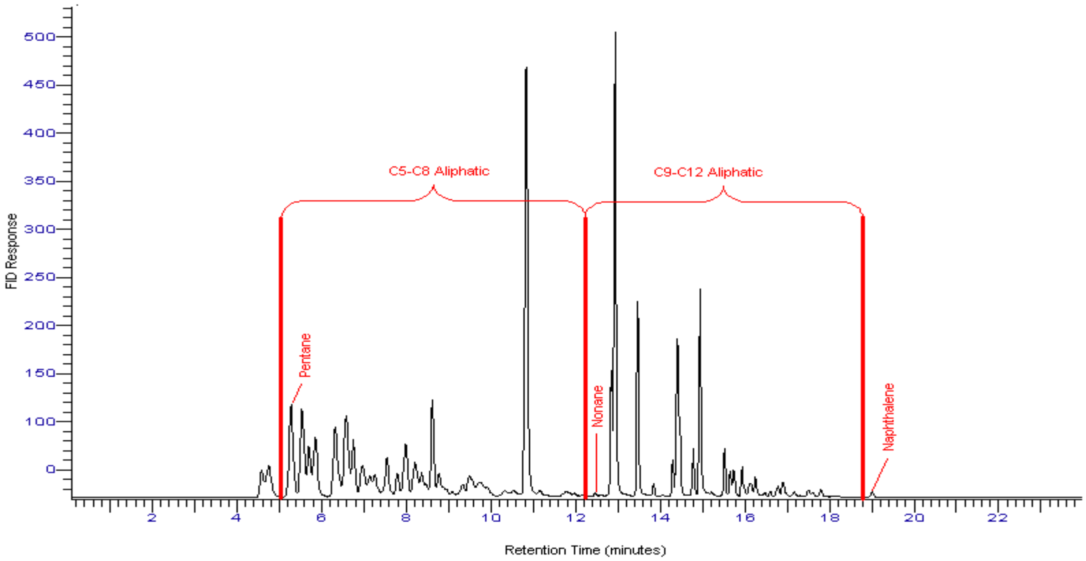


Figure 3 Gas Chromatogram (FID) of the VPH Gasoline Standard

Restek RTX-502.2 capillary column (105-m x 0.53-mm i.d., 3-µm film thickness); PID detector (10.2-eV lamp) in series with an FID detector (O.I. Analytical); Tekmar (model 3000) purge-and-trap concentrator.

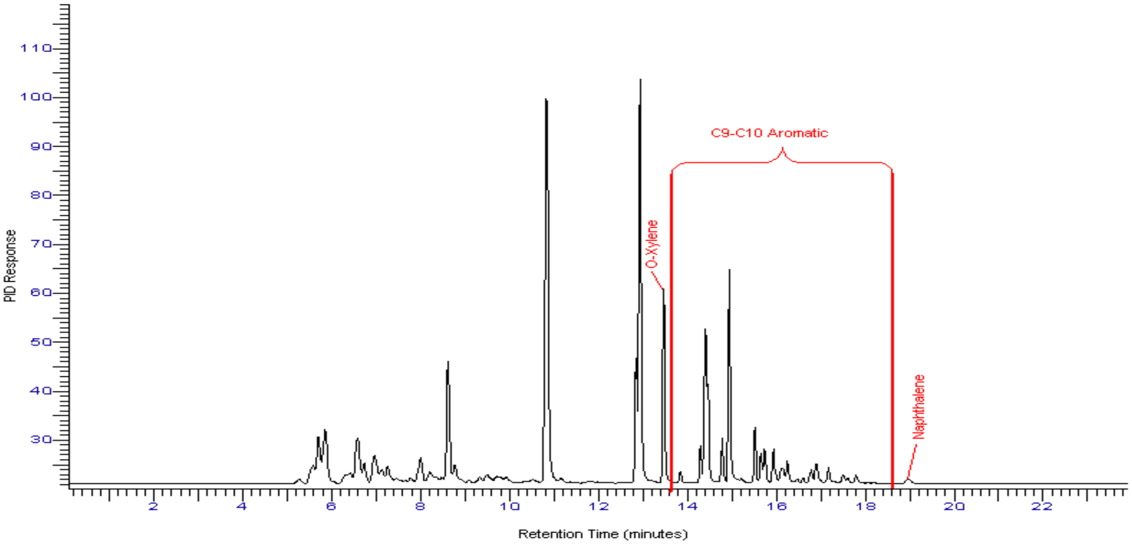


Figure 4. Gas Chromatogram (PID) of the VPH Gasoline Standard

Restek RTX-502.2 capillary column (105-m x 0.53-mm i.d., 3-µm film thickness); PID detector (10.2-eV lamp) in series with an FID detector (O.I. Analytical); Tekmar (model 3000) purge-and-trap concentrator.

APPENDIX 3

REQUIRED VPH DATA REPORT INFORMATION

Exhibit 1 Required VPH Data Report Information

Exhibit 2 MassDEP Analytical Protocol Certification Form

APPENDIX 3
Exhibit 1: Required VPH Data Report Information

SAMPLE INFORMATION

Matrix	☐ Aqueous ☐ Soil ☐ Sediment ☐ Other:		
Containers	☐ Satisfactory ☐ Broken ☐ Leaking:		
	Aqueous (acid-preserved)	☐ N/A ☐ pH ≤ 2 ☐ pH > 2 Comment:	
	Aqueous (TSP-preserved)	☐ N/A ☐ pH ≤ 11 ☐ pH > 11 Comment:	
Sample	Soil or	☐ N/A ☐ Samples NOT preserved in Methanol or air-tight container	mL Methanol/g soil/sediment
Preservatives	Sediment	☐ Samples rec'd in Methanol: ☐ covering soil/sediment ☐ not covering soil/sediment	☐ 1:1 +/- 25%
		☐ Samples received in air-tight container:	☐ Other:
Temperature	☐ Received on Ice ☐ Received at 0-6ºC ☐ Other: _______ºC		

VPH ANALYTICAL RESULTS

Method for Ranges: ☐VPH by GC PID/FID ☐VPH by GC/MS		**Client ID**					
Method for Target Analytes:☐VPH by GC PID/FID ☐VPH by GC/MS ☐VOCs by 8260		**Lab ID**					
Trap & Analytical Column		**Date Collected**					
		Date Received					
		Date Preserved[4]					
VPH Surrogate Standards		**Date Analyzed**					
		Dilution Factor					
		% Moisture (soil/sediment)					
Range/Target Analyte	**Elution Range**	**RL**	**Units**				
Unadjusted C5-C8 Aliphatics[1]	N/A						
Unadjusted C9-C12 Aliphatics[1]	N/A						
Benzene							
Ethylbenzene							
Methyl-tert-butylether							
Naphthalene	N/A						
Toluene							
m- & p- Xylenes							
o-Xylene							
C5-C8 Aliphatic Hydrocarbons[1,2]	N/A						
C9-C12 Aliphatic Hydrocarbons[1,3]	N/A						
C9-C10 Aromatic Hydrocarbons[1]	N/A						
Surrogate % Recovery							
Surrogate Acceptance Range				70-130%	70-130%	70-130%	70-130%

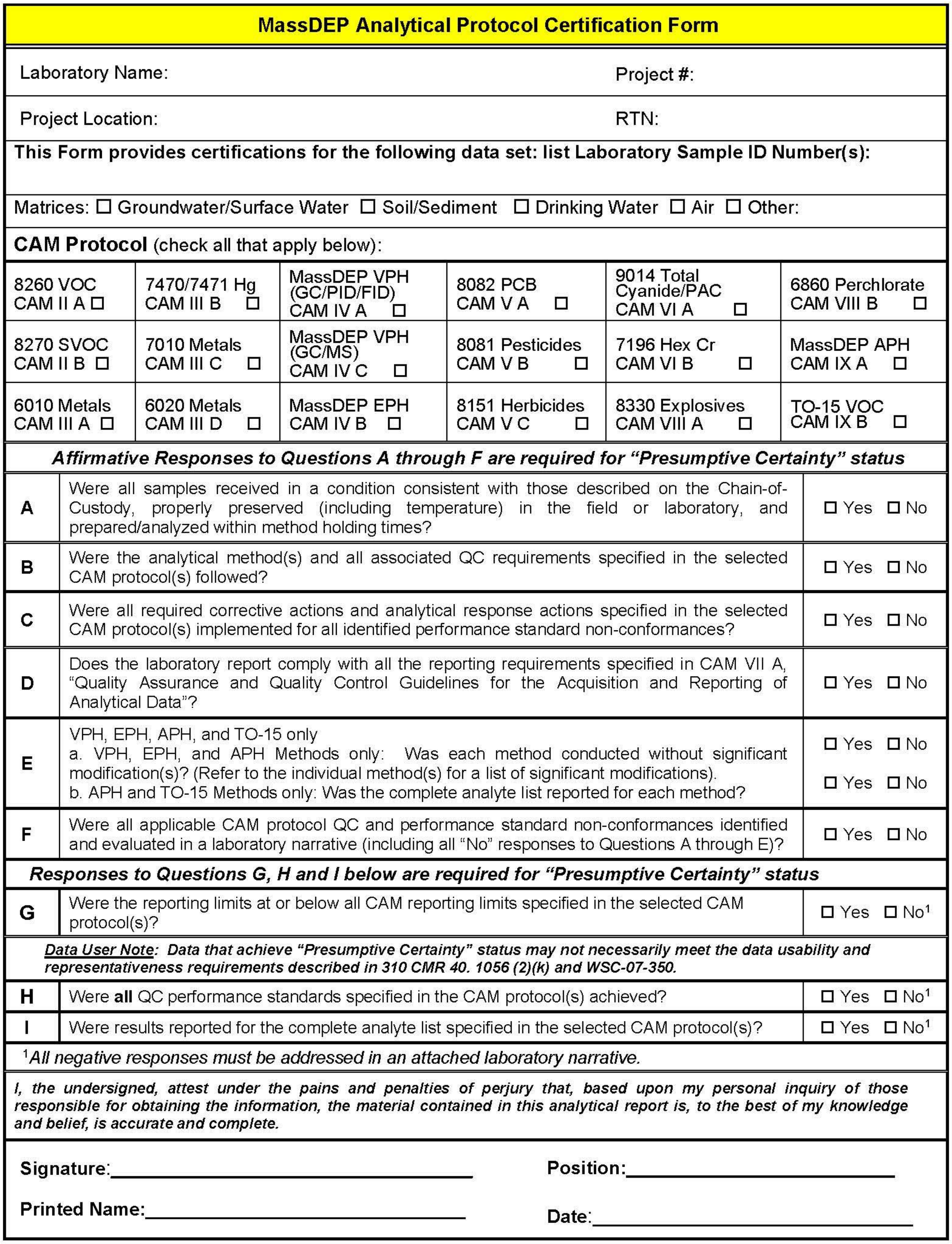
[1] Hydrocarbon range data exclude area counts of any surrogate(s) and/or internal standards eluting in that range.

[2] C_5-C_8 Aliphatic Hydrocarbons exclude the concentration of Target VPH Analytes eluting in that range.

[3] C_9-C_{12} Aliphatic Hydrocarbons exclude concentration of Target VPH Analytes eluting in that range AND concentration of C_9-C_{10} Aromatic Hydrocarbons.

[4] Only applies to soil samples collected in air-tight containers.

APPENDIX 3
Exhibit 2: MassDEP Analytical Protocol Certification Form



MassDEP Analytical Protocol Certification Form

Laboratory Name:	Project #:
Project Location:	RTN:

This Form provides certifications for the following data set: list Laboratory Sample ID Number(s):

Matrices: ☐ Groundwater/Surface Water ☐ Soil/Sediment ☐ Drinking Water ☐ Air ☐ Other:

CAM Protocol (check all that apply below):

8260 VOC CAM II A ☐	7470/7471 Hg CAM III B ☐	MassDEP VPH (GC/PID/FID) CAM IV A ☐	8082 PCB CAM V A ☐	9014 Total Cyanide/PAC CAM VI A ☐	6860 Perchlorate CAM VIII B ☐
8270 SVOC CAM II B ☐	7010 Metals CAM III C ☐	MassDEP VPH (GC/MS) CAM IV C ☐	8081 Pesticides CAM V B ☐	7196 Hex Cr CAM VI B ☐	MassDEP APH CAM IX A ☐
6010 Metals CAM III A ☐	6020 Metals CAM III D ☐	MassDEP EPH CAM IV B ☐	8151 Herbicides CAM V C ☐	8330 Explosives CAM VIII A ☐	TO-15 VOC CAM IX B ☐

Affirmative Responses to Questions A through F are required for "Presumptive Certainty" status

A	Were all samples received in a condition consistent with those described on the Chain-of-Custody, properly preserved (including temperature) in the field or laboratory, and prepared/analyzed within method holding times?	☐ Yes ☐ No
B	Were the analytical method(s) and all associated QC requirements specified in the selected CAM protocol(s) followed?	☐ Yes ☐ No
C	Were all required corrective actions and analytical response actions specified in the selected CAM protocol(s) implemented for all identified performance standard non-conformances?	☐ Yes ☐ No
D	Does the laboratory report comply with all the reporting requirements specified in CAM VII A, "Quality Assurance and Quality Control Guidelines for the Acquisition and Reporting of Analytical Data"?	☐ Yes ☐ No
E	VPH, EPH, APH, and TO-15 only a. VPH, EPH, and APH Methods only: Was each method conducted without significant modification(s)? (Refer to the individual method(s) for a list of significant modifications). b. APH and TO-15 Methods only: Was the complete analyte list reported for each method?	☐ Yes ☐ No ☐ Yes ☐ No
F	Were all applicable CAM protocol QC and performance standard non-conformances identified and evaluated in a laboratory narrative (including all "No" responses to Questions A through E)?	☐ Yes ☐ No

Responses to Questions G, H and I below are required for "Presumptive Certainty" status

G	Were the reporting limits at or below all CAM reporting limits specified in the selected CAM protocol(s)?	☐ Yes ☐ No[1]

<u>Data User Note</u>: Data that achieve "Presumptive Certainty" status may not necessarily meet the data usability and representativeness requirements described in 310 CMR 40. 1056 (2)(k) and WSC-07-350.

H	Were **all** QC performance standards specified in the CAM protocol(s) achieved?	☐ Yes ☐ No[1]
I	Were results reported for the complete analyte list specified in the selected CAM protocol(s)?	☐ Yes ☐ No[1]

[1] *All negative responses must be addressed in an attached laboratory narrative.*

I, the undersigned, attest under the pains and penalties of perjury that, based upon my personal inquiry of those responsible for obtaining the information, the material contained in this analytical report is, to the best of my knowledge and belief, is accurate and complete.

Signature:____________________________ **Position:**______________________

Printed Name:__________________________ **Date:**________________________

APPENDIX 4

1. Collecting and Preserving VPH Soil/Sediment Samples

2. Collecting and Preserving VPH Aqueous Samples

APPENDIX 4
Collecting and Preserving VPH Soil/Sediment Samples

OPTION 1: In-Field Methanol Preservation Technique

PERFORMANCE STANDARD: Obtain undisturbed soil/sediment sample and preserve with methanol at a ratio of 1 mL methanol per 1 gram soil/sediment.

Step 1: Choose appropriate sampling container:

60 mL wide mouth packer bottle; or
60 mL straight sided wide mouth bottle; or
60 mL VOC vial; or
40 mL VOC vial

All sampling containers should have an open-top screw cap with Teflon-coated silicone rubber septa or equivalent.

Step 2: (empty) Pre-label each container with a unique alpha/numerical designation. Obtain and record tare weight of each container to nearest 0.1 gram. *This information must be available to the laboratory performing the analyses.*

Step 3: Add 25 mL of purge-and-trap grade methanol to 60 mL containers, or add 15 mL of purge-and-trap grade methanol to 40 mL containers. *It is essential that the methanol be purge-and-trap grade or equivalent quality*. Immediately cap the container. Make a mark on the 60 mL containers approximately 15 mL above the level of methanol, or a mark on the 40 mL container approximately 10 mL above the level of methanol. The objective is to obtain 25 grams of soil/sediment in the 60 mL container, or 15 grams of soil/sediment in the 40 mL container, which is approximately 15 and 10 mL of soil/sediment volume, respectively, depending upon soil/sediment type and moisture content. Other masses of soil/sediment are permissible, as long as the ratio of [grams soil/sediment]/[mL methanol] is 1:1, ±25%. Store at 0-6ºC. *The use of a methanol trip blank prepared in this manner is recommended.*

Step 4: In the field, carefully add soil/sediment to the sample container, until the level of methanol in the vial reaches the designated volumetric mark. For wet soil/sediment, add slightly beyond the mark. IN NO CASE, HOWEVER, MAY THE LEVEL OF SOIL/SEDIMENT IN THE CONTAINER RISE ABOVE THE LEVEL OF METHANOL. The use of a 10-30 mL disposable syringe with the end cut off is recommended to obtain an undisturbed soil/sediment sample from freshly exposed soil/sediment samples. In such cases, obtain and extrude the soil/sediment into the sample container, avoiding splashing methanol out of the container.

Optional: *Use a field electronic balance to ensure addition of desired mass of soil/sediment (25 grams to 60 mL containers, 15 grams to 40 mL containers).*

Step 5: Use a clean brush or paper towel to remove soil/sediment particles from the threads of the sample container and screw cap. Tightly apply and secure screw cap. Gently swirl sample to break up soil/sediment aggregate, if necessary, until soil/sediment is covered with methanol. DO NOT SHAKE. Duplicate samples obtained in this manner are recommended. A split-sample must also be obtained for a determination of soil/sediment moisture content. This sample must NOT be preserved in methanol. HINT: fill this container 1/2 full, to allow screening of the sample headspace by the field investigator or the laboratory.

Step 6: Immediately place containers in cooler for storage in an upright position. Sample containers can be placed in separate zip-lock bags to protect containers in case of leakage during transport. Transport to analytical laboratory using appropriate chain-of-custody procedures and forms.

OPTION 2: Use of a Sealed-Tube Sampling/Storage Device

PERFORMANCE STANDARD: Obtain undisturbed soil sample and immediately seal in air-tight container, for shipment to laboratory and immersion in methanol within 48 hours.

Step 1: Obtain pre-cleaned and/or disposable samplers/containers that allow the collection and air-tight storage of at least 5-25 grams of soil.

Step 2: In the field, obtain an undisturbed sample from freshly exposed soil. Immediately seal container, and place in a cooler. Obtain a duplicate sample to enable the determination of soil moisture content (this does not need to be in a sealed sampler/container). Transport to analytical laboratory using appropriate chain-of-custody procedures and forms.

Step 3: Samples must be extruded and immersed in purge-and-trap (or equivalent) grade methanol at the laboratory within 48 hours of sampling, at a ratio of 1 mL methanol to 1 gram soil. In no case, however, shall the level of soil in the laboratory container exceed the level of methanol (i.e., the soil must be completely immersed in methanol).

NOTE: Documentation MUST be provided/available on the ability of the sampler/container to provide an air-tight seal in a manner that results in no statistically significant loss of volatile hydrocarbons for at least 48 hours.

SAFETY

Methanol is a toxic and flammable liquid, and must be handled with appropriate care. Use in a well-vented area, and avoid inhaling methanol vapors. The use of protective gloves is recommended when handling or transferring methanol. Vials of methanol should always be stored in a cooler with ice at all times, away from sources of ignition such as extreme heat or open flames.

APPENDIX 4
Collecting and Preserving VPH Aqueous Samples

MOST VPH/VOC AQUEOUS SAMPLES

All aqueous samples that will not be analyzed within 4 hours of collection must be preserved by pH adjustment, in order to minimize analyte losses due to biodegradation. For most samples, this can be accomplished by acidification of the sample to pH < 2, by adding 3-4 drops of 1:1 HCl to a 40 mL vial prior to collection. The sample should then be stored at 0-6ºC until it is analyzed. In lieu of acidification, samples may also be preserved with an appropriate base to pH > 11.0 (see below).

SAMPLES TO BE ANALYZED BY HEATED PURGE

ISSUE Traditionally, VPH and VOC aqueous samples have been preserved by addition of an acid (e.g., HCl) to lower the pH of the sample to less than 2.0. While this is still an acceptable approach for petroleum hydrocarbons and most VOCs, recent information and data have indicated that such a technique can lead to significant losses (up to 89%) of MTBE and other ethers (White, H., Lesnik, B., Wilson, J., *Analytical Methods for Fuel Oxygenates*, LUSTLINE Bulletin #42, New England Interstate Water Pollution Control Commission, 2002 (http://www.epa.gov/swerust1/mtbe/LL42Analytical.pdf). Specifically, the combination of a low pH and high temperature sample preparation technique (e.g., heated purge-and-trap) hydrolyze the ether bonds present in the sample, converting the ethers into alcohols (e.g., tert butyl alcohol).

PRESERVATION To prevent ether hydrolysis, samples should either (a) not be acidified or (b) not be heated. Because heating the sample may be necessary to achieve proper analyte purging/partitioning, an alternative to acidification is likely to be the most efficient means to prevent hydrolysis. Because ethers are not subject to base-catalyzed hydrolysis, raising the pH of the sample is an acceptable alternative to acidification. Studies by the USEPA have shown that preservation of aqueous samples to a pH greater than 11.0 using trisodium phosphate dodecahydrate will effectively prevent biological degradation of dissolved analytes, and will not result in deleterious effects on other dissolved oxygenates or on BTEX analytes.

PROTOCOL A recommended protocol to achieve a pH level > 11.0 is to add between 0.40 and 0.44 grams of trisodium phosphate dodecahydrate to a 40 mL vial prior to collection. For convenience, this can be done in the laboratory prior to sample collection in the field. Because it is more convenient to measure the required amount of trisodium phosphate dodecahydrate on a volume basis rather than by weight, the use of a pre-calibrated spoon is recommended. In the field, each vial is filled with the aqueous sample and sealed without headspace – as is traditionally done for acidified samples. The sample is then stored at 0-6ºC until it is analyzed.

NOTE If heated purge is used for the analysis of MTBE in aqueous samples, this is considered a significant modification as per Section 11.3.1 of the VPH methods. There would be no Presumptive Certainty for results obtained under this condition.

APPENDIX 5

SHIPPING METHANOL-PRESERVED SAMPLES

APPENDIX 5
Shipping Methanol Preserved Samples

Shipping of Hazardous Materials

Methanol is considered a hazardous material by the US Department of Transportation (DOT) and the International Air Transport Association (IATA). Shipments of methanol between the field and the laboratory must conform to the rules established in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and the most current edition of the IATA Dangerous Goods Regulations. Consult these documents or your shipping company for complete details.

Small Quantity Exemption

The volumes of methanol recommended in the VPH methods fall under the small quantity exemption of 49 CFR section 173.4. To qualify for this exemption, all of the following must be met:

- ◊ the maximum volume of methanol in each sample container must not exceed 30 mL.
- ◊ the sample container must not be full of methanol.
- ◊ the sample container must be securely packed and cushioned in an upright position, and be surrounded by a sorbent material capable of absorbing spills from leaks or breakage of sample containers.
- ◊ the package weight must not exceed 64 pounds.
- ◊ the volume of methanol per shipping container must not exceed 500 mL.
- ◊ the packaging and shipping container must be strong enough to hold up to the intended use.
- ◊ the package must not be opened or altered while in transit.
- ◊ the shipper must mark the shipping container as follows:

“*This package conforms to 49 CFR 173.4*”

When shipping domestically by Federal Express via ground or air, the following rules apply:

- ◊ follow the inner packaging requirements of 49 CFR 173.4.
- ◊ no labels, placards, up arrows, or dangerous goods shipping papers are required.
- ◊ if the Federal Express airbill has a shippers declaration for hazardous goods on it, check the Yes box under *Shipper’s Declaration not Required.*

When shipping internationally by Federal Express, the following rules apply*:*

- ◊ follow the inner packaging requirements of 49 CFR 173.4.
- ◊ use dangerous goods shipping papers.
- ◊ apply orientation arrows on opposite vertical sides on the exterior of the package.

Shipping Papers for International Shipments

<u>International shipments must be</u> accompanied by dangerous goods shipping papers that include the following:

Proper Shipping Name:	Methyl Alcohol
Hazardous Class:	Flammable Liquid
Identification Number:	UN1230
Total Quantity:	*(mL methanol/container x the number of containers)*
Emergency Response Info:	Methanol MSDS attached
Emergency Response Phone:	*provide appropriate number*
Shipping Exemption:	Dangerous Goods in Excepted Quantities

APPENDIX 6

VPH BY GC/PID/FID METHOD CALIBRATION AND ANALYSIS USING LINEAR REGRESSION

APPENDIX 6
VPH by GC/PID/FID Method Calibration and Analysis Using Linear Regression

Use of linear regression is permissible to calculate the slope and y-intercept that best describes the linear relationship between Target VPH Analytes or hydrocarbon range concentrations and instrument responses.

1. Prepare VPH Calibration Standards as described in Tables 2a and 2b at a minimum of five concentration levels in accordance with the procedures and specifications contained in Section 7.0. The VPH marker compounds for the C_5-C_8 aliphatic, C_9-C_{12} aliphatic and C_9-C_{10} aromatic ranges are presented in Table 5 of the method.

   Analyze each VPH Calibration Standard following the procedures outlined in Section 9.4. Tabulate area responses against the concentration purged. These data are used to calculate a calibration curve for each Target VPH Analyte (Equation 6-1). The correlation coefficient (r) of the resultant calibration curve must be $\geq$ 0.99.

Equation 6-1: Linear Regression: Target VPH Analytes

$$\boxed{Area\ \ of\ \ peak = a \times concentration\ purged\left(\mu g/L\right) + b}$$

where:

a =the calculated slope of the line
b = the calculated y intercept of the "best fit" line

A calibration curve may also be established for each aliphatic and aromatic hydrocarbon range of interest. Calculate the calibration curve for C_5-C_8 Aliphatic Hydrocarbons and C_9-C_{12} Aliphatic Hydrocarbons using the FID chromatogram. Calculate the calibration curve for the C_9-C_{10} Aromatic Hydrocarbons using the PID chromatogram. Tabulate the summation of the peak areas of all components in that hydrocarbon range (i.e., C_5-C_8 Aliphatic Hydrocarbons, 3 components) against the total concentration purged. These data are used to calculate a calibration curve for each VPH hydrocarbon range (Equation 6-2). The correlation coefficient (r) of the resultant calibration curve must $\geq$ 0.99.

Note: Do not include the area of any surrogates when determining the calibration curve for the hydrocarbon ranges. Do not include the area of naphthalene when determining the calibration curve for C_9 - C_{10} Aromatic Hydrocarbons.

Equation 6-2: Linear Regression: VPH Aliphatic and Aromatic Hydrocarbon Ranges

$$\boxed{Area\ summation of\ \ range\ components = a \times total\ concentration\ purged\left(\mu g/L\right) + b}$$

where:

a = the calculated slope of the line
b = the calculated y intercept of the "best fit" line

2. The concentration of a specific target analyte or hydrocarbon range may be calculated using linear regression analysis by applying Equation 6-3.

Equation 6-3: Determination of Target VPH Analytes and Hydrocarbon Range Concentrations using Linear Regression

$$\boxed{Conc\ Analyte\ or\ HC\ Range(\mu g/L) = \left(\frac{A_x - b}{a}\right) \times D}$$

where:

A_x = Response for the Target VPH Analyte or hydrocarbon range in the sample. Units are in area counts for Target VPH Analytes and the hydrocarbon ranges.
D = Dilution factor; if no dilution was made, D = 1, dimensionless.
a = Slope of the line for Target VPH Analyte or hydrocarbon range,
b = Intercept of the line for Target VPH Analyte or hydrocarbon range,

Note: Do not include the area of any surrogate standard in Ax when calculating a hydrocarbon range concentration.

3. **Conversion of µg/L to µg/kg**

To convert target analyte or hydrocarbon range results from µg/L into µg/kg, use Equations 7 and 9 in the VPH by GC/PID/FID method.

4. At a minimum, the working calibration curve must be verified on each working day, after every 20 samples, and at the end of the analytical sequence to verify instrument performance and linearity. The Percent Drift is determined using Equation 6-4. The Percent Drift for each Target VPH Analyte and surrogate must be ≤ 20. The Percent Drift for each hydrocarbon range must be ≤25. Greater Percent Drifts are permissible for n-nonane. If the Percent Drift for n-nonane is > 30, note the nonconformance in the case narrative. If more than one Target VPH Analyte or hydrocarbon range fails to meet the applicable criterion, the instrument must be recalibrated. Otherwise, sample analysis may proceed.

Equation 6-4: Percent Drift

$$\boxed{\%Drift = \frac{Calculated\ concentration\ -Theoretical\ concentration}{Theoretical\ concentration}\ x\,100}$$

APPENDIX 7

INITIAL DEMONSTRATION OF LABORATORY CAPABILITY FOR THE MassDEP VPH by GC/PID/FID METHOD

1.0 Overview of the Initial Demonstration of Laboratory Capability (IDLC) Approach

2.0 Demonstration of Acceptable System Background

3.0 Initial Demonstration of Accuracy (IDA)

4.0 Initial Demonstration of Precision (IDP)

5.0 Method Detection Limit (MDL)

APPENDIX 7
Initial Demonstration of Laboratory Capability (IDLC) for the MassDEP VPH by GC/PID/FID Method

For purposes of the IDLC accuracy and precision determinations (***and only this application***), the calibration mixture presented in Table 1 of the method is considered to be representative of Volatile Petroleum Hydrocarbon (VPH) Target VPH Analytes and hydrocarbon ranges (cumulative sum of the concentrations of the range calibration standards). Other reference materials or combinations of reference materials with an individual assay for individual Target VPH Analytes and the C_5 through C_8 aliphatic, C_9 through C_{12} aliphatic and C_9 through C_{10} aromatic ranges are also suitable for this determination.

1.0 Overview of the Initial Demonstration of Laboratory Capability (IDLC) Approach

An IDLC must be conducted to characterize instrument and laboratory performance prior to performing analyses using the VPH by GC/PID/FID Method. A laboratory may not report data to be used in support of MCP decisions unless the IDLC quality control requirements and performance standards described below and compiled in Table 7-2 of this Appendix are satisfied.

2.0 Demonstration of Acceptable System Background

Demonstration of acceptable system background is optional. To determine system background, a Laboratory Method Blank (LMB) is prepared and treated exactly as a typical field sample submitted for analysis, including exposure to all glassware, equipment, solvents and reagents. A LMB for aqueous sample analyses is prepared by adding a specified volume of surrogate spiking solution in purge-and-trap grade, or equivalent, methanol to organic-free water (ASTM Type I reagent grade). A LMB for soil/sediment sample analyses is prepared by adding a specified volume of “diluted” (to obtain the same on-column nominal concentration as above) surrogate spiking solution in purge-and-trap grade, or equivalent, methanol to organic-free water (ASTM Type I reagent grade). The volume of surrogate added should be the same as used for samples.

At least seven (7) replicate matrix-specific LMBs should be analyzed and the mean concentration of Target VPH Analytes and hydrocarbon ranges determined, as appropriate. Data produced (mean Target VPH Analyte and hydrocarbon range concentrations detected related to background noise) are used to assess instrument performance of a blank sample and evaluate potential contamination from the laboratory environment, in the absence of any other analytes or system contaminants. Calculate the measured concentration of C_{mean} of the replicate values as follows.

Equation 7-1: Calculation of C_{mean} LMB

$$C_{mean} = \frac{(C_1 + C_2 + C_3 + ...C_n)}{n}$$

where,

C_{mean} = Mean recovered concentration of the replicate LMB analysis.
$C_1, C_2, ...C_n$ = Recovered concentrations of the replicate 1,2...n.
n = at least 7

Any concentration of C_{mean} that exceeds one half of the Reporting Limit (lowest Target VPH Analyte calibration or collective hydrocarbon range calibration standard) for either a Target VPH Analyte or hydrocarbon range is considered unacceptable, and indicates that laboratory and/or LMB contamination is present. The source of the non-conformance must be identified and corrected prior to conducting any sample analysis. For purposes of acceptable system background demonstration, concentrations are determined using Equations 6 and 8 in Section 9.6 of the VPH by GC/PID/FID Method for Target VPH Analytes and collective hydrocarbon ranges, respectively. Calculated concentrations below the lowest calibration standard, including zero (zero area), may be used in these calculations.

3.0 Initial Demonstration of Accuracy (IDA)

Prepare and analyze seven (7) replicate Laboratory Control Samples (LCSs) fortified at a concentration of 50% of the highest calibration curve standard (100 ug/L for aqueous samples and 5 mg/kg for soil/sediment samples). An LCS must be prepared and treated exactly as a typical field sample submitted for analysis, including exposure to all glassware, equipment, solvents and reagents. See Section 10.2.6 of the VPH by GC/PID/FID Method for how to prepare the LCS.

Calculate the mean measured concentration (C_{mean}) of the replicate LCSs for Target VPH Analytes and hydrocarbon ranges as follows.

Equation 7-2: Calculation of C_{mean}

$$C_{mean} = \frac{(C_1 + C_2 + C_3 + ...C_n)}{n}$$

where,

C_{mean} = Mean recovered concentration of the replicate analysis.
$C_1, C_2, ...C_n$ = Recovered concentrations of the replicate 1,2...n.
$n = 7$

The value derived for C_{mean} must be within ± 30% of the true value or between 70 ug/L and 130 ug/L for aqueous samples and 3.5 mg/kg and 6.5 mg/kg for soil/sediment samples.

4.0 Initial Demonstration of Precision (IDP)

Using the results calculated from Section 3.0 above, calculate the percent relative standard deviation (%RSD) of the seven (7) replicate analysis, as indicated below. The %RSD must be ≤ 25 for both aqueous and soil/sediment samples.

Equation 7-3: Calculation of % RSD

$$\% \text{ RSD} = \frac{S_{n-1}}{C_{mean}} \text{ X } 100$$

where,

S_{n-1}= sample standard deviation (n-1) of the replicate analyses.
C_{mean} = mean recovered concentration of the replicate analysis.

5.0 Method Detection Limit (MDL)

The determination of the MDL for the MassDEP VPH by GC/PID/FID Method is optional. The reporting limit for the method is defined as the lowest calibration standard. Determination of the lowest detectable concentration of Target VPH Analytes and hydrocarbon ranges is verified on a continuing basis by analysis of the lowest concentration calibration standard and recovery of method surrogates. The recommended RL concentrations for the VPH by GC/PID/FID Method do not approach (are considerably higher than) the sensitivity limits of the VPH by GC/PID/FID Method for either Target VPH Analytes or hydrocarbon ranges and are more than adequate to meet the most stringent regulatory requirements of the MCP.

An MDL may be established for Target VPH Analytes and hydrocarbon ranges either analytically using the 40 CFR 136 approach or by the statistical evaluation of analytical system noise as a good laboratory practice component of an overall quality control program for the VPH by GC/PID/FID Method.

5.1 Determination of MDL, 40 CFR 136, Appendix B Approach

To determine MDL values, take seven replicate aliquots of reagent water fortified at the estimated or "calculated" MDL concentration determined in Equation 7-6 below or the concentration of the lowest calibration standard, and process through the entire analytical method over a three day period. These seven MDL replicate analyses may be performed gradually over a three day period or may represent data that have been collected, at a consistent MDL "calculated" concentration, over a series of more than three days. Perform all calculations defined in the method and report the concentration values in the appropriate units. Calculate the MDL as follows:

Equation 7-4: Calculation of MDL based on Laboratory Analysis

$$MDL = (t_{n-1}) \times (S_{n-1})$$

where,

t_{n-1} = Student's t value for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom [t_{n-1} = 3.14 for seven replicates]
S_{n-1} = Sample standard deviation (n-1) of 7 replicate MDL analyses (equivalent to a "low-level" LCS)

5.2 Determination of MDL and Limit of Quantitation (LOQ) by Statistical Evaluation of System Noise

Seven (7) replicate aliquots of a System Solvent Blank (SSB) must be prepared and analyzed exactly as a typical field sample submitted for analysis, including exposure to all glassware, equipment, solvents and reagents. A SSB for water analyses is prepared by adding 5 uL of purge-and-trap grade, or equivalent, methanol to 5 mL of organic-free water (ASTM Type I reagent grade). A SSB for soil/sediment analyses is prepared by adding 100 uL purge-and-trap grade, or equivalent, methanol to 4.9 mL of organic-free water (ASTM Type I reagent grade).

Data produced are used to assess the level of noise and the baseline rise attributable solely to the GC/PID/FID system, in the absence of any other analytes or system contaminants. These data are used to calculate the LOQ and MDL using the Keith statistical approach. ***For these analyses, the data system's threshold for peak area integration must be adjusted to ensure that a positive value is recorded for the Target VPH Analytes and hydrocarbon ranges of interest, as practical.*** Tabulate the area responses for each Target VPH Analyte and hydrocarbon range. Calculate the LOQ and MDL using Equations 7-5 and 7-6, respectively. An example LOQ and MDL calculation for the VPH aliphatic and aromatic hydrocarbon ranges for an aqueous sample is presented below in Table 7-1.

Equation 7-5: Calculation of Limit of Quantitation (LOQ)

$$LOQ_x = 10 * S_{x,n-1} CF_x$$

$S_{x,n-1}$ = Sample standard deviations for peak areas of Target VPH Analytes and hydrocarbon ranges of interest for the seven (7) replicate SSBs reported in appropriate units.

CF_x = Representative CF for appropriate Target VPH Analytes or hydrocarbon range

Equation 7-6: Calculation of MDL

$$MDL = LOQ/3$$

Table 7-1 LOQ Sample Calculation for Seven (7) System Solvent Blanks (SSBs) – VPH Hydrocarbon Ranges Only

Replicate Number	**VPH Hydrocarbon Range (Area Units)**		
	C_5 - C_8 aliphatic	**C_9 - C_{12} aliphatic**	**C_9 - C_{10} aromatic**
1	32887	41407	18427
2	54035	26628	18294
3	10991	38536	17885
4	19382	12497	20846
5	9730	32572	14570
6	37624	11564	18709
7	87050	15501	16545
Range Average	24765	25529	17892
Calculations:			
Range $S_{x, n-1}$	15994	11573	1801
Range CF (ug/L * AU^{-1})	0.00010	0.00007	0.00003
LOQ (ug/L)	16	8.1	0.5
MDL (ug/L)	5.3	2.7	0.17

Table 7-2 Initial Demonstration Of Laboratory Capability QC Requirements

Reference Section	Requirement	Specification & Frequency	Acceptance Criteria
2.0	Initial Demonstration of Acceptable System Background (Optional)	Analyze at least 7 replicate Laboratory Method Blanks (LMB) fortified with surrogate spiking solution. Calculate the mean recovered concentration for each Target VPH Analyte and hydrocarbon range. See Equation 7-1 in Section 2.0.	The mean LMB concentrations must be < ½ of the RL (lowest point on calibration curve or lowest cumulative range calibration standard).
3.0	Initial Demonstration of Accuracy (IDA)	Analyze 7 replicate LCSs fortified with VPH calibration standards at a nominal concentration of 100 ug/L or 5 mg/kg for each standard analyte. Calculate the mean recovered concentration (C_{mean}) for each Target VPH Analyte and hydrocarbon range. See Equation 7-2 in Section 3.0.	The C_{mean} must be ± 30% of the true value of the aliphatic and aromatic hydrocarbon ranges and Target VPH Analytes for both aqueous and soil/sediment samples.
4.0	Initial Demonstration of Precision (IDP)	Calculate the percent relative standard deviation (%RSD) of LCS replicates in Section 3.0 for each Target VPH Analyte and hydrocarbon range. See Equation 7-3 in Section 4.0.	The %RSD must be $\leq$ 25% for both aqueous and soil/sediment samples.
5.0	Method Detection Limit (MDL) Determination (Optional)	Select a fortifying level at the estimated or "calculated" MDL or RL for the LCS. See Equation 7-6 in Section 5.2. Analyze these 7 replicate "low-level" LCSs over multiple days and calculate the MDL using Equation 7-4 in Section 5.1. Do not subtract any blank contribution to this value. MDLs may also be determined by a statistical evaluation of system noise based on the analysis of seven (7) system solvent blanks (SSB). See Section 5.2.	See 40 CFR 136, Appendix B. The MDL must be < ½ of the RL for individual Target VPH Analytes and < ½ of the RL for collective VPH hydrocarbon ranges (See Section 12.0 of the method).

METHOD FOR THE DETERMINATION OF AIR-PHASE PETROLEUM HYDROCARBONS (APH)

Massachusetts Department of Environmental Protection

Office of Research and Standards

Bureau of Waste Site Cleanup

Commonwealth of Massachusetts

Executive Office of Energy & Environmental Affairs
Ian A. Bowles
Secretary

Department of Environmental Protection
Laurie Burt
Commissioner

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Final
Revision 1

METHOD FOR THE DETERMINATION OF AIR-PHASE PETROLEUM HYDROCARBONS (APH)

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DISCLAIMER

Mention of trade names or commercial products does not constitute endorsement by the Massachusetts Department of Environmental Protection (MassDEP). Trade names and commercial products specified in this method are based upon their use in validation studies conducted by MassDEP. Equipment and materials cited in this method may be replaced by similar products, as long as adequate data exist or have been produced documenting equivalent or superior performance.

LIST OF ACRONYMS

APH	Air-Phase Petroleum Hydrocarbons
BFB	4-Bromofluorobenzene
CAM	Compendium of Analytical Methods
%D	Percent Difference
DF	Dilution Factor
GC/MS	Gas Chromatography / Mass Spectrometry
HPLC	High Pressure Liquid Chromatography
IDLC	Initial Demonstration of Laboratory Capability
IS	Internal Standard
LCS	Laboratory Control Sample
LMB	Laboratory Method Blank
MassDEP	Massachusetts Department of Environmental Protection
MCP	Massachusetts Contingency Plan
MDL	Method Detection Limit
MTBE	Methyl tertiary butyl ether
NIST	National Institute of Standards and Technology
QA/QC	Quality Assurance / Quality Control
%R	Percent Recovery
r	Correlation Coefficient
r^2	Coefficient of Determination
RL	Reporting Limit
RPD	Relative Percent Difference
RRF	Relative Response Factor
RRT	Relative Retention Time
%RSD	Percent Relative Standard Deviation
Rt	Retention Time
SOP	Standard Operating Procedure
UHP	Ultra High Purity
VPH	Volatile Petroleum Hydrocarbons

NOTE: Abbreviations of units (e.g., amu, in. or mm Hg, m/e, $\mu g/m^3$, mL, min, ng, ppbV, psia, psig, etc.) are not included.

METHOD FOR THE DETERMINATION OF AIR-PHASE PETROLEUM HYDROCARBONS (APH)

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION (MassDEP)

1.0 SCOPE AND APPLICATION

1.1 This method is designed to measure the gaseous-phase concentrations of volatile aliphatic and aromatic petroleum hydrocarbons in air and soil gas. Volatile aliphatic hydrocarbons are collectively quantified within two carbon number ranges: C_5 through C_8 and C_9 through C_{12}. Volatile aromatic hydrocarbons are collectively quantified within the C_9 to C_{10} range. These aliphatic and aromatic hydrocarbon ranges correspond to a boiling point range between approximately 28°C (isopentane) and 218°C (naphthalene).

1.2 This method is based on the collection of whole air samples in passivated stainless steel canisters, with subsequent analysis by gas chromatography/mass spectrometry (GC/MS). This method should be used by, or under the direct supervision of, analysts experienced in the use of GC/MS instrumentation for the identification and quantification of contaminant concentrations in air.

1.3 This method is designed to complement and support the toxicological approach developed by the Massachusetts Department of Environmental Protection to evaluate human health hazards that may result from exposure to petroleum hydrocarbons (MassDEP, 1994 and *Updated Petroleum Hydrocarbon Fraction Toxicity Values For VPH/EPH/APH Methodology*, November 2003). The method is intended to produce data in a format suitable for the characterization of risk at sites undergoing evaluation under the Massachusetts Contingency Plan (MCP, 310 CMR 40.0000) using the aforementioned toxicological approach.

1.4 This method may also be used to directly quantify the individual concentrations of the Target APH Analytes 1,3-butadiene, methyl-tert-butylether (MTBE), benzene, toluene, ethylbenzene, m- & p-xylenes, o-xylene and naphthalene in air and soil gas samples.

1.5 Petroleum products suitable for evaluation by this method include gasoline, as well as the volatile fractions of mineral spirits, kerosene, #2/diesel fuel oil, jet fuels, and certain petroleum naphthas. This method is not suitable for the identification and quantification of entrained aerosols, particulate-phase hydrocarbons, and petroleum products with a significant percentage of hydrocarbons with boiling points > 218°C.

1.6 The Reporting Limit (RL) of this method for each of the Target APH Analytes is determined by the lowest applicable Calibration standard. The nominal RL for the individual target analytes is approximately 2 to 5 $\mu g/m^3$. The RLs for the collective hydrocarbon ranges are empirically determined based on the number and lowest concentration of the component standards used in the calibration of the individual ranges. The nominal RLs for the aliphatic and aromatic ranges are 12 $\mu g/m^3$ and 10 $\mu g/m^3$, respectively.

1.7 This method includes a series of data adjustment steps to determine the concentrations of the collective aliphatic and aromatic hydrocarbon ranges of interest. These steps must be taken by the laboratory.

1.8 Data reports produced using this method must contain all of the information presented in Appendix 3. The format of these reports is left to the discretion of individual laboratories (but must include the same certification statement presented in the aforementioned Appendix and must be provided in a clear, concise, and succinct manner).

1.9 There may be better, more accurate, and/or less conservative ways to produce APH target and range data. MassDEP encourages methodological innovations that: (a) better achieve method and/or data quality objectives, (b) increase analytical precision and accuracy, (c) reduce analytical uncertainties and expenses, and/or (d) reduce the use of toxic solvents and generation of hazardous wastes.

All significant modifications to this method, however, must be disclosed and described on the data report, as detailed in Section 11.1.2. Laboratories that make such modifications, and/or develop and utilize alternative approaches and methods, are further required to demonstrate that:

- Such modifications or methodologies adequately quantify the petroleum hydrocarbon target ranges, as defined in Sections 3.1.9 through 3.1.11 of this document, ensuring that any methodological uncertainties or biases are addressed in a manner that ensures protective (i.e., conservative) results and data (e.g., over, not under-quantification of the more toxic ranges);

- Such modifications and/or methodologies employ and document initial method demonstration and ongoing quality control (QC) procedures consistent with approaches detailed in the MassDEP Compendium of Analytical Methods (CAM); and

- Such method and procedural modifications are fully documented in a detailed standard operating procedure (SOP).

1.10 This method is one way to quantify collective concentrations of volatile aliphatic and aromatic petroleum hydrocarbons within specified carbon number ranges. It has been designed in a manner that attempts to strike a reasonable balance between analytical method performance and utility. In this manner, assumptions and biases have been structured into the method to help ensure protective, though not overly conservative, data.

As an example, MassDEP recognizes that branched alkanes have lower boiling points than their n-alkane counterparts while many of the cycloalkane constituents of gasoline-range volatile organics have higher boiling points than their n-alkane counterpart. As a consequence:

(1) Depending upon the specific chromatographic column used, most branched C_9 alkanes are expected to elute before n-nonane, the beginning marker compound for the C_9 through C_{12} aliphatic hydrocarbon range, and will be conservatively counted in the more toxic C_5 through C_8 aliphatic hydrocarbon range;

(2) Depending upon the specific chromatographic column used, most branched C_5 alkanes will elute before n-pentane and before isopentane, the beginning marker compound for the C_5 through C_8 aliphatic hydrocarbon range, and will not be counted at all in the C_5 through C_8 aliphatic hydrocarbon range; and

(3) Depending upon the specific chromatographic column used, most cycloalkanes within the C_5 through C_8 and C_9 through C_{12} aliphatic hydrocarbon ranges will be counted within their proper range, with the exception of some C_{12} cycloalkanes which will elute after dodecane, the end marker compound for the C_9 through C_{12} aliphatic hydrocarbon range.

Based on the nature of petroleum releases encountered in the environment, the collective concentrations of the volatile aliphatic ranges as measured by the APH Method are considered to be suitable, along with concentrations of target analytes, for the evaluation of the risks posed by these releases, consistent with the toxicological approach developed by MassDEP to evaluate human health hazards that may result from exposure to petroleum hydrocarbons (MassDEP, 1994, and *Updated Petroleum Hydrocarbon Fraction Toxicity Values For VPH/EPH/APH Methodology*, November 2003).

1.11 This method should be used in conjunction with the current version of WSC-CAM-IX A, Quality Control Requirements and Performance Standards for the Analysis of Air-Phase Petroleum Hydrocarbons (APH) by Gas Chromatography/Mass Spectrometry (GC/MS). WSC-CAM-IX A was developed by MassDEP to complement the APH (MassDEP-APH-09) and to provide more detailed guidance regarding compliance with the quality control requirements and performance standards of the MassDEP APH Method.

2.0 SUMMARY OF METHOD AND DATA QUALITY OBJECTIVES

2.1 Samples are collected in pre-cleaned, evacuated, passivated stainless steel canisters.

2.2 A concentrator system capable of the automated collection, trapping, focusing, and injection of measured aliquots of the sample that employs a suitable mechanism for sample moisture control is recommended. Depending on the water retention properties of the packing material, some or most of the water vapor contained in the sample should completely pass through the concentrator during sample processing. Additional drying of the “trapped” sample aliquot, if required, can be accomplished by forward purging the trap with clean, dry helium (or other inert gas). Other water management approaches are also acceptable providing their use does not compromise method performance (see Section 10.2).

2.3 Following preconcentration, the sample is then transferred and cryogenically refocused onto the inlet of the system's capillary column, further concentrating the sample.

2.4 The sample is then released by thermal desorption and carried onto the gas chromatographic capillary column, which separates the individual compounds and hydrocarbon ranges of interest. All compounds are detected using a mass spectrometer. Target APH Analytes are identified and quantified using characteristic ions. Collective concentrations of C_9-C_{10} aromatic hydrocarbons are quantified using extracted ions. Collective concentrations of aliphatic hydrocarbon ranges are quantified using the total ion chromatogram.

2.5 This method is based on USEPA Method TO-15, *Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-prepared Canisters And Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)*.

2.6 Data Quality Objectives should be developed and applied for sampling and analytical efforts involving the use of this method. Key parameters of interest include: (a) the need for and extent of time-integrated air samples, (b) the acceptability of RLs achievable by the laboratory for the contaminants of interest, and (c) the identification and reporting of target and non-target analytes.

3.0 DEFINITIONS AND UNITS OF MEASURE

3.1 Definitions

3.1.1 **Absolute Pressure** is defined as the pressure measured with reference to absolute zero pressure (as opposed to atmospheric pressure), usually expressed as, mm Hg, or psia.

3.1.2 **Air-Phase Petroleum Hydrocarbons** are defined as collective ranges of hydrocarbon compounds eluting from isopentane to n-dodecane, excluding Target APH Analytes. APH is comprised of C_5-C_8 aliphatic hydrocarbons, C_9-C_{12} aliphatic hydrocarbons, and C_9-C_{10} aromatic hydrocarbons.

3.1.3 **Aliphatic Hydrocarbon** is defined as acyclic or cyclic, saturated or unsaturated compounds, excluding aromatic compounds that contain only carbon and hydrogen atoms.

3.1.4 **APH Calibration Check Standard** is defined as a gaseous-phase mixture of APH components that is used to periodically check the calibration state of the GC/MS system. The APH Calibration Check Standard is prepared from the APH working standards and is generally one of the mid-level concentrations.

3.1.5 **APH Calibration Standard** is defined as a gaseous-phase mixture of APH components that is used to calibrate the GC/MS system. The APH calibration standards are prepared from the APH working standards and are prepared at a minimum of five or six different concentrations, depending on the method used to evaluate the calibration.

3.1.6 **APH Components** are defined as the 26-component mixture of the aliphatic and aromatic compounds listed in Table 1. The APH components are used to (a) define the individual retention times and response factors for each of the target APH analytes, (b) define and establish the retention time windows for the collective aliphatic and aromatic hydrocarbon ranges of interest, and (c) determine average response factors which are used to calculate the collective concentrations of hydrocarbons within these ranges.

3.1.7 **APH Working Standards** are defined as gaseous-phase mixtures of all APH components, which are used in the preparation of calibration standards (see Tables 3a and 3b). These standards are prepared with concentrations over the working range of the calibration curve by dynamic dilution of the gaseous stock standard with humidified ultra zero air or ultra high purity (UHP) nitrogen. The stock standard is delivered to a clean, passivated canister using a pump and mass flow controller.

3.1.8 **Aromatic Hydrocarbons** are defined as compounds whose structures include a cyclic structure and a closed conjugated system of double bonds containing only carbon and hydrogen atoms.

3.1.9 **C_5 through C_8 Aliphatic Hydrocarbons** are defined as all aliphatic petroleum hydrocarbon compounds that elute from isopentane to just before n-nonane (C_9).

3.1.10 **C_9 through C_{12} Aliphatic Hydrocarbons** are defined as all aliphatic petroleum hydrocarbon compounds that elute from just before n-nonane to just after n-dodecane.

3.1.11 **C_9 through C_{10} Aromatic Hydrocarbons** are defined as all aromatic petroleum hydrocarbon compounds that elute from just after o-xylene to just before naphthalene.

3.1.12 **Cryogen** is defined as the refrigerant used to obtain very low temperatures in the cryogenic trap of an analytical system. A typical cryogen is liquid nitrogen (boiling point = -196°C).

3.1.13 **Gauge Pressure** is defined as the pressure measured above atmospheric pressure (as opposed to absolute pressure). Zero gauge (0 psig) is equal to ambient atmospheric (barometric) pressure.

3.1.14 **Humidified Canister** is defined as a passivated stainless steel canister containing ultra zero air or UHP nitrogen pressurized to 30 psig with a relative humidity of 30 - 40% at 25°C to simulate moisture conditions in real-world samples. For example, a 6-liter humidified canister may be prepared by fortifying a certified-clean passivated canister with 130 µL of high pressure liquid chromatography (HPLC)-grade water and pressurizing to 30 psig. Alternatively, ultra zero air passed through HPLC-grade water contained in an in-line bubbler (humidifier) may be used to pressurize a certified-clean passivated canister to 30 psig.

3.1.15 **Laboratory Control Sample (LCS)** is defined as a humidified canister containing a separate source gaseous standard obtained from a different source than that used to prepare the APH working standards.

3.1.16 **Laboratory Method Blank (LMB)** is defined as a humidified canister pressurized with ultra zero air or UHP nitrogen to 30 psig.

3.1.17 **Nominal Sample Volume** is defined as the routine sample volume employed by the laboratory for APH Method sample analysis and calibration.

3.1.18 **Petroleum Hydrocarbon** is a generic term used to describe the complex mixture of chemical compounds derived from crude oil containing only carbon and hydrogen atoms.

3.1.19 **Stock Standard** is a gaseous cylinder containing the APH components (all aliphatic and aromatic range calibration compounds and target analytes) and is used to prepare working standards.

3.1.20 **Target APH Analytes** are defined as 1,3-butadiene, MTBE, benzene, toluene, ethylbenzene, m- & p-xylene, o-xylene, and naphthalene.

3.2 Units of Measure

3.2.1 The units of measure referenced in this method for volume, concentration, and pressure are reflective of the conventions and standards that are commonly used by practitioners within this field, and/or the conventions and standards associated with commonly available instrumentation and equipment.

3.2.2 Concentrations of APH target analytes must be reported in $\mu g/m^3$. Collective aliphatic and aromatic hydrocarbon range data can only be reported in $\mu g/m^3$ (See Section 9.6.2).

3.2.3 Other physical measurements (pressure, volume, etc.) should only be reported in units specifically referenced in the APH Method.

4.0 INTERFERENCES AND METHOD LIMITATIONS

4.1 Contamination may occur in the sampling system if canisters are not properly cleaned before use. Additionally, all other sampling equipment (e.g., pump and flow controllers) must be thoroughly cleaned to ensure that the filling apparatus will not contaminate samples.

4.2 System carryover can be a potential problem, particularly for heavier molecular weight hydrocarbons such as naphthalene. Carryover can occur after the analysis of high concentration standards or samples. Measures that must be taken to remove this system contamination can include the analysis of multiple blanks, the use of humidified air through the system, and occasional bake out or replacement of the concentrator system components.

4.3 High methane levels and/or carbon dioxide levels may interfere with the chromatography. Dilution may be performed on samples to minimize this effect; however, the RLs for diluted samples will be proportionately increased. It should be noted that although the concentrator systems must be designed to minimize elevated levels of carbon dioxide, the potential still exists to have interfering levels.

4.4 Certain organic compounds not associated with the release of petroleum products, including chlorinated solvents, ketones, and ethers may be detected by this method and may contribute to the collective response quantified within an aliphatic or aromatic hydrocarbon range. When requested by the data user, the identification of such non-APH compounds must be disclosed on the laboratory report form or laboratory narrative. See Table 7 for a list of potential non-petroleum compounds, which may contribute to hydrocarbon range concentrations.

5.0 HEALTH AND SAFETY ISSUES

5.1 The toxicity and carcinogenicity of each reagent used in this method has not been precisely defined. However, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. The laboratory is responsible for maintaining a current file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of material safety data sheets should also be made available to all personnel involved in the chemical analysis.

6.0 APPARATUS AND MATERIALS

6.1 **Sample Canisters**

Certified clean, leak-free, stainless steel polished or silica–lined, passivated air sampling canisters of 1.0, 2.7, 3.0, and 6.0 liter capacity are most commonly used for the collection of APH Method samples, depending on project requirements.

6.2 **Canister Sample Concentrator**

6.2.1 Two current systems include: Tekmar-Dohrmann AutoCan Autosampler & Cryogenic Concentrating Trap and Entech 7100A Preconcentrator/7016 Canister Autosampler. The mention of these canister sample concentrator systems by name does not preclude the use of other equivalent technologies for the APH Method.

6.2.2 Minimum Sample Concentrator Capabilities

- Concentrator system must have the ability to remove moisture.
- Internal standards must be added to all standards, field samples, and QC samples using the same technique.
- Concentrator system must have the ability to minimize elevated levels of carbon dioxide (can affect integration of C_5-C_8 aliphatic range).

6.3 Gas Chromatograph System

6.3.1 An analytical system complete with a temperature programmable gas chromatograph for use with a capillary column is required.

6.3.2 The required chromatographic column phase is 100% dimethyl polysiloxane (e.g., RTX-1, DB-1, etc.); required column dimensions are 60 meters, 0.25 mm ID, 1-micron film thickness, or a column with demonstrated and documented equivalent chromatographic properties (i.e., same compound elution order).

> **NOTE: Based upon data obtained from the MassDEP Volatile Petroleum Hydrocarbon (VPH) Method Round Robin testing programs, the choice of chromatographic column may have a significant impact on the apportionment and quantification of aliphatic and aromatic compounds within the collective hydrocarbon ranges specified in the method. Substitution of the required column is not allowed, unless it can be demonstrated that the selected column has equivalent chromatographic properties and elution order for the aliphatic and aromatic compounds and ranges of interest.**

To demonstrate equivalency of column chromatography, a mid-range APH calibration standard must be analyzed on both the required column and the proposed substitute column, with all other run and system parameters held constant. The concentrations of C_5-C_8 and, C_9-C_{12} aliphatic hydrocarbons, C_9-C_{10} aromatic hydrocarbon ranges and target analytes must be determined for each column. The relative percent difference (RPD) between the concentrations of each hydrocarbon range and target analyte, excluding naphthalene, obtained from each column must be $\leq$25. The RPD for naphthalene must be $\leq$40. The elution order of APH Components on the proposed substitute column must be equivalent to the elution order on the required column.

6.4 Mass Spectrometer System

6.4.1 The mass spectrometer must be capable of scanning from 35 to 250 amu every three seconds or less, utilizing 70 eV in the electron impact ionization mode and producing a mass spectrum which meets all the criteria in Table 2 when at least 50 ng of 4-bromofluorobenzene (BFB) is injected.

6.4.2 A data station is required that is capable of storing and reintegrating chromatographic data and capable of determining peak areas using a forced baseline projection.

7.0 REAGENTS AND STANDARDS

7.1 Reagents

7.1.1 HPLC-grade water for canister humidification.

7.1.2 UHP helium for the GC/MS system.

7.1.3 Liquid nitrogen for the concentrator system and GC.

7.1.4 Ultra zero air or UHP nitrogen for the concentrator system and standard preparation.

7.2 Stock Standard

7.2.1 Gaseous cylinder containing all aliphatic and aromatic range calibration compounds and target analytes (see Table 1). Recommended concentration is 1 mg/m^3 for all components.

7.2.2 At the time this document was published, National Institute of Standards and Technology (NIST)-certified APH Stock Standards were commercially available from Air Liquide America Specialty Gases (formerly Scott Specialty Gases, Plumsteadville, PA) and Spectra Gases, Inc. (Branchburg, NJ). The mention of any trade name, product or vendor in this document does not constitute an endorsement or recommendation by the MassDEP.

7.3 APH Working Standards

7.3.1 The preparation of gaseous working standards and calibration standards described in the following sections is based on the use of mass flow controllers to accurately measure and dispense volumes of the gaseous standards used in the preparation of intermediate (working) and final (calibration) standards. Other gas metering or measuring devices may be used to prepare working standards and calibration standards for the APH Method so long as the accuracy and precision of standards prepared using these devices is documented and consistent with the overall quality objectives of the method.

> **NOTE:** It is unacceptable to use methanol-based stock standards for preparation of working standards due to fluctuations observed in the analytical system response when high levels of methanol are present in the canister. This option was acceptable in the Draft version of the APH Method but is no longer acceptable.

7.3.2 Prepare gaseous-phase APH working standards in pre-evacuated passivated canisters. The usual laboratory practice is to prepare working standards at two concentration levels (20 µg/m^3 and 500 µg/m^3, as shown in Tables 3a and 3b).

7.3.3 Using a mass flow controller, flow-inject a measured volume (flow rate $*$ time) of the Stock Standard(s) into a pre-evacuated passivated canister using ultra zero air or UHP nitrogen for dilution/pressurization. For example, the working standard concentration to be used to establish the lower end of the calibration range (20 µg/m^3 nominal concentration) should allow for a flow-injection volume of at least 25 mL over a minimum of 10 seconds (150 mL/min x 10 seconds) for the lowest calibration point (the target RL). The working standard concentration to be used to establish the higher end of the calibration range (500 µg/m^3 nominal concentration) should allow for a flow-injection volume of at least 25 mL over 10 seconds (150 mL/min x 10 seconds) for the mid-range calibration point. In practice a known flow rate of ultra zero air or UHP nitrogen is added concurrently with the Stock Standard in most automated devices.

> **NOTE 1:** Other mass flow controllers may allow for lower volumes to be injected. At a minimum, the laboratory should not exceed the mass flow controller manufacturer's minimum flow rate or volume.
>
> **NOTE 2:** Gas-tight syringes can also be used in lieu of mass flow controllers in certain instances. Syringes may be more appropriate when preparing standards in low volume canisters (e.g., 1-liter canisters). In general, the use of the mass flow controllers is preferred for preparation of all working standards.

7.3.4 All working standards must be humidified to a minimum of 30% relative humidity. A ratio of 7.2 µL water/liter of gaseous standard is acceptable for humidification of working standards if the laboratory's calibration preparation system is not equipped with a humidification chamber (e.g., 6-liter canister = 18 liters when pressurized and therefore requires 7.2 µL x 18 L = 130 µL of water). After the addition of the stock standard, dilution gas, and humidification liquid (if required), the working standard canister must be pressurized (maximum 30 psig) with ultra zero air or UHP nitrogen. The internal pressure of the working standard canister should be accurately measured and documented.

7.3.5 It is recommended that all working standard canisters be allowed to equilibrate for at least 24 hours before use.

7.4 APH Calibration Standards

7.4.1 APH calibration standards consist of a series of measured flow-injected volumes of the APH working standards directly injected into the concentrator/GC/MS system.

7.4.2 For the individual APH calibration standards, a pre-designated concentration is directly flow-injected into the concentrator/GC/MS by varying the volumes of the working standards. At a minimum, five different concentrations are required for a valid calibration curve. If non-linear (i.e., quadratic) regression is used, a minimum of six (6) concentrations are required for a valid calibration curve (see Section 9.4.11.1). In either case, the calibration concentrations must be evenly dispersed over the full working range of the detector with the lowest calibration point corresponding to the target RL. Tables 3a and 3b provide recommended concentrations and preparation methods for each calibration standard used for a 5-point initial calibration of hydrocarbon ranges and Target analytes, respectively.

7.4.3 The range of volumes used for the APH calibration standards must be inclusive of the minimum and maximum sample volumes that will be used during routine sample analysis (e.g., as shown in Tables 3a and 3b, the minimum volume is 25 mL and the maximum volume is 250 mL). If sample volumes outside the range of calibration volumes are utilized, the laboratory must statistically demonstrate acceptable recovery of all target analytes over the full dynamic range of the calibration curve using the out-of-range injection volume. This statistical demonstration will be performed using the procedure described in Section 10.4, using the injection volume of interest with the higher concentration working standard. In any case, the minimum sample volume used should not be less than the manufacturer's recommendation for the concentrator (typically 20-25 mL).

7.5 Internal Standard and MS Tuning Standard

The recommended internal standards (IS) are Bromochloromethane, 1,4-Difluorobenzene, and Chlorobenzene-d5. The required MS tuning standard is BFB. Stock standards of these compounds should be prepared or purchased in a humidified canister at a concentration to accurately flow-inject a concentration of 10 ppbV or 10 $\mu g/m^3$ into the trap during the collection time for all calibration, blank, and sample analyses, whether through a mass flow controller or a sample loop injector. The volume of internal standard mixture added for each analysis must be the same from run to run. The concentrations of internal standards can be assigned a nominal value of 10 ppbV or 10 $\mu g/m^3$ for comparison and consistency with the laboratory's selected reporting units. This will vary among laboratories depending on which units are used during the calibration of the instrument.

8.0 SAMPLE COLLECTION AND HANDLING

8.1 Canister and Flow Controller Cleaning

All canisters must be leak tested and certified clean prior to being used for sampling. Associated canister sampling equipment (e.g., flow controllers, critical orifice assemblies) must also be deemed clean and appropriate for use prior to sampling. Cleaning techniques and acceptance criteria may vary between laboratories but, in general, procedures should include backflushing with humidified ultra zero air or UHP nitrogen. Flow controllers are calibrated with NIST-traceable flow meters. A detailed procedure for canister cleaning and maintenance is presented in Appendix 4.

8.2 Sample Collection

8.2.1 All samples must be accompanied by a chain-of-custody form, or equivalent, that documents the canister and flow controller serial numbers, date and time of sample collection, and all other pertinent sampling information.

8.2.2 Grab samples are collected by opening the sampling valve of a pre-evacuated canister (initial vacuum $\geq$ 28 in. Hg) and allowing the canister to fill to ambient pressure. Equalization to atmospheric pressure under these conditions may be completed in a minute or less.

8.2.3 Time-integrated samples require the use of a properly calibrated flow controller. The flow controller's calibration must be performed and verified (by the laboratory) prior to sample collection. Upon receipt at the laboratory, a post-sampling flow controller calibration verification must be performed. The RPD between the initial and post sampling calibration readings must be calculated. As long as the RPD is $\leq$ 20, the calibration and associated time interval are considered valid. If the RPD is >20, a notation must be provided in the data report form and laboratory narrative disclosing the deficient RPD value. The flow controller RPD is one line of evidence in the proper collection of samples for APH analysis. If the canister vacuum is acceptable after sampling and the flow controller RPD is outside of the acceptance criteria, data quality is not adversely affected.

<u>Sampling Note</u>: Flow controllers will be calibrated such that a small amount of vacuum will remain in the canister at the end of sampling (approximately 5 in. Hg). The post-sampling canister vacuum will be measured by the laboratory using an annually calibrated, NIST-traceable vacuum/pressure gauge. The vacuum should be approximately 5 in. Hg to ensure a consistent flow rate throughout the measured time interval. However, due to temperature/pressure differences in the field, as well as site-specific conditions for various sampling applications (e.g., moisture levels, soil type, site access issues), the actual post-sampling canister pressure may be slightly different than 5 in. Hg.

8.2.4 Upon receipt at the laboratory, all samples must be assigned unique laboratory identification numbers.

8.2.5 The canister pressure of all grab and time-integrated samples must be measured and documented upon receipt at the laboratory. An annually calibrated NIST-traceable vacuum/pressure gauge is attached to the canister inlet, the sampling valve is briefly opened and the pressure is recorded. If the canister vacuum on receipt is > 15 in. Hg, or if the canister vacuum measured on receipt at the laboratory differs from the final canister vacuum measured in the field by more than ±5 in. Hg, the client should be contacted to determine if analysis should proceed. If the client indicates that the analysis should proceed, the noted anomalies should be documented on the data report form or the laboratory narrative.

8.2.6 Samples may be pressurized to a maximum of 5 psig with humidified ultra zero air or UHP nitrogen after receipt in the laboratory. Refer to Section 9.5.1.3 for the calculation of dilution factors for pressurized samples.

8.2.7 Documentation Requirements

8.2.7.1 Pre-Sampling Information: Provided by the Laboratory
Canister serial number
Individual or batch certification results
Canister volume
Pre-sampling canister vacuum
Flow controller serial number
Date canister released by the laboratory

8.2.7.2 Sampling Information: Provided by the Sampler

Site location
Sampling date
Sampling location
Sample identification (ID)
Canister serial number for each sample ID
Canister volume (liters) for each sample ID
Sampling duration
Flow controller identification number (if utilized) for each sample ID
Sampling start and end times
Initial and final ambient temperatures and atmospheric pressures
Initial and final interior temperatures
Initial and final canister vacuums (in. Hg)
Date shipped to laboratory

8.2.7.3 Post Sampling Information: Provided by the Laboratory

Date received
Laboratory ID
Vacuum of canister upon receipt at laboratory
Flow controller calibration RPD

8.3 Holding Time

Canisters should be used in the field in a timely manner (i.e., they should not be stockpiled at the site prior to use). The maximum holding time for the analysis of passivated canister samples for APH analyses is 30 days from the date of sample collection.

9.0 ANALYTICAL PROCEDURE

9.1 Sample Preparation and Concentration

9.1.1 Ensure the integrity of the canister sample as described in Section 8.0.

9.1.2 Connect the canister(s) valve to the concentrator autosampler or sample inlet line. The canister must remain closed.

9.1.3 Leak check all canister inlet connections. Analysis may not begin until the leak check has passed for each canister being tested. Refer to the concentrator manufacturer's specifications for leak check criteria. For example, the pressure change should not exceed 2.0 psia over a 30 second period for an Entech 7100A concentrator.

9.1.4 Open the canister valves.

9.1.5 For the analysis of low concentration samples, set up the concentrator system to withdraw the nominal sample volume (i.e., "1x" volume) of air from each canister. If high concentrations are expected, lower volumes may be used, but they should be within the range of volumes used for the initial calibration standards (See Section 7.4.3). The nominal (1x) volume for typical analytical applications is 0.25 liters.

9.1.6 General description of the whole-air sample concentration procedure: commercially available systems typically consist of a 2- to 3-stage trapping procedure that "freezes out" analytes of interest while simultaneously removing as much of the matrix (i.e., nitrogen, oxygen, carbon dioxide, methane, and moisture) as possible. Sample volume and flow rates are controlled via a mass flow controller, which negates the effect of variations in the pressure and temperature of the samples and calibration standards. The sample is withdrawn from the canister by creating a pressure differential with a vacuum pump across the mass flow controller which is in line with the canister. An aliquot of sample is withdrawn at a constant flow rate onto a trap containing a sorbent material capable of adsorbing the analytes of interest. After equilibration, the target analytes are transferred to a cryofocusing unit, and when the GC is ready, the sample is injected by ballistic heating of the cryofocuser. The heating of the cryofocuser transfers the target analytes to the GC/MS system.

9.2 GC/MS Conditions

NOTE: Conditions described below are for an Agilent 6890/5973 GC/MS system.

9.2.1 Gas Chromatograph

9.2.1.1 Recommended oven program: initial temperature 25°C, hold for 5.0 min. Increase temperature to 100°C at 8.0°C/min, and then increase temperature to 220°C at 25°C/minute. Hold for 4.0 min.

GC conditions may vary, but a minimum separation requirement of 50% (maximum peak height to valley height) must be met, particularly for hexane and bromochloromethane (IS1) in a 20 µg/m^3 Calibration standard.

9.2.1.2 Gas Flows: Helium carrier gas flow of 2 mL/min is the recommended flow rate.

9.2.1.3 Recommended Sample Injection

Injection mode: splitless.
Injection port temperature: 220°C.
Inlet pressure: 25.77 psi.
Purge flow: 36.3 mL/min at 0 minutes.
Gas saver flow: 20 mL/min.

9.2.1.4 Recommended MS Conditions

Temperature of MS transfer line: 240°C.
Temperature of MS Quad: 150°C.
Temperature of MS Source: 230°C.
Solvent Delay: 4.0 minutes.
Scanning Parameters: minimum range 35-250 amu.
MS must be tuned to pass BFB criteria listed in Table 2.

9.3 Retention Time Windows

The APH retention time (Rt) window for the C_5 - C_8 aliphatic hydrocarbons is defined as beginning 0.1 minutes before the elution of isopentane and ending 0.01 minutes before the elution of nonane. The C_9 - C_{12} aliphatic hydrocarbon range begins 0.01 minutes before the elution of nonane; therefore there is no overlap of the two ranges and the nonane peak is only included in the C_9 - C_{12} aliphatic hydrocarbon range. The C_9 - C_{12} aliphatic hydrocarbon range ends 0.1 minutes after the elution of dodecane.

The APH Rt window for the C_9 - C_{10} aromatic hydrocarbons is defined as beginning 0.1 minutes **after** the Rt of the beginning marker compound (o-xylene) and ending 0.1 minutes before the Rt of the ending marker compound (naphthalene).

APH marker compounds and windows are summarized in Table 4.

9.4 Calibration

NOTE: Calibration and sample analysis calculations presented in this section are based on the GC/MS system response to multiple calibration standards expressed in units of "nominal" concentration (µg/m^3). Other quantitative approaches such as GC/MS system response to multiple calibration standards expressed in units of on-column mass (µg) are also acceptable.

9.4.1 The APH working standards are used to calibrate the GC/MS system. Two distinct calibration operations are necessary:

9.4.1.1 Target APH Analytes: Relative Response Factors (RRFs) are calculated for the Target APH Analytes, based upon a correlation between the concentration of analyte and area counts for the relevant quantitation ions. This allows for the individual identification and quantitation of these specific compounds. It is not necessary to develop response factors for any other individual APH Components.

9.4.1.2 Collective Aliphatic/Aromatic Hydrocarbon Ranges: RRFs are calculated for C_5-C_8 aliphatic hydrocarbons and C_9-C_{12} aliphatic hydrocarbons based upon a correlation between the TOTAL concentration of aliphatic APH Components eluting within the range of interest and the total ion area count. An RRF is calculated for C_9-C_{10} aromatic hydrocarbons based upon a correlation between the TOTAL concentration of aromatic

APH Components eluting within this range and the total area count of extracted ions 120 and 134. Specified APH Components are designated marker compounds to define the beginning and end of the hydrocarbon ranges (see Table 4).

9.4.2 Primary (quantitation) and secondary extracted ions for all APH Components and the recommended internal standards are provided in Table 5. The recommended internal standards used for quantitation of each Target APH Analyte and hydrocarbon range are provided in Table 6. A listing of the hydrocarbon range compounds used to establish response factors for each hydrocarbon range of interest and their individual component concentration (µg/m^3) is provided in Table 3a.

Initial Calibration

The use of RRFs is the preferred approach to determine the relationship between the detector response and the analyte and collective range concentrations for the APH Method. It is also permissible to utilize linear or non-linear regression (see Section 9.4.11.1). The linear regression approach for APH target analytes and collective ranges is described in Appendix 6. Detailed guidance regarding the use of a non-linear regression calibration model, may be found in SW-846 Method 8000B, Section 7.5.3.

NOTE: A sample calculation demonstrating the proper application of the equations shown in the following sections is presented in Appendix 5, APH METHOD CALCULATIONS.

9.4.3 In all but the most extreme cases, an initial calibration is performed using a minimum of five different concentrations prepared using various volumes of the APH working standards. Recommended range and target analyte calibration standard concentrations are provided in Tables 3a and 3b, respectively. If non-linear (quadratic) regression is used under the circumstances described in Section 9.4.11.1, a minimum of six (6) calibration concentrations must be used. In either case, the calibration concentrations must be evenly dispersed over the full working range of the detector with the lowest calibration point corresponding to the target RL.

9.4.4 Analyze each Calibration standard according to the procedures specified in Sections 9.1 and 9.2.

9.4.5 Target APH Analytes - Tabulate the area response of the primary (or quantitation) ions against the concentration for each Target APH Analyte and internal standard, and calculate an RRF for each compound using Equation 1. Perform this calculation for each Target APH Analyte.

Equation 1: Relative Response Factor for Target APH Analytes

$$\boxed{RRF = [(A_{EC}) * (C_I)] / [(A_{EI}) * (C_c)]}$$

where:

RRF = relative response factor
A_{EC} = area count of the primary (quantitation) ion for the analyte of interest
C_I = concentration of the associated internal standard (µg/m^3): See Sec. 7.5
A_{EI} = area count of the primary (quantitation) ion for the associated internal standard
C_C = concentration of analyte of interest (µg/m^3): refer to last column of Table 3b

9.4.6 Hydrocarbon Ranges - Establish retention time windows for the hydrocarbon ranges using the APH Component marker compounds shown in Table 4.

9.4.7 Calculate an RRF for the C_5-C_8 aliphatic hydrocarbon range using the following steps.

9.4.7.1 Using total ion integration, sum the individual peak areas of the six APH Components that are used to establish an average range RRF for C_5-C_8 aliphatic hydrocarbons, as designated in Table 3a. Do not include the peak areas of internal standards (all of the recommended internal standards elute in this range).

9.4.7.2 Using the total area generated in Section 9.4.7.1, calculate the C_5-C_8 aliphatic hydrocarbon range RRF using Equation 2.

Equation 2: Relative Response Factor for C_5-C_8 Aliphatic Hydrocarbons

$$\text{Range } RRF = [(A_T) * (C_I)] / [(A_{EI}) * (C_T)]$$

where:

A_T = total ion area count of the six aliphatic APH Components which elute within this range (see Table 3a)

C_T = summation of the concentrations of the six aliphatic APH Components ($\mu g/m^3$) which elute within this range: refer to the last column of Table 3a

9.4.8 Calculate an RRF for the C_9-C_{12} aliphatic hydrocarbon range using the following steps.

9.4.8.1 Using total ion integration, sum the individual peak areas of the six APH Components that are used to establish an average range RRF for C_9-C_{12} aliphatic hydrocarbons, as designated in Table 3a. Do not include the peak area of BFB.

9.4.8.2 Using the total area generated in Section 9.4.8.1, calculate the C_9-C_{12} hydrocarbon range RRF using Equation 3.

Equation 3: Relative Response Factor for C_9-C_{12} Aliphatic Hydrocarbons

$$\text{Range } RRF = [(A_T) * (C_I)] / [(A_{EI}) * (C_T)]$$

9.4.9 Calculate an RRF for the C_9-C_{10} aromatic hydrocarbon range using the following steps.

9.4.9.1 Using extracted ion m/e 120, sum the individual peak areas of the five APH Components that are used to establish an average range RRF for C_9-C_{10} aromatic hydrocarbons, as designated in Table 3a.

9.4.9.2 Using extracted ion m/e 134, sum the individual peak areas of the five APH Components that are used to establish an average range RRF for C_9-C_{10} aromatic hydrocarbons, as designated in Table 3a.

9.4.9.3 Sum the area counts from Sections 9.4.9.1 and 9.4.9.2.

9.4.9.4 Using the area count generated in 9.4.9.3, calculate the C_9-C_{10} aromatic range RRF using Equation 4.

Equation 4: Relative Response Factor for C_9-C_{10} Aromatic Hydrocarbons

$$\text{Range } RRF = [(A_T) * (C_I)] / [(A_{EI}) * (C_T)]$$

A_T = summation of area counts for extracted ions 120 and 134 for the five aromatic APH Components which elute within this range (see Table 3a)

C_T = summation of the concentrations of the five aromatic APH Components ($\mu g/m^3$), which elute within this range: refer to the last column of Table 3a

9.4.10 Calculate the average RRF for each of the Target APH Analytes and each hydrocarbon range.

9.4.11 Calculate the percent relative standard deviation (%RSD) of the RRFs over the working range of the curve for each of the Target APH Analytes and each hydrocarbon range using Equation 5.

Equation 5: Percent Relative Standard Deviation

$$\boxed{\%RSD = [(SD_{n-1})/(AVG_X)]*100}$$

where:

%RSD = percent relative standard deviation
SD_{n-1} = standard deviation (n-1 degrees of freedom)
AVG_x = average RRF from the initial calibration curve

9.4.11.1 If the %RSD is ≤30, linearity can be assumed for the associated Target APH Analyte or hydrocarbon range. For naphthalene, the %RSD can be ≤40.

If, under **extenuating** analytical circumstances (e.g., extending the RL beyond the expected linear range of the detector, difficult analytes with non-linear mass/response ratios), the %RSD criteria specified in Section 9.4.11.1 cannot be achieved, then a linear (least squares) or non-linear (quadratic) regression may be used to generate a calibration curve consistent with the guidance provided in SW-846 Method 8000B, Sections 7.5.2 and 7.5.3. **Use of the non-linear calibration alternative must be documented in the laboratory narrative**.

NOTE: It is not the intent of this alternative calibration approach to allow for a non-linear calibration model to be used to compensate for detector saturation or to avoid proper instrument maintenance. As such, non-linear regression must not be employed for analytes that consistently met %RSD criteria specified in Section 9.4.11.1 in previous calibrations.

9.4.11.2 In order for the linear or non-linear regression model to be used for quantitative purposes, r (Correlation Coefficient) or r^2 (Coefficient of Determination) must be greater than or equal to 0.99. In addition, the resulting calibration curve from the linear or non-linear regression must be verified by recalculating concentrations of the target analytes and hydrocarbon ranges in the lowest calibration standard using the final calibration equation. Recoveries must be 70-130% (except naphthalene 60-140%).

If recalculated concentrations from the lowest calibration standard are outside 70-130% (or 60-140% for naphthalene) recovery range, either:

Report the RL as an estimated value, or

Raise the RL to the concentration of the next highest calibration standard that exhibits acceptable recoveries when recalculated using the final calibration equation.

9.4.11.3 The statistical considerations in developing non-linear calibration curves require more data than the linear calibration approach. As described in Section 9.4.3, the linear regression model requires five equally distributed calibration concentrations for initial calibration while the non-linear regression model requires a minimum of six equally distributed calibration concentrations.

For the linear or non-linear regression calculation, the origin (0,0) can not be included as a calibration point.

9.4.11.4 For any calibration model, the concentration of the lowest initial calibration standard, adjusted for sample size, dilution, etc., establishes the method RL.

9.4.12 The initial calibration must be verified through the analysis of an LCS. This analysis must be performed every time an initial calibration is performed and prior to sample analyses on a daily basis.

9.4.12.1 The LCS must be prepared in a certified-clean canister from a different stock standard than that used to prepare the calibration standard. The LCS should be prepared at a mid-range calibration curve concentration.

9.4.12.2 At a minimum, the LCS must contain 1,3-butadiene, benzene, toluene, ethylbenzene, m-xylene, p-xylene, o-xylene, and naphthalene, and at least one compound from each hydrocarbon range (recommended representative range compounds: heptane for C_5-C_8 aliphatics, decane for C_9-C_{12} aliphatics, and 1,3,5-trimethylbenzene for C_9-C_{10} aromatics). The concentration of the representative range compounds must be greater than the lowest summed range concentration in Table 3a (suggest using 20-50 µg/m^3).

9.4.12.3 Calculate the percent recovery of each Target APH Analyte and hydrocarbon range using Equation 6. Percent recoveries must be between 70-130% for target analytes except for naphthalene, which must exhibit percent recoveries between 50-150%.

Equation 6: Percent Recovery

$$\boxed{\%R = [(C_{found}) / (C_{true})]*100}$$

where:

%R = Percent Recovery
C_{found} = Concentration of the analyte or hydrocarbon range detected in the LCS (µg/m^3)
C_{true} = True concentration of the analyte or hydrocarbon range in the LCS (µg/m^3)

<u>**Continuing Calibration**</u>

9.4.13 A continuing calibration check must be performed daily prior to sample analysis. It should be noted that the Percent Differences (%Ds) are calculated (Equation 7) when RRFs are used for the initial calibration and Percent Drifts (Equation 6-5, Appendix 6) are calculated when calibration curves using linear or non-linear regression are used for the initial calibration.

9.4.14 The concentration of the APH Calibration Check Standard must be near the midpoint of the calibration curve.

9.4.15 Calculate the RRF for each APH Target analyte and hydrocarbon range from the Calibration Check Standard using Equations 1 through 4.

9.4.15.1 Calculate the %D of the Calibration Check Standard RRF from the initial calibration average RRF using Equation 7.

Equation 7: Percent Difference

$$\boxed{\%D = [(RRF_C) - (RRF_I)]/[(RRF_I)]*100}$$

where:

%D = Percent Difference
RRF_C = RRF from the APH Calibration Check Standard

RRF_I = average RRF from the initial calibration curve

9.4.16 The %D or Percent Drift for each APH Target analyte and hydrocarbon range must be ≤30. If more than one compound fails to meet the applicable criterion, or if the %D or Percent Drift for any one compound is greater than 50, the instrument must be recalibrated. Otherwise, sample analysis may proceed.

Retention Time Windows

9.4.17 The range retention time windows must be established daily based upon the retention time of the marker compounds in the APH Calibration Check Standard. The marker compounds used for each range are defined in Table 4.

Daily GC/MS Performance Check

9.4.18 A check of the GC/MS tuning must be performed daily prior to sample analyses. The GC/MS system is checked to confirm that acceptable performance criteria for mass spectral ion abundance ratios are met for BFB. These criteria must be met prior to analyzing any additional standards, blanks and samples.

9.4.19 Performance criteria for the required tuning standard, BFB, are provided in Table 2. If the tuning criteria are not met, the GC/MS must be retuned and the analysis repeated.

9.5 GC/MS Analysis of Samples

9.5.1 Pre-concentrate the pre-established nominal volume of sample (typically 0.25 liters) on the concentrator and inject it onto the GC column. When the nominal volume of the sample is analyzed, the dilution factor is 1.0.

Dilution Factors and Sub-Atmospheric Samples

9.5.1.1 For dilutions, sample volumes smaller than the nominal volume can be analyzed. The smallest volume used should not be less than that used for the initial calibration. See Section 7.4.3 for further instructions on sample volumes. When volumes less than the nominal sample volume are analyzed, the dilution factor is calculated as follows:

DF = nominal sample volume/actual volume analyzed

9.5.1.2 For more concentrated samples where analysis of smaller volumes will not be adequate to ensure concentrations are within the calibration range, the canister must be pressurized and an aliquot of sample removed and injected into another canister. The dilution factor is calculated using the following steps:

1. Calculate the dilution factor (DF1) due to the pressurization of the sample using Equation 8 below.
2. Calculate the dilution factor (DF2) of the prepared sample:

$$DF(2) = DF(1) * \frac{\text{volume of sample removed from original canister}}{\text{volume of new canister}}$$

3. Calculate the final dilution factor:

DF = DF(2)* (nominal sample volume/actual volume analyzed)

9.5.1.3 Samples which arrive at the laboratory with a high vacuum (i.e., > 15 in. Hg) must be pressurized with ultra zero air or UHP nitrogen. The laboratory may also choose to pressurize all canisters upon receipt. This pressurization results in sample dilution. The resultant dilution factor is calculated using Equation 8.

Equation 8: Dilution Factor for Pressurization of Subatmospheric Samples

$$\boxed{DF=(P_f + 14.7)/(P_i + 14.7)}$$

where:

P_i = pressure reading of canister prior to pressurization (units = psig)
P_f = pressure reading of canister after pressurization (units = psig)
DF = dilution factor

Note: *To convert from in. Hg to psig*:

psig = in. Hg * 0.491159

9.5.2 Identification of APH Target Analytes

The Target APH analytes in field samples must be identified by a qualified mass spectrometrist competent in the interpretation of chromatograms and mass spectra.

9.5.2.1 The laboratory **must** report all APH target analytes that meet the following criteria:

(1) The relative retention time (RRT) of the target analyte in the sample agrees with the RRT of the target analyte in the associated Calibration Check Standard within ± 0.33 minutes; and
(2) The relative intensities of the primary (quantitation) and secondary ions (Table 5) for the target analyte in the sample agree within ± 20% of the relative intensities of the same ions in the Calibration Check Standard.

9.5.2.2 If co-elution of interfering components prohibits accurate identification of the sample component RRT from the total ion chromatogram, the RRT should be assigned using extracted ion current profiles for the ion unique to the component of interest.

9.5.2.3 If the above-referenced criteria are met but in the analyst's opinion a false positive result is suspected, this must be reported and explained in the laboratory narrative.

9.5.2.4 For comparison of the target analyte's mass spectra between samples and standards, mass spectra of standards obtained on the GC/MS under the same instrument conditions are required (e.g., from the calibrations). Once obtained, these standard spectra must be used for identification and reference purposes.

9.6 Calculations

The concentration of Target APH Analytes and hydrocarbon ranges in a sample may be determined from the peak area response, using the RRF determined in Section 9.4. If linear regression was used for calibration, refer to Appendix 6 for sample concentration calculations. If non-linear regression was used, refer to SW-846 Method 8000B, Section 7.5.3 for guidance. **Use of non-linear regression for concentration calculations must be reported in the laboratory narrative.**

9.6.1 **Individual Target APH Analytes:** The average response factor from the initial calibration is used to calculate the concentration of an analyte detected in the sample. Equation 9 is used to calculate the concentration of Target APH Analytes in $\mu g/m^3$. Equation 10 is used to convert $\mu g/m^3$ to ppbV.

Equation 9: Calculation of Sample Concentration (μg/m^3)

-

$$Cx = [(A_x) * (C_{IS})]/[(A_{IS}) * (RRF_{avg})] * DF$$

where:

Cx= concentration of target analyte, μg/m^3
Ax = area of primary (quantitation) ion for the Target APH Analyte (see Table 5)
C_{IS} = concentration of the associated internal standard, μg/m^3: See Section 7.5
A_{IS} = area of primary (quantitation) ion for the associated internal standard (see Table 5)
RRF_{avg} = average RRF for the Target APH analyte to be measured
DF = dilution factor (See Section 9.5.1)

Equation 10: Conversion of μg/m^3 to ppbV

$$ppbV = Cx * 24.45 / MW$$

where:

MW = molecular weight of the compound of interest, g/mol (see Table 1 for a list of the molecular weights of the Target APH Analytes)
24.45 = molar gas constant; assumes R = 0.08206 L-atm/mole-K, T = 298K and P = 1 atm

9.6.1.1 The integration of Target APH Analytes and internal standards must be performed from valley to valley.

9.6.2 Hydrocarbon Ranges

When calculating the APH Method aliphatic and aromatic hydrocarbon range concentrations, the laboratory **must** include the area of **all** peaks eluting within the retention time windows specified for these ranges, excluding internal standards and target analytes, as described in Sections 9.6.2.1, 9.6.2.2, and 9.6.2.3 below.

The average hydrocarbon range RRF from the initial calibration is used to calculate the concentration (μg/m^3) of hydrocarbon ranges in samples**. Collective peak area integration for the hydrocarbon ranges must be from baseline (i.e., must include the unresolved complex mixture).**

NOTE: Hydrocarbon range concentrations can only be reported in μg/m^3.

At the discretion of the data user, the contribution of non-APH compounds (compounds not meeting the definitions in Sections 3.1.9, 3.1.10 and 3.1.11) that elute within the method-defined retention time windows for the aliphatic and aromatic ranges may be excluded from collective range concentration calculations. Specifically, the total ion area counts (aliphatic ranges) and the 120/134 m/e area counts (aromatic range) for these non-APH compounds may be excluded providing the compound is **positively identified** by GC/MS. However, if the non-APH compound co-elutes with an aliphatic petroleum hydrocarbon, the total ion area count cannot be subtracted from the range. In addition, in complex sample matrices (i.e., many co-eluting peaks, complex petroleum patterns), this type of data adjustment may not be possible. All data adjustments and the presence of these non-APH compounds must be disclosed on the laboratory report form and laboratory narrative. A list of common non-APH compounds that elute within the aliphatic and aromatic ranges is presented in Table 7.

Detailed guidance regarding the identification criteria for these non-APH compounds is presented in Section 11.2.

9.6.2.1 C_5-C_8 Aliphatic Hydrocarbons

- Using total ion integration, sum all peaks in the appropriate retention time window, as specified in Section 9.3 and Table 4.

- From this sum, subtract the total ion area counts of all internal standards which elute in this range (all of the recommended internal standards elute in this range).

- Calculate a preliminary concentration in µg/m^3 using Equation 11.

Equation 11: Calculation of Preliminary Sample Concentration (µg/m^3)

$$\boxed{Cx = [(A_x) * (C_{IS})]/[(A_{IS}) * (RRF_{avg})]}$$

where:

Cx= concentration of hydrocarbon range, µg/m^3
A_x = C_5-C_8 aliphatics: total ion area count of all peaks eluting within aliphatic hydrocarbon range window (excluding the internal standards)
C_{IS} = concentration of the associated internal standard (µg/m^3): See Section 7.5
A_{IS} = area count of the primary (quantitation) ion for the associated internal standard
RRF_{avg} = average RRF for the hydrocarbon range of interest

- From the preliminary concentration (µg/m^3), calculate an adjusted concentration of C_5-C_8 aliphatic hydrocarbons by subtracting the concentrations of target APH analytes, which elute in this range (typically MTBE, benzene, toluene, ethylbenzene, and m-, p- & o- xylenes for the C_5-C_8 aliphatic hydrocarbons).

9.6.2.2 C_9-C_{10} Aromatic Hydrocarbons

- Using extracted ion 120, sum all peaks in the appropriate retention time window, as specified in Section 9.3 and Table 4.

- Using extracted ion 134, sum all peaks in the appropriate retention time window, as determined in Section 9.3 and Table 4.

- Sum the area counts of extracted ions 120 and 134 from the above two steps.

- Calculate the concentration in µg/m^3 using Equation 11, using the summed areas of extracted ions 120 and 134 for Ax.

9.6.2.3 C_9-C_{12} Aliphatic Hydrocarbons

- Using total ion integration, sum all peaks in the appropriate retention time window, as specified in Section 9.3 and Table 4.

- From this sum, subtract the total ion area count of the BFB peak.

- Calculate a preliminary concentration in µg/m^3 using Equation 11, using the area count generated from the previous step for Ax.

- From the preliminary concentration, calculate an adjusted concentration of C_9-C_{12} aliphatic hydrocarbons by subtracting the concentrations of target APH analytes, which elute in this range (possibly naphthalene depending on GC conditions), and by subtracting out the concentration of C_9-C_{10} aromatic hydrocarbons.

10.0 QUALITY CONTROL

10.1 General Requirements and Recommendations

10.1.1 Each laboratory that uses this method is required to operate a formal quality control program. The minimum requirements of this program consist of an Initial Demonstration of Laboratory Capability (IDLC) and an ongoing analysis of prepared QC samples to evaluate and document the quality of data. The laboratory must maintain records to document the quality of the data produced. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance standards for the method.

10.1.2 At a minimum, for each analytical batch (every 24 hours), an Initial Calibration or Calibration Check Standard, LMB, LCS, and a Matrix Duplicate must be analyzed. The Initial Calibration or Calibration Check Standard, LMB, and LCS must be analyzed prior to samples.

10.1.3 The recommended sequence of analysis is as follows:

(1) Analytical batch calibration standards (initial) or mid-range Calibration Check Standard (daily check of initial calibration), either of which are used to evaluate BFB for GC/MS tuning. [**REQUIRED**]
(2) Analytical batch LCS. **[REQUIRED]**
(3) Analytical batch LMB. **[REQUIRED]**
(4) Batch samples (up to 20).
(5) Matrix Duplicate. **[REQUIRED]**

All analytical sequences and data must be recorded in a daily run log.

10.2 Minimum Instrument QC

10.2.1 Internal standards

10.2.1.1 Internal standards must be adequately resolved from individual compounds in the APH Calibration standard. A minimum separation requirement of 50% (maximum peak height to valley height) must be met, particularly for hexane and bromochloromethane (IS1) in a 20 µg/m^3 calibration standard.

10.2.1.2 Internal standard recoveries must be evaluated with each field sample, blank, LCS and Sample Duplicate. The internal standard area counts in each field sample, blank, and LCS must be evaluated. The internal standard area counts must be within 50-200% of the internal standard area counts in the corresponding Calibration Check Standard. If the internal standard area counts fall outside of this range, check calculations to locate possible errors, check the sample introduction system for leaks or other malfunctions, and check for changes in instrument performance. If the cause cannot be determined, reanalyze the sample unless one of the following exceptions applies:

(1) Obvious interference is present on the chromatogram (e.g., unresolved complex mixture).
(2) The internal standard exhibits high recovery and associated target analytes or hydrocarbon ranges are not detected in the sample.

If a sample with an internal standard recovery outside of the acceptable range is not reanalyzed based on any of these aforementioned exceptions, this information must be noted on the data report form and discussed in the laboratory narrative.

Analysis of the sample on dilution may diminish matrix-related internal standard recovery problems. This approach can be used as long as RLs less than or equal to the applicable MCP standards will still be achieved with the dilution. If not, reanalysis without dilution must be performed, unless the concentrations of target analytes do not allow an undiluted run. Recoveries of internal standards outside of the acceptable range after re-analysis must also be noted on the data report form and discussed in the laboratory narrative.

10.2.2 **Mass spectrometer tuning** must be performed daily (once every 24 hours) before any analyses are conducted. Acceptance criteria for the recommended tuning standard, BFB, are provided in Table 2.

10.2.3 **Laboratory Method Blanks** must be analyzed daily (once every 24 hours) prior to sample analyses and after samples, which are highly contaminated (i.e., at concentrations above the highest calibration standard) to determine if sample carryover has occurred. If samples have been analyzed using an autosampler, data should be evaluated for potential carryover and reanalysis conducted, as appropriate. The laboratory method blank must be free of target APH analyte and hydrocarbon range contamination at or above the RL. However, C_{12} hydrocarbons and naphthalene may be present at up to two times the RL.

10.2.4 **Relative Retention Times** must be established for each analyte and hydrocarbon range of interest each time a new GC column is installed and must be verified and/or adjusted on a daily basis. (See Section 9.3).

10.2.5 **Calibration**

10.2.5.1 **Initial Calibration:** RRFs must be calculated for each APH target analyte and hydrocarbon range based upon the analysis of a minimum of 5 calibration standards (or 6 calibration standards for non-linear regression). With the exception of naphthalene, the linearity of RRFs may be assumed if the %RSD over the working range of the calibration curve is ≤ 30. (See Section 9.4). For naphthalene, the %RSD must be ≤ 40. For linear or non-linear regression, r or r^2, respectively, must be ≥ 0.99.

10.2.5.2 **Calibration Check Standard:** The Calibration Check Standard must be analyzed prior to sample analysis to verify the accuracy of the calibration of the instrument. For analytes of interest, the %D must be ≤ 30. If more than one compound fails to meet this criterion, or if the %D for any one compound is greater than 50, the instrument must be recalibrated. Otherwise, sample analysis may proceed.

10.2.6 **Laboratory Control Samples** must be analyzed daily (once every 24 hours) prior to sample analyses. Recoveries of APH target analytes and representative aliphatic and aromatic range compounds must be between 70 and 130% (or 50-150% for naphthalene).

- If the recoveries are low and outside of the acceptance limits, reanalyze the LCS and associated samples. If still outside of the acceptance limits, recalibrate.
- If the recoveries are high and outside of the acceptance limits and the affected compound was detected in the associated samples, reanalyze the LCS and the associated samples. If recoveries are still outside of the acceptance limits, recalibrate.
- If the recoveries are high and sample results were nondetect, data can be reported without qualification; however, the high recoveries should be noted in the laboratory narrative.

10.2.7 **Matrix Duplicate** - One matrix duplicate must be analyzed once every 24 hours per matrix. Matrix duplicates are prepared by analyzing one sample in duplicate. The purpose of the matrix duplicates is to determine the homogeneity of the sample matrix as well as analytical precision. Equation 12 is used to calculate the RPD of the target APH analyte and hydrocarbon range concentrations. The RPD of detected results in the matrix duplicate samples must not exceed 30 when the results are >5x the RL.

- If the RPD exceeds 30 and both results are >5x the RL, the sample analysis must be repeated.
- If an analyte is detected in one analysis at >5x the RL and not detected in the duplicate analysis, the analysis must be repeated.
- If an analyte is detected in one analysis at ≤5x the RL and not detected in the duplicate analysis, the RPD is not calculable and the analysis does not have to be repeated.
- If an analyte is not detected in both the original and duplicate analyses, the RPD is not calculable. No further action is required.

Equation 12. Relative Percent Difference Calculation:

$$\boxed{RPD = [(C_s - C_d)/[(C_s + C_d)/2]]*100}$$

where:

C_s = concentration in original sample analysis
C_d = concentration in duplicate sample analysis

10.3 If any of the performance standards specified in Section 10.2 are not met, the cause of the non-conformance must be identified and corrected before any additional samples may be analyzed. Any samples run between the last QC samples that met the criteria and those that are fallen out must be rerun. These QC samples include the Calibration Check Standard, LMB and LCS. If this is not possible, that data must be reported as suspect.

10.4 Initial and Periodic Method QC Demonstrations

The procedure specified below must be conducted, successfully completed and documented as an IDLC prior to the analysis of any samples by the APH Method. Subsequent to this initial demonstration, additional evaluations of this nature should be conducted on a periodic basis, in response to changes in instrumentation or operations, training new analysts, and/or in response to confirmed or suspected systems, method, or operational problems.

The IDLC includes an initial demonstration of accuracy and precision. The following procedure must be used:

10.4.1 Analyze a minimum of four (4) replicate samples of a Calibration Check Standard.

10.4.2 Calculate the measured concentrations of each analyte and hydrocarbon range in all replicates, the mean accuracy (as a percentage of the true value) for each analyte and hydrocarbon range, and the precision (as %RSD) of the measurements for each analyte and hydrocarbon range.

10.4.3 For each analyte and hydrocarbon range, the mean accuracy, expressed as a percentage of the true value (i.e., recovery), must be between 70% and 130%, and the replicate precision, expressed as %RSD, must be ≤25. The IDLC must meet these conditions for analysis to proceed.

NOTE: Method detection limit (MDL) studies are not required to be performed for the APH method.

11.0 DATA PRODUCTION AND REPORTING

11.1 General Reporting Requirements

11.1.1 The required data report content for the APH Method is presented in Appendix 3. While it is permissible to alter the form and presentation of the data, all of the information must be provided in a clear, concise, and succinct manner. This information provides data users with a succinct and complete summary of pertinent information and data, as well as a clear affirmation that the QC procedures and standards specified in this method were evaluated and achieved.

11.1.2 If a significant modification to the APH Method is utilized, an attachment to the analytical report must be included to demonstrate compliance with the method performance requirements of Section 1.9 on a matrix-specific and petroleum product-specific basis.

"Significant Modifications" to the APH Method shall include, but are not limited to, any of the following:

1. The use of sample collection devices other than evacuated, passivated stainless steel canisters (i.e., Tedlar bags).
2. The use of alternative detectors other than GC/MS to quantify target APH analytes and/or hydrocarbon range concentrations.
3. The use of extracted ions other than 120 and 134 to quantify C_9-C_{10} aromatic hydrocarbons.
4. The failure to provide all of the data and information required in the report form presented in Appendix 3.

Data produced using an analytical method incorporating any of the "Significant Modifications" described above may ***not*** be reported as APH data. APH range concentrations are method-defined parameters and as such may only be reported as APH data when produced using the method without "Significant Modifications."

11.1.3 Positive affirmation that all required QA/QC procedures and performance standards were followed and achieved means that all of the required steps and procedures detailed in Sections 9.0 and 10.0 have been followed, and that all data obtained from these steps and procedures were within the acceptance limits specified for these steps and procedures.

11.1.4 In addition to sample results, the APH data report must contain the following items:

- LMB results.
- LCS results.
- Matrix duplicate results.
- Internal standard results (for all field samples and QC samples).
- Results of re-analyses or dilutions must be reported as follows:

    1. If re-analysis due to internal standard issues yields similar non-conformances, the laboratory must report both results.
    2. If re-analysis due to internal standard issues is performed outside of holding time and yields acceptable internal standard recoveries, the laboratory must report results of both analyses.
    3. If sample is not re-analyzed for internal standard issues due to obvious interference, the laboratory must provide the chromatogram in the data report.
    4. If diluted and undiluted analyses are performed, the laboratory must report results for the lowest dilution within the valid calibration range for each analyte. The associated QC (e.g., method blanks, LCS, etc.) for each analysis must be reported. This may result in more than one analysis per sample being reported.

- If a significant modification to the analytical method is utilized, demonstration of compliance with analytical performance standards specified in Section 1.9 on a matrix-specific and petroleum product-specific basis must be included as an attachment to the analytical report. If the modification was not an analytical modification (e.g., use of tedlar bags), the demonstration of compliance is not required; however, the modification must be noted in the laboratory narrative.

11.1.5 General laboratory reporting requirements are outlined in WSC-CAM-VII A, *Quality Assurance and Quality Control Guidelines for the Acquisition and Reporting of Analytical Data*.

11.2 Reporting Requirements for Non-APH Compounds

As described in Section 9.6.2, the contribution (i.e., area count) of compounds not meeting the regulatory definition of the aromatic and/or aliphatic hydrocarbons, defined in Sections 3.1.9, 3.1.10 and 3.1.11, that elute within the method-defined retention time windows for these hydrocarbon ranges, may be excluded from collective range concentrations **at the discretion of the data user,** providing the compound meets the requirements for positive **GC/MS identification** as described in Section 11.2.1.

- If the non-APH compound co-elutes with an aliphatic petroleum hydrocarbon, the total ion area count may <u>not</u> be subtracted from the aliphatic range.
- In complex sample matrices (i.e., many co-eluting peaks, complex petroleum patterns), this type of data adjustment may not be possible.

All data adjustments and the presence of these positively identified non-APH compounds must be disclosed on the laboratory report form and laboratory narrative. If this data adjustment is requested by the data user, the laboratory will be required to evaluate those peaks with a peak height ≥ ½ of the peak height of the closest internal standard. Refer to Table 7 for a list of common non-APH compounds that elute within the aliphatic and aromatic hydrocarbon ranges.

11.2.1 Requirements for Positive GC/MS Identification of Non-APH Compounds:

- Spectral identification must be evaluated by a qualified mass spectrometrist.
- The spectral library match must be ≥ 85% for an identification to be made.
- The major ions in the reference spectrum (i.e., ions greater than 10% of the most abundant ion) should be present in the sample spectrum.
- The relative intensities of the major ions should agree within ± 20%.
- Molecular ions present in the reference spectrum should be present in the sample spectrum.
- Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or for the presence of co-eluting compounds.
- Ions present in the reference spectrum but not in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or co-eluting peaks.
- Structural isomers that produce very similar mass spectra can be explicitly identified only if they have sufficiently different chromatographic retention times. Acceptable resolution is achieved if the height of the valley between two peaks is less than 25% of the average height of the two peaks. Otherwise, structural isomers are identified as isomeric pairs (as a mixture of two isomers).

  <u>NOTE:</u> The analyst may use professional judgment for the identification of non-APH compounds. If non-APH compounds are identified using criteria different than the criteria listed above, this should be disclosed in the laboratory narrative.
- If the data user determines that the presence of the non-APH compound reported by the laboratory may appreciably increase the overall risk posed by the site or the utility/cost of the potential remedial measures under consideration, additional analytical work is recommended to verify the identification and/or concentration of the reported non-APH compound, either by reanalysis or resampling. This contingency will require additional coordination and communication between the laboratory and the data user.

12.0 REPORTING LIMITS

The RLs for Target APH Analytes and hydrocarbon ranges will be determined as follows.

12.1 **Target APH Analyte RLs**

The RLs for the Target APH Analytes shall be based upon the concentration of the lowest calibration standard for the analyte of interest. The RL must be greater than or equal to the concentration of the lowest calibration standard.

Example: Benzene:

- Lowest calibration standard concentration = 2 µg/m^3
- RL for benzene = 2 µg/m^3

12.2 C_9-C_{10} Aromatic Hydrocarbons

The RL for the C_9-C_{10} aromatic hydrocarbons range is determined empirically and is based upon the concentration of the lowest range calibration standard for the components which make up this range. The RL is calculated by multiplying the concentration of the lowest calibration standard by the number of APH range component compounds used in the calibration of the range.

Example: C_9-C_{10} aromatic hydrocarbons:

- Lowest calibration standard concentration = 2 µg/m^3
- Number of APH components in this range = 5
- Total concentration of lowest calibration standard = 2 µg/m^3 * 5 = 10 µg/m^3
- RL for C_9-C_{10} aromatic hydrocarbons = 10 µg/m^3

12.3 C_5-C_8 and C_9-C_{12} Aliphatic Hydrocarbons

The RLs for the C_5-C_8 aliphatic and C_9-C_{12} aliphatic hydrocarbons range are determined empirically and are based upon the concentration of the lowest range calibration standard for the components which make up these ranges. The RLs are calculated by multiplying the concentration of the lowest calibration standard by the number of APH range component compounds used in the calibration of these ranges.

Example: C_5-C_8 aliphatic hydrocarbons:

- Lowest calibration standard concentration = 2 µg/m^3
- Number of APH components in this range = 6
- Total concentration of lowest calibration standard = 2 µg/m^3 * 6 = 12 µg/m^3
- RL for C_5-C_8 aliphatic hydrocarbons = 12 µg/m^3

NOTE: The empirical determination of RLs for the aliphatic and aromatic hydrocarbon ranges is supported by past MDL studies performed by laboratories. Appendix 1 summarizes the results of MDL studies performed by five different laboratories for the hydrocarbon ranges. In all cases, the calculated RLs (3x the MDL) were below or close to the empirically determined RLs above.

13.0 METHOD PERFORMANCE

MDL study results from five laboratories for APH Method aliphatic and aromatic hydrocarbon ranges are provided in Appendix 1. An example APH Method chromatogram is provided in Appendix 2.

14.0 REFERENCES

(1) ENSR, 1999: *Laboratory Method Validation Study for the Determination of Volatile Petroleum Hydrocarbons in Indoor Air*, ENSR Corporation, June 1999.

(2) EPA, 1987: *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, US EPA, EPA-600/4-84-041, 1987. Research Triangle Park, NC.

(3) MassDEP, 1994: *Interim Final Petroleum Report: Development of Health-Based Alternative to the Total Petroleum Hydrocarbon (TPH) Parameter*, Massachusetts Department of Environmental Protection, August 1994.

(4) MassDEP, 1998: *Report on Results of the Fall 1997 VPH/EPH Round Robin Testing Program*, Massachusetts Department of Environmental Protection, January 12, 1998.

(5) MassDEP, 2002a: *Indoor Air Sampling and Evaluation Guide*, Massachusetts Department of Environmental Protection, WSC Policy # 02-430, April 2002.

(6) MassDEP, 2002b: *Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MADEP VPH/EPH Approach*, Massachusetts Department of Environmental Protection, WSC Policy # 02-411, October 31, 2002

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(7) MassDEP, 2003: *Updated Petroleum Hydrocarbon Fraction Toxicity Values For VPH/EPH/APH Methodology*, Massachusetts Department of Environmental Protection, November 2003.

(8) MassDEP, 2004: *Method for the Determination of Volatile Petroleum Hydrocarbons (VPH),* Massachusetts Department of Environmental Protection, May 2004.

(9) MassDEP, 2007: *Standard Operating Procedure for Indoor Air Contamination*, Massachusetts Department of Environmental Protection, SOP BWSC-07-01, August 2007.

TABLES

Table 1. APH Components

Compound	CAS Number	Boiling Point (°C)	Mol. Wt. (g/mol)	APH Analysis Function	Retention Time (minutes)[1]	Concentration Conversion[2] (ppbV → µg/m^3)
1,3-Butadiene	106990	- 4.4	54.09	TA	5.76	2.21
Isopentane	78784	28	72.15	RC/RM	7.27	2.95
Methyl tertiary butyl ether (MTBE)	1634044	55	88.15	TA	9.64	3.61
n-Hexane	110543	69	86.17	RC	10.71	3.53
Benzene	71432	80	78.11	TA	12.37	3.19
Cyclohexane	110827	81	84.16	RC	12.66	3.44
2,3-Dimethylpentane	565593	90	100.20	RC	12.91	4.10
n-Heptane	142825	98	100.20	RC	13.81	4.10
Toluene	108883	111	92.14	TA	15.44	3.77
n-Octane	111659	126	114.23	RC	16.29	4.67
Ethylbenzene	100414	136	106.17	TA	17.28	4.34
2,3-Dimethylheptane	3074713	141	128.26	RC	17.32	5.25
m-Xylene	108383	139	106.17	TA	17.42	4.34
p-Xylene	106423	138	106.17	TA	17.42	4.34
o-Xylene	95476	144	106.17	TA/RM	17.78	4.34
n-Nonane	111842	151	128.26	RC/RM	17.91	5.25
Isopropylbenzene	98828	152	120.20	RC	18.21	4.92
1-Methyl-3-ethylbenzene	620144	161	120.20	RC	18.65	4.92
1,3,5-Trimethylbenzene	108678	165	120.20	RC	18.74	4.92
n-Decane	124185	174	142.28	RC	19.08	5.83
1,2,3-Trimethylbenzene	526738	176	120.20	RC	19.36	4.92
p-Isopropyltoluene	99876	177	134.22	RC	19.35	5.49
Butylcyclohexane	1678939	181	140.27	RC	19.54	5.74
n-Undecane	1120214	196	156.32	RC	20.03	6.39
Naphthalene	91203	218	128.17	TA/RM	21.04[3]	5.24
n-Dodecane	112403	216	170.33	RC/RM	20.92[3]	6.97

[1] Results obtained using the RTX-1 column and chromatographic conditions described in Sections 6.3 and 9.2, respectively.
[2] Conversion factors assume standard temperature and pressure (R = 0.08026 L-atm/mole-K; T = 298K; P = 1 atm).
[3] The elution order of naphthalene and dodecane may be reversed, depending on the exact chromatographic conditions.

TA- Target Analyte	**RC - Range Calibration Aliphatic**
RM - Range Marker	**RC - Range Calibration Aromatic**

Table 2. BFB Key Ions and Abundance Criteria

Mass	Ion Abundance Criteria
50	8.0 to 40.0 percent of m/e 95
75	30.0 to 66.0 percent of m/e 95
95	Base peak, 100 percent relative abundance
96	5.0 to 9.0 percent of m/e 95
173	Less than 2.0 percent of m/e 174
174	50.0 to 120.0 percent of m/e 95
175	4.0 to 9.0 percent of m/e 174
176	93.0 to 101.0 percent of m/e 174
177	5.0 to 9.0 percent of m/e 176

Table 3a. Initial Calibration of APH Hydrocarbon Range Components

Hydrocarbon Range	Hydrocarbon Range Compounds Used to Establish Range Response Factor	Calib. Level	Calibration Standard Preparation		Component Standard Calibration Concentration (based on a 0.25 liter “nominal” sample volume)	
			Working Standard Concentration ($\mu g/m^3$)	Injection Volume (mL)*	Individual Range Component Concentration ($\mu g/m^3$)	Hydrocarbon Range Total Concentration ($\mu g/m^3$)
C_5-C_8 Aliphatic	Isopentane	1	20	25	2.0	12
	n-Hexane	2	20	50	4.0	24
	Cyclohexane	3	20	250	20.0	120
	2,3-Dimethylpentane	4	500	25	50.0	300
	n-Heptane	5	500	125	250	1500
	n-Octane	6	500	250	500	3000
C_9-C_{12} Aliphatic	2,3-Dimethylheptane	1	20	25	2.0	12
	n-Nonane	2	20	50	4.0	24
	n-Undecane	3	20	250	20.0	120
	n-Dodecane	4	500	25	50.0	300
	Butylcyclohexane	5	500	125	250	1500
	n-Decane	6	500	250	500	3000
C_9-C_{10} Aromatic	Isopropylbenzene	1	20	25	2.0	10
	1-Methyl-3-ethylbenzene	2	20	50	4.0	20
	1,3,5-Trimethylbenzene	3	20	250	20.0	100
	1,2,3-Trimethylbenzene	4	500	25	50.0	250
	p-Isopropyltoluene	5	500	125	250	1250

* nominal sample volume for purposes of this calibration is 250 mL

** concentration of the individual hydrocarbon range compound multiplied by the total # of hydrocarbon range compounds used to generate the range response factor

Table 3b. Initial Calibration of APH Target Analytes

APH Target Analytes	Level	Working Standard		Calibration Standard
		Concentration ($\mu g/m^3$)	Volume (mL)*	Concentration ($\mu g/m^3$)
1,3-Butadiene Methyl tertiary butyl ether (MTBE) Benzene Toluene Ethylbenzene m-Xylene p-Xylene o-Xylene Naphthalene	1	20	25	2.0
	2	20	50	4.0
	3	20	250	20
	4	500	25	50
	5	500	125	250
	6	500	250	500

* nominal sample volume for purposes of this calibration is 250 mL

Table 4. APH Range Marker Compounds and Range Retention Time Windows

Hydrocarbon Range	Beginning Marker	Ending Marker
C_5-C_8 Aliphatic Hydrocarbons	0.1 min. before isopentane	0.01 min. before n-nonane
C_9-C_{12} Aliphatic Hydrocarbons	0.01 min. before n-nonane	0.1 min. after dodecane
C_9-C_{10} Aromatic Hydrocarbons	0.1 min. after o-xylene	0.1 min. before naphthalene

Table 5. Primary (Quantitation) & Secondary Ions for APH Components/Internal Standards

APH Components	CAS Number	Target APH Analyte	Primary (Quantitation) Ion	Secondary Ion(s)
Bromochloromethane (IS #1)	74975		128	49, 130
1,3-Butadiene	106990	✓	54	53, 50
Isopentane	78784		43	42, 41, 57
Methyl tertiary butyl ether (MTBE)	1634044	✓	73	45
n-Hexane	110543		57	41, 43, 56
Cyclohexane	110827		56	84, 41
1,4-Difluorobenzene (IS #2)	540363		114	63
2,3-Dimethylpentane	565593		56	43, 57, 41
Benzene	71432	✓	78	52, 51
n-Heptane	142825		43	71, 57, 100
Toluene	108883	✓	91	92
Chlorobenzene-d5 (IS #3)	3114554		117	119, 82
n-Octane	111659		43	85, 57, 71
2,3-Dimethylheptane	3074713		43	84, 85
Ethylbenzene	100414	✓	91	106
m- & p-Xylene	1330207	✓	91	106, 105
n-Nonane	111842		43	57, 85
o-Xylene	95476	✓	91	106, 105
Isopropylbenzene	98828		105	120
1-Methyl-3-ethylbenzene	620144		105	120
1,3,5-Trimethylbenzene	108678		105	120
n-Decane	124185		57	43, 71, 85
Butylcyclohexane	1678939		83	55, 82
p-Isopropyltoluene	99876		119	105, 134
1,2,3-Trimethylbenzene	526738		105	120
n-Undecane	1120214		57	43, 71, 85
n-Dodecane	112403		57	43, 71, 85
Naphthalene	91203	✓	128	

NOTE: All APH Components are listed in Table 5 for reference purposes. Only the RRFs for Target APH Analytes need to be determined on a compound-specific basis.

Table 6. Internal Standards and Associated Target APH Analytes and Hydrocarbon Ranges

Bromochloromethane (IS #1)	**1,4-Difluorobenzene (IS #2)**	**Chlorobenzene-d5 (IS #3)**
1,3-Butadiene Methyl tertiary butyl ether (MTBE)	Benzene C_5-C_8 Aliphatics	Toluene Ethylbenzene m-&p-Xylenes o-Xylene Naphthalene C_9-C_{12} Aliphatics C_9-C_{10} Aromatics

Table 7. List of Common Non-APH Compounds That Elute Within the APH Method Ranges

Hydrocarbon Range	**Potential Non-APH Compounds**
C_5-C_8 Aliphatic Hydrocarbons	Acetone may co-elute/interfere with isopentane. Isopropyl alcohol, methyl ethyl ketone, trichloroethene, tetrachloroethene, tetrahydrofuran, hexanal, 1-butanol, hexamethylsiloxane
C_9-C_{12} Aliphatic Hydrocarbons	Terpenes (e.g., a-pinene, d-limonene), phenol, benzaldehyde, n-chain aldehydes, 2-ethyl-1-hexanol, siloxanes, dichlorobenzenes
C_9-C_{10} Aromatic Hydrocarbons	Siloxanes, a-pinene, and d-limonene may slightly interfere if present at high concentrations (contribute to the area of ions 120/134)

APPENDIX 1
APH METHOD DETECTION LIMIT (MDL) STUDIES
Results from five laboratories

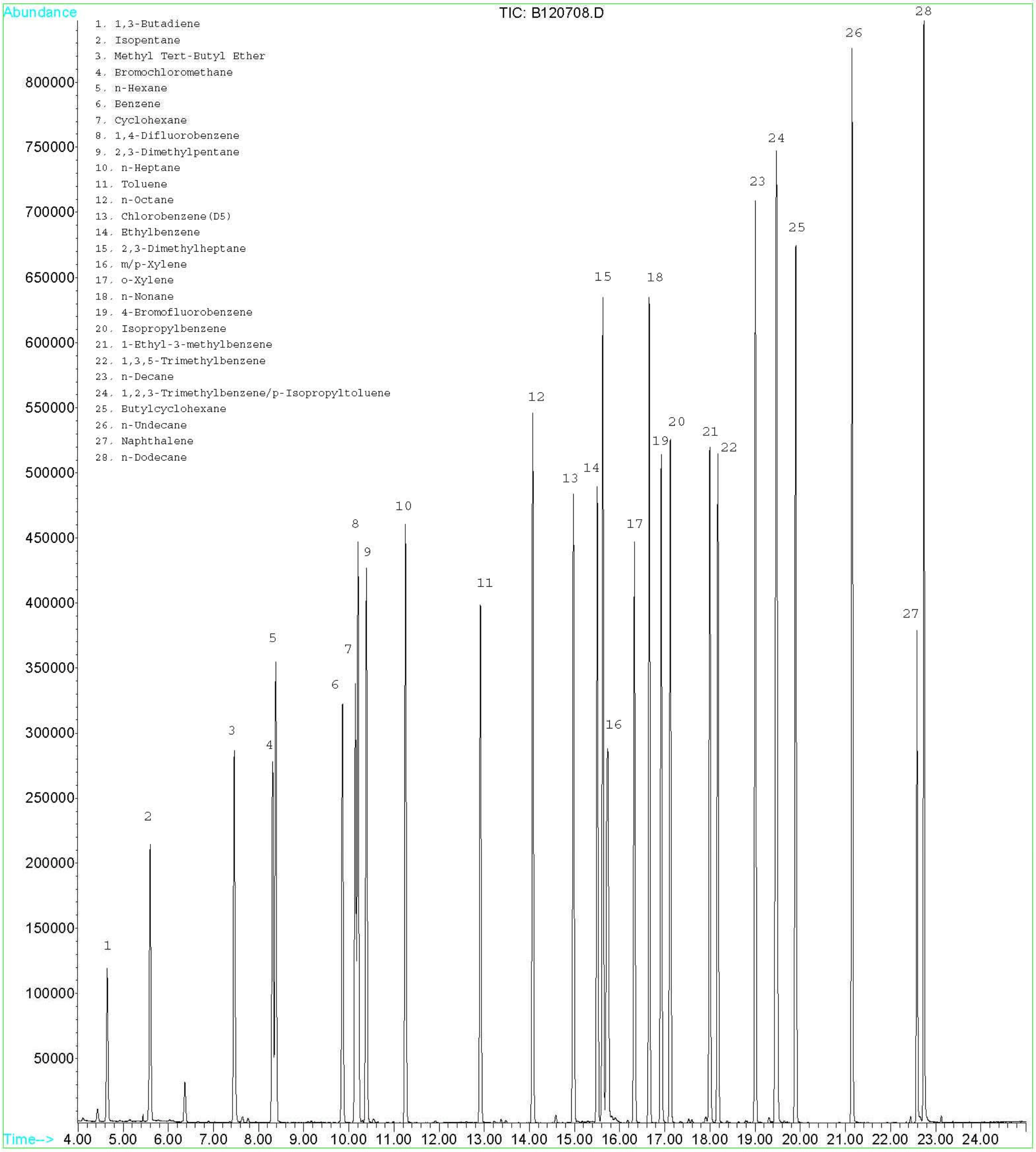
	MDL C_5-C_8 Aliphatics (µg/m^3)	MDL C_9-C_{12} Aliphatics (µg/m^3)	MDL C_9-C_{10} Aromatics (µg/m^3)
Lab 1	1.8	1.0	0.67
Lab 2	3.7	1.0	0.29
Lab 3	5.7	5.0	1.9
Lab 4	4.6	6.3	1
Lab 5	4.1	4.7	5.9

	MDL C_5-C_8 Aliphatics (µg/m^3)	Calculated RL C_5-C_8 Aliphatics (µg/m^3)	MDL C_9-C_{12} Aliphatics (µg/m^3)	Calculated RL C_9-C_{12} Aliphatics (µg/m^3)	MDL C_9-C_{10} Aromatics (µg/m^3)	Calculated RL C_9-C_{10} Aromatics (µg/m^3)
Lab 1	1.8	5.4	1.0	3	0.67	2.01
Lab 2	3.7	11.1	1.0	3	0.29	0.87
Lab 3	5.7	17.1	5.0	15	1.9	5.7
Lab 4	4.6	13.8	6.3	18.9	1	3
Lab 5	4.1	12.3	4.7	14.1	5.9	17.7

Calculated RL = 3xMDL
MDL studies performed in Fall 2008.

APPENDIX 2
APH METHOD CHROMATOGRAM

```
File       : D:\HPCHEM\1\DATA\ARCHIVES\B120708.D
Operator   : TPH
Acquired   :  7 Dec 2009   5:49 pm using AcqMethod TO060909
Instrument :    SYSB
Sample Name: APH STD                       Column: Restek Rxi-1ms, 60m, 0.32 mmID, 1.0 um df
Misc Info  :                               Oven Temp: 35°C for 5min,ramp@7°C/min,final temp 220°C
Vial Number: 4                             Carrier Gas: Helium @1.2mL/min
                                           Concentrator: Entech 7100
                                           Runtime: 24 to 28 min
```



APPENDIX 3
REQUIRED APH DATA REPORTING INFORMATION

SAMPLE INFORMATION (check all that apply)

Sample Type(s)	☐ Grab ☐ Time-integrated: ☐ 2 hour ☐ 4 hour ☐ 8 hour ☐ 24 hour ☐ Other:
Sample Container(s)	☐ Canister(s) size: ☐ Other:
Sampling Flow Controller(s)	☐ Mechanical ☐ Fixed-Orifice ☐ Electronic ☐ Other:
Sampling Flow Meter(s)	RPD of pre- & post-sampling calibration check(s): ☐ ≤ 20% ☐ > 20%

APH ANALYTICAL RESULTS

	Client ID					
Internal Standards:	**Lab ID**					
	Date Collected					
	Date Received					
	Date Analyzed					
	Pre-sample vacuum (field)		**in. Hg**		**in. Hg**	
MS Tuning Standard:	**Post-sample vacuum (field)**		**in. Hg**		**in. Hg**	
	Lab receipt vacuum		**in. Hg**		**in. Hg**	
	Dilution Factor					
Target APH Analytes & Hydrocarbon Ranges	**Reporting Limit**		**Sample Results**		**Sample Results**	
	µg/m^3	**ppb v/v**	**µg/m^3**	**ppb v/v**	**µg/m^3**	**ppb v/v**
1,3-Butadiene						
Methyl tertiary butyl ether (MTBE)						
Benzene						
Toluene						
Ethylbenzene						
m- & p- Xylenes						
o-Xylene						
Naphthalene						
C_5-C_8 Aliphatic Hydrocarbons[1, 2]		**N/A**		**N/A**		**N/A**
C_9-C_{12} Aliphatic Hydrocarbons[1, 3]		**N/A**		**N/A**		**N/A**
C_9-C_{10} Aromatic Hydrocarbons		**N/A**		**N/A**		**N/A**

[1] Hydrocarbon range data from total ion chromatogram excluding any internal/tuning standards eluting in that range

[2] C_5-C_8 aliphatic hydrocarbons exclude the concentration of Target APH Analytes eluting in that range

[3] C_9-C_{12} aliphatic hydrocarbons exclude concentration of Target APH Analytes eluting in that range AND concentration of C_9-C_{10} aromatic hydrocarbons

CERTIFICATION

Were all QA/QC procedures REQUIRED by the APH Method followed? ☐ **Yes** ☐ **No - Details Attached**

Were all performance/acceptance standards for required QA/QC procedures achieved? ☐ **Yes** ☐ **No - Details Attached**

Were any significant modifications made to the APH method, as specified in Sect 11.1.2? ☐ **No** ☐ **Yes - Details Attached**

I attest under the pains and penalties of perjury that, based upon my inquiry of those individuals immediately responsible for obtaining the information, the material contained in this report is, to the best of my knowledge and belief, accurate and complete.

SIGNATURE: ________________________ **POSITION:** ________________________

PRINTED NAME: ________________________ **DATE:** ________________________

(mm/dd/yyyy)

APPENDIX 4
RECOMMENDED SOP FOR CLEANING, CERTIFICATION, AND CALIBRATION OF APH AIR SAMPLING EQUIPMENT

1.0 Canister Cleaning

All canisters must be certified clean and verified as leak free prior to being used for sampling.

1.1 Recommended Equipment and Supplies

- Flow Manifold – For attaching canisters and conveying flow during evacuation and flushing.
- Flushing Gas Source – Ultra zero air or UHP Nitrogen (compressed cylinder or on-site source) with appropriate cleaning media in line to ensure gas cleanliness.
- Roughing Pump – For initial evacuation stage.
- High Vacuum Pump – For final evacuation. Alcatel or equivalent molecular drag recommended. Alternatively, a non-oil equivalent pump may be used.
- Controls/Gauges:
    - ♦ Control valves or solenoids for enacting cycles.
    - ♦ Electronic gauges for measuring rough pressures (in psia or mm Hg) and fine pressure values (millitorrs).
    - ♦ Rough vacuum/pressure gauges used for field pressure and vacuum measurements.
- Humidification Device – Fixture or device to add humidity to canisters and flushing gas during cleaning and batch certification. Water should be deionized double distilled or HPLC grade.
- Canister Heaters – Heating belts or ovens for heating canisters to 100 degrees C to enhance removal of organic compounds.
- Laboratory Notebook/Log Book – Used to record dates and canister conditioning actions and certifications. Canisters last use must be tracked.

1.2 Recommended Procedures

- Empty all canisters to ambient pressure and attach to the manifold. Make sure that there are no leaks. This can be performed in one of two ways:
    - ♦Pressurize canisters with ultra zero air or UHP nitrogen to 30 psig. The canister pressure cannot vary by more than ±2 psig over a 24 hour period.
    - ♦Apply vacuum pimp to the manifold to reduce manifold pressure. The system is leak free if the vacuum prior to cleaning is less than 500 mtorr.
- Evacuate canisters to at least 1 torr (1 mm Hg).
- Pressurize with humidified UHP nitrogen or ultra zero air up to 30 psig. Activate heating source during cleaning cycle.
- Repeat above two steps (evacuating and pressurizing). Note cycle numbers and ensure that a minimum of three cleaning cycles are completed. On the final cycle, turn off

heating source and pump down with high vacuum pump to a maximum of 0.05 mm Hg (50 mtorr). This vacuum would correspond to 30 in. Hg. Close canister sampling valve prior to turning off high vacuum pump or placing the system in a standby mode.

- Remove treated canisters from the manifold. A properly evacuated canister should have a canister pressure of ≤ 0.05 mm Hg (50 mtorr; vacuum of 30 in. Hg).

Associated canister sampling equipment (e.g., flow controllers, critical orifice assemblies) should also be deemed clean and appropriate for use prior to sampling. Cleaning techniques may vary between laboratories but all procedures will include backflushing with humidified ultra zero air or UHP nitrogen. All flow controllers will be calibrated by the laboratory such that a small amount of vacuum (approximately 5 in. Hg) will remain in the canister at the end of sampling.

2.0 Recommended Equipment Certification Procedures

Batch or individual canister certification may be required depending on the requirements of the testing program.

2.1 Batch Canister Certification

- After the cleaning process is completed, a minimum of one canister per batch must be tested. A batch size of up to 20 canisters is allowed.

- Remove the canister from the manifold that exhibited the highest levels of contamination prior to cleaning (according to the analytical results). Pressurize the canister to a maximum of 30 psig with humidified ultra zero air or UHP nitrogen and analyze as a Laboratory Method Blank. Record in a laboratory notebook the serial number of this canister used for batch certification. If any of the APH target analytes or hydrocarbon range concentrations are detected at a concentration greater than one-half of their respective RLs, the entire batch of canisters must be rejected and recleaned. If three consecutive certifications fail, system maintenance is required.

- If the batch certification canister passes certification, batch canisters should be held for 24 hours uncapped prior to issue for field use. The vacuum in each canister should be rechecked prior to release for field use. The acceptance criterion for the “stored” canister vacuum is ≥ 28 in. Hg. Canisters not meeting this criterion must be retained for leak repair and not released for field use.

- At a minimum, the following information regarding canister certification should be permanently recorded and retained for a minimum of 5 years:

    Processing Date
    Canister Serial Number
    Canister Volume (liters)
    Serial Number for Canister used for Batch Certification
    Post-cleaning Vacuum (in. Hg)
    Results of the Certification Analysis

2.2 Individual Canister Certification

- After the cleaning process is completed, each canister from the batch must be tested.

- Remove each canister from the manifold. Pressurize the canister to a maximum of 30 psig with humidified ultra zero air or UHP nitrogen and analyze as a Laboratory Method Blank. Record in a laboratory notebook the serial number of the canisters being certified. If any of the APH Target analytes or hydrocarbon range concentrations are detected at a concentration greater than one-half of their respective RLs, the individual canister must be recleaned and re-certified.

- If the individual canister passes certification, it must be reevacuated and held for 24 hours uncapped prior to issue for field use. The vacuum in each canister should be re-checked prior to release for field use. The acceptance criterion for the "stored" canister vacuum is ≥ 28 in. Hg. Canisters not meeting this criterion must be retained for leak repair and not released for field use.

- At a minimum, the same information listed above for Batch Canister Certification should be permanently recorded and retained for a minimum of 5 years.

Certification procedures associated with canister sampling equipment (e.g., flow controllers, critical orifice assemblies) will vary between laboratories. If certification is required, the data user must request this from the laboratory when ordering the sampling equipment.

3.0 Flow Controller Calibration

Flow controllers may be calibrated by either simulating a vacuum on the outlet side of the flow controller (the end that attaches to the canister) or by applying positive pressure to the inlet side of the flow controller. Using a NIST-traceable primary standard flow calibrator (e.g., BIOS Dry-Cal), the flow rate of air passing through the flow controller is measured. The flow rate may be adjusted by changing the size of the critical orifice used and/or performing coarse/fine adjustments on the flow controller itself. Specific procedures will vary depending on the model flow controller that is used.

The NIST-traceable primary standard flow calibrator is a mass flow meter used to accurately measure flow rates of 0 to 200 cubic centimeters per minute. This device must be constructed of inert materials. These flow calibrators must be calibrated at least annually using a certified volumetric measuring device (soap film or equivalent) and an accurate stopwatch.

The flow controller's calibration must be verified prior to sample collection by the laboratory. Upon receipt of the canister and associated flow controller back at the laboratory, a post-sampling calibration verification must be performed and the relative percent difference (RPD) between the initial and post sampling calibration calculated.

$$\text{RPD} = \frac{| F_f - F_i |}{(F_i + F_f)/2} \text{ X } 100$$

F_i = Pre-sampling Flow Rate
F_f = Post-Sampling Flow Rate

The flow calibration and associated sample collection interval are considered valid if the RPD is $\leq$20. If the RPD is >20, re-sampling may be required to achieve data quality objectives. If the "elevated RPD" sample is analyzed, a notation must be provided in the laboratory narrative documenting the "compromised RPD" flow rate value. The flow controller RPD is one line of evidence in the proper collection of samples for APH analysis. If the canister vacuum is acceptable after sampling and the flow controller RPD is outside of the acceptance criteria, data quality is not adversely affected.

APPENDIX 5
APH METHOD CALCULATIONS

This Appendix provides, (1) example RRF calculations for APH aliphatic and aromatic ranges and the target analyte Benzene based on multi-point calibration data, and (2) example calculations of sample concentrations for APH aliphatic and aromatic ranges and the target analyte Benzene based on the calculated RRFs, simulated area counts, and other sample-specific data. The APH Method Analytical Flow Chart is shown in Figure 5-1.

Example Calculations

Refer to information found on Tables 5-1 through 5-4. An APH Method Calculation Worksheet in Microsoft Excel format using the analytical data presented in Tables 5-1 through 5-4 is available on the APH Method web page.

Equation 1: Relative Response Factor for Target APH Analytes

RRFs are calculated for each APH Target analyte using the area response of the analyte’s characteristic ion, its true concentration, the area response of the associated internal standard’s characteristic ion, and its concentration, using Eq. 1.

RRF calculated for Benzene, Calibration Level 1, using data found in Tables 5-2 and 5-3:

$$\boxed{RRF_{Benzene} = [(A_{EC}) * (C_I)] / [(A_{EI}) * (C_c)]}$$

$A_{EC} = 3556$	area count of the primary quantitation ion for Benzene (m/e 78)
$C_I = 37\ \mu g/m^3$	concentration of internal standard (IS2)
$A_{EI} = 143419$	area count of the primary quantitation ion for the associated internal standard (m/e 114)
$C_C = 2\ \mu g/m^3$	concentration of Benzene, Calibration Level 1

$$RRF_{Benzene} = [(3556) * (37)] / [(143419) * (2)]$$
$$RRF_{Benzene} = 0.4587$$

Equation 2: Relative Response Factor for C_5-C_8 Aliphatic Hydrocarbons

The RRF for the C_5-C_8 Aliphatic range is based on a correlation between the total concentration of aliphatic components eluting within this range and their total ion area counts.

RRF calculated for C_5-C_8 Aliphatic Hydrocarbons, Calibration Level 1, using data found in Tables 5-2 and 5-3:

$$\boxed{RRF_{Range_x} = [(A_T) * (C_I)] / [(A_{EI}) * (C_T)]}$$

$A_T = 18097$	total ion area count of C_5-C_8 Aliphatic range (six aliphatic components)
$C_I = 37\ \mu g/m^3$	concentration of internal standard (IS2)
$A_{EI} = 143419$	area count of the primary ion for the associated internal standard (m/e 114)
$C_T = 12\ \mu g/m^3$	total concentration of C_5-C_8 Aliphatic range, Calibration Level 1 (six aliphatic components)

$$RRF_{Range} = [(18097) * (37)] / [(143419) * (12)]$$
$$RRF_{Range} = 0.3891$$

Equation 3: Relative Response Factor for C_9-C_{12} Aliphatic Hydrocarbons

The RRF for the C_9-C_{12} Aliphatic range is based on a correlation between the total concentration of aliphatic components eluting within this range and their total ion area counts.

RRF calculated for C_9-C_{12} Aliphatic Hydrocarbons, Calibration Level 1, using data found in Tables 5-2 and 5-3:

$$\boxed{RRF_{Range_x} = [(A_T) * (C_I)] / [(A_{EI}) * (C_T)]}$$

A_T = 32296 total ion area count of C_9-C_{12} Aliphatic range (six aliphatic components)
C_I = 38 ug/m^3 concentration of internal standard (IS3)
A_{EI} = 316020 area count of the primary ion for the associated internal standard (m/e 117)
C_T = 12 ug/m^3 total concentration of C_9-C_{12} Aliphatic range, Calibration Level 1 (six aliphatic components)

$$RRF_{Range} = [(32296) * (38)] / [(316020) * (12)]$$
$$RRF_{Range} = 0.3236$$

Equation 4: Relative Response Factor for C_9-C_{10} Aromatic Hydrocarbons
The RRF for the C_9-C_{10} Aromatic range is calculated using a summation of the m/e 120 and m/e 134 extracted ion area counts for the APH aromatic components eluting within this range (see Table 3a of the method).

RRF calculated for C_9-C_{10} Aromatic Hydrocarbons, Calibration Level 1, using data found in Tables 5-2 and 5-3:

$$\boxed{RRF_{Range_x} = [(A_T) * (C_I)] / [(A_{EI}) * (C_T)]}$$

A_T = 54343 summation of extracted ion area counts (m/e 120 + m/e 134: five aromatic components)
C_I = 38 ug/m^3 concentration of internal standard (IS3)
A_{EI} = 316020 area count of the primary ion for the associated internal standard (m/e 117)
C_T = 10 ug/m^3 total concentration of C_9-C_{10} Aromatic range, Calibration Level 1 (five aromatic components)

$$RRF_{Range} = [(54343) * (38)] / [(316020) * (10)]$$
$$RRF_{Range} = 0.6535$$

Equation 5: Percent Relative Standard Deviation
For each target compound and range a percent relative standard deviation (%RSD) is calculated from the RRFs generated for each point of the curve using equation 5 below.

Example: Benzene from Table 5-1:

Compound	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5	Cal 6	Mean	SD
Benzene	0.4587	0.5119	0.5167	0.4679	0.5540	0.5083	0.5029	0.03490

$$\boxed{\%RSD_{Benzene} = [(SD_{n-1}) / (AVG_X)] * 100}$$

%RSD = percent relative standard deviation
SD_{n-1} = 0.03490 standard deviation (n-1 degrees of freedom)
AVG_x = 0.5029 mean response factor from the initial calibration

$$\%RSD_{Benzene} = (0.03490 / 0.5029) * 100$$
$$\%RSD_{Benzene} = 6.9$$

Equation 7: Percent Difference
Calculate a percent difference for Benzene in a continuing calibration standard having a calculated RRF of 0.4769:

$$\boxed{\%D_{Benzene} = [(RRF_C) - (RRF_I)] / [(RRF_I)] * 100}$$

%D = percent difference
RF_C = 0.4769 response factor from the continuing calibration
RF_I = 0.5029 mean response factor from the initial calibration

$$\%D_{Benzene} = [(0.4769) - (0.5029)]/[(0.5029)]*100$$
$$\%D_{Benzene} = -5.2$$

Equation 8: Dilution Factor for Pressurization of Subatmospheric Samples

$$DF = (P_f + 14.7) / (P_i = 14.7)$$

P_i = pressure reading of canister prior to pressurization (in psig)
P_f = pressure reading of canister after pressurization (in psig)
DF = dilution factor

Note: To convert from in. Hg to psig: psig = in. Hg * 0.491159

Example Canister Dilution Calculation Final Pressure >0

P_i = -2.5 in. Hg = -1.28 psig
P_f = 10 psig

$$DF = (10 + 14.7)/(-1.28 + 14.7)$$
$$DF = 1.84$$

Example Canister Dilution Calculation Final Pressure <0

P_i = -2.5 in. Hg = -1.28 psig
P_f= -0.5 in. Hg = -0.246 psig

$$DF = (-0.246 + 14.7)/(-1.28 + 14.7)$$
$$DF = 1.08$$

Equation 9: Calculation of Sample Results in µg/m^3: Target Analyte (Benzene)
Calculate a final µg/m^3 concentration for Benzene using data found in the Sample Data Table 5-4 (Note: sample aliquot volumes are assumed to be 0.250 L):

$$\boxed{\mu g / m3_{Benzene} = [(A_x)*(C_{IS})]/[(A_{IS})*(RRF_{avg})]*DF}$$

A_x =	60285	area count of the primary ion for Benzene (m/e78)
C_{IS} =	37 µg/m^3	concentration of internal standard (IS2)
A_x =	115082	area count of the primary ion for the associated internal standard (m/e 114)
RRF_{avg} =	0.5029	average RRF for benzene
DF =	1.0	dilution factor

$$\mu g / m3_{Benzene} = [(60285)*(37)]/[115082)*(0.5029)]*1.0$$
$$\mu g / m3_{Benzene} = 38.5$$

Equation 11: Calculation of Sample Results in µg/m^3: C_5-C_8 Aliphatic Range

A. Calculate a preliminary µg/m^3 concentration for C_5-C_8 Aliphatic range using data found in the Sample Data Table 5-4 (Note: sample aliquot volumes are assumed to be 0.250 L):

$$\boxed{\mu g / m3_{Aliphatic} = [(A_x)*(C_{IS})]/[(A_{IS})*(RRF_{avg})]*DF}$$

$A_x =$ 823563 total ion area count of all peaks eluting within this range (excluding internal standard areas)
$C_{IS} =$ 37 µg/m^3 concentration of internal standard (IS2)
$A_{IS} =$ 115082 area count of the primary ion for the associated internal standard (m/e 114)
$RRF_{avg} =$ 0.4177 average RRF for C_5-C_8 Aliphatic range
DF= 1.0 dilution factor

$$\mu g/m3_{Aliphatic} = [(823563)*(37)]/[(115082)*(0.4177)]*1.0$$

$$\mu g/m3_{Aliphatic} = 634$$

B. Calculate a final µg/m^3 concentration for C_5-C_8 Aliphatic range using data found in the Sample Data Table 5-4:

Final C_5-C_8 Aliphatic range µg/m^3 concentration = (Preliminary µg/m^3 concentration) – (concentrations of target analytes which elute within the C_5-C_8 Aliphatic range)

Final C_5-C_8 Aliphatic range µg/m^3 concentration = (634 µg/m^3) – (concentrations of MTBE, benzene, toluene, ethylbenzene, xylenes)

Final C_5-C_8 Aliphatic range µg/m^3 concentration = (634 µg/m^3) – (44.5 + 38.5 + 37.7 + 41.0 + 78.0 + 37.9 µg/m^3)

Final C_5-C_8 Aliphatic range µg/m^3 concentration = 356 µg/m^3

Equation 11: Calculation of Sample Results in µg/m^3: C_9-C_{10} Aromatic Range

Calculate a final µg/m3 concentration for C_9-C_{10} Aromatic range using data found in the Sample Data Table 5-4 (Note: sample aliquot volumes are assumed to be 0.250 L):

$$\boxed{\mu g/m3_{Aromatic} = [(A_x)*(C_{IS})]/[(A_{IS})*(RRF_{avg})]*DF}$$

$A_x =$ 3217570 summation of extracted ion area counts (m/e 120 + m/e 134) eluting within range
$C_{IS} =$ 38 µg/m^3 concentration of internal standard (IS3)
$A_{IS} =$ 289465 area count of the primary ion for the associated internal standard (m/e 117)
$RRF_{avg} =$ 0.8187 average RRF for C_9-C_{10} Aromatic range
DF= 1.0 dilution factor

$$ug/m3_{Aromatic} = [(3217570)*(38)]/[(289465)*(0.8187)]*1.0$$

$$ug/m3_{Aromatic} = 516$$

Equation 11: Calculation of Samples Results in µg/m^3: C_9-C_{12} Aliphatic Range

A. Calculate a preliminary µg/m^3 concentration for C_9-C_{12} Aliphatic range using data found in the Sample Data Table 5-4 (Note: sample aliquot volumes are assumed to be 0.250L):

$$\boxed{\mu g/m3_{Aliphatic} = [(A_x)*(C_{IS})]/[(A_{IS})*(RRF_{avg})]*DF}$$

$A_x =$ 1971741 total ion area count of all peaks eluting within this range (excluding BFB)
$C_{IS} =$ 38 µg/m^3 concentration of internal standard (IS3)
$A_{IS} =$ 289465 area count of the primary ion for the associated internal standard (m/e 117)
$RRF_{avg} =$ 0.3677 average RRF for C_9-C_{12} Aliphatic range
DF= 1.0 dilution factor

$$\mu g/m3_{Aliphatic} = [(1971741)*(38)]/[(289465)*(0.3677)]*1.0$$

$$\mu g/m3_{Aliphatic} = 704$$

B. Calculate a final µg/m^3 concentration for C_9-C_{12} Aliphatic range using data found in the Sample Data Table 5-4:

Final C_9-C_{12} Aliphatic range µg/m^3 concentration = (Preliminary µg/m^3 concentration) – (concentrations of naphthalene and C_9-C_{10} Aromatics)

Final C_9-C_{12} Aliphatic range µg/m^3 concentration = (704 µg/m^3) – (38 + 516 µg/m^3)

Final C_9-C_{12} Aliphatic range µg/m^3 concentration = 150 µg/m^3

Equation 6: Percent Recovery
From information found in Table 5-4 (Sample Data Table), calculate a percent recovery for Benzene having a true, or spiked concentration of 40 µg/m3.

$$\boxed{\%R_{Benzene} = [(C_{found})/(C_{true})]*100}$$

%R =		percent recovery
C_{found} =	38.5	concentration of the analyte or range (µg/m^3)
C_{true} =	40	true concentration of the analyte or range (µg/m^3)

$$\%R_{Benzene} = [(38.5)/(40)]*100$$
$$\%R_{Benzene} = 96$$

Equation 10: Conversion of µg/m^3 to ppbV
To convert target analyte results from µg/m3 into ppbv, use the flowing equation. NOTE: this equation is not applicable to the hydrocarbon ranges.

$$\boxed{ppbV_{Benzene} = (\mu g/m3)_{Benzene} * 24.45/MW_{Benzene}}$$

µg/m3$_{Benzene}$=	38.5
$MW_{Benzene}$=	78.1

$$ppbV_{Benzene} = 38.5 * 24.45/78.1$$
$$ppbV_{Benzene} = 12.05$$

TABLE 5-1: RELATIVE RESPONSE FACTORS

Compound	**Cal 1**	**Cal 2**	**Cal 3**	**Cal 4**	**Cal 5**	**Cal 6**	**Mean**	**%RSD**
1,3-Butadiene	3.7454	4.2517	3.8698	3.7343	4.0661	2.5931	3.7101	15.7
Methyl tertiary butyl ether (MTBE)	3.9877	5.0958	4.6380	4.4756	5.9072	5.0969	4.8669	13.5
Bromochloromethane (IS1)								
Benzene	0.4587	0.5119	0.5167	0.4679	0.5540	0.5083	0.5029	6.9
1,4-Difluorobenzene (IS2)								
Toluene	0.3663	0.3700	0.3991	0.3792	0.4910	0.4887	0.4157	14.1
Chlorobenzene-d5 (IS3)								
Ethylbenzene	0.9927	1.0447	1.1267	1.0705	1.0902	0.9343	1.0432	6.7
Xylene (m, p)	0.7869	0.8913	0.9613	0.9133	0.9041	0.7809	0.8730	8.4
Xylene (o)	0.7809	0.8473	0.9138	0.8682	0.9504	0.8417	0.8671	6.8
4-Bromofluorobenzene (BFB)								
Naphthalene	0.4234	0.2969	0.3203	0.3043	0.3681	0.3530	0.3443	13.8
C_5-C_8 Aliphatic Hydrocarbons	0.3891	0.4618	0.4662	0.4221	0.4073	0.3594	0.4177	10.0
C_9-C_{12} Aliphatic Hydrocarbons	0.3236	0.3598	0.3881	0.3687	0.4018	0.3640	0.3677	7.3
C_9-C_{10} Aromatics (m/e 120)	0.5452	0.6602	0.7121	0.6765	0.7895	0.6795	0.6772	11.7
C_9-C_{10} Aromatics (m/e 134)	0.1082	0.1330	0.1435	0.1363	0.1668	0.1612	0.1415	14.9
C_9-C_{10} Aromatic Hydrocarbons	0.6535	0.7932	0.8555	0.8128	0.9563	0.8406	0.8187	12.1

TABLE 5-2: CALIBRATION CURVE AREA COUNTS

Compound	**Cal 1**	**Cal 2**	**Cal 3**	**Cal 4**	**Cal 5**	**Cal 6**
1,3-Butadiene	6337	14664	36660	183300	980573	1854649
Isopentane	2223	7456	18640	93200	459196	1031595
Methyl tertiary butyl ether (MTBE)	6747	17575	43937	219688	1424596	3645385
n-Hexane	1391	3384	8460	42300	255744	761077
Bromochloromethane (IS1)	35531	36214	39788	41232	40515	60078
Benzene	3556	8201	20502	102512	647506	1691722
1,4-Difluorobenzene (IS2)	143419	148189	146799	162114	172980	246302
Cyclohexane	1788	5250	13125	65625	374747	967332
2,3-Dimethylpentane	2999	6325	15812	79062	471028	1248544
n-Heptane	1827	6002	15005	75025	489349	1288707
Toluene	6092	12494	31235	156175	1086109	2437046
n-Octane	7869	15973	39932	199662	806445	1881104
Chlorobenzene-d5 (IS3)	316020	320770	297404	313031	336207	378992
Ethylbenzene	16511	35273	88182	440912	2411322	4659148
2,3-Dimethylheptane	9786	21985	54962	274812	1301031	2402318
Xylene (m, p)	26176	60190	150475	752375	3999652	7788338
Xylene (o)	12988	28608	71520	357600	2102284	4197368
n-Nonane	6763	14581	36452	182262	1060313	2016617
4-Bromofluorobenzene (BFB)	342161	346944	362579	373001	397666	422781
Isopropylbenzene	12267	29472	73680	368400	2221982	3497442
1-Methyl-3-ethylbenzene	10155	24432	61080	305400	2021310	4120625
1,3,5-Trimethylbenzene	9935	25420	63550	317750	1965146	4005654
n-Decane	4417	10654	26635	133175	821407	1690516
1,2,3-Trimethylbenzene	9383	23154	57885	289425	1785313	3709878
4-Isopropyltoluene	9002	22455	56137	280687	1844647	4019022
Butylcyclohexane	4510	11261	28152	140762	841313	1747933
n-Undecane	3083	7327	18317	91587	641647	1558980
Naphthalene	7042	10026	25065	125325	814108	1760433
n-Dodecane	3737	7084	17710	88550	666786	1473457
C_5-C_8 Aliphatic Hydrocarbons	18097	44390	110974	554874	2856509	7178359
C_9-C_{12} Aliphatic Hydrocarbons	32296	72892	182228	911148	5332497	10889821
C_9-C_{10} Aromatics (m/e 120)	45341	111460	278650	1393250	8731610	16941208
C_9-C_{10} Aromatics (m/e 134)	9002	22455	56137	280687	1844647	4019022
C_9-C_{10} Aromatic Hydrocarbons	54343	133915	334787	1673937	10576257	20960230

TABLE 5-3: CALIBRATION STANDARD CONCENTRATIONS (µg/m^3)

Compound	**Cal 1**	**Cal 2**	**Cal 3**	**Cal 4**	**Cal 5**	**Cal 6**
1,3-Butadiene	2	4	10	50	250	500
Isopentane	2	4	10	50	250	500
Methyl tertiary butyl ether (MTBE)	2	4	10	50	250	500
n-Hexane	2	4	10	50	250	500
Bromochloromethane (IS1)	42	42	42	42	42	42
Benzene	2	4	10	50	250	500
1,4-Difluorobenzene (IS2)	37	37	37	37	37	37
Cyclohexane	2	4	10	50	250	500
2,3-Dimethylpentane	2	4	10	50	250	500
n-Heptane	2	4	10	50	250	500
Toluene	2	4	10	50	250	500
n-Octane	2	4	10	50	250	500
Chlorobenzene-d5 (IS3)	38	38	38	38	38	38
Ethylbenzene	2	4	10	50	250	500
2,3-Dimethylheptane	2	4	10	50	250	500
Xylene (m, p)	4	8	20	100	500	1000
Xylene (o)	2	4	10	50	250	500
n-Nonane	2	4	10	50	250	500
4-Bromofluorobenzene (BFB)	57	57	57	57	57	57
Isopropylbenzene	2	4	10	50	250	500
1-Methyl-3-ethylbenzene	2	4	10	50	250	500
1,3,5-Trimethylbenzene	2	4	10	50	250	500
n-Decane	2	4	10	50	250	500
1,2,3-Trimethylbenzene	2	4	10	50	250	500
4-Isopropyltoluene	2	4	10	50	250	500
Butylcyclohexane	2	4	10	50	250	500
n-Undecane	2	4	10	50	250	500
Naphthalene	2	4	10	50	250	500
n-Dodecane	2	4	10	50	250	500
C_5-C_8 Aliphatic Hydrocarbons	12	24	60	300	1500	3000
C_9-C_{12} Aliphatic Hydrocarbons	12	24	60	300	1500	3000
C_9-C_{10} Aromatics (m/e 120)	10	20	50	250	1250	2500
C_9-C_{10} Aromatics (m/e 134)	10	20	50	250	1250	2500
C_9-C_{10} Aromatic Hydrocarbons	10	20	50	250	1250	2500

TABLE 5-4: SAMPLE ANALYSIS DATA

Compound	**RT**	**Area**	**ISTD µg/m^3**	**Concentration µg/m^3***
1,3-Butadiene	5.262	100452		36.1
Methyl tertiary butyl ether (MTBE)	7.572	162682		44.5
Bromochloromethane (IS1)	8.332	31534	42	
Benzene	9.654	60285		38.5
1,4-Difluorobenzene (IS2)	9.852	115082	37	
Toluene	12.724	119314		37.7
Chlorobenzene-d5 (IS3)	15.399	289465	38	
Ethylbenzene	16.098	325648		41.0
Xylene (m, p)	16.447	518803		78.0
Xylene (o)	17.374	250488		37.9
4-Bromofluorobenzene (BFB)	18.317	425176	57	
Naphthalene	29.274	99759		38.0
C_5-C_8 Aliphatic Hydrocarbons		823563		634
C_9-C_{12} Aliphatic Hydrocarbons		1971741		704
C_9-C_{10} Aromatics (m/e 120)		2256810		
C_9-C_{10} Aromatics (m/e 134)		960760		
C_9-C_{10} Aromatic Hydrocarbons		3217570		516

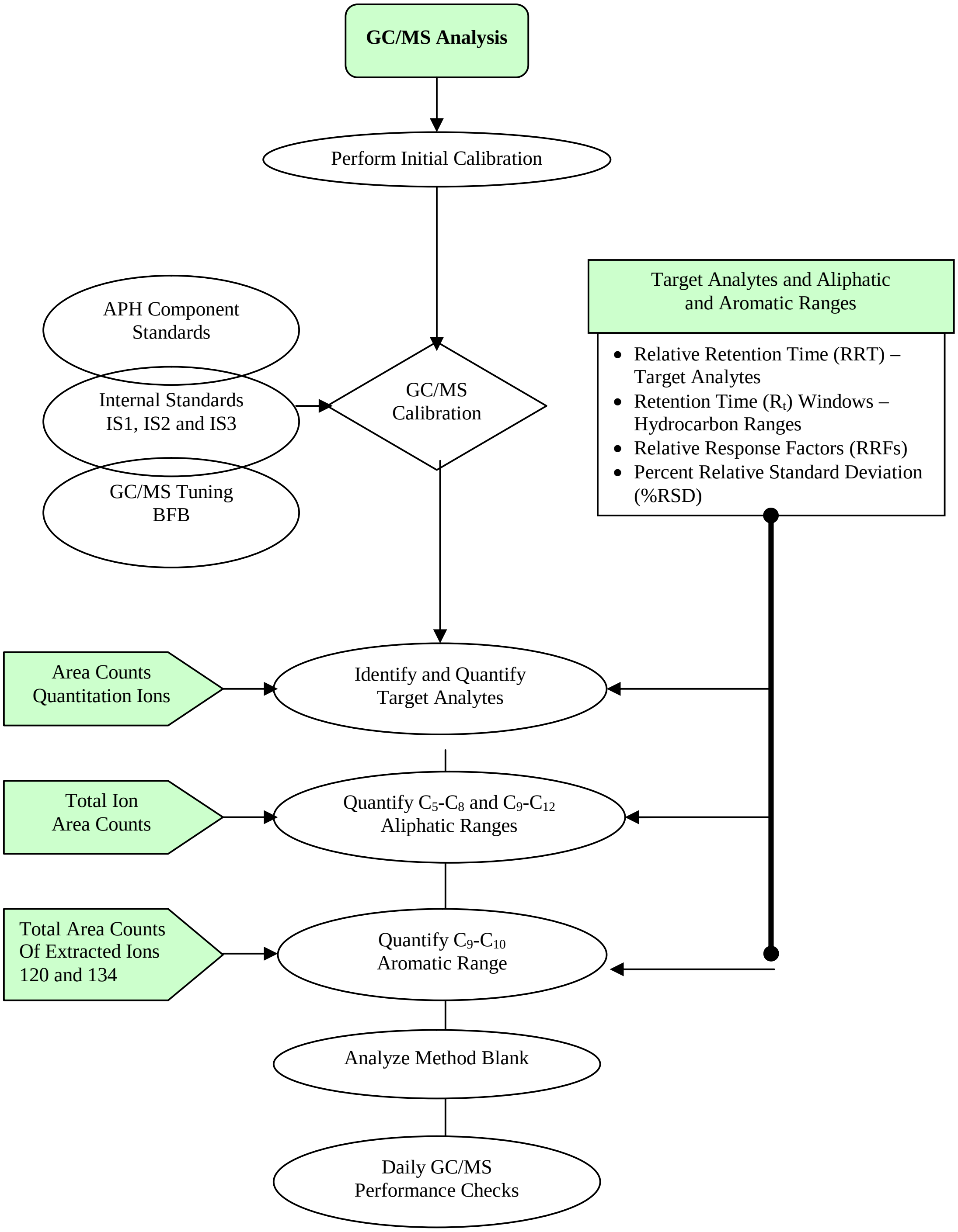
*Sample aliquot volume = 0.250 L

From Table 4 of Method. APH Range Marker Compounds and Range Retention Times

C_5-C_8 Aliphatic Hydrocarbons	0.1 min. before isopentane	0.01 min. before n-nonane
C_9-C_{12} Aliphatic Hydrocarbons	0.01 min. before n-nonane	0.1 min. after dodecane
C_9-C_{10} Aromatic Hydrocarbons	0.1 min. after o-xylene	0.1 min. before naphthalene

Ranges for Sample Data	**Range Start RT**	**Range End RT**
C_5-C_8 Aliphatic Hydrocarbons	6.028	17.744
C_9-C_{12} Aliphatic Hydrocarbons	17.744	29.724
C_9-C_{10} Aromatic Hydrocarbons	17.474	29.174

Figure 5-1: Air-Phase Hydrocarbons (APH) Method Analytical Flow Chart



APPENDIX 6
APH METHOD CALIBRATION AND ANALYSIS USING LINEAR REGRESSION

Use of linear regression is permissible to calculate the slope and y-intercept that best describes the linear relationship between APH target analytes or range concentrations and instrument responses.

1. Prepare APH Calibration Standards as described in Tables 3a and 3b at a minimum of five concentration levels in accordance with the procedures and specifications contained in Section 9.4. The APH marker compounds for the C_5-C_8 aliphatic, C_9-C_{12} aliphatic and C_9-C_{10} aromatic ranges are presented in Table 4.

   Analyze each APH calibration standard following the procedures outlined in Section 9.4. Tabulate area response ratios (area of target analyte/ area of internal standard) against the concentration ratio (concentration of the target analyte/concentration of internal standard). These data are used to calculate a calibration curve for each target analyte (Equation 6-1). The correlation coefficient (r) of the resultant calibration curve must be greater than or equal to 0.99.

   Equation 6-1: Linear Regression: APH Target Analytes

$$\boxed{\frac{A_s\ C_{IS}}{A_{IS}} = a\ C_S + b}$$

   where:

   a = the calculated slope of the line
   b = the calculated y intercept of the “best fit” line
   C_S = Concentration of the target analyte (µg/m^3)
   A_S = Area count of the primary (quantitation) ion for the analyte of interest
   C_{IS} = Concentration of associated internal standard (µg/m^3)
   A_{IS} = Area count of the primary (quantitation ion) for the associated internal standard

   A calibration curve may also be established for each aliphatic and aromatic hydrocarbon range of interest. Calculate the calibration curve for C_5-C_8 Aliphatic Hydrocarbons and C_9-C_{12} Aliphatic Hydrocarbons using the total ion integration and sum of the individual peak areas of the APH components within each range. Calculate the calibration curve for the C_9-C_{10} Aromatic Hydrocarbons using the sum of the 120 and 134 extracted-ion chromatograms within the designated window for the range. Tabulate the ratio of the summation of the peak areas to the area of the internal standard of all components in that fraction (i.e., C_5-C_8 Aliphatic Hydrocarbons, 6 components) against the ratio of the total concentration of the range to the concentration of the internal standard. These data are used to calculate a calibration curve for each APH hydrocarbon range (Equation 6-2). The correlation coefficient (r) of the resultant calibration curve must be greater than or equal to 0.99.

   Note: Do not include the area of BFB when determining the calibration curve for C_9-C_{12} Aliphatic Hydrocarbons. Do not include the area of the three internal standards when determining the calibration curve for C_5-C_8 Aliphatic Hydrocarbons.

Equation 6-2: Linear Regression: APH Aliphatic and Aromatic Hydrocarbon Ranges

$$\boxed{\frac{A_T\ C_{IS}}{A_{IS}} = aC_T + b}$$

where:

a = the calculated slope of the line
b = the calculated y intercept of the "best fit" line
C_T = summation of the concentrations (µg/m^3) of the six aliphatic APH components which elute within this range for C_5-C_8 or C_9-C_{12} Aliphatic Hydrocarbons or summation of the concentrations of the five APH components which elute within this range for C_9-C_{10} Aromatic Hydrocarbons
A_T = total ion area of the six aliphatic APH components which elute within this range for C_5-C_8 or C_9-C_{12} Aliphatic Hydrocarbons or summation of areas of the extracted ions 120 and 134 for five APH components which elute within this range for C_9-C_{10} Aromatic Hydrocarbons

2. The concentration of a specific target analyte or hydrocarbon range may be calculated using linear regression analysis by applying Equation 6-3.

Equation 6-3: Determination of APH Target Analyte and Hydrocarbon Range Concentrations using Linear Regression

$$\boxed{\left(\frac{A_X\ C_{IS}}{A_{IS}} - b\right) \div a \times D = Conc.\ Analyte\ or\ HC\ Range\ (\mu g / m^3)}$$

where:

A_x = Response for the analyte or hydrocarbon range in the sample. Units are in area counts for APH Target Analytes and the hydrocarbon ranges.
D = Dilution factor; if no dilution was made, D = 1, dimensionless
a = Slope of the line for APH Target Analyte or hydrocarbon range
b = Intercept of the line for APH Target Analyte or hydrocarbon range

3. At a minimum, the working calibration curve must be verified every 24 hours prior to the analysis of samples to verify instrument performance and linearity. If the Percent Drift (% Drift) for more than one compound varies from the predicted response by more than ±30 or if the % Drift for any one compound is greater than 50, as determined using Equation 6-5, a new five-point calibration must be performed for that analyte.

Equation 6-5: Percent Drift

$$\boxed{\%Drift = \frac{Calculated\ concentration\ - Theoretical\ concentration}{Theoretical\ concentration}\ x\,100}$$

Appendix D

Maine Department of Environmental Protection

Remedial Action Guidelines for Contaminated Sites (RAGs)

Effective Date: November 15, 2023

Approved by: ____________________

Date: November 2, 2023

Susanne Miller, Director

Bureau of Remediation & Waste Management

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1 Disclaimer

This guidance provides a DEP-accepted approach for determining human health risk and clean-up goals at remediation sites. These guidelines are not rules and are not intended to have the force of law. This guidance does not create or affect any legal rights of any individual, all of which are determined by applicable law. This guidance does not supersede statutes or rules.

2 Introduction and Purpose

2.1 Purpose

Maine law charges the Commissioner of the Department of Environmental Protection (DEP) with abating pollution to protect public health and welfare. This guidance is one approach that may be used to:

1. Determine which sites pose a risk and therefore warrant abatement, mitigation, and/or remediation;
2. Establish target clean-up levels; and
3. Clear sites for reuse (close-out sites) once remediation is completed.

The purpose of this guidance is to ensure:

1. Protection of public health and welfare at and near remediation sites;
2. Consistency of remediation decisions in Maine; and
3. Certainty for the regulated community.

2.2 Consistency with Superfund Risk Assessment

The Maine Remedial Action Guidelines (RAGs) for Contaminated Sites were developed with toxicological assistance from the Maine Department of Health and Human Services' Center for Disease Control and Prevention (CDC). These guidelines are consistent with EPA's Superfund Program,[1] which responds to releases of hazardous substances to the environment. RAGs are based upon EPA's risk assessment guidance and are supported by the Maine CDC.

2.3 When to Use RAGs and When to Develop a Site-Specific Risk Assessment

Maine DEP provides two options for assessing the risk posed by a contaminated site, determining target clean-up goals, and determining if the site can be closed out. The first option is to use these RAGs, and the second option is to do a site-specific risk assessment using the procedures in Attachment B. The RAGs are

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[1] *United States Comprehensive Environmental Response, Compensation, and Liability Act*, 42 U.S.C. §§ 9601-9675

intended to simplify derivation of clean-up goals for sites and speed up the decision-making process.

The choice of which procedure to use (RAGs or site-specific risk assessment) is generally at the discretion of the project lead on the clean-up, which may be the site owner/operator, Potential Responsible Party, DEP, EPA, Department of Defense, or other party. The exception to this is if DEP determines, in consultation with Maine CDC, that a media/scenario/route-of-exposure will likely cause a greater risk due to site-specific circumstances than contemplated when the RAGs were developed. In this case, the DEP will require that the project lead develop a risk assessment using the procedures in Attachment B: Supplemental Guidance for Conducting Site-Specific Risk Assessments in Maine. For example, if a person was only exposed to metals at an agricultural site via plant uptake and subsequent ingestion of the plants, then site-specific target clean-up goals would need to be developed for that route of exposure and scenario. Another example is if there are subsistence anglers consuming contaminated fish tissue, then a site-specific risk assessment is required.

3 Applicability

3.1 Applicable Programs & DEP Approval Process

This procedure applies to the DEP programs listed below. In general, DEP reviews an applicant’s proposal and reaches agreement on appropriate RAGs for a specific site. Ideally, clean-up should allow for unrestricted site use. DEP determinations that soil clean-up levels will be protective of public health and welfare are made in clean-up decisions in the form of DEP Orders, Administrative Agreements, Consent Agreements, No Further Action determinations, Certificates of Completion, and other legally binding decision documents.

Consult staff in the following programs to determine the administrative procedures for review and approval of site-specific clean-up goals. Details on each of these programs are available on the DEP website at: http://www.maine.gov/dep/programs/.

3.1.1 Uncontrolled Hazardous Substance Sites

The project lead may decide to use RAGs to determine clean-up levels at an Uncontrolled Hazardous Substance Site (Uncontrolled Site) under 38 M.R.S. § 1364(5). The Uncontrolled Sites Program (USP) directs the investigation and removal of threats to public health, safety or welfare that are posed by hazardous substances at sites. Basically, the USP is the State of Maine equivalent to the federal Superfund Program. At DEP led sites, DEP establishes clean-up goals in formal DEP Decision Documents, usually after a management review meeting.

3.1.2 Voluntary Response Action Program

Maine’s Voluntary Response Action Program (VRAP), under 38 M.R.S. § 343-E, allows applicants to voluntarily investigate and clean-up properties to the satisfaction of the DEP in exchange for protections from future DEP enforcement actions. The project lead may decide to use this guidance to determine clean-up levels for a site in the VRAP.

3.1.3 Brownfields

The project lead may decide to use these procedures to determine clean-up levels at a Brownfields site. The Brownfields program provides grants to assist with the assessment and remediation of "[r]eal property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant," pursuant to the Business Liability Relief and Brownfields Revitalization Act, 42 U.S.C. §§ 9601-9628.

3.1.4 Superfund/CERCLA

At sites subject to clean-up under the federal Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. § 9601 et seq. of 1980, as amended (CERCLA or Superfund), clean-up levels are determined by Applicable or Relevant and Appropriate Requirements (ARARs) and the “Nine Criteria” found in 40 C.F.R. 300.430 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The DEP will recommend that EPA and other federal lead agencies consider using this guidance to establish clean-up goals for sites being investigated and remediated under Superfund in Maine. Site specific remediation decisions are finalized in a Record of Decision for each site.

3.1.5 RCRA

In Maine, the Resource Conservation and Recovery Act (RCRA) subtitle C corrective action sites are subject to the *Maine Hazardous Waste, Septage and Solid Waste Management Act* and associated regulations (06-096, C.M.R. Chs. 850 through 857). These laws generally require that releases of hazardous waste and constituents be completely removed where practical. When not practical, the RAGs are used to ensure corrective action prevents current and future exposure to contaminants that pose a risk to human health or the environment. Site-specific remediation clean-up goals and procedures are established in DEP Orders and Licenses.

Note that RCRA requirements are not risk-based, so additional clean-up may be necessary even if the chemicals do not meet Hazardous Waste classification. For example, a PCB release of less than 50 ppm would not be a hazardous waste but could result in concentrations over the RAG for all scenarios, meaning further assessment would be warranted to protect public health. Conversely, a site with Bis(2-ethylhexyl) phthalate in soil below 530 mg/kg would not pose a health risk, but the soil would still be considered hazardous waste. See 06-096 C.M.R. ch. 850 for lists of hazardous waste. Additionally, EPA's CompTox database can be used to determine if the chemicals at a given site are listed Hazardous Wastes.

3.1.6 Petroleum Remediation Sites

Except for DEP licensed Marine Oil Terminals, the petroleum remediation program utilizes the RAGs to complete risk-based cleanup decisions at oil discharge sites in Maine in accordance with Attachment C of this document. An important distinction is that the petroleum remediation program does not typically utilize institutional controls or use restrictions when mitigating exposure risk at contaminated sites. Sections of this document discussing institutional controls and use restrictions are not generally applicable to the petroleum remediation program.

3.1.7 Municipal Landfill Closure and Remediation Program

The project lead may decide to use RAGs to determine clean-up levels at a Municipal Landfill Closure and Remediation Program site (Closed Municipal Landfill) under 38 M.R.S. § 1310-C. The Program is responsible for overseeing the closure and long-term maintenance and monitoring of municipally owned and/or operated landfills as well as overseeing post closure remediation projects to address issues that have developed since the landfill was closed. The Program also oversees post closure landfill re-use projects, such as solar panel development and recreational fields.

3.1.8 Not Applicable to other DEP Programs

DEP does not intend that these guidelines be used by programs that are not listed above.

3.1.9 Relation to Beneficial Reuse of Remediated Debris

Remediated soils or other debris may qualify for a subsequent reuse, such as fill, even though pollutants in the material may exceed normal background concentrations, as described below.

3.1.9.1 Hazardous Waste

The beneficial reuse of contaminated material that is classified as a hazardous waste is subject to the hazardous waste laws described in Section 3.1.5 above, and the project lead should consult with the DEP's RCRA Corrective Action staff (207-287-7688) regarding its reuse requirements.

3.1.9.2 Other Residuals

The beneficial reuse of contaminated material that is not classified as a hazardous waste is subject to the DEP's Solid Waste Management Rules. Specifically, if the material is to be beneficially used for Agronomic Utilization, such as for topsoil, fertilizer, soil amendment, or for any other plant growth purpose, then the reuse is subject to the *Maine Solid Waste Management Rules: Agronomic Utilization of Residuals*, 06-096 C.M.R. ch. 419. If the material is to be used for another purpose, such as construction fill or a building material, then that activity would be subject to the *Maine Solid Waste Management Rules: Beneficial Use of Solid Wastes*, 06-096 C.M.R. ch. 418. These rules generally have exemptions to allow the storage and reuse of materials on the site of generation if DEP is the project lead. See the rules and discuss with the DEP's materials management staff (207-287-7688) about any intended storage or reuse of materials from a remediation project to determine if it is an exempt activity or if a license under 06-096 C.M.R. chs. 418 and 419 is needed.

3.2 Applicable Pollutants and Contaminants

3.2.1 Applicable to Hazardous Substances

This procedure is applicable to determining clean-up levels for media contaminated by hazardous substances, including waste oil, as defined in the *Uncontrolled Hazardous Substance Sites Law*, 38 M.R.S. § 1362.

3.2.2 Applicable to Petroleum

Except for DEP licensed Marine Oil Terminals, this procedure applies to media that are contaminated with petroleum. Petroleum sites must also follow the procedures in Attachment C: 2023 Remedial Action Guidelines Addendum for Petroleum Remediation. Petroleum includes leaded and non-leaded gasoline, aviation fuels, methyl tertiary butyl ether (MTBE), kerosene, #2 heating oil, other heating oils including heavy oils, diesel fuel, or other comparable petroleum hydrocarbons, and gasoline-ethanol blends with 15% ethanol or less.

3.2.3 Applicable to Mixtures

This procedure is applicable to clean-up levels for media contaminated by a mixture of hazardous substances and petroleum.

3.3 Applicable Media, Scenarios and Routes-of-Exposure

This guidance is specifically developed for sites or operable units with the media, scenarios, and routes-of-exposure that the DEP and Maine CDC identified as the most likely to present the greatest risk at contaminated sites, as summarized in Table 1. This procedure does not apply to establishing clean-up guidelines for public drinking water supplies, surface water, or any other media/scenarios/routes-of-exposure that are not included in Table 1. If DEP determines that other media/scenarios/routes-of-exposure may create a greater risk under site-specific circumstances, DEP will require a risk assessment following the procedures in Attachment B as an alternative to using these RAGs.

3.4 Not Applicable to Ecological Risk

This procedure applies to groundwater, soil, and sediment clean-up guidelines protective of human health impacts only. This guidance is not applicable to ecological impacts. If DEP believes that hazardous substances in media pose significant risk to ecological receptors, it may require that the project lead conduct an ecological assessment before the RAGs are applied at the site. DEP generally requires an ecological assessment if evidence indicates that a current or future potential exists for exposure of ecological receptors to contaminants from the site. Evidence includes visible physical evidence (sheens or neat product, etc.) or analytical data suggesting that contaminants from the site are impacting surface water, sediment, wetlands, or biota. This includes data suggesting potential adverse impacts to terrestrial biota, such as contaminants that can bioaccumulate and that are within the top two (2) feet of soil. Evidence also includes runoff or other exposure pathways that will likely result in ecological impacts. Additional guidance on assessing ecological risk at contaminated sites is available at: http://www.epa.gov/risk/superfund-risk-assessment-ecological-risk-topics.

3.5 Not Applicable to Selection of COPCs for Full Risk Assessment

The RAGs should not be used in selecting Contaminants of Potential Concern (COPCs) for a risk assessment. Rather, COPCs should be developed in accordance with Attachment B. This is because the RAGs are set at an Incremental Lifetime Cancer Risk (ILCR) of 10^{-5} and a Hazard Quotient (HQ) of 1. Risk-based concentrations for use in selecting COPCs should reflect an ILCR of 10^{-6} and non-carcinogenic HQ of 0.1. The use of risk-based concentrations at the lower target risk and hazard levels is consistent with Superfund guidance, aimed at ensuring that contaminants that could possibly contribute significantly to risk and hazard are included in the quantitative assessment. Because the intent of the COPCs selection process is to generate a conservative list of contaminants requiring quantitative evaluation, recommended screening criteria are conservative so as not to omit contaminants that may contribute significantly toward cumulative site risk.

3.6 Not Applicable to Radionuclides

Radionuclides are not addressed in the RAGs. Contact the CDC’s Maine Radiation Control Program for protocols in assessing and mitigating risk from radionuclides.

Table 1: Media, Scenario and Routes-of-Exposure Included in the Remedial Action Guidelines

Media	Scenario	Route of Exposure	Description
Soil (including hydric)	Residential	Ingestion	Incidental exposure while working/playing outside including dust from dirt tracked indoors
		Skin Contact	Incidental exposure while working/playing outside including dust from dirt tracked indoors
		Inhalation	Incidental exposure while working/playing outside including dust from dirt tracked indoors
	Recreational / Park User	Ingestion	Incidental exposure while working/playing outside
		Skin Contact	Incidental exposure while working/playing outside
		Inhalation	Incidental exposure while working/playing outside
	Commercial Worker	Ingestion	Incidental exposure while working outside
		Skin Contact	Incidental exposure while working outside
		Inhalation	Incidental exposure while working outside
	Construction / Excavation Worker	Ingestion	Incidental exposure while working outside
		Skin Contact	Incidental exposure while working outside
		Inhalation	Incidental exposure while working outside, including to trench air
Groundwater	Residential	Ingestion	Use as drinking water
		Skin Contact	Exposure during showering or bathing
		Inhalation	Incidental exposure during showering
	Construction / Excavation Worker	Ingestion	Incidental exposure while working outside
		Skin Contact	Incidental exposure while working outside
		Inhalation	Incidental exposure while working outside
Sediment	Recreational / Park User	Ingestion	Incidental exposure while wading
		Skin Contact	Incidental exposure while wading
Ambient Air	Residential	Inhalation	Exposure while living outdoors
Indoor Air	Residential	Inhalation	Exposure while living indoors
	Commercial Worker	Inhalation	Exposure while working indoors
Fish Tissue	Recreational Angler*	Ingestion	Secondary source in diet
* For Subsistence Angler exposure pathway, a Site-Specific Risk Assessment is required because ingestion rates will vary between sites.			

4 Risk Protocols Used to Develop the RAGs

This section provides an overview of how the RAGs were derived. A detailed description including the references to the formulas and factors used to develop RAGs for each media/scenario/route-of-exposure is available in Attachment A: Technical Support Document for Maine 2023 Remedial Action Guidelines.

4.1 RSL Calculator for Superfund Risk Assessments

Maine CDC and DEP developed these RAGs using EPA’s "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (“Regional Screening Levels” or “RSLs”) risk calculator.[2] The RSL calculator uses the risk assessment protocols that have been developed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), more commonly called the Superfund Program. The RAGs are therefore based on Reasonable Maximum Exposure (RME) scenarios, which are common situations that result in the highest exposure that is reasonably anticipated to occur at a site. The RSL calculator allows the user to select exposure factors. Some of the major inputs to the RSL calculator were:

4.1.1 Target Risk Level for RAGs

The goal for site clean-up and closure is to reduce risk posed by contaminants to acceptable levels. Consistent with the Site-Specific Risk Assessment Guidance, provided in Attachment B, sites are closed out when the cumulative (combined) effects of contaminants at the site do not pose a risk that is greater than a Hazard Index (HI) of 1 by target organ, and an Incremental Lifetime Cancer Risk (ILCR) of greater than 1×10^{-5}. This goal is presumed to have been met when each contaminant is below its respective media guideline presented in Table 4 through Table 7.

4.1.2 Chronic or Subchronic Exposure

Chronic exposure refers to an individual being impacted by contamination for a long-time, typically a lifetime, while subchronic exposure refers to an individual being impacted by contamination for a shorter duration, typically between 2 weeks and 7 years. RAGs for the Residential, Park User/Recreational, and Commercial Worker Scenarios are based on chronic exposure to contamination. That is, the RAG is set at a level where an individual with a RME over a lifetime will not exceed the target risk levels described in Section 4.1.1 above. On the other hand, because a construction worker is expected to be exposed to site contamination for a year or less, the Construction Worker RAGs are based on subchronic exposure. Subchronic toxicity factors are used when available, when not available, chronic toxicity factors are substituted. Given the use of

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[2] EPA Regional Screening Levels (RSLs) webpage: https://www.epa.gov/risk/regional-screening-levels-rsls.

subchronic toxicity factors and the relative intensity of the Construction Worker exposure, Construction Worker RAGs may be lower than the Residential and/or Soil Leaching to Groundwater RAGs, for some compounds.

4.1.3 Additional Pathways

Maine CDC and DEP had to supplement the RSL risk calculator for some scenarios that were not included in the RSLs, such as exposure of construction workers to groundwater. When supplementing the RSLs, we used default exposure factors and risk assessment formulas consistent with those used in the RSL calculator.

4.1.4 Contaminant Units, Wet- vs. Dry-Weight

The RAGs are expressed as a unit of contaminant per unit of media. For example, in soil the RAG might be expressed as 10 mg/kg. This means for every kilogram of soil, there are 10 milligrams of contaminant. Due to the relatively high weight of water, the weight of soil will vary greatly by location and over time as its moisture content changes. To standardize this variability, RAGs for solids are usually expressed on a dry-weight basis. This means that sample results for solids obtained at a site need to be expressed on a dry-weight basis as well. This is done by drying the sample at a standard temperature while weighing the soil, until the weight does not vary any more. Steps are taken to ensure that volatile or semi-volatile contaminants are not driven off during the drying process.

One exception to expressing solids on a dry weight basis is for fish-tissue, which is expressed as wet-weight. Each RAG table specifies the units of the guideline, and whether the units are based on wet- or dry-weight.

4.1.5 Complete Details on Derivation of RAGs and Factors

The toxicity of each contaminant will vary due to a variety of factors including the contaminant’s chemical and physical properties, the route of exposure (eating, breathing or skin contact), the duration of exposure, the intensity of exposure, and the sensitivity of the exposed people. The formulas and factors used to derive each RAG are referenced in Attachment A: Technical Support Document for Maine 2023 Remedial Action Guidelines.

4.2 Definitions Used in the RAGs

4.2.1 Background Contaminants

“Background Contaminants” means those contaminants that are not attributable to a release of contaminants to the environment at a Hazardous Substance Site. The background contaminants may be naturally occurring in the environment (e.g., arsenic) or man-made (e.g., DDT). Hazardous Substance Site activity may chemically transform or release naturally occurring substances into other environmental media. These additional concentrations of the naturally occurring substance that are released from the Hazardous Substance Site activity are not representative of natural background concentrations. For example, biological degradation of buried organic materials (such as tannery wastes) at a site can deprive the subsurface of oxygen, causing changes to subsurface chemical conditions that favor elements (like arsenic) to become more soluble in groundwater. In this case, the increase in arsenic in groundwater is a site-related contaminant and a consideration in remediation of the site, even though it came from the parent rock, rather than the site waste.

4.2.2 Background Locations

"Background Locations" means areas with relevant media (e.g., soil, groundwater, air) that are similar to the Hazardous Substance Site (i.e., media with similar physical characteristics), that have been influenced to the same degree by regional deposition, runoff, or other contaminant inputs, but where contaminants released at the Hazardous Substance Site have not come to be located. Some chemicals may be present in background locations because of both natural and man-made conditions (such as naturally occurring arsenic and arsenic from pesticide applications or mining operations).

4.2.3 Contaminant

"Contaminant" means chemicals that are hazardous substances, as defined in Maine's Uncontrolled Sites Law,[3] which references the Superfund definition of hazardous substances or petroleum.

4.2.4 Contaminant or Chemical of Potential Concern (COPC)

A "Chemical of Potential Concern" or "Contaminant of Potential Concern" (COPC) means a contaminant that may have been released at a site and further risk evaluation is warranted.

4.2.5 Contaminant or Chemical of Concern (COC)

A "Chemical of Concern" or "Contaminant of Concern" (COC) means a contaminant that has been released at a site and risk evaluation indicates that mitigation or remediation is necessary to prevent exposure to the contaminant.

4.2.6 Environmental Covenant; Covenant

"Environmental Covenant" or "Covenant" means a servitude arising under an environmental response project and documented in a recordable instrument (usually a deed) that imposes activity and use limitations on a parcel of land. "Environmental Covenant" does not include a municipal ordinance, a voluntary or other remedial action plan or action plan

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[3] *Maine's Uncontrolled Hazardous Substance Sites* law, 38 M.R.S. §§ 1361–1371.

condition, or an administrative or judicial order, even if it imposes activity or use limitations.[4]

4.2.7 Environmental Media Management Plan

An “Environmental Media Management Plan (EMMP)” describes property owner obligations and procedures to ensure owners, contractors, employees, or other persons engaged in site disturbance activities appropriately manage impacted groundwater, soil, air, and other media to prevent human health and environmental impacts.

4.2.8 Exposure Pathway / Complete Exposure Pathway

“Exposure Pathway” means the route a contaminant takes from its source (where it began) to a receptor. An exposure pathway has five parts: a source of contamination (such as a leaking tank), an environmental medium and transport mechanism (such as movement through groundwater), a point of exposure (such as a private well), a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). An exposure pathway is termed a completed exposure pathway only when all five parts are present.[5]

4.2.9 Exposure Point

“Exposure Point” means an area or location of potential contact between a receptor and a contaminant.

4.2.10 Exposure Point Concentration

“Exposure Point Concentration (EPC)” means the concentration of a contaminant to which an individual is exposed at the exposure point. Calculation of an appropriate EPC for site-specific risk assessment is described in Attachment B.

4.2.11 Hazard Quotient

The “Hazard Quotient (HQ)” is a calculation used to determine whether an adverse health risk, other than cancer, might occur to an individual exposed to a given contaminant at a site. Specifically, the HQ applies to non-carcinogenic effects and is the ratio of estimated site-specific exposure from a single chemical from a site over a specified period (exposure level) to the estimated daily exposure level at which no adverse health effects are likely to occur (toxicity guideline).

4.2.12 Hazard Index

The “Hazard Index (HI)” is the sum of the Hazard Quotients and is used to calculate whether an adverse health risk, other than cancer, might occur to

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[4] 38 M.R.S. § 3002(4).

[5] Adopted from the Agency for Toxic Substances and Disease Registry (ATSDR) Glossary of Terms: https://www.atsdr.cdc.gov/glossary.html..

an individual exposed to contaminants at a site. Specifically, the HI applies to non-carcinogenic effects and is the sum of hazard quotients for substances that affect the same target organ or organ system. The Hazard Index is estimated as the Average Daily Dose or Average Daily Exposure for the exposure period divided by the Reference Dose or Reference Concentration, respectively. The Hazard Index is also described as a weighted sum of the exposure measures for the contaminant mixture. The "weight" factor according to dose addition should be a measure of the relative toxic strength, sometimes called "potency."

4.2.13 Hazardous Substance

"Hazardous Substances" are chemicals that might pose a health risk if individuals are exposed to them above a specific dose. For purposes of this guidance, Hazardous Substance has the same meaning as defined under the *Uncontrolled Hazardous Substance Sites Law*, 38 M.R.S. § 1362(1), which defines "Hazardous Substances" as:

1. Any substance identified by the Board of Environmental Protection under Section 1319-O;
2. Any substance identified by the Board of Environmental Protection under Section 1319;
3. Any substance designated pursuant to the United States Comprehensive Environmental Response, Compensation and Liability Act of 1980, Public Law 96-510, Sections 101 and 102 (Superfund);
4. Any toxic pollutant listed under the United States Federal Water Pollution Control Act, Section 307(a);
5. Any hazardous air pollutant listed under the United States Clean Air Act, Section 112;
6. Any imminently hazardous chemical substance or mixture with respect to which the Administrator of the United States Environmental Protection Agency has taken action pursuant to the United States Toxic Substances Control Act, Section 7;
7. Waste oil as defined in Section 1303-C; and
8. Any substance defined as a hazardous substance or a pollutant or contaminant under the United States Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 United States Code, Section 9601.

4.2.14 Hazardous Substance Site

"Hazardous Substance Site" or "Site" means any site where hazardous substances have come to be located.

4.2.15 Incremental Lifetime Cancer Risk

The “Incremental Lifetime Cancer Risk (ILCR)” is the method used to calculate the increased, upper-bound risk of cancer that might occur to an individual exposed to contaminants at a site, with the exposure averaged over a lifetime. Specifically, ILCR means the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a contaminant.

4.2.16 Project Lead

The “Project Lead” is the agency, group, organization, or person that is the primary leader and funder for remedial activities at the site and generally hires the contractor that undertakes the remediation. The project lead may be the site owner/operator or other Potential Responsible Party, a state or federal agency, a developer, or other person.

4.2.17 Public Water

“Public Water” or “Public Drinking Water Supply” means any publicly or privately-owned well or other source of drinking water that furnishes water for human consumption for 15 service connections, regularly serves an average of at least 25 individuals daily at least 60 days out of the year or supplies bottled water for sale.

4.2.18 Receptor

“Receptor,” for the purposes of this document, is defined as an individual or group of people that may become exposed to a contaminant as a result of a release to the environment.

4.2.19 Sediment

“Sediment,” for the purposes of this document only, is defined as any granular material and/or fine organic material that is located beneath water for most the year. Materials that are located under water but are frequently exposed (e.g. tidal areas) are considered soils for purposes of this guidance.

4.2.20 Urban Fill

“Urban Fill” means soil mixed with other materials used to modify site elevation to facilitate property development and that is unrelated to a specific property activity. Urban fill is a soil matrix that includes such material as brick, concrete, wood, wood ash, coal, coal ash, boiler ash, clinkers, other ash, asphalt, glass, plastic, metal, demolition debris, and roadside ditch materials. Certain urban areas of Maine, such as the Bayside area of Portland, have large quantities of urban fill present. Many properties in Maine have smaller quantities of urban fill present, including developed properties in rural areas of the state. To distinguish urban fill from site related contaminants, soil descriptions should include the components of fill materials that are present, and the Conceptual Site

Model should include the extent or approximate extent of the materials both vertically and horizontally.

5 Responsibilities

5.1 Project Leads

The primary leader for remedial activities at a hazardous substance site should develop media specific clean-up goals for DEP's consideration that are consistent with this guidance, or the site-specific risk assessment guidance provided in Attachment B.

5.2 BRWM Staff

DEP program staff should encourage adherence to this guidance to facilitate site clean-up. Staff should alert their supervisors when alternative approaches are proposed for a site.

5.3 BRWM Unit Supervisors

Unit supervisors should ensure that remediation decisions are consistent within their units. Unit supervisors must receive pre-approval from the Division or Bureau Director before recommending any clean-up approvals that vary from this guidance.

5.4 BRWM Division Directors

Division Directors are responsible for ensuring that the staff in their division are trained in how to use this procedure and that clean-up guidelines are consistently applied within the Division's programs and between other divisions to which this procedure is applicable. Division Directors will consult with each other on variances to this guidance in their respective programs, generally through a project specific management review meeting.

6 Where RAGs Fit in the Site Assessment and Remediation Process

6.1 Introduction

Establishing contaminant specific RAGs is one part of the site investigation and remediation process. The focus of this guidance is on development and application of RAGs. To provide context, however, this Section provides a brief overview of the site assessment and remediation steps that must come before employing the RAGs. This overview is not a primer on those processes. Guidance for site assessment and remediation is available on the DEP website at: http://www.maine.gov/dep/spills/publications/guidance/index.html, including links to Maine DEP Sampling & Data Validation SOPs. Legal requirements for the handling, storage, treatment, and disposal of contaminated materials at Hazardous Substance Sites is not described in this guidance.

6.2 Emergency Removal

Before employing RAGs, acute hazards posing imminent risk to public health or welfare should be subject to emergency removal. Before implementing RAGs, the following minimum actions should be taken at sites:

1- Imminent threats to public health or safety (including the threat of explosions) must be removed and properly disposed;

2- Hazardous substances stored in unmarked containers, containers of questionable integrity, inappropriate containers, or containers that are otherwise in violation of hazardous materials or hazardous waste laws must be removed and properly disposed; and

Neat materials not properly stored and environmental media containing neat material must be recovered and removed. "Neat material" means liquid or solid hazardous substances which occur in a pure or nearly pure form, and which may or may not be in a container. Neat material is distinct from dissolved contamination. In keeping with this policy, the RAG values for contaminants in Table 4 through Table 7 were capped at saturation points for individual contaminants whenever available. When saturation points were not available, DEP used the RSL default ceiling limit of 10% or 100,000 mg/kg.

Emergency removal units often leave residual contamination at the site, which would be subject to this guidance. Note that when contamination can be readily identified, recovered, and removed for less cost than investigating the site, then the contamination should simply be removed, per DEP approvals.

6.3 Conceptual Site Model Development

Prior to using the RAGs, the project lead will need to develop a conceptual site model (CSM) for DEP approval, using guidance such as ASTM E1689 - 20, Standard Guide for Developing Conceptual Site Models for Contaminated Sites, as updated.[6] This guideline defines a CSM as "a written or pictorial representation of an environmental system and the biological, physical and chemical processes that determine the transport of contaminants from sources through environmental media to environmental receptors within the system."

The CSM is a dynamic tool that directs the project lead's investigation and risk mitigation decisions at the site.[7] The CSM should be developed as early in the assessment process as possible (it does not require site specific hydrogeologic or

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[6] ASTM E1689 - 20, Standard Guide for Developing Conceptual Site Models for Contaminated Sites is available at: https://www.astm.org/Standards/E1689.htm.

[7] ASTM E1903-11, Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process is a good reference for applying a CSM to an environmental site assessment and is available at: https://www.astm.org/Standards/E1903.htm.

laboratory data) and updated as new information becomes available. For instance, the CSM will be used to focus site investigation work plans (Scope of Work, Site Specific Quality Assurance Project Plans, etc.) on the collection of data needed to support a site-specific, risk-based decision. The data obtained may change the understanding of the site's risk, and if so, the CSM should be revised accordingly, and then be used to assess risk mitigation options.

Per the ASTM Guideline,[8] developing a CSM includes the following steps (in any order):

1. Identification of potential contaminants of concern;
2. Identification and characterization of the source(s) of contaminants;
3. Delineation of potential migration pathways through environmental media, such as groundwater, surface water, soils, sediment, biota, and air;
4. Establishment of background areas of contaminants for each contaminated medium;
5. Identification and characterization of potential environmental receptors (human and ecological); and
6. Determination of the limits of the study area or system boundaries.

The CSM narrative should concisely (in less than three pages) focus on the site's contaminant source, migration pathway, and potential receptors. The narrative summarizes site information and should include a description of:

1. The site;
2. Potential sources (containers, disposal units) and other areas of concern, primary release mechanisms (leaking containers, spills, disposal areas) and secondary sources (high concentrations in soil and/or groundwater);
3. A list of site related contaminants of concern, their distribution, and background conditions;
4. A discussion of actual or potential migration pathways, including fate and transport mechanisms and the hydrogeologic setting within the flow field; and
5. Potential ecological and/or human receptors.

The narrative is typically supported by several figures and perhaps a table, depending on site complexity. The CSM can be a stand-alone document or part of another site document. Detailed description of hydrogeology, properties of contaminants, contaminant distribution, and so forth should be included in other documents or Sections, rather than the CSM. Its language should be understandable by both investigators and future property owners.

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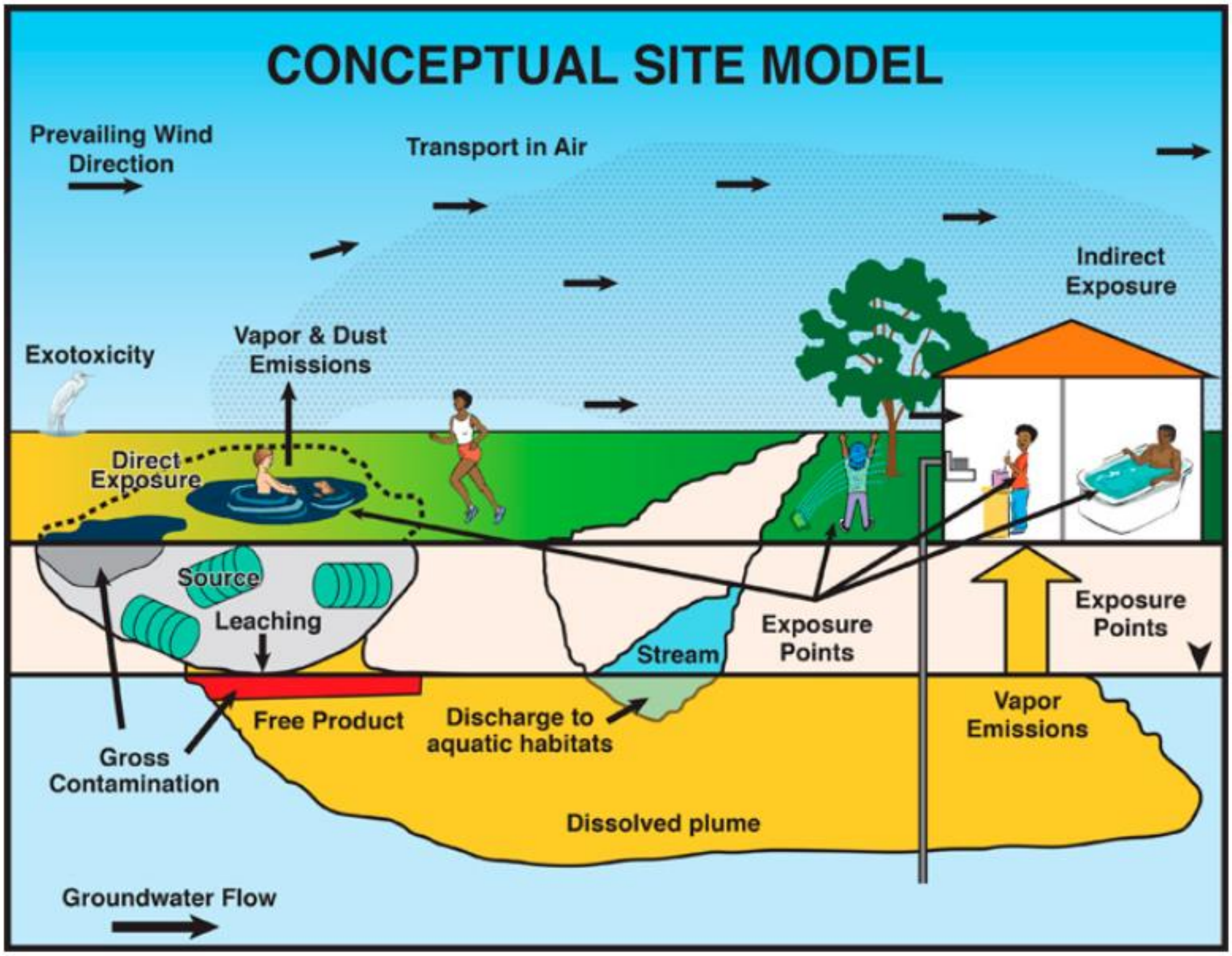
[8] ASTM E1689 - 20, Standard Guide for Developing Conceptual Site Models for Contaminated Sites is available at: https://www.astm.org/Standards/E1689.htm.

Figure 1: Example of a Conceptual Site Model with Multiple Pathways[9]



6.4 Sampling

6.4.1 Detection Levels & Data Quality Objectives

It is important to consider the site's clean-up goals when establishing the Data Quality Objectives (DQOs) for a site sampling plan.[10] For most sites, detection below the RAG levels should be possible if the appropriate sampling and testing procedures are used. The Practical Quantitation Limit (PQL) for a given sample will depend on a combination of factors including matrix interference, analytical method, instrument sensitivity

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[9] From Interstate Technology Regulatory Council (ITRC), TPH Risk Evaluation at Petroleum-Contaminated Sites, at: https://tphrisk-1.itrcweb.org/5-conceptual-site-models-and-investigative-strategies/.

[10] Data quality objectives, or DQOs, are a description of the data that must be obtained during a site investigation to support decisions regarding the site, such as the potential risk posed by the site, and how to address those potential risks. DQOs are based on the end use of the data. For more information, see http://www.epa.gov/fedfac/guidance-systematic-planning-using-data-quality-objectives-process (EPA QA/G-4), EPA/240/B-06/001, February 2006.

and lab precision. Under some site-specific circumstances, however, a given RAG may be below the level that can be accurately measured using current sampling and analytical protocols. Contact DEP (207-287-7688) for further guidance in these cases, or for additional help in establishing site DQOs.

6.4.2 Soil Sampling Depths

The plow layer, or upper two feet, are considered accessible surface soils in Maine for risk assessment purposes. Soils between 2 and 15 feet are considered potentially accessible. Potentially accessible soils should be considered accessible for risk assessment purposes until an environmental covenant and EMMP are in place to prevent excavation of foundations or other construction from inadvertently bringing this soil to the surface. Based on the CSM, a more discrete sampling interval may be appropriate, such as the upper 6 inches for a surface release. Soils below 15 feet are generally considered inaccessible for risk assessment purposes in Maine.

6.4.3 Assessing Vapor Intrusion

Vapor intrusion (VI) is the volatilization of hazardous substances from contaminated soil or groundwater into buildings. DEP considers measurement of contaminants in soil vapor and indoor air to be the best representation of VI potential and risk, as opposed to modeling. For additional information on VI, see DEP’s Supplemental Guidance for Vapor Intrusion of Chlorinated Solvents and Other Persistent Chemicals.[11]

6.4.4 The Chromium RAGs and Sampling for Chromium

To use the soil RAGs for chromium, the exposure point concentration must be expressed as hexavalent (Chromium (+6), CAS 18540-29-9) and trivalent chromium (Chromium (+3), CAS 16065-83-1), rather than total chromium. This is because the toxicity of chromium varies significantly with its valence state. Hexavalent Chromium is orders of magnitude more toxic than trivalent chromium.

6.5 Exposure Point Concentrations

RAGs are compared to the Exposure Point Concentration (EPC) for each medium at the site. The EPC is the concentration of a contaminant in a specific medium at an exposure point, such as a well or soil in a residential yard. Unless otherwise approved by DEP, the EPC should be set at the 95th upper confidence interval of the mean. If this value exceeds the maximum value in the dataset or there is insufficient data to run a statistical analysis, please refer to Attachment B: Supplemental Guidance for Conducting Risk Assessments in Maine. In the case of Multi-Incremental Sampling (i.e., establishing grid-based Decision Units and systematic compositing of soil samples within a Decision Unit), if the Decision Unit represents the EPC, then the incremental sampling result is directly

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[11] Available at: http://www.maine.gov/dep/spills/publications/guidance/index.html.

compared to the RAG. If an EPC is represented by multiple Decision Units, then the 95th upper confidence interval of the mean of the Decision Unit samples applies as described above. Further guidance on establishing EPC is provided in Attachment B: Supplemental Guidance for Conducting Site-Specific Risk Assessments in Maine.

7 Determine Target Clean-Up Levels Using RAGs

7.1 Introduction

Once the procedures in Sections 6 are completed, subject to Section 2.3, use either this guidance or a site-specific risk assessment to determine whether remedial action is necessary. When remedial action is indicated, establish target clean-up levels. The RAGs in Table 4 through 7 present the target clean-up guidelines by medium and exposure scenario for hazardous substances commonly encountered at sites in Maine. Contaminants are listed by CAS number and a common name to ensure the correct identification.[12] To determine site-specific RAGs, use the process detailed in the Sections below.

1- Exclude contamination determined to be attributable to background contamination in accordance with Section 7.2;

2- Based on a site's CSM, determine which media are contaminated and the applicable scenario(s), and then select the appropriate table (see Table 2);

3- Determine the appropriate land use scenario for the site, considering current and potential future land uses. The descriptions of the scenarios are found in Section 7.3, and the criteria for exclusion of scenarios in Section 7.4;

4- In each media, for each identified contaminant of concern select the lowest RAG value of the applicable exposure scenarios;

5- Plan and undertake the clean-up, if necessary; and

6- Following remedial action, confirm through sampling that target clean-up goals have been met and that the site may be closed out or confirm that further action is needed.

The following sections discuss in more detail the above process for selecting the appropriate RAG for a given site.

7.2 Assessing Risk Contribution from Background Contaminants

In some cases, background (see definitions in Section 4.2) concentrations of contaminants may exceed acceptable clean-up guidelines for soil. The DEP

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[12] Most chemical names have numerous synonyms. See EPA's CompTox database for a compendium of synonyms: https://comptox.epa.gov/dashboard.

allows the project lead to increase a clean-up level from the risk-based RAG to account for background concentrations.

7.2.1 Background Concentrations Policy

DEP will not require a clean-up of site soil to be more stringent than the local background concentration. Therefore:

1- When the established background concentration of a contaminant exceeds the applicable RAG, then the concentration of the contaminant in the background location becomes the clean-up level for the site.

2- When the established background concentration of a contaminant is less than the applicable RAG, then the RAG remains the clean-up level for the site.

7.2.2 Determining Background Concentrations

The methodology used to establish background contamination levels at a site should be reviewed and approved by DEP. Generally, DEP accepts four methods of determining background concentrations:

1- Site-Specific Samples - The most accurate approach is to use representative sample results from the site or similar nearby areas to determine representative background concentrations. If samples are collected to establish background concentrations, DEP should review and approve the sampling and analytical plan and any statistical methods used in establishing the background concentrations;[13]

2- Background Threshold Values (BTVs) presented in Table 4 represent typical background concentrations in Maine soil. The BTVs provided in Table 4 are Upper Tolerance Limits (UTLs) and are intended to be used when evaluating results from individual, discrete samples. These values may be used if there is not better, representative, site-specific background data available;

3- Background values provided in Table 4 are not applicable to sample results that represent average or mean concentrations over an area, such as those determined using Incremental Sampling Methodology (a.k.a Multi-Incremental Sampling). Background Threshold Values based on the Upper Confidence Limit on the mean (UCLs) are provided in Table 8. When assessing results of incremental sampling

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[13] For sample sets large enough to do statistical analysis, DEP recommends calculating the 95% Upper Tolerance Limit with 95% coverage (UTL 95-95) using the most recent PRO-UCL software. Follow the software's recommendations regarding the use of parametric or non-parametric tests and the handling of non-detected concentrations. Consult with DEP when determining which sample results, if any, should be considered outliers. A report on the datasets and statistical methods used to establish background for the RAGs is discussed in section 7.2.4. Similar statistical approaches should be used with site-specific data to compare the site-specific dataset to the Maine background dataset. Incremental sampling may also be used to establish site-specific background concentrations.

or broad composite sampling, the RAGs UCLs should be used as the background values for comparison;

4- Literature Values - A review and report on published literature or data from similar sites may be appropriate for establishing background concentrations. These may be used if there is no representative, site-specific background data available; or

5- Other - Other scientifically based methods for establishing background concentrations may be approved by the DEP, when there is no representative, site-specific background data available.

7.2.3 Arsenic Background Concentrations vs. Anthropogenic Sources

Maine soil often contains naturally occurring arsenic above the risk-based RAG. Further, degradation of contaminants or remedial activities at a site may release arsenic from parent materials. If arsenic is identified in on-site soil above the arsenic RAG, the project lead should determine if it was released by site activities, is naturally occurring, or both. Arsenic introduced through site activities must be remediated to the RAG or to the established background concentration, whichever is greater.

7.2.4 Background Concentrations of Polycyclic Aromatic Hydrocarbons

Table 4 lists Maine background concentrations for polycyclic aromatic hydrocarbons (PAHs) in soil in Rural Developed areas, Urban Developed areas, and Urban Fill. PAHs are often elevated in developed areas from historic PAH source materials that are mixed with soil, such as coal, coal ash, wood ash, degraded asphalt, driveway sealants, other road wear materials, and Polycyclic Organic Matter (POM) from atmospheric deposition. The DEP has found that PAH concentrations differ between Urban Developed areas, Rural Developed areas, and Urban Fill materials. The distinction between rural developed and urban developed areas is based on the Department of Transportation's (DOT's) definition of an urban compact zone and the DOT urban compact zone mapping (http://www.maine.gov/dep/gis/datamaps/statewide_layers/state_urban_compact_areas.kmz.).

Urban Fill, as defined in section 4.2.20, includes components in the soil matrix that are unrelated to a specific property activity or past property use. The fill material has been placed over an area to modify the elevation of the land surface for the development of the property or properties. Certain urban areas of Maine, such as the Bayside Area of Portland, have large quantities of Urban Fill present. Many properties in Maine have smaller quantities of Urban Fill present, including developed properties in rural areas of the state. Soil descriptions should include the components of fill materials present and the CSM should include the extent or approximate extent of the materials both vertically and horizontally. A soil cover or other barrier, and an EMMP are usually appropriate for managing potential exposure risks associated with Urban Fill material.

The PAH background concentrations in Table 4 should not be used at sites that are undeveloped. In these instances, site-specific background samples should be collected.

7.2.5 Background PFAS Concentrations

Table 4 lists Maine Background Threshold Concentrations (BTVs) of per- and polyfluoroalkyl substances (PFAS) in soil. Maine background UCLs for PFAS are included in Table 8 (see section 7.2.2 for guidance on when to use the BTVs in Table 4 vs. the UCLs in Table 8). In 2021, DEP contracted a study of typical background levels of PFAS in Maine that was executed in 2022. PFAS do not occur naturally in the environment; therefore, all PFAS are anthropogenic contaminants. However, the 2022 Background Level of PFAS and PAHs in Maine Shallow Soils study found several PFAS to be ubiquitous in Maine soil. While research is ongoing, the working conceptual model for background levels of PFAS in soil was that PFAS were emitted from regional or distant sources and were transported via the atmosphere.[14]

7.2.6 Addressing Risk Due to Background

Even though the DEP does not require remediation of media with background contaminant concentrations that exceed the RAGs, these background contaminants may still pose a risk to public health. In these cases, DEP recommends that the site land use and exposures be limited to meet an alternative RAG for the contaminant if feasible. For example, arsenic, PAHs, or PFAS at background concentrations may pose a risk if a site is used as residential property, but not pose a risk if the site is used as a commercial property. When a property owner determines that remediation or site use restrictions are not practical, then the DEP recommends that the property owner ensure that potentially affected parties, such as buyers or site occupants, are notified of the health risk from the background contaminant.

7.3 Application of Exposure Pathways and Scenarios

The DEP prefers that clean-up levels allow for unrestricted site use, so whenever practicable, clean-up levels must be set at the lowest level of a contaminant for all the exposure scenarios in the RAG tables (see the Media to RAG Crosswalk in Table 2). Likewise, land use may change in the future and exposure scenarios protective of all potential future uses should be selected. When DEP finds that it is not practical to meet the lowest clean-up values, DEP may approve clean-up to an exposure scenario with a less stringent RAG value, provided that an Environmental Covenant (Section 7.4.2) is put in place to restrict site uses that would result in the RAG for the omitted exposure scenario being exceeded. For instance, for the soil exposure pathway, the Outdoor Commercial Worker, Construction/Excavation Worker, and Recreational/Park User are common

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[14] See https://www.maine.gov/dep//spills/topics/pfas/Maine_Background_PFAS_Study_Report.pdf.

alternative land uses to residential use, so RAGs have been developed for these scenarios. Based on a site's CSM along with the current and future site use, determine the appropriate exposure scenario for the site. Establish Exposure Point Concentrations under that scenario and then compare to the RAGs in the appropriate column of the table.

Table 2: Media to RAG Table Crosswalk

Contaminated Media	**Use Table**
Soil (including hydric) and Sediment	Table 4
Indoor Air and Ambient Air	Table 5
Groundwater	Table 6
Fish Tissue – Recreational Angler	Table 7

The following is a general description of the exposure scenarios that are included in the exposure pathway tables. These descriptions are intended to aid the RAGs user in applying the correct exposure scenario for a given site. If there is a significant exposure pathway or exposure scenario that is not covered in the RAGs, but is applicable to the site (e.g., the only exposure to site contaminants would be through eating cattle that graze extensively on plants that have taken up contaminants at the site), then the site-specific risk assessment guidance provided in Attachment B should be used to assess risk and establish clean-up goals at the site, rather than these RAGs. Likewise, if the project lead believes that any of the assumptions used in developing the RAGs is overly conservative relative to site conditions, then alternative remedial goals should be developed using procedures described in Attachment B, unless otherwise specified below. All the factors used to develop the RAGs are available in Attachment A.

7.3.1 Leaching to Groundwater Exposure Scenario

DEP has developed RAGs to prevent the migration of contaminants from soil to a groundwater aquifer, such that the resulting contaminant concentrations in groundwater would not exceed the Residential Groundwater RAGs.

Since technically all groundwater in Maine is classified as GW-A, which must be of drinking water quality, the DEP requires that whenever practical, contaminated soil and/or groundwater be remediated to meet the Residential Groundwater RAG (see Section 7.4.3). The Leaching to Groundwater RAGs in Table 4 are concentrations of contaminants in soil that when leached out are not expected to result in concentrations of the contaminant in groundwater above the Residential Groundwater RAGs. DEP has modeled dilution and attenuation of contaminants in groundwater assuming a source area 15 feet deep, and contaminants migrating to a well

50 feet away. The RSL calculators use a soil to groundwater leaching model which does not consider distance or degradation, but instead allows a single Dilution Attenuation Factor (DAF) to modify expected groundwater concentrations at an exposure point such as a drinking water supply well. Based on the modeling performed in support of earlier RAGs, DEP has selected a DAF of 55 (See Attachment A for further details) for use in calculating soil leaching to groundwater RAGs.

In situations where a drinking water source is located within 50 feet of the contaminated soil source area, or the depth to the water table or bedrock is less than 15 feet, DEP reserves the right to require that a site-specific clean-up level be developed for review and approval by the DEP. The project lead may choose to use site-specific modeling to generate site-specific soil clean-up targets that are less stringent than the soil leaching to groundwater RAGs but still will not cause the Residential Groundwater RAG to be exceeded. For more modeling details, see Attachment A. The project lead may propose other alternative approaches such as analytical procedures to using EPA's Leaching Environmental Assessment Framework (LEAF) to show that Groundwater RAGs will not be exceeded,[15] or hydrogeological studies to demonstrate that a historic spill has not contaminated groundwater at the site and is unlikely to do so in the future. Any alternative approach must be reviewed and approved by the DEP (see Section 3.1) before being implemented.

7.3.2 Residential Exposure Scenarios

Soils, indoor air, and groundwater cleaned to the RAGs for the Residential Exposure Scenario are calculated to protect all residential uses of sites, and exposures at daycares, eldercare and medical treatment facilities. When developing these RAGs, DEP and CDC assumed continuous exposure to children and adults over a 26-year period as the population passes through childhood and into adulthood. Use these scenarios for exposures of 26 years or less.

7.3.2.1 Soil

Exposures to soil by incidental ingestion, dermal contact, and inhalation of contaminants in both fugitive dust and ambient air are assumed to occur with a high frequency and high intensity when the ground is not frozen or snow covered, as children and adults play and work in a residential yard and engage in activities that disturb and displace soil (e.g., lawn mowing, gardening, and bike riding). This pathway also assumes exposure to dust stemming from dirt tracked into the house during times of the year when the ground is not frozen or snow covered. Using Maine-specific climate data, it was determined that soil is accessible 256 days per

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[15] EPA webpage, "How-To Guide for the Leaching Environmental Assessment Framework: https://www.epa.gov/hw-sw846/how-guide-leaching-environmental-assessment-framework.

year. Please see Attachment A for details of soil exposure frequency.

7.3.2.2 Indoor and Ambient Air

Exposure to indoor air contaminants occurs while breathing, or inhaling contaminants from indoor sources or from vapor intrusion sources. Vapor intrusion (VI) is the volatilization of hazardous substances from contaminated soil or groundwater into buildings. Because VI potential is dictated by numerous factors, contaminant levels in soil or groundwater are not a reliable indicator of VI potential. Therefore, DEP was not able to develop soil or groundwater guidelines that are protective of the vapor intrusion pathway.

Compare results of direct measurement of contaminants in soil vapor and indoor air to the Indoor Air RAG. Sub-slab concentrations should be multiplied by an attenuation factor of 0.03, and then compared to Table 5. For additional information on VI, see the DEP's Supplemental Guidance for Vapor Intrusion of Chlorinated Solvents and Other Persistent Chemicals.[16]

Exposure to Ambient Air occurs while breathing, or inhaling contaminants in outside air. This may be from a non-point source (e.g. off-gassing of volatiles from contaminated soil), point source (e.g. off-gasses from a groundwater treatment system) or mobile sources (e.g. on-road or off-road vehicles and equipment).

7.3.2.3 Groundwater

Exposure to contaminants in groundwater occurs by drinking (ingesting) contaminated groundwater, absorption of contaminants through skin (dermal contact) and breathing of contaminants that evaporate from the water while showering. Previous editions of the RAGs used Maine's Maximum Exposure Guidelines (MEGs), which are based on exposure to water through ingestion only, and included a Relative Source Contribution (RSC) factor to account for other routes of exposure (inhalation and dermal exposure to water) and exposure pathways (e.g. contaminants in soil and/or diet). The agencies discontinued the RSC approach with the 2018 RAG update.

When investigating contaminated groundwater, the sample plan must consider what is being ingested. When sampling monitoring wells, DEP generally recommends using filtered samples to develop exposure point concentrations. However, when assessing drinking water supply wells, DEP recommends using unfiltered sample results to develop exposure point concentrations.

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[16] Available at: http://www.maine.gov/dep/spills/publications/guidance/index.html.

7.3.3 Park User / Recreational Exposure Scenario

7.3.3.1 Soil

RAGs for the Park User Scenario are calculated to be protective of recreational activities at a park, recreational areas, or other open space. The Park User Scenario is like the Residential Scenario in that it assumes exposure to children and adults over a period of 26 years. Use this scenario for exposures of 26 years or less. However, the frequency of exposure of recreational activities at a park or other open space is reasonably anticipated to be less than that occurring in a residential yard. The RAGs assume that a Park User is exposed to soil 90 days per year (3 days per week, for 30 weeks from April through October). Soil exposure time (3 hours per day) is the mean time spent outdoors at a park/golf course for the Northeast Region as presented in Table 16-20 of the EPA Exposure Factors Handbook.[17]

Soil exposures are assumed to occur by incidental ingestion, dermal contact, and inhalation of contaminants in fugitive dust and ambient air when the ground is not frozen or snow-covered.

7.3.3.2 Sediment

The sediment pathway assumes exposure to children and adults over a 26-year period via incidental ingestion and dermal contact while wading, with increased frequency during warmer times of the year. Use this scenario for exposures of 26 years or less. The RAGs assume that a recreator is exposed to sediment 78 days per year (3 days per week, for 26 weeks from May through October). Sediment exposure time, 3.7 hours per day, is the mean time spent outdoors at a pool/river/lake for the Northeast Region as presented in Table 16-20 of the EPA Exposure Factors Handbook.[18]

Note, if the CSM suggests that contaminants are leaching from sediments to surface water in concentrations that might pose a risk, then a site-specific risk assessment should be conducted to evaluate the actual risk from surface water exposure.

7.3.4 Commercial Worker Exposure Scenarios

Note that the RAGs are superseded by any applicable OSHA standards, which are promulgated, as detailed in Section 7.3.6. Exceedance of RAGs should trigger an evaluation of whether OSHA standards apply. If OSHA

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[17] EPA Exposure Factors Handbook: 2011 Edition with chapter updates, from: https://www.epa.gov/expobox/about-exposure-factors-handbook.

[18] EPA Exposure Factors Handbook: 2011 Edition with chapter updates, from: https://www.epa.gov/expobox/about-exposure-factors-handbook.

standards are not applicable, the RAGS should be used to assess the threat posed by the contaminant.

7.3.4.1 Soil

RAGs for the Outdoor Commercial Worker Exposure Scenario are calculated to protect all indoor and outdoor commercial uses of sites, including full-time industrial and maintenance workers whose jobs require that they be outdoors for a portion of the workday such as groundskeepers, loading dock workers, parking lot attendants, and mechanics. This scenario can also be used to conservatively evaluate indoor workers who may be routinely exposed to soil briefly during work breaks and outdoor lunches. These RAGs assume exposures to soil by incidental ingestion, dermal contact, and inhalation of contaminants in fugitive dust and ambient air occur over 25 years for the workdays of the year when the ground is not frozen or snow covered. Using Maine specific climate data adjusted for the work week, the RAGs assume a soil exposure frequency of 183 days per year. Contact with soil is assumed to be of lower intensity than assumed for an excavation or construction work scenario since these workers are unlikely to be displacing soil (i.e., digging).

7.3.4.2 Indoor Air

Commercial Indoor Air RAGs are calculated to protect workers at commercial establishments who may be exposed to contaminants from vapor intrusion (VI) or indoor sources. The RAGs are based on chronic exposure default factors of 8 hours per day for 250 days per year for 25 years of exposure.

7.3.5 Excavation or Construction Worker

Note that the RAGs are superseded by any applicable OSHA standards, which are promulgated, as detailed in Section 7.3.6. Exceedance of RAGs should trigger an evaluation of whether OSHA standards apply. If OSHA standards are not applicable, the RAGs should be used to assess the threat posed by the contaminant.

7.3.5.1 Soil

RAGs for the Excavation or Construction Worker Scenario are calculated to be protective of exposures to soil during high intensity soil disturbance activities such as digging, grading, and back-filling for a construction project lasting up to one year. This scenario can be used to conservatively evaluate a utility worker or landscaper whose exposure may be as intense as an excavation or construction worker but is expected to be of a lesser duration than a year. Exposures to soil by incidental ingestion, dermal contact and inhalation of contaminants on fugitive dust and in ambient air are assumed to occur at a greater intensity than that assumed for the Outdoor Commercial Worker due to the degree of soil disturbance and displacement anticipated. Due to the exposure intensity and use of subchronic toxicity factors (see section 4.1.2), for some compounds, the Construction Worker soil guideline may be lower than the residential or leaching to groundwater guidelines.

7.3.5.2 Groundwater

Groundwater RAGs for the excavation or construction worker scenario are calculated to be protective of exposures to groundwater during high intensity groundwater disturbance activities such as digging, grading, and back-filling for a construction project lasting up to a year. This scenario can be used to conservatively evaluate a utility worker or landscaper whose exposure may be as intense as an excavation or construction worker but is expected to be of a lesser duration than one year. The RAGs assume that a construction worker is exposed to water in a trench 1 day per week for 4 hours per event. Exposures to groundwater by incidental ingestion, dermal contact and inhalation of contaminants that volatilize into ambient air were included in the RAG development.

Contaminants associated with suspended colloidal material may be ingested and would affect the receptor the same as any dissolved material. Therefore, when assessing groundwater exposure risk to construction workers, DEP recommends using unfiltered samples to determine Exposure Point Concentrations so that the samples represent total exposure rather than just exposure from the dissolved phase contamination.

7.3.6 Role of OSHA Standards for Commercial and Excavation or Construction Worker Exposure Scenarios

Commercial guidelines in this document are superseded by OSHA regulations when the exposure stems from the commercial facilities’ own operations and when the employer is required by OSHA regulations to train its employees in awareness and protection from the contaminants of concern for a given exposure pathway. OSHA standards and guidelines pertaining to air quality will need to be followed when undertaking trenching activities, when the construction/excavation worker soil RAGs are exceeded at a site. Air monitoring should be undertaken during construction activities in areas where groundwater exceeds the Construction Worker RAG levels in Table 6, and appropriate action taken when air concentrations exceed OSHA standards. When the Construction Worker Scenario for groundwater is exceeded at a site, DEP recommends that procedures be put into place to warn construction workers to follow OSHA standards, including appropriate monitoring, during construction activities.

7.3.7 Surface Water

RAGs have not been developed for surface water. Surface water exposure point concentrations should be compared to *Surface Water Quality Criteria for Toxic Pollutants*, 06-096 C.M.R. ch. 584. These rules are available at: https://www.maine.gov/sos/cec/rules/06/chaps06.htm.

7.3.8 Other Scenarios

There are other potential exposure scenarios. Generally, they will not pose a greater risk than the scenarios presented. However, under unusual circumstances the DEP may determine that other scenarios may be important or the default exposure factors may not be protective. These exposure scenarios and exposure factors should be considered on a site-specific basis using the CSM, as illustrated in Figure 1, and a site-specific risk assessment should be conducted using the protocols in the site-specific risk assessment guidance provided in Attachment B.

7.3.9 Soil Accessibility Determines Exposure

The depth to contaminated soil or a cover or barrier layer may make the soil at a site inaccessible to a person so that the exposure route is not complete. However, future site activities may disturb the soil such that formerly inaccessible deep soils are raised to the land surface, or become accessible if pavement or a building is removed. A list of DEP approved cover systems is provided below. Contaminated soil is considered inaccessible, and therefore the pathway is not complete, when the contaminated soil is either:

1. “Isolated" because it is located at a depth greater than 15 feet below the surface; for buildings having earthen floors, the floor is considered the soil surface;
2. Completely covered by intact pavement or concrete, an EMMP controls digging activities and ensures inspection and maintenance of the cover, and a DEP approved environmental covenant is recorded with the deed;
3. Covered with a high visibility geotextile fabric or plastic marker layer (e.g., orange snow fencing), then at least 6 inches of clean soil, and then at least 6 inches of loam, which supports a healthy vegetative cover; a DEP approved environmental covenant and an EMMP controls digging activities and ensures inspections and maintenance of the cover; or
4. Covered with at least 2 feet of clean fill, and a DEP approved environmental covenant and an EMMP controls digging activities and ensures inspections and maintenance of the cover.

7.3.10 Source Control RAGs at Vapor Intrusion Sites

If soil clean-up is necessary to prevent VI risk instead of diverting the vapors themselves, then the project lead must develop site-specific remediation goals in consultation with the DEP to meet the applicable indoor air targets shown in Table 5.

7.4 Exclusion of Pathways

7.4.1 General Exclusions

The DEP may approve excluding certain RAG scenarios or exposure pathways at a given site through the procedures developed by the programs identified in Section 3.1. Using those program specific procedures, the DEP will determine which exposure scenarios and/or exposure pathways are applicable to the site, based on current and future land use, environmental covenants, and other program requirements. Exposure scenarios and routes-of-exposure may be excluded if DEP determines that clean-up to a more stringent guideline is not practical and if current and all future exposures are precluded by site use restrictions meeting the standards in the *Uniform Environmental Covenants Act*, 38 M.R.S. §§ 3001-3013 (UECA). Deed restrictions and environmental covenants must be approved by the DEP. UECA templates can be found on the DEP website at: http://www.maine.gov/dep/spills/publications/guidance/index.html.

7.4.2 Use of Institutional Controls / Environmental Covenants

DEP’s primary objective is to have sites restored so that unrestricted use will not cause unacceptable risk to site users. However, this is not always practical and sometimes site use restrictions (i.e., institutional controls) are necessary to protect public health. As an example, environmental covenants can be used to prohibit drinking onsite water and residential uses, so that the remedial action goal for soil would be the lesser of the RAGs for the Park User, Outdoor Commercial Worker, and Excavation or Construction Worker Scenarios. In this example, the environmental covenant must be adequate to prevent residential exposure given the soil clean-up levels and may include such elements as preventing any future residential development, restricting soil excavation, and/or restricting groundwater withdrawal.

Covenants usually include the following minimal elements:

1. Notice provisions must provide adequate notification of the environmental covenant(s) to future owners of the property and/or operators at the site. The notice must include the condition(s) imposed by the environmental covenants and clearly define the party responsible for maintaining the environmental covenant;
2. All required oversight and maintenance of any environmental covenant must be enforceable; and

3. Environmental covenants must remain protective for the life of the selected remedy.

Environmental covenants where a single authority has control over the land use and/or groundwater are preferred.

7.4.3 Exclusion of the Residential Groundwater RAGs

Subject to applicable law, the DEP will allow exclusions of meeting the Groundwater RAGS in Table 6 and/or the Soil Leaching to Groundwater RAGs in Table 4 when the project lead demonstrates that the groundwater contamination will not have any present or future adverse impact on human health.

Specifically, exclusion of the groundwater pathway is appropriate under any of the following circumstances:

1- The site geology will prevent contaminant migration to or in groundwater;

2- The area is served by Public Water and all the following are true:

  a- No potential or existing Public or Private water supply sources are located in the contaminant source or potential groundwater plume areas;

  b- Groundwater is non-potable due to the presence of prior contamination; and

  c- Institutional Controls approved by the DEP will prevent current and future exposure to contaminated groundwater.

3- It is not technically and/or economically feasible to clean up discharges, and passive or active measures (including alternative water supplies and permanent, enforceable institutional controls) permanently mitigate or eliminate current and future exposure; or

4- There is a high probability that contaminants will degrade prior to reaching the point of exposure, and a funded contingency plan is in place to remediate the site if area conditions change, or new information suggests an imminent exposure potential.

The following are examples of situations where the DEP is not likely to approve exclusion of the groundwater pathway:

1. Environmental Covenants do not prevent exposure to the contaminated groundwater;
2. There is off-site migration of contamination and area residences or businesses utilize the surrounding aquifer;
3. The area of the contaminant source and potential groundwater contamination plume is not served by Public Water;

4. The area of the contaminant source and potential groundwater contamination plume is over or up gradient of a mapped sand and gravel aquifer or high yield bedrock aquifer or a recharge zone;
5. The area of the contaminant source and potential groundwater contamination plume is within a wellhead or source protection area;
6. The discharge of contaminated groundwater to the ground surface or surface water causes a violation of surface water quality standards or otherwise adversely impacts human health or ecological resources;
7. The area of the contaminant source and potential groundwater contamination plume is within a sole source aquifer; or
8. The contamination plume is expanding, not under control, and migrating from the source area.

7.5 Additional Instructions for Select Contaminant Groups

7.5.1 Isomers of xylene, 1,2 dichloroethylene and 1,3-dichloropropane

The following parameters should be addressed as follows:

- Compare the sum of all xylene isomers to the total xylenes RAG.
- Compare 1,2-dichloroethylene results to the cis-1,2-dichloroethylene RAG.
- Compare the trans 1,3-dichloropropane to the 1,3-dichloropropane RAG.

7.5.2 Pesticide Classes

DDT, Endosulfan, Chlordane and Endrin are totaled for each pesticide class and compared to the parent compound’s RAG, as follows:

- Total DDT. The terms “DDT”, “DDE”, and “DDD” are used to refer to the sum of isomer concentrations of p,p'-DDT and o,p'-DDT, p,p'-DDE and o,p'-DDE, and p,p'-DDD and o,p'-DDD, respectively. “DDTs” refers to any or all of the six compounds identified above, as well as the metabolites and degradation products of these six compounds. “Total DDT” refers to the sum of the concentrations of p,p'-DDT, o,p'-DDT, p,p'-DDE, o,p'-DDE, p,p'-DDD, and o,p'-DDD.
- Total Endosulfan is the sum of α- and β-isomers, endosulfan diol, endosulfan ether, endosulfan sulfate, and endosulfan lactone.
- Total Chlordane is the sum of cis and trans-chlordane, heptachlor, heptachlor epoxide, oxychlordane and cis-nonachlor, trans-nonachlor.

- Total Endrin is the sum of endrin, endrin aldehyde, endrin ketone, heptachlorobicycloheptene, hexachloronorbornadiene, and isodrin.

7.5.3 Dioxins and Co-Planar PCBs

The number and position of chlorines on the dioxin, furan and PCB molecule dictate its toxicity. Dioxins and furans occur as a mixture of congeners, as do PCBs. To address the additive effect of the toxicity of the mixture, the risk from dioxin is calculated on a toxicity equivalency (TEQ) basis. Co-planar PCBs have dioxin-like impacts. The RAGs are based on the TEQ for dioxin and these dioxin-like compounds. To calculate the TEQ of dioxin and co-planar PCBs use the following EPA guidance:[19]

> In order to calculate a TEQ, a toxic equivalent factor (TEF) is assigned to each member of the dioxin and dioxin-like compounds category. The TEF is the ratio of the toxicity of one of the compounds in this category to the toxicity of the two most toxic compounds in the category, which are each assigned a TEF of 1: 2,3,7,8-tetrachlorodibenzo-p-dioxin ([2,3,7,8-TCDD]) and 1,2,3,7,8-pentachlorodibenzo-p-dioxin. TEFs that have been established through international agreements currently range from 1 to 0.0001.
>
> A TEQ is calculated by multiplying the [measured concentration in a given environmental media] of each dioxin and dioxin-like compound by its corresponding TEF (e.g., 10 [pico]grams X 0.1 TEF = 1 [pico]gram TEQ) and then summing the results. The number that results from this calculation is referred to as the TEQ. [This TEQ is then compared directly to the applicable 2,3,7,8-TCDD RAGs.]
>
> For example, consider the following 60 mg/kg mixture:
> 10 mg/kg of compound A, with a TEF of 1
> 20 mg/kg of compound B, with a TEF of 0.5
> 30 mg/kg of compound C, with a TEF of 0.2
>
> The TEQ of this mixture would be:
> (10 mg/kg x 1) + (20 mg/kg x 0.5) + (30 mg/kg x 0.2) = 26 mg/kg TEQ.
>
> In other words, this mixture of 60 mg/kg of various compounds would be as toxic as 26 mg/kg of [2,3,7,8-TCDD].

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[19] EPA Website, "Toxics Release Inventory (TRI) Program, Dioxin and Dioxin-Like Compounds Toxic Equivalency Information, How TEQs Are Calculated" from: https://www.epa.gov/toxics-release-inventory-tri-program/dioxin-and-dioxin-compounds-toxic-equivalency-information#:~:text=A%20TEQ%20is%20calculated%20by,and%20then%20summing%20the%20results.&text=In%20other%20words%2C%20this%20mixture,the%20two%20most%20toxic%20compounds.)

In cases where the analytical lab has reported two or more dioxin-like-compounds with a single concentration, due to compounds coeluting, the higher, or more stringent corresponding TEF should be applied to the reported concentration for calculation of the TEQ.

The TEFs to use in this calculation are shown in Table 3.

Table 3: Recommended toxicity equivalence factors (TEFs) for human health risk assessment of polychlorinated dibenzo-p-dioxins, dibenzofurans, and dioxin-like polychlorinated biphenyls[20]

Compound	TEF
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003
3,3',4,4'-TCB (77)	0.0001
3,4,4',5-TCB (81)	0.0003
3,3',4,4',5-PeCB (126)	0.1
3,3',4,4',5,5'-HxCB (169)	0.03
2,3,3',4,4'-PeCB (105)	0.00003
2,3,4,4',5-PeCB (114)	0.00003
2,3',4,4',5-PeCB (118)	0.00003
2',3,4,4',5-PeCB (123)	0.00003
2,3,3',4,4', 5 -HXCB (156)	0.00003
2,3,3',4,4',5'-HxCB (157)	0.00003

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[20] From: USEPA, Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds (EPA/100/R-10/005 from: https://www.epa.gov/sites/production/files/2013-09/documents/tefs-for-dioxin-epa-00-r-10-005-final.pdf).

Compound	TEF
2,3',4,4',5,5'-HxCB (167)	0.00003
2,3,3',4,4',5,5'-HpCB (189)	0.00003
The numbers in parentheses following each PCB are the PCB congener numbers.	

7.5.4 Per- and Polyfluoroalkyl Substances (PFAS)

7.5.4.1 Incorporate Additional PFAS Guidance

Development of RAGs for per- and polyfluoroalkyl substances (PFAS) is difficult due to the rapidly advancing science and evolving toxicity information. Currently the EPA CompTox Chemicals Dashboard lists over 10,000 PFAS but has default toxicity values in its EPA RSL calculator for only eight (8) of them: PFOA, PFOS, PFNA, PFHxA, PFHxS, PFBA, PFBS and HFPO-DA. Due to the lack of toxicity values for other PFAS in the EPA RSL calculator, RAGs for PFAS are limited to the eight PFAS listed above. EPA is developing toxicity values for additional PFAS and may include these in ongoing updates to the RSL.[21] Any reference to an individual PFAS, in this document, is intended to include the PFAS and its anions and salts.

Given the evolving science for PFAS investigation, risk assessment, and remediation, PFAS risk should be addressed as follows:

1. Compare Exposure Point Concentrations to the limited RAG values, published in the RAG tables (groundwater, soil/sediment and fish tissue);
2. Then compare all PFAS EPCs to the “Maine PFAS Screening Levels” at: https://www1.maine.gov/dep/spills/topics/pfas/index.html. In cases involving agricultural farmland or future use as farmland, compare EPCs to the Crop-Specific Soil Screening Levels. If there has been an update to any guidelines at this location, use those guidelines instead of the RAGs; and
3. DEP will determine remedial action for PFAS compounds for which there are no DEP published guidelines on a case-by-case basis.

7.5.4.2 PFAS Residential Groundwater Guidance

On June 21, 2021, Maine adopted an Interim Drinking Water Standard of 20 ng/L for the sum of 6 PFAS compounds - perfluorooctanoic acid

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[21] https://www.epa.gov/iris/iris-recent-additions

(PFOA), perfluorooctane sulfonic acid (PFOS), perfluoroheptanoic acid (PFHpA), perfluorohexane sulfonic acid (PFHxS), perfluorononanoic acid (PFNA), and perfluorodecanoic acid (PFDA).[22] These PFAS, including their anions and salts, are referred to as the "Maine Regulated PFAS Contaminants." This standard for the Maine Regulated PFAS Contaminants should be used when assessing the residential groundwater exposure pathway.

These RAGs include individual Residential Groundwater guidelines for PFOA, PFOS, PFHxS, and PFNA; however, there is not currently available toxicity information for establishing individual RAGs for PFHpA or PFDA. These RAGs also include groundwater guidelines for four PFAS not included in the Maine Regulated PFAS Contaminants: perfluorobutanoic acid (PFBA), perfluorobutane sulfonic acid (PFBS), perfluorohexanoic acid (PFHxA), and hexafluoropropylene oxide dimer acid (HFPO-DA, commonly known as GenX Chemicals).

Additionally on March 14, 2023, EPA announced the proposed National Primary Drinking Water Regulation (NPDWR) to establish legally enforceable levels, called Maximum Contaminant Levels (MCLs), for six PFAS in drinking water, including PFOA, PFOS, PFNA, PFHxS, HFPO-DA, and PFBS. As of the date of this document, these proposed MCLs are for PFOA and PFOS as individual contaminants, and PFHxS, PFNA, PFBS, and HFPO-DA as a PFAS mixture and are anticipated to be finalized by the end of 2023. The proposed MCLS are:

PFOA: 4.0 ng/L
PFOS: 4.0 ng/L
PFNA, PFHxS, PFBS, HFPO-DA: Hazard Index of 1.0 (unitless)

Until EPA finalizes these MCLs, or until the Maine State Legislature adopts these or other standards, the Maine PFAS Interim Drinking Water Standard should be used when assessing risk from PFAS contamination in drinking water and residential groundwater receptors.

EPA maintains a current list of PFAS in its CompTox database, along with known and estimated physical, chemical, and toxicological properties. [23]

7.5.4.3 PFAS Soil Guidance

Preliminary site investigations in Maine suggest that soil screening levels based on direct soil contact may be inadequate to protect individuals from exposure through cow's milk at farms where PFOS is present in the soil.

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[22] Resolve, To Protect Consumers of Public Drinking Water by Establishing Maximum Contaminant Levels for Certain Substances and Contaminants, Downloaded December 8, 2022 from: http://www.mainelegislature.org/legis/bills/getPDF.asp?paper=SP0064&item=3&snum=130

[23] Note, see EPA's CompTox database for the current list of PFAS compounds at: https://comptox.epa.gov/dashboard/chemical_lists/.

That is, PFAS are an unusual case where, rather than direct soil contact by a child, risk is driven by a soil-to-fodder, fodder-to-cow's milk, and milk-to-human exposure pathway. Therefore, at PFAS sites where soil leaching to groundwater RAGs are not applied (e.g. public water is available and land use controls prohibit groundwater extraction), the agricultural exposure pathway must be assessed, in addition to direct contact scenarios.

The Soil Leaching to Groundwater guidelines in this document, for PFOA, PFOS, PFHxS, and PFNA are based on a residential groundwater receptor exposure concentration of 20 ng/L, in accordance with the Maine PFAS Interim Drinking Water Standard.

7.6 Technical Impracticability Waivers

DEP's goal is to restore contaminated aquifers to drinking water quality whenever possible, and to prevent the spread of further contamination in aquifers. However, in some instances, it is not economically feasible using current technology to restore aquifers to the Groundwater RAGs found in Table 6. The DEP will make remediation decisions that encourage the development of new remediation technologies, but also recognizes the need to use limited funds wisely. Consistent with EPA's Technical Impracticability (TI) Waiver policies,[24] before issuing a TI Waiver DEP will first ensure that the following baseline actions are complete:

1. Source control has been completed. That is, localized high concentrations of contaminants in soil and/or groundwater have been treated to levels that will significantly reduce a continuing pollutant load to the aquifer; and
2. Current and future users of the aquifer are not at risk. This may require: an understanding of whether contamination is still spreading in the aquifer, providing alternative water supplies, provisions to mitigate VI risks, and in some cases operation of active plume containment systems to prevent the spread of contamination. Environmental covenants may be used to help prevent exposure, but alone do not justify a TI waiver.

In addition to the completion of baseline actions, the factors that DEP will consider before granting a TI waiver are:

1- The results of a focused feasibility study of potential treatment options, including cost and the chances of further significant reductions in contamination or of attaining the RAGs levels; and

2- The resource and people at risk.

DEP has concurred with formal TI waivers at the following sites:

- Two sites at the former Loring Air Force Base in Limestone;

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[24] USEPA OSWER Directive 9283.1-33, "Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration from: http://www.epa.gov/superfund/contaminant-media-and-site-type-specific-consultation-directives.

- The F. O'Connor Superfund site in Augusta;
- The McKin Superfund site in Gray; and
- The Hows Corner Superfund site in Plymouth.

At TI waiver sites, DEP usually requires a Technology review every 5 years to determine if a new technology is now feasible to remediate contaminated groundwater.

7.7 Variances from Default Exposure Factors

The RAGs were derived using average and conservative default exposure factors in accordance with Superfund Risk Assessment Guidance and the RSL calculator. Not all potential pathways were considered (e.g. gardening pathway) and for some contaminants certain routes of exposure could not be quantified (e.g. dermal contact). To employ less conservative exposure assumptions, the site must be adequately characterized, and a full risk assessment conducted using the procedures in the site-specific risk assessment guidance provided in Attachment B.

The default exposure factors that were used to establish the RAGs are available in Attachment A. In general, the Agencies used the EPA default exposure factors in the RSL calculator. However, some region-specific exposure factors were selected, particularly related to weather, that are more appropriate for Maine. Attachment A details the exposure factors used and the rationale for their use.

7.8 Other Applicable, or Relevant and Appropriate Requirements

As discussed in Section 3.1, some of the DEP programs implementing the RAGs will have promulgated standards or other guidance that may dictate more stringent clean-up goals than the risk-based guidelines established in this document. For instance, under Superfund, promulgated standards such as Maximum Contaminant Levels will become the point-of-departure for establishing remedial goals for groundwater at a site, and RAGs along with other guidance such as Drinking Water Health Advisories (HAs) must be considered. Additionally, the intended future use of the site may also dictate other clean-up goals than those in this document. For example, if the site goal is to remediate groundwater for use as a public water supply, then the Department of Health and Human Services (DHHS) Drinking Water Program will need to be involved in establishing remedial goals. In addition to meeting RAGs, the groundwater will likely need to meet MCLs and HAs.

A good way to determine if the chemical(s) detected at a given site may be subject to other standards is to access EPA's CompTox Database and use the list look-up tool. In that database you can also select a list of interest when using the Chemical Batch look-up tool.

8 Technical Help & Technical Basis of the RAGs

8.1 Technical Assistance

For Technical Assistance, contact your DEP project manager, the DEP program reviewing your proposal (see Section 3), or the Division of Remediation at 207-287-7688.

8.2 References to Technical Basis

The RAGs were derived based on the protocols in the Technical Support Document for the 2023 Remedial Action Guidelines provided in Attachment A. Attachment A provides additional information on the calculation methods, factors, assumptions, and data that were used to develop the RAG values.

9 RAGs Tables

NOTE: Microsoft Excel™ versions of Tables 4-8 can be found on the DEP website at: http://www.maine.gov/dep/spills/publications/guidance/index.html

Table 4: Maine Remedial Action Guidelines for the Soil Exposure Pathway, by Exposure Scenario

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	Chemical	Chemical Class	Leaching to Groundwater	Resident	Commercial Worker	Park User	Recreator Sediment	Construction Worker	Undeveloped	Rural Developed	Urban Developed	Urban Fill
83-32-9	Acenaphthene	SVOC	300	4,900	62,000	14,000	16,000	48,000		0.22	0.21	0.29
208-96-8	Acenaphthylene	SVOC	290	4,900	45,000	14,000	16,000	48,000		1.9	2	0.49
67-64-1	Acetone	VOC	200	96,000	100,000	100,000	100,000	100,000				
75-05-8	Acetonitrile	VOC	1.4	1,200	5,100	28,000	100,000	4,600				
98-86-2	Acetophenone	SVOC	32	11,000	100,000	30,000	35,000	100,000				
107-02-8	Acrolein	VOC	0.00046	0.21	0.90	4.7	180	0.58				
107-13-1	Acrylonitrile	VOC	0.0063	3.7	17	34	58	14				
15972-60-8	Alachlor	PESTICIDE	0.48	130	560	380	440	2,600				
309-00-2	Aldrin	SVOC	0.083	0.54	2.5	1.6	1.8	14				
107-05-1	Allyl Chloride	VOC	0.037	2.5	10	56	1,500	14				
7429-90-5	Aluminum	METAL	100,000	100,000	100,000	100,000	100,000	27,000				
62-53-3	Aniline	SVOC	2.5	610	5,500	1,700	2,000	1,700				
120-12-7	Anthracene	SVOC	3,200	25,000	100,000	70,000	81,000	100,000		2.3	2.2	3.7
7440-36-0	Antimony (metallic)	METAL	19	43	640	120	140	130				
12674-11-2	Aroclor 1016	PCB	7.4	5.6	70	16	18	16				

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	Chemical	Chemical Class	Leaching to Groundwater	Resident	Commercial Worker	Park User	Recreator Sediment	Construction Worker	Undeveloped	Rural Developed	Urban Developed	Urban Fill
7440-38-2	Arsenic, Inorganic	METAL	0.83	9.3	41	26	30	54	28			
1912-24-9	Atrazine	SVOC	0.11	32	140	92	110	770				
7440-39-3	Barium	METAL	8,600	21,000	100,000	61,000	70,000	20,000	79			
100-52-7	Benzaldehyde	SVOC	2.3	2,400	11,000	6,800	7,800	62,000				
71-43-2	Benzene	VOC	0.13	17	75	230	570	240				
56-55-3	Benzo(a)anthracene	SVOC	5.8	16	280	45	52	1,700		17	4.6	16
50-32-8	Benzo(a)pyrene	SVOC	16	1.6	29	4.5	5.2	9.9		5.4	4.6	16
205-99-2	Benzo(b)fluoranthene	SVOC	170	16	290	45	52	1,700		6.9	19	34
191-24-2	Benzo(g,h,i)perylene	SVOC	100,000	2,500	23,000	7,000	8,100	72,000		3	8.2	6
207-08-9	Benzo(k)fluoranthene	SVOC	1,600	160	2,900	450	520	17,000		3.6	6.6	14
65-85-0	Benzoic Acid	SVOC	830	100,000	100,000	100,000	100,000	11,000				
100-51-6	Benzyl Alcohol	SVOC	26	8,600	100,000	25,000	28,000	77,000				
100-44-7	Benzyl Chloride	VOC	0.054	16	70	120	180	81				
7440-41-7	Beryllium and compounds	METAL	1,100	210	3,200	610	700	110				
92-52-4	Biphenyl, 1,1'-	SVOC	0.48	71	300	1,600	3,900	400				
111-44-4	Bis(2-chloroethyl)ether	SVOC	0.002	3.3	15	21	28	62				
117-81-7	Bis(2-ethylhexyl)phthalate	SVOC	730	530	2,200	1,500	1,700	26				
7440-42-8	Boron And Borates Only	METAL	700	21,000	100,000	61,000	70,000	43,000				
108-86-1	Bromobenzene	VOC	2.3	380	650	530	2,800	620				
74-97-5	Bromochloromethane	VOC	1.1	220	940	4,000	100,000	330				
75-27-4	Bromodichloromethane	VOC	0.02	4.4	19	83	500	70				
75-25-2	Bromoform	VOC	0.48	280	790	720	4,000	890				
74-83-9	Bromomethane	VOC	0.11	10	45	160	490	120				

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	Chemical	Chemical Class	Leaching to Groundwater	Resident	Commercial Worker	Park User	Recreator Sediment	Construction Worker	Undeveloped	Rural Developed	Urban Developed	Urban Fill
106-94-5	Bromopropane, 1-	VOC	0.26	24	110	550	100,000	390				
106-99-0	Butadiene, 1,3-	VOC	0.021	1.1	4.9	17	52	1.6				
75-65-0	Butyl Alcohol, tert-	ALCOHOL	17	19,000	89,000	54,000	62,000	67,000				
85-68-7	Butyl Benzyl Phthalate	SVOC	130	3,900	17,000	11,000	13,000	99,000				
104-51-8	Butylbenzene, n-	VOC	180	5,400	80,000	15,000	18,000	34,000				
135-98-8	Butylbenzene, sec-	VOC	320	11,000	100,000	30,000	35,000	34,000				
98-06-6	Butylbenzene, tert-	VOC	86	11,000	100,000	30,000	35,000	34,000				
DEP2041	C11-C22 Aromatics	FUEL	340	2,600	33,000	7,300	8,400	74,000				
DEP2042	C19-C36 Aliphatics	FUEL	NC	100,000	100,000	100,000	100,000	1,200,000				
DEP2038	C5-C8 Aliphatics	FUEL	92	1,700	11,000	7,500	9,500	430				
DEP2040	C9-C10 Aromatics	FUEL	15	660	3,500	4,700	7,000	2,600				
DEP2039	C9-C12 Aliphatics	FUEL	5,800	2,500	14,000	17,000	24,000	2,300				
DEP2043	C9-C18 Aliphatics	FUEL	26,000	2,500	14,000	17,000	24,000	4,800				
7440-43-9	Cadmium (Diet)	METAL	7.6	9.8	140	28	32	42	0.62			
86-74-8	Carbazole	SVOC	15	270	110	750	870	6,700				
75-15-0	Carbon Disulfide	VOC	13	690	740	720	35,000	720				
56-23-5	Carbon Tetrachloride	VOC	0.097	9.7	43	150	450	160				
12789-03-6	Chlordane	PESTICIDE	1.5	24	110	69	80	100				
115-28-6	Chlorendic acid	SVOC	15	0.81	35	230	270	2,000				
75-68-3	Chloro-1,1-difluoroethane, 1-	VOC	2,900	1,200	1,200	1,200	100,000	1,200				
106-47-8	Chloroaniline, p-	SVOC	0.086	37	160	110	120	130				
108-90-7	Chlorobenzene	VOC	2.9	410	740	680	7,000	740				
67-66-3	Chloroform	VOC	0.034	4.7	21	97	1,000	75				

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	Chemical	Chemical Class	Leaching to Groundwater	Resident	Commercial Worker	Park User	Recreator Sediment	Construction Worker	Undeveloped	Rural Developed	Urban Developed	Urban Fill
74-87-3	Chloromethane	VOC	2.7	160	690	1,300	100,000	1,300				
91-58-7	Chloronaphthalene, Beta-	SVOC	210	6,500	82,000	19,000	22,000	48,000				
95-57-8	Chlorophenol, 2-	SVOC	4.9	540	8,000	1,500	1,800	2,700				
76-06-2	Chloropicrin	VOC	0.014	2.9	12	66	100,000	1.7				
95-49-8	Chlorotoluene, o-	VOC	13	2,100	32,000	6,100	7,000	800				
106-43-4	Chlorotoluene, p-	VOC	13	2,100	32,000	6,100	7,000	68,000				
16065-83-1	Chromium(III), Insoluble Salts	METAL	100,000	100,000	100,000	100,000	100,000	27,000				
18540-29-9	Chromium(VI)	INORGANIC	0.37	4.2	89	12	14	46				
218-01-9	Chrysene	SVOC	5,000	1,600	29,000	4,500	5,200	100,000		32	13	21
7440-48-4	Cobalt	METAL	15	32	480	91	110	100	12			
7440-50-8	Copper	METAL	1,600	4,300	64,000	12,000	14,000	14,000	23			
108-39-4	Cresol, m-	SVOC	41	4,300	56,000	12,000	14,000	100,000				
95-48-7	Cresol, o-	SVOC	41	4,300	56,000	12,000	14,000	51,000				
106-44-5	Cresol, p-	SVOC	16	1,700	22,000	4,900	5,700	5,100				
59-50-7	Cresol, p-chloro-m-	SVOC	94	8,600	100,000	25,000	28,000	26,000				
98-82-8	Cumene	VOC	41	260	270	270	35,000	270				
57-12-5	Cyanide (CN-)	INORGANIC	0.81	33	220	160	210	38				
110-82-7	Cyclohexane	VOC	720	120	120	120	100,000	120				
75-99-0	Dalapon	HERBICIDE	6.8	2,600	34,000	7,400	8,500	7,700				
72-54-8	DDD, p,p`- (DDD)	PESTICIDE	4.1	31	130	88	100	130				
72-55-9	DDE, p,p'-	PESTICIDE	6.0	27	130	79	92	100				
50-29-3	DDT	PESTICIDE	43	26	120	73	85	160				
124-18-5	Decane	VOC	NC	NC	NC	NC	NC	100,000				

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	**Chemical**	**Chemical Class**	**Leaching to Groundwater**	**Resident**	**Commercial Worker**	**Park User**	**Recreator Sediment**	**Construction Worker**	**Undeveloped**	**Rural Developed**	**Urban Developed**	**Urban Fill**
53-70-3	Dibenz(a,h)anthracene	SVOC	53	1.6	29	4.5	5.2	170		0.73	1.4	0.46
132-64-9	Dibenzofuran	SVOC	8.0	110	1,600	300	350	1,400				
96-12-8	Dibromo-3-chloropropane, 1,2-	PESTICIDE	0.000079	0.078	1.0	1.5	8.6	3.5				
124-48-1	Dibromochloromethane	VOC	0.13	110	530	320	370	3,000				
106-93-4	Dibromoethane, 1,2-	VOC	0.0012	0.54	2.4	6.8	16	8.9				
74-95-3	Dibromomethane (Methylene Bromide)	VOC	0.11	35	150	800	100,000	190				
84-74-2	Dibutyl Phthalate	SVOC	130	8,600	100,000	25,000	28,000	100,000				
110-57-6	Dichloro-2-butene, trans-1,4-	VOC	0.00034	0.11	0.48	2.5	100,000	1.8				
95-50-1	Dichlorobenzene, 1,2-	SVOC	16	360	380	370	32,000	380				
541-73-1	Dichlorobenzene, 1,3-	SVOC	16	290	300	290	32,000	280				
106-46-7	Dichlorobenzene, 1,4-	VOC	0.25	39	170	770	5,800	620				
91-94-1	Dichlorobenzidine, 3,3'-	SVOC	0.45	17	70	47	54	400				
75-71-8	Dichlorodifluoromethane	VOC	17	130	550	830	70,000	730				
107-06-2	Dichloroethane, 1,2-	VOC	0.027	6.9	30	110	340	110				
75-34-3	Dichloroethane,1,1-	VOC	0.43	53	230	980	5,500	850				
75-35-4	Dichloroethylene, 1,1-	VOC	5.6	340	1,200	1,100	18,000	4.2				
156-59-2	Dichloroethylene, 1,2-cis-	VOC	0.41	90	540	480	700	800				
156-60-5	Dichloroethylene, 1,2-trans-	VOC	1.2	100	450	1,400	7,000	1,200				
120-83-2	Dichlorophenol, 2,4-	SVOC	1.2	260	3,400	740	850	5,100				
78-87-5	Dichloropropane, 1,2-	VOC	0.15	23	99	420	840	32				
142-28-9	Dichloropropane, 1,3-	VOC	7.1	2,100	32,000	6,100	7,000	68,000				
542-75-6	Dichloropropene, 1,3-	VOC	0.093	27	120	210	310	120				

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	Chemical	Chemical Class	Leaching to Groundwater	Resident	Commercial Worker	Park User	Recreator Sediment	Construction Worker	Undeveloped	Rural Developed	Urban Developed	Urban Fill
60-57-1	Dieldrin	PESTICIDE	0.039	0.46	2.0	1.3	1.5	12				
84-66-2	Diethyl Phthalate	SVOC	330	69,000	100,000	100,000	100,000	100,000				
108-20-3	Diisopropyl Ether	VOC	21	2,300	2,300	2,300	100,000	2,000				
105-67-9	Dimethylphenol, 2,4-	SVOC	23	1,700	22,000	4,900	5,700	13,000				
576-26-1	Dimethylphenol, 2,6-	SVOC	0.70	52	670	150	170	1,500				
528-29-0	Dinitrobenzene, 1,2-	SVOC	0.098	8.6	110	25	28	260				
99-65-0	Dinitrobenzene, 1,3-	SVOC	0.097	8.6	110	25	28	130				
100-25-4	Dinitrobenzene, 1,4-	SVOC	0.097	8.6	110	25	28	260				
51-28-5	Dinitrophenol, 2,4-	SVOC	2.4	170	2,200	490	570	5,100				
121-14-2	Dinitrotoluene, 2,4-	SVOC	0.18	24	100	68	78	600				
606-20-2	Dinitrotoluene, 2,6-	SVOC	0.037	5.0	21	14	16	130				
88-85-7	Dinoseb	PESTICIDE	7.1	86	1,100	250	280	260				
123-91-1	Dioxane, 1,4-	SVOC	0.052	74	340	260	310	1,700				
115-29-7	Endosulfan	PESTICIDE	76	640	9,600	1,800	2,100	1,700				
72-20-8	Endrin	PESTICIDE	5.1	26	340	74	85	150				
75-00-3	Ethyl Chloride	VOC	130	2,100	2,100	2,100	100,000	2,000				
60-29-7	Ethyl Ether	VOC	48	21,000	100,000	61,000	70,000	8,100				
97-63-2	Ethyl Methacrylate	VOC	8.1	1,100	1,100	1,100	100,000	830				
637-92-3	Ethyl Tertiary Butyl Ether (ETBE)	VOC	9.6	1,900	2,900	2,800	100,000	2,900				
100-41-4	Ethylbenzene	VOC	0.9	86	380	400	2,800	470				
107-21-1	Ethylene Glycol	VOC	180	69,000	100,000	100,000	100,000	100,000				
111-76-2	Ethylene Glycol Monobutyl Ether	VOC	22	8,600	100,000	25,000	28,000	18,000				
206-44-0	Fluoranthene	SVOC	4,900	3,300	41,000	9,300	11,000	24,000		59	22	30

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	**Chemical**	**Chemical Class**	**Leaching to Groundwater**	**Resident**	**Commercial Worker**	**Park User**	**Recreator Sediment**	**Construction Worker**	**Undeveloped**	**Rural Developed**	**Urban Developed**	**Urban Fill**
86-73-7	Fluorene	SVOC	300	3,300	41,000	9,300	11,000	96,000		0.67	0.47	0.64
16984-48-8	Fluoride	ANION	6,600	4,300	64,000	12,000	14,000	12,000				
50-00-0	Formaldehyde	VOC	0.043	160	720	1,100	1,500	2,500				
76-44-8	Heptachlor	PESTICIDE	0.063	1.9	8.7	5.9	6.9	34				
1024-57-3	Heptachlor Epoxide	PESTICIDE	0.016	1.0	4.5	2.9	3.4	4.4				
118-74-1	Hexachlorobenzene	SVOC	0.068	1.1	14	3.0	3.5	3.4				
87-68-3	Hexachlorobutadiene	SVOC	0.15	15	16	16	350	17				
319-84-6	Hexachlorocyclohexane, Alpha-	PESTICIDE	0.023	1.2	5.0	3.4	3.9	29				
319-85-7	Hexachlorocyclohexane, Beta-	PESTICIDE	0.081	4.1	17	12	14	100				
58-89-9	Hexachlorocyclohexane, Gamma- (Lindane)	PESTICIDE	0.13	7.8	35	22	26	200				
67-72-1	Hexachloroethane	SVOC	0.11	27	120	210	250	450				
13252-13-6	Hexafluoropropylene oxide dimer acid (HFPO-DA)	PFAS	0.00081	0.32	4.8	0.9	1.1	10				
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	WMD	0.20	110	530	320	370	3,000				
110-54-3	Hexane, N-	VOC	570	140	140	140	100,000	140				
591-78-6	Hexanone, 2-	VOC	0.48	290	2,000	1,000	1,800	300				
193-39-5	Indeno(1,2,3)pyrene	SVOC	540	16	290	45	52	1,700		7.3	9.4	9.7
7439-89-6	Iron	METAL	19,000	75,000	100,000	100,000	100,000	100,000				
78-59-1	Isophorone	SVOC	14	7,800	33,000	22,000	26,000	100,000				
67-63-0	Isopropanol	ALCOHOL	4.6	8,300	36,000	93,000	100,000	94,000				
7439-92-1	Lead	METAL	50	200	440	420	420	460	52			
121-75-5	Malathion	PESTICIDE	5.6	1,700	22,000	4,900	5,700	4,900				

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	Chemical	Chemical Class	Leaching to Groundwater	Resident	Commercial Worker	Park User	Recreator Sediment	Construction Worker	Undeveloped	Rural Developed	Urban Developed	Urban Fill
7439-96-5	Manganese (Non-diet)	METAL	1,600	2,600	38,000	7,300	8,400	280	770			
94-74-6	MCPA	HERBICIDE	0.11	43	560	120	140	130				
93-65-2	MCPP	HERBICIDE	0.26	86	1,100	250	280	2,600				
7487-94-7	Mercuric Chloride	METAL	NC	32	480	91	110	640				
7439-97-6	Mercury (elemental)	METAL	1.8	3.1	3.1	3.1	100,000	3.1				
72-43-5	Methoxychlor	PESTICIDE	110	430	5,600	1,200	1,400	1,300				
79-20-9	Methyl Acetate	VOC	230	100,000	100,000	100,000	100,000	740				
78-93-3	Methyl Ethyl Ketone (2-Butanone)	VOC	64	20,000	28,000	25,000	100,000	11,000				
108-10-1	Methyl Isobutyl Ketone (4-methyl-2-pentanone)	VOC	78	3,400	3,400	3,400	100,000	3,300				
22967-92-6	Methyl Mercury	METAL	770	11	160	30	35	34				
80-62-6	Methyl Methacrylate	VOC	17	2,300	2,400	2,400	100,000	2,200				
1634-04-4	Methyl tert-Butyl Ether (MTBE)	VOC	1.8	690	3,000	5,600	17,000	8,300				
88-19-7	Methylbenzene sulfonamide, 2-	SVOC	2.3	3,500	33,000	9,800	11,000	10,000				
70-55-3	Methylbenzene sulfonamide, 4-	SVOC	41	9,900	94,000	28,000	32,000	29,000				
75-09-2	Methylene Chloride	VOC	1.5	490	2,500	1,200	2,100	1,900				
90-12-0	Methylnaphthalene, 1-	SVOC	3.3	240	990	680	790	6,000				
91-57-6	Methylnaphthalene, 2-	SVOC	10	330	4,100	930	1,100	960		0.15	0.9	0.08
7439-98-7	Molybdenum	METAL	110	540	8,000	1,500	1,800	7,400	1.3			
91-20-3	Naphthalene	SVOC	0.21	29	120	150	190	130		5	2.9	0.2
7440-02-0	Nickel Soluble Salts	METAL	1,400	2,100	32,000	6,100	7,000	990	35			
14797-55-8	Nitrate	NUTRIENT	NC	100,000	100,000	100,000	100,000	100,000				
100-01-6	Nitroaniline, 4-	SVOC	0.87	350	1,600	980	1,100	2,500				

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	Chemical	Chemical Class	Leaching to Groundwater	Resident	Commercial Worker	Park User	Recreator Sediment	Construction Worker	Undeveloped	Rural Developed	Urban Developed	Urban Fill
55-63-0	Nitroglycerin	WMD	0.047	8.6	110	25	28	26				
86-30-6	Nitrosodiphenylamine, N-	SVOC	37	1,500	6,400	4,300	5,000	37,000				
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	WMD	70	5,300	78,000	15,000	17,000	17,000				
117-84-0	Octyl Phthalate, di-N-	SVOC	3,100	860	11,000	2,500	2,800	26,000				
56-38-2	Parathion	PESTICIDE	24	520	6,700	1,500	1,700	110				
608-93-5	Pentachlorobenzene	SVOC	1.3	86	1,300	240	280	2,700				
87-86-5	Pentachlorophenol	HERBICIDE	0.031	14	54	40	46	340				
78-11-5	Pentaerythritol tetranitrate (PETN)	WMD	14	780	7,300	2,200	2,600	2,300				
14797-73-0	Perchlorate and Perchlorate Salts	INORGANIC	NC	75	1,100	210	250	240				
375-73-5	Perfluorobutane sulfonic acid (PFBS)	PFAS	0.11	26	340	74	85	230				
375-22-4	Perfluorobutanoic acid (PFBA)	PFAS	0.36	110	1,600	300	350	2,000		0.00043		
355-46-4	Perfluorohexanesulfonic acid (PFHxS)	PFAS	0.00047	1.7	22	4.9	5.7	5.1				
307-24-4	Perfluorohexanoic acid (PFHxA)	PFAS	0.13	43	560	120	140	130		0.0015		
375-95-1	Perfluorononanoic acid (PFNA)	PFAS	0.0046	0.26	3.4	0.74	0.85	0.77		0.0019		
1763-23-1	Perfluorooctane sulfonic acid (PFOS)	PFAS	0.001	0.17	2.2	0.49	0.57	0.51		0.00055	0.003	
335-67-1	Perfluorooctanoic acid (PFOA)	PFAS	0.017	0.26	3.4	0.74	0.85	0.77		0.0022		
85-01-8	Phenanthrene	SVOC	320	2,500	23,000	7,000	8,100	72,000		54	11	18
108-95-2	Phenol	SVOC	180	26,000	100,000	74,000	85,000	100,000				
298-02-2	Phorate	PESTICIDE	0.19	17	220	49	57	51				
88-99-3	Phthalic Acid	SVOC	790	100,000	100,000	100,000	100,000	94,000				

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	**Chemical**	**Chemical Class**	**Leaching to Groundwater**	**Resident**	**Commercial Worker**	**Park User**	**Recreator Sediment**	**Construction Worker**	**Undeveloped**	**Rural Developed**	**Urban Developed**	**Urban Fill**
1336-36-3	Polychlorinated Biphenyls (high risk)	PCB	3.8	3.1	13	9.6	11	74				
103-65-1	Propyl benzene	VOC	67	260	260	260	35,000	260				
107-98-2	Propylene Glycol Monomethyl Ether	VOC	36	44,000	97,000	71,000	100,000	100,000				
129-00-0	Pyrene	SVOC	720	2,500	31,000	7,000	8,100	72,000		33	20	28
7782-49-2	Selenium	METAL	29	540	8,000	1,500	1,800	1,700				
7440-22-4	Silver	METAL	44	540	8,000	1,500	1,800	1,700				
7440-24-6	Strontium, Stable	METAL	23,000	64,000	100,000	100,000	100,000	100,000				
100-42-5	Styrene	VOC	73	830	870	860	70,000	860				
1746-01-6	TCDD, 2,3,7,8- Dioxin and Dioxin-like PCBs, TEQ	DIOXIN/FURAN	0.000033	0.000065	0.0003	0.00019	0.00022	0.0016				
95-94-3	Tetrachlorobenzene, 1,2,4,5-	SVOC	0.044	3.2	48	9.1	11	10				
630-20-6	Tetrachloroethane, 1,1,1,2-	VOC	0.12	30	130	410	1,200	480				
79-34-5	Tetrachloroethane, 1,1,2,2-	VOC	0.016	8.9	39	88	160	150				
127-18-4	Tetrachloroethylene	VOC	1.0	120	160	150	2,100	84				
58-90-2	Tetrachlorophenol, 2,3,4,6-	SVOC	9.9	2,600	34,000	7,400	8,500	2,600				
109-99-9	Tetrahydrofuran	VOC	41	27,000	100,000	100,000	100,000	20,000				
479-45-8	Tetryl (Trinitrophenylmethylnitramine)	WMD	20	210	3,200	610	700	6,800				
7440-28-0	Thallium (Soluble Salts)	METAL	0.78	1.1	16	3.0	3.5	14				
7440-31-5	Tin	METAL	100,000	64,000	100,000	100,000	100,000	100,000				
108-88-3	Toluene	VOC	42	750	810	790	28,000	820				
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2-	VOC	1,400	910	910	910	100,000	910				

Dry Weight Basis			Soil RAG (mg/kg)						BTVs (mg/kg)			
CAS	Chemical	Chemical Class	Leaching to Groundwater	Resident	Commercial Worker	Park User	Recreator Sediment	Construction Worker	Undeveloped	Rural Developed	Urban Developed	Urban Fill
87-61-6	Trichlorobenzene, 1,2,3-	VOC	1.2	86	1,300	240	280	2,700				
120-82-1	Trichlorobenzene, 1,2,4-	SVOC	0.64	86	380	360	1,100	400				
71-55-6	Trichloroethane, 1,1,1-	VOC	150	640	640	640	100,000	640				
79-00-5	Trichloroethane, 1,1,2-	VOC	0.0074	2.2	9.4	49	550	68				
79-01-6	Trichloroethylene	VOC	0.056	6.1	28	77	180	4.2				
75-69-4	Trichlorofluoromethane	VOC	180	32,000	100,000	91,000	100,000	940				
95-95-4	Trichlorophenol, 2,4,5-	SVOC	220	8,600	100,000	25,000	28,000	77,000				
88-06-2	Trichlorophenol, 2,4,6-	SVOC	0.64	86	1,100	250	280	1,300				
93-76-5	Trichlorophenoxyacetic Acid, 2,4,5-	PESTICIDE	3.7	860	11,000	2,500	2,800	26,000				
93-72-1	Trichlorophenoxypropionic acid, -2,4,5	HERBICIDE	3.4	690	9,000	2,000	2,300	2,100				
96-18-4	Trichloropropane, 1,2,3-	VOC	0.00018	0.07	1.5	0.20	0.23	4.3				
526-73-8	Trimethylbenzene, 1,2,3-	VOC	4.4	230	290	270	3,500	290				
95-63-6	Trimethylbenzene, 1,2,4-	VOC	4.4	180	220	200	3,500	220				
108-67-8	Trimethylbenzene, 1,3,5-	VOC	4.8	160	180	170	3,500	180				
118-96-7	Trinitrotoluene, 2,4,6-	SVOC	3.1	50	700	140	160	150				
7440-33-7	Tungsten	METAL	130	86	1,300	240	280	2,700				
7440-62-2	Vanadium and Compounds	METAL	4,800	540	8,000	1,500	1,800	490	40			
108-05-4	Vinyl Acetate	VOC	4.8	1,400	2,700	2,700	100,000	140				
593-60-2	Vinyl Bromide	VOC	0.059	3.8	17	87	100,000	61				
75-01-4	Vinyl Chloride	VOC	0.0036	0.64	24	0.71	0.71	80				
1330-20-7	Xylenes	VOC	11	260	260	260	70,000	260				
7440-66-6	Zinc and Compounds	METAL	21,000	32,000	100,000	91,000	100,000	100,000	98			

Notes: PFAS*, also see the guidelines at: https://www1.maine.gov/dep/spills/topics/pfas/index.html.
VOC** see section 7.5.1.
BTVs† provided are UTLs for comparison to individual, discrete sample results. See section 7.2.2.
DIOXIN/FURAN*** for Dioxins and Co-Planar PCBs see section 7.5.3.
NC means “not calculated.”
WMD means “Weapons of Mass Destruction.”

Table 5: Maine Remedial Action Guidelines for the Indoor Air Exposure Pathway, by Exposure Scenario

CAS	Chemical	Chemical Class	Molecular Weight (g/mol)	Air RAG (ug/m3)		
				Residential	Commercial	Ambient
75-05-8	Acetonitrile	VOC	41.053	63	260	60
107-02-8	Acrolein	VOC	56.065	0.021	0.088	0.02
107-13-1	Acrylonitrile	VOC	53.064	0.41	1.8	0.15
309-00-2	Aldrin	SVOC	364.92	0.0057	0.025	0.002
107-05-1	Allyl Chloride	VOC	76.526	1.0	4.4	1.0
7429-90-5	Aluminum	METAL	26.982	5.2	22	5.0
62-53-3	Aniline	SVOC	93.129	1.0	4.4	1.0
12674-11-2	Aroclor 1016	PCB	257.55	1.4	6.1	0.50
7440-38-2	Arsenic, Inorganic	METAL	74.922	0.0065	0.029	0.0023
7440-39-3	Barium	METAL	137.33	0.52	2.2	0.50
71-43-2	Benzene	VOC	78.115	3.6	16	1.3
56-55-3	Benzo(a)anthracene	SVOC	228.3	0.17	2.0	0.10
50-32-8	Benzo(a)pyrene	SVOC	252.32	0.0021	0.0088	0.002
205-99-2	Benzo(b)fluoranthene	SVOC	252.32	0.17	2.0	0.10
207-08-9	Benzo(k)fluoranthene	SVOC	252.32	1.7	20	1.0
100-44-7	Benzyl Chloride	VOC	126.59	0.57	2.5	0.20
7440-41-7	Beryllium and compounds	METAL	9.01	0.012	0.051	0.0042
92-52-4	Biphenyl, 1,1'-	SVOC	154.21	0.42	1.8	0.40
111-44-4	Bis(2-chloroethyl)ether	SVOC	143.01	0.085	0.37	0.03
117-81-7	Bis(2-ethylhexyl)phthalate	SVOC	390.57	12	51	4.2
7440-42-8	Boron And Borates Only	METAL	13.84	21	88	20

CAS	Chemical	Chemical Class	Molecular Weight (g/mol)	Air RAG (ug/m3)		
				Residential	Commercial	Ambient
108-86-1	Bromobenzene	VOC	157.01	63	260	60
74-97-5	Bromochloromethane	VOC	129.38	42	180	40
75-27-4	Bromodichloromethane	VOC	163.83	0.76	3.3	0.27
75-25-2	Bromoform	VOC	252.73	26	110	9.1
74-83-9	Bromomethane	VOC	94.939	5.2	22	5.0
106-94-5	Bromopropane, 1-	VOC	122.99	7.6	33	2.7
106-99-0	Butadiene, 1,3-	VOC	54.092	0.9	4.1	0.33
75-65-0	Butyl Alcohol, tert-	ALCOHOL	74.124	5,200	22,000	5,000
DEP2041	C11-C22 Aromatics	FUEL	152	52	220	50
DEP2038	C5-C8 Aliphatics	FUEL	93	210	880	200
DEP2040	C9-C10 Aromatics	FUEL	120	52	220	50
DEP2039	C9-C12 Aliphatics	FUEL	149	210	880	200
DEP2043	C9-C18 Aliphatics	FUEL	170	210	880	200
7440-43-9	Cadmium (Diet)	METAL	112.4	0.01	0.044	0.0056
75-15-0	Carbon Disulfide	VOC	76.139	730	3,100	700
56-23-5	Carbon Tetrachloride	VOC	153.82	4.7	20	1.7
12789-03-6	Chlordane	PESTICIDE	409.78	0.28	1.2	0.10
115-28-6	Chlorendic acid	SVOC	388.9	1.1	4.7	0.39
75-68-3	Chloro-1,1-difluoroethane, 1-	VOC	100.5	52,000	220,000	50,000
108-90-7	Chlorobenzene	VOC	112.56	52	220	50
67-66-3	Chloroform	VOC	119.38	1.2	5.3	0.44
74-87-3	Chloromethane	VOC	50.488	94	390	90
76-06-2	Chloropicrin	VOC	164.38	0.42	1.8	0.40
18540-29-9	Chromium(VI)	INORGANIC	52	0.00012	0.0015	0.000072
218-01-9	Chrysene	SVOC	228.3	17	200	10

CAS	Chemical	Chemical Class	Molecular Weight (g/mol)	Air RAG (ug/m3)		
				Residential	Commercial	Ambient
7440-48-4	Cobalt	METAL	58.93	0.0031	0.014	0.0011
108-39-4	Cresol, m-	SVOC	108.14	630	2,600	600
95-48-7	Cresol, o-	SVOC	108.14	630	2,600	600
106-44-5	Cresol, p-	SVOC	108.14	630	2,600	600
98-82-8	Cumene	VOC	120.2	420	1,800	400
57-12-5	Cyanide (CN-)	INORGANIC	26.018	0.83	3.5	0.80
110-82-7	Cyclohexane	VOC	84.163	6,300	26,000	6,000
72-54-8	DDD, p,p`- (DDD)	PESTICIDE	320.05	0.41	1.8	0.15
72-55-9	DDE, p,p'-	PESTICIDE	318.03	0.29	1.3	0.10
50-29-3	DDT	PESTICIDE	354.49	0.29	1.3	0.10
53-70-3	Dibenz(a,h)anthracene	SVOC	278.36	0.017	0.20	0.01
96-12-8	Dibromo-3-chloropropane, 1,2-	PESTICIDE	236.33	0.0017	0.02	0.001
106-93-4	Dibromoethane, 1,2-	VOC	187.86	0.047	0.20	0.017
74-95-3	Dibromomethane (Methylene Bromide)	VOC	173.84	4.2	18	4.0
110-57-6	Dichloro-2-butene, trans-1,4-	VOC	125	0.0067	0.029	0.0024
95-50-1	Dichlorobenzene, 1,2-	SVOC	147	210	880	200
106-46-7	Dichlorobenzene, 1,4-	VOC	147	2.6	11	0.9
91-94-1	Dichlorobenzidine, 3,3'-	SVOC	253.13	0.083	0.36	0.029
75-71-8	Dichlorodifluoromethane	VOC	120.91	100	440	100
107-06-2	Dichloroethane, 1,2-	VOC	98.96	1.1	4.7	0.39
75-34-3	Dichloroethane,1,1-	VOC	98.96	18	77	6.3
75-35-4	Dichloroethylene, 1,1-	VOC	96.944	210	880	200
156-59-2	Dichloroethylene, 1,2-cis-	VOC	96.944	42	180	40
156-60-5	Dichloroethylene, 1,2-trans-	VOC	96.944	42	180	40
78-87-5	Dichloropropane, 1,2-	VOC	112.99	4.2	18	2.7

CAS	Chemical	Chemical Class	Molecular Weight (g/mol)	Air RAG (ug/m3)		
				Residential	Commercial	Ambient
542-75-6	Dichloropropene, 1,3-	VOC	110.97	7.0	31	2.5
60-57-1	Dieldrin	PESTICIDE	380.91	0.0061	0.027	0.0022
108-20-3	Diisopropyl Ether	VOC	102.18	730	3,100	700
121-14-2	Dinitrotoluene, 2,4-	SVOC	182.14	0.32	1.4	0.11
123-91-1	Dioxane, 1,4-	SVOC	88.107	5.6	25	2.0
75-00-3	Ethyl Chloride	VOC	64.515	4,200	18,000	4,000
97-63-2	Ethyl Methacrylate	VOC	114.15	310	1,300	300
637-92-3	Ethyl Tertiary Butyl Ether (ETBE)	VOC	102.18	350	1,500	130
100-41-4	Ethylbenzene	VOC	106.17	11	49	4.0
107-21-1	Ethylene Glycol	VOC	62.069	420	1,800	400
111-76-2	Ethylene Glycol Monobutyl Ether	VOC	118.18	1,700	7,000	1,600
16984-48-8	Fluoride	ANION	38	14	57	13
50-00-0	Formaldehyde	VOC	30.026	2.2	9.4	0.77
76-44-8	Heptachlor	PESTICIDE	373.32	0.022	0.094	0.0077
1024-57-3	Heptachlor Epoxide	PESTICIDE	389.32	0.011	0.047	0.0039
118-74-1	Hexachlorobenzene	SVOC	284.78	0.061	0.27	0.022
87-68-3	Hexachlorobutadiene	SVOC	260.76	1.3	5.6	0.46
319-84-6	Hexachlorocyclohexane, Alpha-	PESTICIDE	290.83	0.016	0.068	0.0056
319-85-7	Hexachlorocyclohexane, Beta-	PESTICIDE	290.83	0.053	0.23	0.019
58-89-9	Hexachlorocyclohexane, Gamma- (Lindane)	PESTICIDE	290.83	0.091	0.40	0.032
67-72-1	Hexachloroethane	SVOC	236.74	2.6	11	0.9
110-54-3	Hexane, N-	VOC	86.178	730	3,100	700
591-78-6	Hexanone, 2-	VOC	100.16	31	130	30
193-39-5	Indeno(1,2,3)pyrene	SVOC	276.34	0.17	2.0	0.10
78-59-1	Isophorone	SVOC	138.21	2,100	8,800	2,000

CAS	Chemical	Chemical Class	Molecular Weight (g/mol)	Air RAG (ug/m3)		
				Residential	Commercial	Ambient
67-63-0	Isopropanol	ALCOHOL	60.097	210	880	200
7439-92-1	Lead	METAL	207.2	NC	NC	0.15
7439-96-5	Manganese (Non-diet)	METAL	54.938	0.052	0.22	0.05
7487-94-7	Mercuric Chloride	METAL	271.5	0.31	1.3	0.30
7439-97-6	Mercury (elemental)	METAL	200.59	0.31	1.3	0.30
78-93-3	Methyl Ethyl Ketone (2-Butanone)	VOC	72.108	5,200	22,000	5,000
108-10-1	Methyl Isobutyl Ketone (4-methyl-2-pentanone)	VOC	100.16	3,100	13,000	3,000
80-62-6	Methyl Methacrylate	VOC	100.12	730	3,100	700
1634-04-4	Methyl tert-Butyl Ether (MTBE)	VOC	88.151	110	470	39
75-09-2	Methylene Chloride	VOC	84.933	630	2,600	600
91-20-3	Naphthalene	SVOC	128.18	0.83	3.6	0.29
7440-02-0	Nickel Soluble Salts	METAL	58.71	0.094	0.39	0.039
100-01-6	Nitroaniline, 4-	SVOC	138.13	6.3	26	6.0
86-30-6	Nitrosodiphenylamine, N-	SVOC	198.23	11	47	3.9
87-86-5	Pentachlorophenol	HERBICIDE	266.34	5.5	24	2.0
108-95-2	Phenol	SVOC	94.114	210	880	200
88-99-3	Phthalic Acid	SVOC	166.13	21	88	20
1336-36-3	Polychlorinated Biphenyls (low risk)	PCB	291.99	0.049	0.22	0.018
103-65-1	Propyl benzene	VOC	120.2	1,000	4,400	1,000
107-98-2	Propylene Glycol Monomethyl Ether	VOC	90.123	2,100	8,800	2,000
7782-49-2	Selenium	METAL	78.96	21	88	20
100-42-5	Styrene	VOC	104.15	1,000	4,400	1,000
1746-01-6	TCDD, 2,3,7,8- Dioxin and Dioxin-like PCBs, TEQ	DIOXIN/FURAN	321.98	0.00000074	0.0000032	0.00000026
630-20-6	Tetrachloroethane, 1,1,1,2-	VOC	167.85	3.8	17	1.4

CAS	Chemical	Chemical Class	Molecular Weight (g/mol)	Air RAG (ug/m3)		
				Residential	Commercial	Ambient
79-34-5	Tetrachloroethane, 1,1,2,2-	VOC	167.85	0.48	2.1	0.17
127-18-4	Tetrachloroethylene	VOC	165.83	42	180	39
109-99-9	Tetrahydrofuran	VOC	72.108	2,100	8,800	2,000
108-88-3	Toluene	VOC	92.142	5,200	22,000	5,000
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2-	VOC	187.38	5,200	22,000	5,000
120-82-1	Trichlorobenzene, 1,2,4-	SVOC	181.45	2.1	8.8	2.0
71-55-6	Trichloroethane, 1,1,1-	VOC	133.41	5,200	22,000	5,000
79-00-5	Trichloroethane, 1,1,2-	VOC	133.41	0.21	0.88	0.20
79-01-6	Trichloroethylene	VOC	131.39	2.1	8.8	2.0
88-06-2	Trichlorophenol, 2,4,6-	SVOC	197.45	9.1	40	3.2
96-18-4	Trichloropropane, 1,2,3-	VOC	147.43	0.31	1.3	0.30
526-73-8	Trimethylbenzene, 1,2,3-	VOC	120.2	63	260	60
95-63-6	Trimethylbenzene, 1,2,4-	VOC	120.2	63	260	60
108-67-8	Trimethylbenzene, 1,3,5-	VOC	120.2	63	260	60
7440-62-2	Vanadium and Compounds	METAL	50.94	0.10	0.44	0.10
108-05-4	Vinyl Acetate	VOC	86.091	210	880	200
593-60-2	Vinyl Bromide	VOC	106.95	1.9	8.2	0.67
75-01-4	Vinyl Chloride	VOC	62.499	1.7	28	1.1
1330-20-7	Xylenes	VOC	106.17	100	440	100

Notes:

1. Multiply sub slab concentrations by an attenuation factor of 0.03 before comparing the results to the appropriate indoor air RAG in this table (see Section 6.4.2).

2. Conversion to parts per billion (volume): Concentration (ug/m^3) = 0.0409 x concentration (ppb) x molecular weight, when at 1 ATM pressure and temperature of 25° Celsius.[25]
3. The Ambient Air Lead RAG is based on the National Ambient Air Quality Standard for Lead, which was last reviewed in 2016, and adopted by Maine under 38 MRS §584-A.[26]
4. VOC** see section 7.5.1.
5. DIOXIN/FURAN*** for Dioxins and Co-Planar PCBs see section 7.5.3.

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[25] Center for Hazardous Substance Research, Understanding Units of Measure (Downloaded January 29, 2021 from: https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.files/fileid/14285) October 2006

[26] EPA Lead Air Pollution Website, National Ambient Air Quality Standards (NAAQS) for Lead (Pb) Fact Sheets and Additional Information, Downloaded January 29, 2021 from: https://www.epa.gov/lead-air-pollution/national-ambient-air-quality-standards-naaqs-lead-pb-fact-sheets-and-additional#:~:text=On%20September%2016%2C%202016%2C%20EPA,a%203%2D%20month%20average%20concentration.

Table 6: Maine Remedial Action Guidelines for the Groundwater Exposure Pathway, by Exposure Scenario

			Groundwater RAGs (ug/L)	
CAS	**Chemical**	**Chemical Class**	**Residential**	**Construction Worker**
83-32-9	Acenaphthene	SVOC	540	74,000
208-96-8	Acenaphthylene	SVOC	520	71,000
67-64-1	Acetone	VOC	18,000	100,000
75-05-8	Acetonitrile	VOC	130	4,800
98-86-2	Acetophenone	SVOC	1,900	100,000
107-02-8	Acrolein	VOC	0.042	0.53
107-13-1	Acrylonitrile	VOC	0.52	11
15972-60-8	Alachlor	PESTICIDE	11	16,000
309-00-2	Aldrin	SVOC	0.0092	2.9
107-05-1	Allyl Chloride	VOC	2.1	44
7429-90-5	Aluminum	METAL	20,000	100,000
62-53-3	Aniline	SVOC	130	86,000
120-12-7	Anthracene	SVOC	1,800	100,000
7440-36-0	Antimony (metallic)	METAL	7.8	2,100
12674-11-2	Aroclor 1016	PCB	1.4	350
7440-38-2	Arsenic, Inorganic	METAL	0.52	5,800
1912-24-9	Atrazine	SVOC	3.0	11,000
7440-39-3	Barium	METAL	3,800	100,000
100-52-7	Benzaldehyde	SVOC	190	100,000
71-43-2	Benzene	VOC	4.6	350
56-55-3	Benzo(a)anthracene	SVOC	0.30	470
50-32-8	Benzo(a)pyrene	SVOC	0.25	11,000
205-99-2	Benzo(b)fluoranthene	SVOC	2.5	100,000
191-24-2	Benzo(g,h,i)perylene	SVOC	600	100,000

			Groundwater RAGs (ug/L)	
CAS	Chemical	Chemical Class	Residential	Construction Worker
207-08-9	Benzo(k)fluoranthene	SVOC	25	100,000
65-85-0	Benzoic Acid	SVOC	75,000	100,000
100-51-6	Benzyl Alcohol	SVOC	2,000	100,000
100-44-7	Benzyl Chloride	VOC	0.89	26
7440-41-7	Beryllium and compounds	METAL	25	1,400
92-52-4	Biphenyl, 1,1'-	SVOC	0.83	29
111-44-4	Bis(2-chloroethyl)ether	SVOC	0.14	54
117-81-7	Bis(2-ethylhexyl)phthalate	SVOC	56	3,700
7440-42-8	Boron And Borates Only	METAL	4,000	100,000
108-86-1	Bromobenzene	VOC	62	1,200
74-97-5	Bromochloromethane	VOC	83	600
75-27-4	Bromodichloromethane	VOC	1.3	130
75-25-2	Bromoform	VOC	33	5,500
74-83-9	Bromomethane	VOC	7.6	490
106-94-5	Bromopropane, 1-	VOC	15	1,100
106-99-0	Butadiene, 1,3-	VOC	0.71	7.4
75-65-0	Butyl Alcohol, tert-	ALCOHOL	1,500	100,000
85-68-7	Butyl Benzyl Phthalate	SVOC	160	100,000
104-51-8	Butylbenzene, n-	VOC	1,000	100,000
135-98-8	Butylbenzene, sec-	VOC	2,000	100,000
98-06-6	Butylbenzene, tert-	VOC	690	25,000
DEP2041	C11-C22 Aromatics	FUEL	600	100,000
DEP2042	C19-C36 Aliphatics	FUEL	40,000	100,000
DEP2038	C5-C8 Aliphatics	FUEL	180	960
DEP2040	C9-C10 Aromatics	FUEL	71	2,700
DEP2039	C9-C12 Aliphatics	FUEL	350	3,700
DEP2043	C9-C18 Aliphatics	FUEL	350	3,900
7440-43-9	Cadmium (Water)	METAL	1.8	940
86-74-8	Carbazole	SVOC	15	13,000
75-15-0	Carbon Disulfide	VOC	810	3,100
56-23-5	Carbon Tetrachloride	VOC	4.6	700

			Groundwater RAGs (ug/L)	
CAS	Chemical	Chemical Class	Residential	Construction Worker
12789-03-6	Chlordane	PESTICIDE	0.20	3.7
115-28-6	Chlorendic acid	SVOC	8.4	100,000
75-68-3	Chloro-1,1-difluoroethane, 1-	VOC	100,000	100,000
106-47-8	Chloroaniline, p-	SVOC	3.7	2,700
108-90-7	Chlorobenzene	VOC	78	2,600
67-66-3	Chloroform	VOC	2.2	170
74-87-3	Chloromethane	VOC	190	11,000
91-58-7	Chloronaphthalene, Beta-	SVOC	750	81,000
95-57-8	Chlorophenol, 2-	SVOC	91	29,000
76-06-2	Chloropicrin	VOC	0.83	2.6
95-49-8	Chlorotoluene, o-	VOC	240	3,300
106-43-4	Chlorotoluene, p-	VOC	250	100,000
16065-83-1	Chromium(III), Insoluble Salts	METAL	23,000	100,000
18540-29-9	Chromium(VI)	INORGANIC	0.35	690
218-01-9	Chrysene	SVOC	250	100,000
7440-48-4	Cobalt	METAL	6.0	81,000
7440-50-8	Copper	METAL	800	100,000
108-39-4	Cresol, m-	SVOC	930	100,000
95-48-7	Cresol, o-	SVOC	930	100,000
106-44-5	Cresol, p-	SVOC	370	79,000
59-50-7	Cresol, p-chloro-m-	SVOC	1,500	100,000
98-82-8	Cumene	VOC	450	500
57-12-5	Cyanide (CN-)	INORGANIC	1.5	3.6
110-82-7	Cyclohexane	VOC	13,000	83,000
75-99-0	Dalapon	HERBICIDE	600	100,000
72-54-8	DDD, p,p`- (DDD)	PESTICIDE	0.32	28
72-55-9	DDE, p,p'-	PESTICIDE	0.46	140
50-29-3	DDT	PESTICIDE	2.3	19,000
124-18-5	Decane	VOC	NC	100,000
53-70-3	Dibenz(a,h)anthracene	SVOC	0.25	26,000

			Groundwater RAGs (ug/L)	
CAS	**Chemical**	**Chemical Class**	**Residential**	**Construction Worker**
132-64-9	Dibenzofuran	SVOC	7.9	1,200
96-12-8	Dibromo-3-chloropropane, 1,2-	PESTICIDE	0.0033	1.2
124-48-1	Dibromochloromethane	VOC	8.7	53,000
106-93-4	Dibromoethane, 1,2-	VOC	0.075	8.7
74-95-3	Dibromomethane (Methylene Bromide)	VOC	8.3	280
84-74-2	Dibutyl Phthalate	SVOC	900	100,000
110-57-6	Dichloro-2-butene, trans-1,4-	VOC	0.013	1.0
95-50-1	Dichlorobenzene, 1,2-	SVOC	300	12,000
541-73-1	Dichlorobenzene, 1,3-	SVOC	300	6,200
106-46-7	Dichlorobenzene, 1,4-	VOC	4.8	400
91-94-1	Dichlorobenzidine, 3,3'-	SVOC	1.3	2,000
75-71-8	Dichlorodifluoromethane	VOC	200	5,400
107-06-2	Dichloroethane, 1,2-	VOC	1.7	140
75-34-3	Dichloroethane,1,1-	VOC	28	2,200
75-35-4	Dichloroethylene, 1,1-	VOC	290	20
156-59-2	Dichloroethylene, 1,2-cis-	VOC	25	1,900
156-60-5	Dichloroethylene, 1,2-trans-	VOC	68	3,900
120-83-2	Dichlorophenol, 2,4-	SVOC	46	27,000
78-87-5	Dichloropropane, 1,2-	VOC	8.3	51
142-28-9	Dichloropropane, 1,3-	VOC	370	100,000
542-75-6	Dichloropropene, 1,3-	VOC	4.7	200
60-57-1	Dieldrin	PESTICIDE	0.018	13
84-66-2	Diethyl Phthalate	SVOC	15,000	100,000
108-20-3	Diisopropyl Ether	VOC	1,500	3,700
105-67-9	Dimethylphenol, 2,4-	SVOC	360	100,000
576-26-1	Dimethylphenol, 2,6-	SVOC	11	15,000
528-29-0	Dinitrobenzene, 1,2-	SVOC	1.9	8,900
99-65-0	Dinitrobenzene, 1,3-	SVOC	2.0	5,500
100-25-4	Dinitrobenzene, 1,4-	SVOC	2.0	11,000
51-28-5	Dinitrophenol, 2,4-	SVOC	39	100,000
121-14-2	Dinitrotoluene, 2,4-	SVOC	2.4	15,000
606-20-2	Dinitrotoluene, 2,6-	SVOC	0.49	2,700
88-85-7	Dinoseb	PESTICIDE	15	1,200
123-91-1	Dioxane, 1,4-	SVOC	4.6	8,600

CAS	Chemical	Chemical Class	Groundwater RAGs (ug/L) Residential	Groundwater RAGs (ug/L) Construction Worker
115-29-7	Endosulfan	PESTICIDE	100	12,000
72-20-8	Endrin	PESTICIDE	2.3	170
75-00-3	Ethyl Chloride	VOC	8,300	16,000
60-29-7	Ethyl Ether	VOC	3,900	14,000
97-63-2	Ethyl Methacrylate	VOC	630	12,000
637-92-3	Ethyl Tertiary Butyl Ether (ETBE)	VOC	700	100,000
100-41-4	Ethylbenzene	VOC	15	1,400
107-21-1	Ethylene Glycol	VOC	16,000	100,000
111-76-2	Ethylene Glycol Monobutyl Ether	VOC	2,000	100,000
206-44-0	Fluoranthene	SVOC	800	100,000
86-73-7	Fluorene	SVOC	290	100,000
16984-48-8	Fluoride	ANION	800	100,000
50-00-0	Formaldehyde	VOC	3.9	22,000
76-44-8	Heptachlor	PESTICIDE	0.014	3.9
1024-57-3	Heptachlor Epoxide	PESTICIDE	0.014	5.5
118-74-1	Hexachlorobenzene	SVOC	0.098	13
87-68-3	Hexachlorobutadiene	SVOC	1.4	230
319-84-6	Hexachlorocyclohexane, Alpha-	PESTICIDE	0.073	80
319-85-7	Hexachlorocyclohexane, Beta-	PESTICIDE	0.25	280
58-89-9	Hexachlorocyclohexane, Gamma- (Lindane)	PESTICIDE	0.42	460
67-72-1	Hexachloroethane	SVOC	3.3	470
13252-13-6	Hexafluoropropylene oxide dimer acid (HFPO-DA)	PFC	0.06	1,100
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	WMD	9.7	100,000
110-54-3	Hexane, N-	VOC	1,500	8,300
591-78-6	Hexanone, 2-	VOC	38	240
193-39-5	Indeno(1,2,3)pyrene	SVOC	2.5	100,000
7439-89-6	Iron	METAL	14,000	100,000
78-59-1	Isophorone	SVOC	780	100,000
67-63-0	Isopropanol	ALCOHOL	410	100,000
7439-92-1	Lead	METAL	1	NC

CAS	Chemical	Chemical Class	Groundwater RAGs (ug/L) Residential	Groundwater RAGs (ug/L) Construction Worker
121-75-5	Malathion	PESTICIDE	390	100,000
7439-96-5	Manganese (Non-diet)	METAL	430	37,000
94-74-6	MCPA	HERBICIDE	7.5	680
93-65-2	MCPP	HERBICIDE	16	16,000
7487-94-7	Mercuric Chloride	METAL	5.7	7,800
7439-97-6	Mercury (elemental)	METAL	0.63	2.1
72-43-5	Methoxychlor	PESTICIDE	37	1,400
79-20-9	Methyl Acetate	VOC	20,000	670
78-93-3	Methyl Ethyl Ketone (2-Butanone)	VOC	5,600	9,000
108-10-1	Methyl Isobutyl Ketone (4-methyl-2-pentanone)	VOC	6,300	5,800
22967-92-6	Methyl Mercury	METAL	2.0	1,900
80-62-6	Methyl Methacrylate	VOC	1,400	4,200
1634-04-4	Methyl tert-Butyl Ether (MTBE)	VOC	140	14,000
88-19-7	Methylbenzene sulfonamide, 2-	SVOC	790	100,000
70-55-3	Methylbenzene sulfonamide, 4-	SVOC	2,300	100,000
75-09-2	Methylene Chloride	VOC	110	4,900
90-12-0	Methylnaphthalene, 1-	SVOC	11	8,800
91-57-6	Methylnaphthalene, 2-	SVOC	36	1,500
7439-98-7	Molybdenum	METAL	100	100,000
91-20-3	Naphthalene	SVOC	1.2	19
7440-02-0	Nickel Soluble Salts	METAL	390	100,000
14797-55-8	Nitrate	NUTRIENT	32,000	100,000
14797-65-0	Nitrite	NUTRIENT	2,000	100,000
100-01-6	Nitroaniline, 4-	SVOC	38	100,000
55-63-0	Nitroglycerin	WMD	2.0	1,300
86-30-6	Nitrosodiphenylamine, N-	SVOC	120	100,000

			Groundwater RAGs (ug/L)	
CAS	**Chemical**	**Chemical Class**	**Residential**	**Construction Worker**
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	WMD	1,000	100,000
117-84-0	Octyl Phthalate, di-N-	SVOC	200	100,000
56-38-2	Parathion	PESTICIDE	86	10,000
608-93-5	Pentachlorobenzene	SVOC	3.2	930
87-86-5	Pentachlorophenol	HERBICIDE	0.41	240
78-11-5	Pentaerythritol tetranitrate (PETN)	WMD	170	79,000
14797-73-0	Perchlorate and Perchlorate Salts	INORGANIC	14	14,000
375-73-5	Perfluorobutane sulfonic acid (PFBS)	PFAS	6.0	32,000
375-22-4	Perfluorobutanoic acid (PFBA)	PFAS	19	28,000
355-46-4	Perfluorohexanesulfonic acid (PFHxS)*	PFAS	0.39	310
307-24-4	Perfluorohexanoic acid (PFHxA)	PFAS	9.9	10,000
375-95-1	Perfluorononanoic acid (PFNA)*	PFAS	0.059	42
1763-23-1	Perfluorooctane sulfonic acid (PFOS)*	PFAS	0.04	75
335-67-1	Perfluorooctanoic acid (PFOA)*	PFAS	0.06	110
85-01-8	Phenanthrene	SVOC	180	58,000
108-95-2	Phenol	SVOC	5,800	100,000
298-02-2	Phorate	PESTICIDE	3.0	280
88-99-3	Phthalic Acid	SVOC	40,000	100,000
1336-36-3	Polychlorinated Biphenyls	PCB	0.44	67
103-65-1	Propyl benzene	VOC	660	4,900
107-98-2	Propylene Glycol Monomethyl Ether	VOC	3,200	100,000
129-00-0	Pyrene	SVOC	120	36,000
7782-49-2	Selenium	METAL	100	96,000
7440-22-4	Silver	METAL	94	12,000
7440-24-6	Strontium, Stable	METAL	12,000	100,000
100-42-5	Styrene	VOC	1,200	15,000
1746-01-6	TCDD, 2,3,7,8- Dioxin and Dioxin-like PCBs, TEQ	DIOXIN/FURAN	0.0000012	0.00033
95-94-3	Tetrachlorobenzene, 1,2,4,5-	SVOC	0.17	5.6

			Groundwater RAGs (ug/L)	
CAS	**Chemical**	**Chemical Class**	**Residential**	**Construction Worker**
630-20-6	Tetrachloroethane, 1,1,1,2-	VOC	5.7	620
79-34-5	Tetrachloroethane, 1,1,2,2-	VOC	0.76	90
127-18-4	Tetrachloroethylene	VOC	41	250
58-90-2	Tetrachlorophenol, 2,3,4,6-	SVOC	240	3,100
109-99-9	Tetrahydrofuran	VOC	3,400	16,000
479-45-8	Tetryl (Trinitrophenylmethylnitramine)	WMD	40	100,000
7440-28-0	Thallium (Soluble Salts)	METAL	0.20	770
7440-31-5	Tin	METAL	12,000	100,000
108-88-3	Toluene	VOC	1,100	24,000
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2-	VOC	10,000	100,000
87-61-6	Trichlorobenzene, 1,2,3-	VOC	7.0	2,900
120-82-1	Trichlorobenzene, 1,2,4-	SVOC	4.0	140
71-55-6	Trichloroethane, 1,1,1-	VOC	8,000	29,000
79-00-5	Trichloroethane, 1,1,2-	VOC	0.42	68
79-01-6	Trichloroethylene	VOC	2.8	12
75-69-4	Trichlorofluoromethane	VOC	5,200	5,900
95-95-4	Trichlorophenol, 2,4,5-	SVOC	1,200	100,000
88-06-2	Trichlorophenol, 2,4,6-	SVOC	12	3,500
93-76-5	Trichlorophenoxyacetic Acid, 2,4,5-	PESTICIDE	160	100,000
93-72-1	Trichlorophenoxypropionic acid, -2,4,5	HERBICIDE	110	8,400
96-18-4	Trichloropropane, 1,2,3-	VOC	0.0075	2.1
526-73-8	Trimethylbenzene, 1,2,3-	VOC	55	1,000
95-63-6	Trimethylbenzene, 1,2,4-	VOC	56	1,000
108-67-8	Trimethylbenzene, 1,3,5-	VOC	60	1,100
118-96-7	Trinitrotoluene, 2,4,6-	SVOC	9.8	6,800
7440-33-7	Tungsten	METAL	16	100,000
7440-62-2	Vanadium and Compounds	METAL	86	10,000
108-05-4	Vinyl Acetate	VOC	410	180
593-60-2	Vinyl Bromide	VOC	3.7	250
75-01-4	Vinyl Chloride	VOC	0.19	0.22

			Groundwater RAGs (ug/L)	
CAS	**Chemical**	**Chemical Class**	**Residential**	**Construction Worker**
1330-20-7	Xylenes	VOC	190	2,100
7440-66-6	Zinc and Compounds	METAL	6,000	100,000

Notes: * PFAS compounds PFOA, PFOS, PFHpA, PFHxS, PFNA, and PFDA are defined as a group as the Maine Regulated PFAS Contaminants and should be compared to the Maine PFAS Interim Drinking Water Standard for evaluation of drinking water exposure. See Section 7.5.4.2.

Table 7: Maine Remedial Action Guidelines for Fish Consumption – Recreational Angler

CAS	Chemical	Chemical Class	Fish Tissue RAG (mg/kg wet weight)
83-32-9	Acenaphthene	SVOC	150
208-96-8	Acenaphthylene	SVOC	150
67-64-1	Acetone	VOC	2,300
75-05-8	Acetonitrile	VOC	NC
98-86-2	Acetophenone	SVOC	260
107-02-8	Acrolein	VOC	1.3
107-13-1	Acrylonitrile	VOC	0.13
15972-60-8	Alachlor	PESTICIDE	1.2
309-00-2	Aldrin	SVOC	0.0041
107-05-1	Allyl Chloride	VOC	3.3
7429-90-5	Aluminum	METAL	2,600
62-53-3	Aniline	SVOC	12
120-12-7	Anthracene	SVOC	770
7440-36-0	Antimony (metallic)	METAL	1.0
12674-11-2	Aroclor 1016	PCB	0.18
7440-38-2	Arsenic, Inorganic	METAL	0.046
1912-24-9	Atrazine	SVOC	0.30
7440-39-3	Barium	METAL	520
100-52-7	Benzaldehyde	SVOC	17
71-43-2	Benzene	VOC	1.3
56-55-3	Benzo(a)anthracene	SVOC	0.69
50-32-8	Benzo(a)pyrene	SVOC	0.069
205-99-2	Benzo(b)fluoranthene	SVOC	0.69
191-24-2	Benzo(g,h,i)perylene	SVOC	77
207-08-9	Benzo(k)fluoranthene	SVOC	6.9
65-85-0	Benzoic Acid	SVOC	10,000
100-51-6	Benzyl Alcohol	SVOC	260
100-44-7	Benzyl Chloride	VOC	0.41
7440-41-7	Beryllium and compounds	METAL	5.2
92-52-4	Biphenyl, 1,1'-	SVOC	8.7
111-44-4	Bis(2-chloroethyl)ether	SVOC	0.063
117-81-7	Bis(2-ethylhexyl)phthalate	SVOC	5.0
7440-42-8	Boron And Borates Only	METAL	520
108-86-1	Bromobenzene	VOC	21

CAS	Chemical	Chemical Class	Fish Tissue RAG (mg/kg wet weight)
74-97-5	Bromochloromethane	VOC	NC
75-27-4	Bromodichloromethane	VOC	1.1
75-25-2	Bromoform	VOC	8.8
74-83-9	Bromomethane	VOC	3.6
106-94-5	Bromopropane, 1-	VOC	0
106-99-0	Butadiene, 1,3-	VOC	0.12
75-65-0	Butyl Alcohol, tert-	ALCOHOL	140
85-68-7	Butyl Benzyl Phthalate	SVOC	37
104-51-8	Butylbenzene, n-	VOC	130
135-98-8	Butylbenzene, sec-	VOC	260
98-06-6	Butylbenzene, tert-	VOC	260
DEP2041	C11-C22 Aromatics	FUEL	77
DEP2042	C19-C36 Aliphatics	FUEL	5,200
DEP2038	C5-C8 Aliphatics	FUEL	100
DEP2040	C9-C10 Aromatics	FUEL	77
DEP2039	C9-C12 Aliphatics	FUEL	260
DEP2043	C9-C18 Aliphatics	FUEL	260
7440-43-9	Cadmium (Water)	METAL	0.26
86-74-8	Carbazole	SVOC	2.5
75-15-0	Carbon Disulfide	VOC	260
56-23-5	Carbon Tetrachloride	VOC	1.0
12789-03-6	Chlordane	PESTICIDE	0.20
115-28-6	Chlorendic acid	SVOC	0.76
75-68-3	Chloro-1,1-difluoroethane, 1-	VOC	NC
106-47-8	Chloroaniline, p-	SVOC	0.35
108-90-7	Chlorobenzene	VOC	52
67-66-3	Chloroform	VOC	2.2
74-87-3	Chloromethane	VOC	NC
91-58-7	Chloronaphthalene, Beta-	SVOC	210
95-57-8	Chlorophenol, 2-	SVOC	13
76-06-2	Chloropicrin	VOC	NC
95-49-8	Chlorotoluene, o-	VOC	52
106-43-4	Chlorotoluene, p-	VOC	52
16065-83-1	Chromium(III), Insoluble Salts	METAL	3,900
18540-29-9	Chromium(VI)	INORGANIC	0.14
218-01-9	Chrysene	SVOC	69
7440-48-4	Cobalt	METAL	0.77

CAS	Chemical	Chemical Class	Fish Tissue RAG (mg/kg wet weight)
7440-50-8	Copper	METAL	100
108-39-4	Cresol, m-	SVOC	130
95-48-7	Cresol, o-	SVOC	130
106-44-5	Cresol, p-	SVOC	52
59-50-7	Cresol, p-chloro-m-	SVOC	260
98-82-8	Cumene	VOC	260
57-12-5	Cyanide (CN-)	INORGANIC	1.5
110-82-7	Cyclohexane	VOC	NC
75-99-0	Dalapon	HERBICIDE	77
72-54-8	DDD, p,p`- (DDD)	PESTICIDE	0.29
72-55-9	DDE, p,p'-	PESTICIDE	0.20
50-29-3	DDT	PESTICIDE	0.20
124-18-5	Decane	VOC	NC
53-70-3	Dibenz(a,h)anthracene	SVOC	0.069
132-64-9	Dibenzofuran	SVOC	2.6
96-12-8	Dibromo-3-chloropropane, 1,2-	PESTICIDE	0.087
124-48-1	Dibromochloromethane	VOC	0.83
106-93-4	Dibromoethane, 1,2-	VOC	0.035
74-95-3	Dibromomethane (Methylene Bromide)	VOC	NC
84-74-2	Dibutyl Phthalate	SVOC	260
110-57-6	Dichloro-2-butene, trans-1,4-	VOC	NC
95-50-1	Dichlorobenzene, 1,2-	SVOC	230
541-73-1	Dichlorobenzene, 1,3-	SVOC	230
106-46-7	Dichlorobenzene, 1,4-	VOC	13
91-94-1	Dichlorobenzidine, 3,3'-	SVOC	0.15
75-71-8	Dichlorodifluoromethane	VOC	520
107-06-2	Dichloroethane, 1,2-	VOC	0.76
75-34-3	Dichloroethane,1,1-	VOC	12
75-35-4	Dichloroethylene, 1,1-	VOC	130
156-59-2	Dichloroethylene, 1,2-cis-	VOC	5.2
156-60-5	Dichloroethylene, 1,2-trans-	VOC	52
120-83-2	Dichlorophenol, 2,4-	SVOC	7.7
78-87-5	Dichloropropane, 1,2-	VOC	1.9
142-28-9	Dichloropropane, 1,3-	VOC	52
542-75-6	Dichloropropene, 1,3-	VOC	0.69
60-57-1	Dieldrin	PESTICIDE	0.0043
84-66-2	Diethyl Phthalate	SVOC	2,100

CAS	Chemical	Chemical Class	Fish Tissue RAG (mg/kg wet weight)
108-20-3	Diisopropyl Ether	VOC	NC
105-67-9	Dimethylphenol, 2,4-	SVOC	52
576-26-1	Dimethylphenol, 2,6-	SVOC	1.5
528-29-0	Dinitrobenzene, 1,2-	SVOC	0.26
99-65-0	Dinitrobenzene, 1,3-	SVOC	0.26
100-25-4	Dinitrobenzene, 1,4-	SVOC	0.26
51-28-5	Dinitrophenol, 2,4-	SVOC	5.2
121-14-2	Dinitrotoluene, 2,4-	SVOC	0.22
606-20-2	Dinitrotoluene, 2,6-	SVOC	0.046
88-85-7	Dinoseb	PESTICIDE	2.6
123-91-1	Dioxane, 1,4-	SVOC	0.69
115-29-7	Endosulfan	PESTICIDE	15
72-20-8	Endrin	PESTICIDE	0.77
75-00-3	Ethyl Chloride	VOC	NC
60-29-7	Ethyl Ether	VOC	520
97-63-2	Ethyl Methacrylate	VOC	NC
637-92-3	Ethyl Tertiary Butyl Ether (ETBE)	VOC	2,600
100-41-4	Ethylbenzene	VOC	6.3
107-21-1	Ethylene Glycol	VOC	2,100
111-76-2	Ethylene Glycol Monobutyl Ether	VOC	260
206-44-0	Fluoranthene	SVOC	100
86-73-7	Fluorene	SVOC	100
16984-48-8	Fluoride	ANION	100
50-00-0	Formaldehyde	VOC	3.3
76-44-8	Heptachlor	PESTICIDE	0.015
1024-57-3	Heptachlor Epoxide	PESTICIDE	0.0076
118-74-1	Hexachlorobenzene	SVOC	0.026
87-68-3	Hexachlorobutadiene	SVOC	0.89
319-84-6	Hexachlorocyclohexane, Alpha-	PESTICIDE	0.011
319-85-7	Hexachlorocyclohexane, Beta-	PESTICIDE	0.039
58-89-9	Hexachlorocyclohexane, Gamma- (Lindane)	PESTICIDE	0.063
67-72-1	Hexachloroethane	SVOC	1.7
13252-13-6	Hexafluoropropylene oxide dimer acid (HFPO-DA)	PFAS	0.0077
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	WMD	0.87
110-54-3	Hexane, N-	VOC	NC
591-78-6	Hexanone, 2-	VOC	13
193-39-5	Indeno(1,2,3)pyrene	SVOC	0.69

CAS	Chemical	Chemical Class	Fish Tissue RAG (mg/kg wet weight)
7439-89-6	Iron	METAL	1,800
78-59-1	Isophorone	SVOC	73
67-63-0	Isopropanol	ALCOHOL	5,200
121-75-5	Malathion	PESTICIDE	52
7439-96-5	Manganese (Non-diet)	METAL	360
94-74-6	MCPA	HERBICIDE	1.3
93-65-2	MCPP	HERBICIDE	2.6
7487-94-7	Mercuric Chloride	METAL	0.77
7439-97-6	Mercury (elemental)	METAL	NC
72-43-5	Methoxychlor	PESTICIDE	13
79-20-9	Methyl Acetate	VOC	2,600
78-93-3	Methyl Ethyl Ketone (2-Butanone)	VOC	1,500
108-10-1	Methyl Isobutyl Ketone (4-methyl-2-pentanone)	VOC	NC
22967-92-6	Methyl Mercury	METAL	0.26
80-62-6	Methyl Methacrylate	VOC	3,600
1634-04-4	Methyl tert-Butyl Ether (MTBE)	VOC	39
88-19-7	Methylbenzene sulfonamide, 2-	SVOC	100
70-55-3	Methylbenzene sulfonamide, 4-	SVOC	290
75-09-2	Methylene Chloride	VOC	15
90-12-0	Methylnaphthalene, 1-	SVOC	2.4
91-57-6	Methylnaphthalene, 2-	SVOC	10
7439-98-7	Molybdenum	METAL	13
91-20-3	Naphthalene	SVOC	0.58
7440-02-0	Nickel Soluble Salts	METAL	52
14797-55-8	Nitrate	NUTRIENT	4,100
100-01-6	Nitroaniline, 4-	SVOC	3.5
55-63-0	Nitroglycerin	WMD	0.26
86-30-6	Nitrosodiphenylamine, N-	SVOC	14
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	WMD	130
117-84-0	Octyl Phthalate, di-N-	SVOC	26
56-38-2	Parathion	PESTICIDE	15
608-93-5	Pentachlorobenzene	SVOC	2.1
87-86-5	Pentachlorophenol	HERBICIDE	0.17
78-11-5	Pentaerythritol tetranitrate (PETN)	WMD	16
14797-73-0	Perchlorate and Perchlorate Salts	INORGANIC	1.8
375-73-5	Perfluorobutane sulfonic acid (PFBS)	PFAS	0.77
375-22-4	Perfluorobutanoic acid (PFBA)	PFAS	2.6

CAS	Chemical	Chemical Class	Fish Tissue RAG (mg/kg wet weight)
355-46-4	Perfluorohexanesulfonic acid (PFHxS)	PFAS	0.052
307-24-4	Perfluorohexanoic acid (PFHxA)	PFAS	1.3
375-95-1	Perfluorononanoic acid (PFNA)	PFAS	0.0077
1763-23-1	Perfluorooctane sulfonic acid (PFOS)	PFAS	0.0052
335-67-1	Perfluorooctanoic acid (PFOA)	PFAS	0.0077
85-01-8	Phenanthrene	SVOC	77
108-95-2	Phenol	SVOC	770
298-02-2	Phorate	PESTICIDE	0.52
88-99-3	Phthalic Acid	SVOC	5,200
1336-36-3	Polychlorinated Biphenyls	PCB	0.035
103-65-1	Propyl benzene	VOC	260
107-98-2	Propylene Glycol Monomethyl Ether	VOC	1,800
129-00-0	Pyrene	SVOC	77
7782-49-2	Selenium	METAL	13
7440-22-4	Silver	METAL	13
7440-24-6	Strontium, Stable	METAL	1,500
100-42-5	Styrene	VOC	520
1746-01-6	TCDD, 2,3,7,8- Dioxin and Dioxin-like PCBs, TEQ	DIOXIN/FURAN	0.00000053
95-94-3	Tetrachlorobenzene, 1,2,4,5-	SVOC	0.077
630-20-6	Tetrachloroethane, 1,1,1,2-	VOC	2.7
79-34-5	Tetrachloroethane, 1,1,2,2-	VOC	0.35
127-18-4	Tetrachloroethylene	VOC	15
58-90-2	Tetrachlorophenol, 2,3,4,6-	SVOC	77
109-99-9	Tetrahydrofuran	VOC	2,300
479-45-8	Tetryl (Trinitrophenylmethylnitramine)	WMD	5.2
7440-28-0	Thallium (Soluble Salts)	METAL	0.026
7440-31-5	Tin	METAL	1,500
108-88-3	Toluene	VOC	210
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2-	VOC	77,000
87-61-6	Trichlorobenzene, 1,2,3-	VOC	2.1
120-82-1	Trichlorobenzene, 1,2,4-	SVOC	2.4
71-55-6	Trichloroethane, 1,1,1-	VOC	5,200
79-00-5	Trichloroethane, 1,1,2-	VOC	1.2
79-01-6	Trichloroethylene	VOC	1.3
75-69-4	Trichlorofluoromethane	VOC	770
95-95-4	Trichlorophenol, 2,4,5-	SVOC	260
88-06-2	Trichlorophenol, 2,4,6-	SVOC	2.6

CAS	Chemical	Chemical Class	Fish Tissue RAG (mg/kg wet weight)
93-76-5	Trichlorophenoxyacetic Acid, 2,4,5-	PESTICIDE	26
93-72-1	Trichlorophenoxypropionic acid, -2,4,5	HERBICIDE	21
96-18-4	Trichloropropane, 1,2,3-	VOC	0.0023
526-73-8	Trimethylbenzene, 1,2,3-	VOC	26
95-63-6	Trimethylbenzene, 1,2,4-	VOC	26
108-67-8	Trimethylbenzene, 1,3,5-	VOC	26
118-96-7	Trinitrotoluene, 2,4,6-	SVOC	1.3
7440-33-7	Tungsten	METAL	2.1
7440-62-2	Vanadium and Compounds	METAL	13
108-05-4	Vinyl Acetate	VOC	2,600
593-60-2	Vinyl Bromide	VOC	NC
75-01-4	Vinyl Chloride	VOC	0.096
1330-20-7	Xylenes	VOC	520
7440-66-6	Zinc and Compounds	METAL	770

Notes: A Site-Specific Risk Assessment must be conducted for Subsistence Anglers.
These values are different from the Fish Tissue Action Levels (FTAL).

Table 8: Maine Soil Background UCLs*

Dry Weight Basis			Background UCLs (mg/kg)**			
CAS	Chemical	Chem Class	Undeveloped	Rural Developed	Urban Developed	Urban Fill
83-32-9	Acenaphthene	SVOC		0.06	0.1	0.085
208-96-8	Acenaphthylene	SVOC		0.8	0.64	0.18
120-12-7	Anthracene	SVOC		1.2	1	2.4
7440-38-2	Arsenic	METAL	12			
7440-39-3	Barium	METAL	44			
56-55-3	Benzo(a)anthracene	SVOC		13	1.60	8.9
50-32-8	Benzo(a)pyrene	SVOC		2	1.80	8.0
205-99-2	Benzo(b)fluoranthene	SVOC		2.40	10	21
191-24-2	Benzo(g,h,i)perylene	SVOC		1.10	4.3	2.8
207-08-9	Benzo(k)fluoranthene	SVOC		1.80	3.3	10
7440-43-9	Cadmium	METAL	0.25			
218-01-9	Chrysene	SVOC		2.1	7.4	13
7440-48-4	Cobalt	METAL	6.2			
7440-50-8	Copper	METAL	13			
53-70-3	Dibenzo(a,h)anthracene	SVOC		0.3	0.5	0.18
206-44-0	Fluoranthene	SVOC		3.7	11.00	16
86-73-7	Fluorene	SVOC		0.23	0.15	0.24
193-39-5	Indeno(1,2,3-cd)pyrene	SVOC		4.5	4.9	4
7439-92-1	Lead	METAL	22			
7439-96-5	Manganese	METAL	370			
91-57-6	Methylnaphthalene, 2-	SVOC		0.038	0.078	0.029
7439-98-7	Molybdenum	METAL	0.7			
91-20-3	Naphthalene	SVOC		0.2	0.24	0.073
7440-02-0	Nickel	METAL	18			
375-22-4	Perfluorobutanoic acid (PFBA)	PFAS		0.00014		
307-24-4	Perfluorohexanoic acid (PFHxA)	PFAS		0.00022		
375-95-1	Perfluorononanoic acid (PFNA)	PFAS		0.00015		
1763-23-1	Perfluorooctane sulfonic acid (PFOS)	PFAS		0.00028	0.0012	
335-67-1	Perfluorooctanoic acid (PFOA)	PFAS		0.00039		
85-01-8	Phenanthrene	SVOC		2.8	6	10

Dry Weight Basis			Background UCLs (mg/kg)**			
CAS	Chemical	Chem Class	Undeveloped	Rural Developed	Urban Developed	Urban Fill
129-00-0	Pyrene	SVOC		27.00	10	15
7440-62-2	Vanadium and Compounds	METAL	22			
7440-66-6	Zinc and Compounds	METAL	59			

Notes: * Background values in this table are 95% Upper Confidence Limits (UCLs) on the mean, determined using Maine statewide background data.

** The provided Background UCLs are for comparison to average soil concentration results. See Section 7.2.2.

- END -

Attachment A

Technical Support Document
For
2023 Remedial Action Guidelines

Effective Date: November 15, 2023

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
17 State House Station | Augusta, Maine 04333-0017
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Contents

Table of Tables

1 Introduction

This document presents the technical support for the 2023 Maine Remedial Action Guidelines (RAGs) for sites Contaminated with Hazardous Substances. The intention is to provide enough information so that the reader can reproduce the calculations that resulted in the 2023 RAG values. The document also explains the key changes from 2021 RAGs to the 2023 RAGs.

1.1 Consistency with Superfund Risk Assessment

The Maine Department of Environmental Protection (DEP) and Maine Center for Disease Control and Prevention (CDC) within the Maine Department of Health and Human Services (together "the Agencies") work collaboratively to develop the RAGs and its updates. The RAGs methodology is consistent with EPA's Superfund Risk Assessment Program.[1] Maine's RAGs are calculated based on:

- EPA Regional Screening Level (RSL) risk calculators (see Section 2);
- Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals) (RAGs Part B);[2] and
- Soil Screening Guidance: User's Guide, Technical Background Document and Supplemental Guidance.[3]

1.2 Scenarios, Media, Exposure Routes, and Risk End Points

The RAGs are based on exposure scenarios that typically drive the risk at contaminated sites (sites), namely: Resident (including leaching to groundwater), Park User, Commercial Worker, Construction Worker, and Recreational Fish Angler. The RAGs derived for these selected scenarios and specific media (i.e., soil, groundwater, sediment, indoor air, ambient air, and fish tissue) incorporate appropriate routes for potential exposure (ingestion, inhalation, and dermal contact). The RAGs target Maine's risk goal of not exceeding a 1 x 10^{-5} increased incremental lifetime cancer risk (ILCR) and/or a hazard quotient (HQ) of 1 for a Reasonably Maximum Exposed individual (RME). Following Superfund risk assessment protocol, the RME is derived by selecting a combination of average and high-end values for factors included in a risk assessment calculation. This results in above average exposure, or a "high end" exposure estimate, which is the highest exposure that is reasonably expected to occur at a site but that is still within the range of possible exposures. Following Superfund Risk Assessment protocol, cancer and non-cancer risks are first calculated separately. Then the lowest of the cancer and noncancer screening levels is selected as the final RAG.

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[1] Superfund is the name given to the *United States Comprehensive Environmental Response, Compensation, and Liability Act*, 42 U.S.C. §§ 9601-9675 .

[2] EPA webpage, "Risk Assessment: Risk Assessment Guidance for Superfund (RAGS): Part A [through part F]" from: https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part.

[3] EPA webpage, "Superfund Soil Screening Guidance," from: https://www.epa.gov/superfund/superfund-soil-screening-guidance.

The RAGs are presented in Tables 4 through 7 of the 2023 Maine Remedial Action Guidelines (RAGs) for contaminated sites.

2 Use of RSL Calculators to Generate Maine RAGs

2.1 Use of RSL Calculator

Beginning with the 2018 RAGs, the Agencies shifted from using internally developed and maintained Excel® workbooks for calculating RAG values, to using the United States Environmental Protection Agency's (EPA) Regional Screening Levels for Chemical Contaminants at Superfund Sites (RSL calculator).[4] The Agencies use the RSL calculator because it eliminates the need for Maine to duplicate much of the infrastructure being maintained by EPA and enhances consistency between Maine's clean-up guidance and those of the federal government and other states.

At that time, the principal changes were:

- Use of EPA RSL methodology to calculate most RAGs, instead of Maine-developed Excel® workbooks;
- A re-examination and refinement of methodologies used to calculate the RAGs that could not be calculated with the RSL methodology;
- The development of new RAGs for sediment exposure and fish consumption;
- Increased emphasis on the inhalation route of exposure from contaminated soil and water;
- Updated exposure assumptions based on EPA's 2011 Exposure Factors Handbook (including Residential Soil Inhalation Exposure Time);
- A review of available data on Maine-specific exposure assumptions;
- Reliance on the EPA hierarchy of toxicity values rather than former Maine approach of CDC researching each individual toxicity value to derive the most defensible;
- The use of contaminant specific inhalation and dermal contact modeling/exposure in the groundwater pathway, rather than a generic Relative Source Contribution factor of 20%; and
- Different exposure models were used for soil volatilization and soil dispersion modeling for the Construction Worker.

Details of these changes are described in the Technical Support Document (TSD) for the October 19, 2018 RAGs.

2.2 Introduction to RSLs

The Agencies use the EPA's RSL calculator to derive the RAGs. EPA's RSL team maintains a robust risk assessment methodology for deriving chemical-specific screening levels for various media (soil, water, air) at contaminated sites

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[4] EPA webpage, "Regional Screening Levels (RSLs)" from: https://www.epa.gov/risk/regional-screening-levels-rsls.

across the country. The EPA RSL website provides a user's guide, documentation of all equations used to generate screening levels, tables that present default chemical-specific parameters, generic screening level tables,[5] and a calculator tool that was used to derive more local, site-specific screening levels.[6] The home page of the EPA Regional Screening Level Generic Tables provides a convenient index with hyperlinks:

- Home Page[7]
- User's Guide
- What's New
- Frequent Questions
- Equations
- RSL Calculator
- Generic Tables
- Contact Us

The User's Guide and Frequent Questions sections provide explanations of the RSL approaches. The Equations section presents all the equations used for the screening level calculations. Please review the EPA Guidance for details of the default screening level derivation approaches. Maine has adopted most of EPA's default factors for risk assessment that are in the RSL calculator. This TSD focuses on the decisions the Maine agencies made in running EPA's RSL calculator, where Maine departs from standard RSL default factors, and where supplemental modeling was necessary.

2.3 Terminology Differences Between RSLs and Maine RAGs

This section discusses several RSL terms that have a different common term in Maine.

2.3.1 Chemical and Contaminant

In the RSL, hazardous substances are referred to as "chemicals," while DEP uses the term "contaminant" in the RAGs.

2.3.2 Residential Tap Water and Groundwater Scenario

The Residential Groundwater RAGs apply to residents exposed via ingestion, dermal contact, and inhalation to contaminated groundwater from a private water supply well. The RSL calculator refers to this pathway as the Tap Water pathway. Exposure occurs from consuming the contaminated water, during showering and bathing by inhalation, and dermal contact. Rather than using the term "groundwater," EPA's RSL

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[5] The screening levels use EPA default parameters from various regions of the US and use several target risk levels (i.e., 1×10^{-6} incremental lifetime cancer risk and a hazard quotient of 1 or 0.1). They are useful for screening in contaminants for further evaluation in a risk assessment but are too conservative to be suitable for clean-up criteria at sites.

[6] EPA Regional Screening Levels: https://www.epa.gov/risk/regional-screening-levels-rsls.

[7] EPA webpage, "Risk Assessment: Regional Screening Levels (RSLs), from: https://www.epa.gov/risk/regional-screening-levels-rsls.

team terms this the “Tap Water” route of exposure because in other parts of the country, this exposure can also occur via contamination of surface water supplies that are then supplied to residences. Such an exposure is improbable in Maine because public water supply standards would apply. So, while the RSL Residential calculator refers to this exposure scenario as Tap Water, the Agencies continue to refer to this exposure scenario as the Residential Groundwater scenario for the Maine RAGs.

2.3.3 Composite Worker and Commercial Worker

Maine has RAGs for the Commercial Worker. The Agencies modeled this scenario using the RSL Composite Worker scenario. The Composite Worker is a full-time employee working mostly outdoors on maintenance at a commercial facility, but also working indoors. The worker is exposed to surface soils from moderate digging and landscaping. The Composite Worker is expected to have an elevated incidental soil ingestion rate (100 milligrams per day) compared to an Indoor Commercial Worker and is assumed to be exposed to contaminants via the following pathways: incidental ingestion of soil, dermal contact with soil, and inhalation of volatiles and fugitive dust. The RSL Composite Worker scenario assumes year-round exposure (250 days/year) but is otherwise identical to the Outdoor Commercial Worker RSL scenario.

2.3.4 Recreator and Park User

The RSL uses the term Recreator while Maine continues to use its traditional term for this receptor, which is Park User. The current Park User soil RAG was derived with the RSL Recreator calculator, using Maine specific inputs for incidental ingestion of soil, dermal contact with contaminants in soil, and inhalation of volatiles and fugitive dust. The RAGs will continue to use the term Park User. The RAGs also include a sediment exposure pathway that was derived using the Recreator calculator. The term Recreator is retained for the sediment exposure pathway, to be consistent with the RSL and because the recreation will just as often occur at a lake front seasonal residence (aka camp, cottage, or cabin) in addition to a park setting.

2.3.5 Ambient Air and Indoor Air

The RSL refers to all air as “ambient air.” Maine has indoor air RAGs for the Residential and Commercial Worker scenarios that apply to exposure to air on the inside of a building. This is important because EPA risk assessment protocols call for an exposure period of 26 years to indoor air, but 70 years for outdoor air. In addition to Indoor Air Guidelines, DEP calculated Ambient Air RAGs, which are also called Maine’s Ambient Air Guidelines (AAGs). The Ambient Air RAGs apply to exposure to outdoor air and assume a lifetime (70 years) of exposure. In summary, while the RSL only uses the term “ambient air,” the Maine RAGs uses these procedures to calculate separate indoor and outdoor air guidelines.

2.4 RSL Calculator for Site-Specific Risk Assessments

The RSL calculators may also be used to conduct site-specific risk assessments for Maine sites. If risks are estimated using the RSL calculators, deviations from the Maine-specific inputs described in this document should be discussed with the Agencies. See Attachment B to the RAGs for further details.

3 General Inputs Into the RSL Calculators to Generate RAGs

The RSL calculators were used to generate Maine-specific RAGs based on Maine's target risk levels (HQ=1, ILCR=10^{-5}) and Maine-specific exposure parameters. Use of the calculators is a two-step process:

In Step 1, the first user input screen of the calculator requires selection of: target risk values, the specific exposure scenario and media being modeled, the chemicals for which RAGs are calculated, and the option to run the calculator in "Site-Specific" mode with "User-Provided" inputs. To meet the risk target used in Maine, the RSL calculator was used with a HQ of 1 and a target cancer risk level of $1\text{x}10^{-5}$.

Step 2 involves modifying the default exposure parameters to Maine-specific values. As detailed below, the current Maine RAGs were mostly derived using the EPA recommended exposure assumptions for Portland, Maine. The remaining Maine specific inputs included climate and activity pattern adjustments that were made due to significant differences from the national average.

The specific steps for running the calculator can be found in Standard Operating Procedure RWM-DR-029: Deriving and Updating the Maine Remedial Action Guidelines Using the EPA Regional Screening Levels Calculator, available at: https://www.maine.gov/dep/spills/publications/sops/index.html.

3.1 Exposure Inputs

The exposure factors input into the RSL calculator to generate the current RAGs are presented in TSD Table 21.

3.2 Regional-Specific Climate

Weather factors are an input into the RSL volatilization models. The weather inputs for Portland, Maine were selected for several reasons: Portland is the only Maine default city in the RSL model and Portland is representative of climatic conditions for most of Maine's population. Additionally, a sensitivity analysis indicates that variations in climate inputs within the State do not make a significant difference in the final RAG values.

3.2.1 Maine Climate & Soil Exposure Frequencies

Maine has historically departed from EPA default assumptions for the number of days per year that residents and commercial workers are exposed to soil, because the ground is frozen or snow covered a portion of the year, thus preventing incidental exposure. The Agencies derived the number of days that soil is frozen or snow-covered from 2001-2017 climatic data at five representative sites in Maine: (Portland, Bangor, Farmington, Caribou, and Gray). See TSD Table 1.

The Climate Change Institute (CCI) provided snow depth but not soil temperature. The 2-meter air temperature (T2) was used as a surrogate for soil temperature. Snow depth and T2 air temperatures were downloaded from the NOAA Applied Climate Information System website (https://scacis.rcc-acis.org/), which compiles various daily climate data sources and includes primarily data from the Global Historical Climatology Network (GHCN).[8] The CCI calculated daily average temperature by averaging hourly temperature measurements. The number of days per year with bare, unfrozen ground were calculated by subtracting the number of days per year with both bare (snow depth = 0) and frozen ground (average air temperature < 32° F) from the total number of days per year with bare ground. This is based on professional judgement that the number of days in the fall when the air is below freezing but the ground is unfrozen, is equal to the number of days in spring when the air is above freezing but the ground is still frozen. Years with any missing data were dropped from the analysis.

The Portland station is consistent with the RME approach since it averages the most bare, unfrozen ground days of the areas analyzed. The ground is neither frozen nor snow covered in the Portland area for an average of 256 days per year. The Commercial Worker exposure frequency was based on the 256 days per year adjusted by 5-workdays / 7-day-weeks to account for the work week for a total of 183 days per year.

3.2.2 Maine Rainfall - Construction Worker Soil Dispersion

The RSL model uses the number of days with total precipitation amounts greater than or equal to 0.01 inches to calculate the Construction Worker soil RAG. This factor was calculated from the days with total precipitation of at least 0.01 inches using the GHCN dataset for the five representative sites in Maine, as summarized in TSD Table 1.

The City of Portland was selected for the RAGs with 131 days per year as the number of days with ≥0.01″ precipitation.

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[8] Menne, M. J., Durre, I., Vose, R. S., Gleason, B. E., & Houston, T. G. (2012). An overview of the global historical climatology network-daily database. *Journal of Atmospheric and Oceanic Technology*, 29(7), 897-910.

TSD Table 1: Maine Precipitation Data Summary

	Days Bare Unfrozen Ground		Days with Precipitation ≥ 0.01"	
SITE	**Mean**	**Range**	**Mean**	**Range**
Portland	256	231-292	130.8	116-142
Bangor	251	229-278	137.1	115-149
Farmington	215	200-234	139.5	117-156
Caribou	215	197-244	162.5	147-174
Gray	237	216-268	141.7	122-161

3.3 RAG Contaminant List

The 2023 RAGs were updated to include 5 chemicals that have been found at contaminated sites in Maine and for which toxicity values were available in the RSL calculator. The following sections describe the process used to determine this list and describes which chemicals were detected in Maine environmental samples that require the development of toxicity factors to develop a RAG in the future.

3.3.1 Contaminants Detected in Maine's Environment That Do Not Have a RAG

DEP searched the Maine DEP Environmental and Geographic Analysis Database (EGAD) and determined the contaminants that had been detected in environmental media, in ten or more samples, in the past two years that did not have an associated RAG. EGAD contains most but not all results from environmental samples obtained by DEP. The comparison identified 39 contaminants for which a RAG was not available. These compounds were combined with the list identified during the 2021 RAGs update. TSD Table 2 groups the chemicals by classes for purposes of developing risk-based guidelines. TSD Table 3 shows the media that these missing guidelines fall into, ranked by the number of samples in EGAD that did not have a corresponding RAG.

As shown in TSD Table 2, most of these compounds fall into the PCB, PAH and PFAS categories so, if possible, methods should be developed to include these compounds into the chemical class. For PCBs, EPA has established a system for determining the risk of Aroclors and Co-planar PCBs (see TSD Section 3.4.5). EPA has also established protocols for evaluating risk posed by PAHs, and for the next RAG update the Agencies need to modify this approach to address the risk posed by the additional PAHs detected. As discussed in Section 3.4.7, a method needs to be established to determine the risk posed by the detected PFAS compounds for which toxicity factors are not available, as well as the thousands of PFAS compounds for which detection methods have not been developed.

In addition to the chemical classes described above, TSD Table 2 indicates that four compounds missing RAGs are radioactive. The DHHS low-level radioactive program is consulted when radioactive compounds are detected at a site. The table also indicates that the RSL calculator has toxicity factors for 5 compounds, and RAGs were developed for these compounds in this update of the RAGs, as listed in TSD Table 4. Finally, as listed in TSD Table 5, the Agencies should develop toxicity factors for developing RAGs for these compounds. TSD Table 5 lists the number of detections of these compounds over the past 7 years, which can be used to help prioritize the development of RAGs.

TSD Table 2: Number of Compounds in EGAD Without a Corresponding RAG, by Toxicity Groups

Category	Number of compounds
PCB compounds	278
PAH compounds	67
PFAS compounds	46
Radioactive	4
In RSL Calculator	13
Still Need Toxicity Data	76
Total identified	484

TSD Table 3: Percentage of Needed RAGs by Media Type

Media Type	%	Sample Type in Media Class
Tissue	39%	WHOLE
		HEPATOPANCREAS (TOMALLEY)
		MUSCLE
		WHOLE WITHOUT SKIN
		SKINLESS FILET
		SKIN-ON FILET
Solid	22%	SOIL
		SEDIMENT
		WIPE
		BUILDING MATERIAL
		SURFACE WATER SUBSTRATE
		VEGETATION
Aqueous	36%	GROUNDWATER
		SURFACE WATER
		LEACHATE
		PORE WATER
		STORM WATER RUNOFF
		PROCESS WATER
		LEAK DETECTION FLUIDS
		WASTE WATER

Gas	2%	SOIL GAS
		INDOOR AIR
		SUBSLAB GAS
		AIR
		OUTDOOR AIR
		LANDFILL GAS
Other	0.40%	NEAT SAMPLE
		WASTE
		UNKNOWN

TSD Table 4: RAGs Developed for These Contaminants

CAS-RN	**DTXSID**	**CONTAMINANT NAME**
75-65-0	DTXSID8020204	Tert-butyl-alcohol
637-92-3	DTXSID0025604	Ethyl t-butyl ether
355-46-4	DTXSID7040150	Perfluorohexane sulfonic acid
375-95-1	DTXSID8031863	Perfluorononanoic acid
13252-13-6	DTXSID70880215	Hexafluoropropylene oxide dimer acid
375-22-4	DTXSID4059916	Perfluorobutanoic acid
307-24-4	DTXSID3031862	Perfluorohexanoic acid

TSD Table 5: Compounds for Which RAGs are Still Needed

CASRN or EGAD ID	**PARAMETER NAME**	**Number of Detects in past 7 years**
Various	Aroclor-PCB (89 compounds)	25,363
Various	PFAS (45 compounds)	27,412
Various	PAH (67 compounds)	5,513
24959679	BROMIDE	953
99876	P-ISOPROPYLTOLUENE	799
594207	2,2-DICHLOROPROPANE	629
563586	1,1-DICHLOROPROPENE	629
7631869	SILICA	442
18496258	SULFIDE	387
110565	1,4-DICHLOROBUTANE	249
64175	ETHANOL	231
108703	1,3,5-TRICHLOROBENZENE	186
131113	DIMETHYL PHTHALATE	174
142825	N-HEPTANE	165
622968	P-ETHYLTOLUENE	154
115071	PROPYLENE	154
98953	NITROBENZENE	126
101553	4-BROMOPHENYL PHENYL ETHER	113
534521	4,6-DINITRO-O-CRESOL	113
108601	BIS(2-CHLOROISOPROPYL) ETHER	113

CASRN or EGAD ID	PARAMETER NAME	Number of Detects in past 7 years
621647	N-NITROSO-DI-N-PROPYLAMINE	113
100027	4-NITROPHENOL	113
111911	BIS(2-CHLOROETHOXY) METHANE	113
88744	2-NITROANILINE	113
7005723	4-CHLOROPHENYLPHENYL ETHER	113
99092	3-NITROANILINE	113
88755	2-NITROPHENOL	113
110861	PYRIDINE	112
77474	HEXACHLOROCYCLOPENTADIENE	110
994058	T-AMYL METHYL ETHER (TAME)	105
92875	BENZIDINE	101
103333	AZOBENZENE	98
62759	N-NITROSODIMETHYLAMINE	98
DEP1103	EXCHANGEABLE ALUMINUM	96
108872	METHYLCYCLOHEXANE	95
483658	RETENE	87
141786	ETHYL ACETATE	87
31317187	2,4-DIMETHYLDIBENZOTHIOPHENE	75
540841	2,2,4-TRIMETHYLPENTANE	75
76017	PENTACHLOROETHANE	74
76142	1,2-DICHLOROTETRAFLUOROETHANE	61
74884	METHYL IODIDE	54
94826	2,4-DB	18
120365	DICHLOROPROP	17
1918009	DICAMBA	17
94757	2,4-D (2,4-DICHLOROPHENOXYACETIC ACID)	17
DEP2002	PHENOL, TOTAL	16
68122	N,N-DIMETHYLFORMAMIDE	15
DEP2004	TRICHLOROTRIFLUOROETHANE	13
107415	N-BUTANOIC ACID	10
79094	PROPANOIC ACID	9
7726956	BROMINE	9
872980	5,5-DIMETHYL-1,3-DIOXANE	8
593453	N-OCTADECANE	7
6117993	2,4-DIMETHYLDODECANE	6
95932	1,2,4,5-TETRAMETHYLBENZENE	6
64186	FORMIC ACID	5
110758	2-CHLOROETHYL VINYL ETHER	5
7553562	IODINE	5
109524	VALERIC ACID	4
105055	1,4-DIETHYLBENZENE	3
109660	N-PENTANE	3
503742	I-PENTANOIC ACID	3
111842	NONANE	3
496117	INDAN	2

CASRN or EGAD ID	PARAMETER NAME	Number of Detects in past 7 years
142621	HEXANOIC ACID	2
7664382	PHOSPHORIC ACID	2
57556	PROPYLENE GLYCOL	2
57103	HEXADECANOIC ACID	1
634902	1,2,3,5-TETRACHLOROBENZENE	1
526750	2,3-DIMETHYLPHENOL	1
57114	STEARIC ACID	1
634662	1,2,3,4-TETRACHLOROBENZENE	1
527844	1-METHYL-2-ISOPROPYLBENZENE	1
756426581	9-CHOLOROHEXADECAFLUORO-3-OXANONANE-1-SULFONIC ACID	1
98555	ALPHA-TERPINEOL	1

3.3.2 Addressing Contaminants Not in RSL

Some contaminants detected at Maine sites are not included in the RSL database. However, RAG values can still be derived using the calculator, by typing the chemical name into the “Select Chemicals” entry box and then entering the physical-chemical properties of those contaminants. In the 2023 RAGs, this was done for 15 compounds, whose input parameters are presented in TSD Table 22**.**

3.4 Toxicity Values

3.4.1 Chronic Toxicity Hierarchy

The RSL Calculator uses EPA’s preferential hierarchy in selection of toxicity values. Maine first adopted EPA’s hierarchy with the 2018 RAGs after EPA put significant effort into updating its Integrated Risk Information System (IRIS), which is EPA’s primary tier for selecting toxicity factors. Further analysis is provided in the 2018 TSD for the RAGs.

3.4.2 Subchronic Toxicity Values

The Construction Worker exposure is a subchronic duration, and thus uses subchronic toxicity values where available. This may include some values from the Provisional Peer-Reviewed Toxicity Value (PPRTV) database, which are not as thoroughly vetted as other sources such as IRIS. Some of these toxicity values are even lower than the chronic toxicity values used in the RSL residential calculations. While it does not make sense that a chemical could be more toxic in a subchronic exposure (shorter time-period) than over the long-term at the same concentration, that is the result of using different toxicity data sources. The CDC decided to accept the EPA subchronic toxicity values as presented in the RSL with the expectation that the values will be updated by EPA RSL in the future.

3.4.3 Contaminants Lacking RSL Toxicity Values

Some contaminants in the RSL database do not have assigned toxicity values. For these contaminants, the Agencies selected toxicity values and entered them manually. For some compounds, toxicity values were not available, but the Agencies applied the toxicity factor from a surrogate compound that CDC believes would have a similar toxic impact. For a summary of these decisions, see TSD Table 6 below.

TSD Table 6: Source of Toxicity Values for Contaminants Lacking Toxicity Criteria in RSL

Contaminant Lacking RSL Toxicity Criteria	Toxicity Source or Surrogate Compound
Carbazole	Cancer Slope Factor - HEAST 1997
Acenaphthylene	Acenaphthene
Phenanthrene	Pyrene
Benzo(g,h,i)perylene	Pyrene
Dichlorobenzene, 1,3-	Dichlorobenzene, 1,2-

3.4.4 RfDs for Manganese and Cadmium

The IRIS database has two oral reference doses for both Manganese and Cadmium. Likewise, the RSL has two entries. After reviewing the basis, CDC determined that:

- **Manganese**: When making the chemical selection for manganese within the RSL calculator, the ‘Manganese (Non-diet)’ option should be selected for all soil, air, and water/tap water exposure calculations.
- **Cadmium:** When making the chemical selection for cadmium, within the RSL calculator the ‘Cadmium (Diet)’ option should be selected for all soil and air exposure calculations; the ‘Cadmium (Water)’ option should be selected for all water/tap water exposure calculations.

3.4.5 Toxicity Factors for PCBs and PCB groupings

Polychlorinated biphenyls (PCBs) are stable when heated and resist environmental degradation. They have been added to oils used in electrical transformers, light ballasts, and hydraulic fluids. They have also been added to caulks, paints, and a host of other products. PCBs are a contaminant of concern at numerous Superfund and uncontrolled hazardous substance sites in Maine.

The toxicity information for PCBs that is used in the RSL calculator is based on values published in IRIS and are further described in ATSDR toxicity profiles for PCBs.[9] Section 5.8 of the RSLs User’s Guide also has an explanation of how PCBs are handled. However, Brian Davis and Michael Wade have described the problems with applying these toxicity

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[9] ATSDR webpage, Toxicological Profile for Polychlorinated Biphenyls (PCBs), from: https://wwwn.cdc.gov/TSP/ToxProfiles/ToxProfiles.aspx?id=142&tid=26.

factors to the results of environmental samples and the adjustments that EPA has made to address these problems,[10] as follows.

PCBs are sold as Aroclors and are named based on the percentage of chlorine in the mixture: an Aroclor that is 60% chlorine by weight is marketed as Aroclor 12**60**. These Aroclors are mixtures of varying amounts of 209 differing PCB congeners. PCBs are biphenyl molecules linked by a carbon-carbon bond at the 1-1’ position, with 10 additional positions on the phenyl rings that a chlorine may attach to. Each of the 209 congeners is defined by where 1 to 10 of these additional chlorines attach.

The Aroclors transform in the environment, as some congeners more readily degrade, sorb to carbon, volatilize, and solubilize in water or solvents as compared to other congeners. Davis and Wade found the following.[10]

FATE AND TRANSPORT OF PCBs

- Variability in the physical and chemical properties of different PCB congeners results in variable behavior in the environment.
- Volatility and mobility in the atmosphere increase with decreasing chlorination. Atmospheric transport is an important mechanism for worldwide dispersion.
- PCBs enter water bodies from water channels and atmospheric deposition. PCBs leave water bodies by volatilization. PCBs are exchanged between the water column and sediments.
- PCBs strongly sorb to soils, limiting mobility.
- Rates of photochemical degradation in the atmosphere decrease with increasing chlorination. Half-lives of PCB congeners in soils and sediments are on the order of months and years.
- Biodegradation (bacterial) results in selective dechlorination, enriching ortho-substituted congeners.

Toxicity information is only available for select, virgin Aroclors, not weathered Aroclors. The ramification is that when environmental samples are collected and analyzed for a given Aroclor, due to changes during transport and weathering, the actual make-up of the congeners within the Aroclor will be different than the mixtures upon which the toxicity studies were performed. To address this fate, transport and weathering issue, EPA’s IRIS database has different slope factors and recommendations on which toxicity factor to apply to PCBs found in different media, routes of exposure, and life stage, as summarized in TSD Table 7. RSL uses the recommendations of IRIS. The toxicity information on PCBs is additionally complex because non-carcinogenic Reference Doses are only available for two Aroclors (1016 and 1254), while slope factors (for carcinogenic effects) are available for four (1016, 1242, 1254 and 1260)

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[10] Brian Davis and Michael Wade, Risk Assessment of Polychlorinated Biphenyls at Hazardous Waste Sites, from: https://dtsc.ca.gov/wp-content/uploads/sites/31/2018/01/Risk-Assess-PCB.pdf, March 2003.

and are published as ranges. However, the non-carcinogenic effects will sometimes result in an adverse impact at a lower concentration than carcinogenic effects (i.e. "drive the risk"). Therefore, Davis and Wade recommend always evaluating the non-cancer impacts. However, there is no good surrogate RfD for Low persistent PCBs, as shown in TSD Table 7.

Non-carcinogenic risk from PCBs is considered for the Construction Worker Soil exposure scenario. This is viewed as appropriate based on the shorter exposure period for this scenario. Per EPA guidance, as illustrated in TSD Table 7, Aroclor 1254 is used as a surrogate for the evaluation of exposure risk from PCBs (high-risk), for the Construction Worker Soil scenario only. Employment of the subchronic, non-carcinogenic reference dose for Aroclor 1254 results in a lower Construction Worker Soil RAG than would be calculated using the PCBs (high-risk) default values in the RSL database.

TSD Table 7: Classification of PCB Aroclors in RAGs[11]

Persistence (resistance to weathering)	High	Low	Lowest
Non-Cancer Toxicity Based on Aroclor	1254	N/A	1016
Cancer Toxicity Based on Aroclor	1260 & 1254	1242	1016
Criteria for use	• Food chain exposure • Sediment or soil ingestion • Dust or aerosol inhalation • Dermal exposure if absorption factor applied • Dioxin-like, tumor-promoting, or persistent congeners • Early-life exposure	• Ingestion of water-soluble congeners • Inhalation of evaporated congeners • Dermal exposure, if no absorption factor has been applied	• Congeners with more than four chlorines comprise less than 0.5% of total PCBs

A more direct way to measure PCB toxicity is to analyze for individual congeners at the site, then compare results based on the toxicity of the congener. IRIS does not publish toxicity information on the congener level. However, "coplanar PCB" congeners (lacking two chlorines in the ortho position) have toxicity effects like dioxins, and at very low concentrations, so are included in the dioxin-TEQ RAG.

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[11] Adopted from Brian Davis and Michael Wade, Risk Assessment of Polychlorinated Biphenyls at Hazardous Waste Sites from: https://dtsc.ca.gov/wp-content/uploads/sites/31/2018/01/Risk-Assess-PCB.pdf, March 2003.

3.4.6 Dioxins

Dioxins and dioxin-like compounds are handled in accordance with the toxic equivalence approach of the World Health Organization.[12] EPA in its Chem Tox Database,[13] summarizes this system as follows:

> "Dioxins and dioxin-like compounds (DLCs) are compounds that are highly toxic environmental persistent organic pollutants. Dioxins have different toxicity depending on the number and position of the chlorine atoms. Because dioxins refer to such a broad class of compounds that vary widely in toxicity, the concept of toxic equivalency factor (TEF) has been developed to facilitate risk assessment and regulatory control. Toxic equivalence factors (TEFs) exist for seven congeners of dioxins, ten furans and twelve PCBs as identified in a World Health Organization Report. The reference congener is the most toxic dioxin 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) which per definition has a TEF of one. This compound is extremely stable and consequently tends to accumulate in the food chain having a half-life of 7 to 9 years in humans. This list of DLCs include those for which TEFs were reported in the WHO report."

TSD Table 8: List of Dioxin & Dioxin Like Compounds

DTXSID	PREFERRED NAME	CASRN
DTXSID2021315	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6
DTXSID5022514	3,3',4,4'-Tetrachlorobiphenyl	32598-13-3
DTXSID6023781	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408-74-3
DTXSID0023824	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	57653-85-7
DTXSID4025799	Octachlorodibenzo-p-dioxin	3268-87-9
DTXSID6029915	1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9
DTXSID7030066	2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4
DTXSID4032116	2,3',4,4',5-Pentachlorobiphenyl	31508-00-6
DTXSID3032179	3,3',4,4',5-Pentachlorobiphenyl	57465-28-8
DTXSID8038306	2,3,3',4,4'-Pentachlorobiphenyl	32598-14-4
DTXSID2038314	3,3',4,4',5,5'-Hexachlorobiphenyl	32774-16-6
DTXSID1052034	1,2,3,4,6,7,8-Heptachlorodibenzodioxin	35822-46-9
DTXSID3052062	Octachlorodibenzofuran	39001-02-0
DTXSID8052067	1,2,3,4,7,8-Hexachlorodibenzodioxin	39227-28-6
DTXSID7052078	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	40321-76-4
DTXSID3052147	2,3,7,8-Tetrachlorodibenzofuran	51207-31-9
DTXSID9052216	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7

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[12] Martin Van den Berg, Linda S. Birnbaum, Michael Denison, Mike De Vito, William Farland, Mark Feeley, Heidelore Fiedler, Helen Hakansson, Annika Hanberg, Laurie Haws, Martin Rose, Stephen Safe, Dieter Schrenk, Chiharu Tohyama, Angelika Tritscher, Jouko Tuomisto, Mats Tysklind, Nigel Walker, Richard E. Peterson, "The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds", Toxicological Sciences, Volume 93, Issue 2, October 2006, Pages 223–241 from: https://academic.oup.com/toxsci/article/93/2/223/1707690.

[13] EPA's CompTox Chemistry Dashboard from: https://comptox.epa.gov/dashboard/chemical_lists/DIOXINS.

DTXSID	PREFERRED NAME	CASRN
DTXSID7052234	1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6
DTXSID3052276	2,3,4,6,7,8-Hexachlorodibenzo[b,d]furan	60851-34-5
DTXSID8052350	1,2,3,4,6,7,8-Heptachlorodibenzo[b,d]furan	67562-39-4
DTXSID9052470	1,2,3,7,8,9-Hexachlorodibenzo[b,d]furan	72918-21-9
DTXSID0052706	2,3,3',4,4',5-Hexachlorobiphenyl	38380-08-4
DTXSID2069155	1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9
DTXSID4074144	2,3,3',4,4',5,5'-Heptachlorobiphenyl	39635-31-9
DTXSID7074165	2,3',4,4',5,5'-Hexachlorobiphenyl	52663-72-6
DTXSID6074205	2,3,3',4,4',5'-Hexachlorobiphenyl	69782-90-7
DTXSID6074209	3,4,4',5-Tetrachlorobiphenyl	70362-50-4
DTXSID9074226	2,3,4,4',5-Pentachlorobiphenyl	74472-37-0
DTXSID50867160	2',3,4,4',5-Pentachlorobiphenyl	65510-44-3

3.4.7 Toxicity Factors for Perfluoroalkyl Substances (PFAS)

Per- and polyfluoroalkyl Substances (PFAS) refers to a family of manmade per- and polyfluorinated organic chemicals. PFAS are carbon chain atoms that are totally fluorinated (perfluorinated) or partially fluorinated (polyfluorinated). Compared to other contaminants, PFAS physical and chemical properties are unique (e.g. surfactant, oil-repelling, water-repelling), which impacts fate and transport in unique ways. PFAS present risks at low concentrations, are found in environmental media and biota worldwide, are resistant to degradation, and bioaccumulate.[14] EPA’s COMPTOX database lists more than 10,000 known individual PFAS by a unique identification number (DTXSID) and the traditional Chemical Abstract System Registry Number (CASRN).[15] Any reference to an individual PFAS, in this document, is intended to include the PFAS and its anions and salts.

PFAS toxicity and mode of actions are being intensely studied and our understanding is rapidly changing. There are currently eight PFAS with default toxicity values included in the RSL database. These PFAS are perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorobutane sulfonic acid (PFBS), perfluorobutanoic acid (PFBA), perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS), perfluorohexanoic acid (PFHxA), and hexafluoropropylene oxide dimer acid (HFPO-DA, commonly known as GenX Chemicals). Any site-

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[14] Interstate Technology Regulatory Council (ITRC), Per- and Polyfluoroalkyl Substances (PFAS) Fact Sheets, from: https://pfas-1.itrcweb.org/fact-sheets/.

[15] EPA, Comptox Database website, Lists page from: https://comptox.epa.gov/dashboard/chemical_lists). Citation: The CompTox Chemistry Dashboard: a community data resource for environmental chemistry, Antony J. Williams, Christopher M. Grulke, Jeff Edwards, Andrew D. McEachran, Kamel Mansouri, Nancy C. Baker, Grace Patlewicz, Imran Shah, John F. Wambaugh, Richard S. Judson & Ann M. Richard, Journal of Cheminformatics volume 9, Article number: 61 (2017)

specific risk assessment performed under this guidance should include all PFAS with toxicity factors included in the RSL database and should use the most current chemical-specific and toxicity information.

On June 21, 2021, Maine adopted an Interim Drinking Water Standard of 20 ng/L for the sum of 6 PFAS compounds: PFOA, PFOS, PFHpA, PFHxS, PFNA, and PFDA.[16] These PFAS, including their anions and salts, are referred to as the "Maine Regulated PFAS Contaminants." This standard for the Maine Regulated PFAS Contaminants should be used when assessing the residential groundwater exposure pathway.

For this version of the RAGs, the Soil Leaching to Groundwater RAGs for PFOA, PFOS, PFHxS and PFNA were calculated based on a residential groundwater receptor concentration of 20 ng/L, in accordance with the Maine PFAS Interim Drinking Water Standard.

DEP studies and CDC risk analysis suggests that crop pathways may drive the risk for PFAS in some instances. The science and legal status of PFAS is rapidly changing. Therefore, this version of the RAGs references the DEP website for additional exposure scenarios. This version also directs a "case-by-case" determination of potential risk from the vast majority of PFAS for which the Agencies have not developed risk-based guidelines. See section 7.8.

4 Groundwater Calculations

4.1 Residential Exposure to Groundwater

The Residential Groundwater RAGs assume that the groundwater is consumed at a residence from a well installed in the contaminated aquifer. To derive the Residential Groundwater RAGs, the Agencies used the RSL calculator for Tap Water and EPA default exposure parameters. A groundwater ceiling value of 100,000 µg/L was applied for contaminants exceeding 100,000 µg/L in accordance with RSL protocols.

Note that the EPA Drinking Water Program's approach to developing risk-based guidance differs from the EPA Superfund risk assessment approach that is built into the RSL calculator. Under the drinking water methodology, only ingestion risk is calculated. Then EPA applies a generic Relative Source Contribution (RSC) factor to account for all other uncalculated exposures, including ingestion from other sources (e.g. soil, food), and inhalation and dermal contact during showering or bathing. In contrast, the RSL calculates ingestion risk as well as chemical-specific risk from dermal contact and inhalation during showering and

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[16] Resolve, To Protect Consumers of Public Drinking Water by Establishing Maximum Contaminant Levels for Certain Substances and Contaminants, Downloaded December 8, 2022 from: http://www.mainelegislature.org/legis/bills/getPDF.asp?paper=SP0064&item=3&snum=130

bathing. RAGs are also developed to address exposure to contaminants from other media at the site (e.g. soil, sediment, fish tissue). This discrepancy is justifiable since the Superfund Program prevents exposure to these other sources at a site, while the Drinking Water Program does not have the regulatory ability to control exposure to these other sources. In Maine, laws like the Uncontrolled Sites Law afford the same ability to control risks from all media at a site, not just groundwater.

4.2 Construction Worker Exposure to Groundwater

Maine is one of the few states that develops clean-up guidance for Construction Worker exposure to contaminated groundwater. These RAGs are based on risks posed to workers performing subsurface construction and utility maintenance, typically in a trench, that may be exposed to contaminated groundwater. They were derived using the EPA RSL calculator for Residential Tap Water exposure in the site-specific mode. This calculator includes dermal, incidental ingestion and inhalation exposure pathways from water. TSD Table 9 shows the changes made to the various parameters within the RSL Residential Tap Water calculator to adjust for a Construction Worker exposure scenario. This scenario models an average adult Construction Worker that spends half of an eight-hour workday in an excavation trench, in contact with contaminated groundwater, one day per week over a one-year period. The Construction Worker groundwater ingestion rate of 0.015 liter/day is based on U.S. EPA Exposure Factors Handbook, 2019, Table 3-93. Estimated Water Ingestion During Water Recreation Activities,[17] mean ingestion rate while wading/splashing (3.7 milliliter per hour, 4 hours per day).

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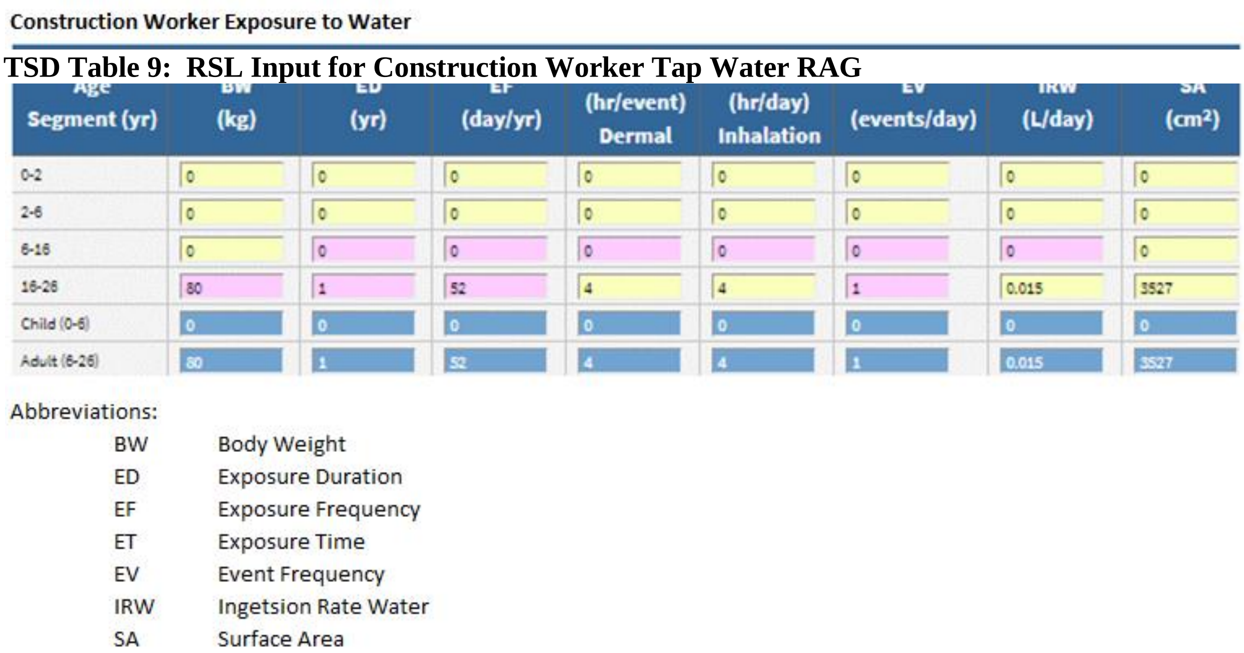
[17] EPA's Exposure Factors Handbook, 2019, Chapter 3: Ingestion of Water and Other Select Liquids. https://www.epa.gov/sites/default/files/2015-09/documents/efh-chapter03.pdf

TSD Table 9: RSL Input for Construction Worker Tap Water RAG



Construction Worker Exposure to Water

Age Segment (yr)	BW (kg)	ED (yr)	EF (day/yr)	(hr/event) Dermal	(hr/day) Inhalation	EV (events/day)	IRW (L/day)	SA (cm²)
0-2	0	0	0	0	0	0	0	0
2-6	0	0	0	0	0	0	0	0
6-16	0	0	0	0	0	0	0	0
16-26	80	1	52	4	4	1	0.015	3527
Child (0-6)	0	0	0	0	0	0	0	0
Adult (6-26)	80	1	52	4	4	1	0.015	3527

Abbreviations:

BW	Body Weight
ED	Exposure Duration
EF	Exposure Frequency
ET	Exposure Time
EV	Event Frequency
IRW	Ingetsion Rate Water
SA	Surface Area

The equations used in the RSL Residential Tap-water calculator are appropriate to estimate ingestion and dermal risks for the Construction Worker. However, the Residential model is not appropriate for inhalation of vapors in a trench. Therefore, the Residential Tap Water RSL volatilization factor (VF) was set to 1 and volatilization in an excavation trench was calculated externally using methodology developed by the Virginia Department of Environmental Quality.[18] The modeled VFs were applied to the Residential Tap-water calculator's inhalation pathway output. After the volatilization factor was applied, the calculated screening values for the ingestion, dermal, and inhalation exposure pathways were combined and the lower of the cancer and noncancer RAG was selected. A groundwater ceiling value of 100,000 µg/L was applied for contaminants with very high risk-based screening levels, consistent with RSL guidance.

5 Indoor Air and Ambient Air

Use caution with Indoor Air and Ambient Air terminology, as discussed in Section 2.3.5. The primary differences between the Residential Air RAGs, the Commercial Air RAGs, and the Ambient Air RAGs are the exposure time, exposure duration, and exposure frequency used to model the exposure scenarios.

The Residential and Commercial Air RAGs assume that the contamination is local to the subject residence or business. Therefore, if an individual moves to a new home or place of business, they are no longer exposed. The Residential Air RAGs use an exposure time

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[18] Virginia Unified Risk Assessment Model-VURAM User's Guide, Appendix 3, 2016

of 24 hours/day, an exposure frequency of 350 days/year to account for the number of days that the average person would be expected to be away from their home (vacations, holidays, etc.) and an exposure duration of 26 years (the standard time period that a person might be expected to live at one location). These are the default exposure parameters for this exposure scenario in the RSL calculator.

The Commercial Worker Air RAGs use a similar scenario with an exposure time of 8 hours/day and an exposure frequency of 250 days/year and an exposure duration of 25 years, to model a typical work week of 40 hours (accounting for annual holidays) over a career.

The Ambient Air RAGs are intended to be applied to outdoor air over a broad area. If an individual lives in a town with contamination in the outdoor air, moving to another home in that town might not change their exposure. Therefore, the Ambient Air Guidelines use an exposure time of 24 hours/day, an exposure frequency of 365 days/year and an exposure duration of 70 years (lifetime). Note that, the exposure duration for exposure to chemicals with mutagenic effects was also adjusted to a total of 70 years, when calculating the Ambient Air RAGs.

6 Fish Tissue – Recreational Angler Only

The RAGs for Fish Consumption were calculated using the RSL calculator. Note that unlike most RAG values, Fish RAGs are presented in wet-weight rather than on a dry-weight basis. For inputs to the RSL calculators, the Agencies used a fish tissue ingestion rate of a single 8-ounce meal per week, which equates to 32.4 g per day. This exposure corresponds to a recreational angler in Maine, not a subsistence angler. Please be sure to consult with DEP to determine appropriate fish sampling and analysis as these will have a large impact on accurately calculating Exposure Point Concentrations. All other inputs to the RSL Fish Tissue calculator were EPA defaults.

The Agencies were unable to develop RAGs for subsistence Anglers because consumption rates vary too much between sites. However, the RSL calculator could be used on a site-specific basis to estimate risk for subsistence anglers, after consulting with CDC on appropriate consumption rates for the site.

7 Soil & Sediment Calculations

7.1 Introduction

Be sure to review section 2.3 for the terminology differences between the Maine RAGs and RSL calculator. The Agencies ran the RSL calculators to derive the RAGs for the Resident, Park User, Commercial Worker, Construction Worker and Recreator Sediment exposures using the inputs provided in TSD Table 21. As discussed in section 3.2 above, Maine-specific climate inputs were used to generate soil RAGs. The RSL output for each exposure scenario was compiled into the final RAG tables.

7.1.1 Exposure Time to Residential Soil

The Agencies use the default EPA exposure time of 24-hours per day for potential exposure to volatiles from soil. This is a protective assumption to compensate for volatiles from soil that may migrate to the air inside a residence.

7.1.2 Soil Ceiling Limit

Maine remediation programs have a long-standing policy of removing neat product and saturated soil before applying risk-based clean-up levels to a site. The RSL Guidance uses a default ceiling limit of 100,000 mg/kg for a contaminant, which is equivalent to a chemical representing 10% by weight of the soil sample. At this contaminant concentration (and higher), the assumptions for soil contact may be violated (for example, soil adherence and wind-borne dispersion assumptions) due to the presence of the foreign substance itself. Maine applies the theoretical ceiling limit of the RSL for consistency with EPA. Note that the RSL calculator does not currently present the option to apply the ceiling limit to the Leaching to Groundwater scenario, so any chemicals with calculated Leaching values over 100,000 mg/kg were manually overridden.

7.2 Overview: RAGs for Petroleum Hydrocarbon Fractions

Petroleum consists of a complex mixture of hydrocarbons. After grouping the petroleum hydrocarbons into hydrocarbon fractions, risk assessors apply toxicity factors to each fraction, and thereby calculate the risk of the whole mixture. The Agencies have employed this approach in Maine since 2010. Note that Maine does not use the default RSL calculator for petroleum. Because the RSL ranges do not correspond to the results of any established laboratory method, it is not possible to develop an exposure point concentration to compare to the RSL petroleum hydrocarbon ranges.

The soil RAGs for the petroleum hydrocarbon fractions are derived with user-provided chemical information for the hydrocarbon fractions measured by the Extractable Petroleum Hydrocarbon (EPH) and Volatile Petroleum Hydrocarbon (VPH) test methods (see TSD Table 10). The Agencies obtained these inputs from the 2003 MADEP "Updated Petroleum Hydrocarbon Fraction Toxicity Values for the VPH/EPH/APH Methodology" and the 2002 MADEP "Characterizing Risks Posed by Petroleum Contaminated Sites." These constants are presented in TSD Table 22. EPH/VPH methods report concentrations for specific petroleum target compounds. The toxicity of the ranges is calculated after the toxicity of the target compound concentrations have been subtracted.

The petroleum hydrocarbon range soil RAGs were generated using two volatilization models: Infinite Source with no C_{sat} substitution for the inhalation pathway; and use of Mass-Limited volatilization with a source depth of 3 meters.[19] The three RSL results were compared, and the highest value was selected as the RAG (per EPA's RSL guidance).

More details on the reasons for generating Petroleum RAGs using this approach are in the sections below.

TSD Table 10: EPH/VPH Defined Hydrocarbon Fractions

Hydrocarbon Fraction	Analytical Method
C9-C18 aliphatics	EPH
C19-C36 aliphatics	EPH
C11-C22 aromatics	EPH
C5-C8 aliphatics	VPH
C9-C12 aliphatics	VPH
C9-C10 aromatics	VPH

7.3 Volatilization Modeling: Infinite vs. Finite Source

7.3.1 Overview

The RSL soil calculators combine the exposure pathways of ingestion (SL_{ing}), inhalation (SL_{inh}), and dermal absorption (SL_{der}). The SL_{inh} includes exposure from chemical constituents both adhered to inhaled particulates, and those that are volatilized into the air. For chemicals that are volatile, the RSL calculates a Volatilization Factor (VF) to model vapor released from soil from a wide range of contaminants. The RSLs have the option to calculate chemical-specific VFs with two different volatilization models, the Infinite Source model and the Mass-Limit model. The Infinite Source model assumes an infinite source of contamination continues to add vapors based on chemical-specific properties. The Mass-Limit model assumes a finite source fully volatilizing at a constant rate over a defined period, based on one set of generic chemical properties.

EPA's SSL guidance recommends running both models, then, selecting the higher of the two SSLs as the final SSL for each parameter within each exposure pathway (Residential, Construction Worker, Commercial Worker, Park User and Recreational Sediment). However, the Mass-Limit model can only be run when contaminant mass can be reliably estimated, requiring site-specific inputs for source depth and area.

Also note that the Infinite Source model does not account for degradation of chemicals over time, which can be significant for compounds like petroleum. This Section explains how the Agencies handled these two issues.

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[19] Average depth to groundwater in Maine.

7.3.2 Run I: Infinite Source of Volatile Chemicals

The "Infinite Source" approach assumes a constant supply of vapors from the chemical source in the soil. This approach has the potential to derive SSLs that defy conservation of mass in the case of small spills and/or highly volatile chemicals. These compounds would be depleted over time in a real-world scenario, but the model still assumes constant replenishment. On the positive side, chemical-specific parameters are used to model environmental fate.

7.3.3 Option II: Finite Source of Volatile Chemicals

The RSL's "Mass-Limit" model of volatilization, on the other hand, limits the total mass that is volatilized. However, the Mass-Limit model does not utilize any chemical specific information.[20] Instead the model simply volatilizes the entire mass of contamination at a constant rate, over the exposure time period until the source has been depleted. This tends to overestimate volatilization of heavy molecules with low vapor pressures,[21] such as dioxins, that might not fully volatilize on their own over the given time period (26 years for the Residential scenario). Further, the model requires site-specific source depth and area information to calculate the initial contaminant mass at the site, so EPA's RSL recommendation is to only use this model in site-specific circumstances.[22]

7.3.4 Use of Mass-Limit Model for Petroleum Hydrocarbon Fractions

The default, Infinite Source RSL volatilization model does not consider a chemical's degradation in soil over time. The relatively high degradability of petroleum contamination makes the RSL's Infinite Source Volatilization Model overly conservative for calculation of the petroleum RAGs. To address this over estimation, DEP developed a reasonable worst-case source mass to run the RSL Mass-Limit Volatilization Model for calculating soil RAGs for the six petroleum hydrocarbon fractions. Per EPA guidance, both volatilization models were run and the higher of the two resulting SLs was chosen as the RAG. Only the Construction Worker Soil scenario has petroleum hydrocarbon RAGs that are based on the Infinite Source volatilization model.

Research by DEP's petroleum program indicates that the reasonable worst-case scenario is a release from a large, underground petroleum

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[20] The Mass-Limit VF method assumes the entire contaminant mass is released over a defined exposure period regardless of chemical-specific volatilization parameters. The only parameters needed for the Mass-Limit VF equation are source depth, soil bulk density, exposure, and a time dispersion factor that is based on climate-specific conditions and contamination area in acres.

[21] The RSLs consider volatilization for any chemical with a vapor pressure >1 mmHg or a Henry's Law constant >0.00001 atm*m^3/mole.

[22] EPA 1996 Soil Screening Guidance: Technical Background Document from: https://nepis.epa.gov/Exe/ZyPDF.cgi/100025LM.PDF?Dockey=100025LM.PDF, May 1996 and EPA RSL User's Guide from: https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide.

tank.[23] The total mass is set at 15,000 gallons, because 93% of registered tanks are 15,000 gallons or less. The depth of the contamination mass is limited by the release point, (the bottom of the tank) and the top of the water table, because petroleum is a light non-aqueous phase liquid (LNAPL) that floats on the water table. The top of the water table is based on the average depth to groundwater in Maine.

7.3.5 Hazardous Substances - Used Infinite Source Volatilization Model

Following EPA guidance, the Infinite Source VF method was used as the default method to generate the RAGs for hazardous substances because the DEP could not establish generic default values for thickness of the source area and area of the release. For hazardous substance there is too much variability between individual sites to develop a reasonable worst-case generic scenario.

If site-specific information is available and the project lead wishes to generate site-specific risk-based cleanup goals for a select set of contaminants at a site, then the RSL calculator is available to run both the Infinite Source and Mass Limit models.

7.4 Soil Saturation with VOCs

7.4.1 Hazardous Substances – Replace SL_{inh} with C_{sat}

The RSL calculator derives a soil saturation concentration (Csat) for those contaminants that are both volatile and liquid at ambient soil temperatures. The C_{sat} is the contaminant concentration in bulk soil at which free-phase product is predicted to be present. The presence of free-phase product violates a key principle of the volatilization factor (VF) model (i.e., that Henry's Law applies) making RSL VF model results unreliable at concentration levels above the C_{sat}. For most contaminants, the Agencies selected the option to substitute the C_{sat} for the inhalation-based soil screening level if the C_{sat} was lower than the calculated risk-based inhalation screening level. This results in a lower allowable soil concentration and therefore a lower RAG. Selection of the C_{sat} substitution in the RSL calculator replaced the SL_{inh} value with the C_{sat} for 22 volatile chemicals for the residential scenario as shown in TSD Table 11, resulting in SLs that are between 1% and 93% of the default soil inhalation model.

If a project lead wants a more accurate site-specific risk-based number, pore vapor concentrations should be measured directly. Alternatively, the project lead can use an appropriate four-phase model with site-specific inputs to more accurately estimate inhalation risk.

7.4.2 Petroleum - No C_{sat} Substitution

At petroleum remediation sites in Maine, free product/light non-aqueous phase liquid (LNAPL) and oil-saturated soils are required to be removed

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[23] Maine DEP, Remediation Guidelines for Petroleum Contaminated Sites in Maine, Appendix D, Development of Leaching Based Soil Guidelines (Maine DEP, 17 SHS, Augusta, Maine 04333-0017), amended May 23, 2014 from: https://www.maine.gov/dep/spills/petroleum/lust-qap-2019/Apx-D-2019.pdf.

upon discovery, per Maine statute. Therefore, the C_{sat} substitution is not necessary at petroleum contaminated sites for modeling long term exposure risk due to volatilization. The use of the C_{sat} to generate screening levels for petroleum results in exaggerated inhalation risks (see Section 7.5). Therefore, the C_{sat} substitution option was not utilized for calculating the petroleum hydrocarbon fraction RAGs.

7.5 Sensitivity Analysis: Volatilization Model and Soil Saturation

The effect of not considering mass-limited VFs and substituting the C_{sat} on the RAGs is illustrated in TSD Table 11. In the examples, the RSL calculator was used to generate soil RAGs using the default Infinite Source VF model with and without the C_{sat} substitution (see Section 7.3).

TSD Table 12 evaluates the use of the Mass-Limit VF model and the omission of the C_{sat} substitution for the petroleum hydrocarbon ranges. The first three data columns represent 1) calculated SLs with the infinite source VF model and the C_{sat} substitution; 2) calculated SLs with the infinite source VF model and no C_{sat}; 3) calculated SLs with the Mass Limit VF model and no C_{sat}. For the C5-C8 Aliphatic hydrocarbon fraction Residential soil exposure, the infinite source VF with C_{sat} substitution results in the lowest screening level of 153 mg/kg. Without the C_{sat} applied, the level is 246 mg/kg. If a 3-meter source depth is assumed with the mass limit VF model, the screening level is 1660 mg/kg. Particularly for petroleum hydrocarbon fractions, application of the C_{sat} results in much lower screening levels. Four out of the six petroleum hydrocarbon fraction RAGs are based on a mass limit VF based inhalation risk SL.

TSD Table 11: Effect of C_{sat} Substitution for Inhalation on Residential Soil Screening Levels

					2018 Residential Soil RAG with Csat		SL without Csat	
Chemical	**2018 Residential Soil RAG with Csat (mg/kg)[24]**	**SL without Csat**	**% Csat SL / default model SL**	**Csat**	**Ingestion SL (mg/kg)**	**Inhalation SL (mg/kg)**	**Ingestion SL (mg/kg)**	**Inhalation SL (mg/kg)**
Cyclohexane	117	9720	1.2%	117	-	117	-	9720
Chloro-1,1-difluoroethane, 1-	1150	79900	1.4%	1150	-	1150	-	79900
Propyl benzene	258	5390	4.8%	264	10700	264	10700	10900
Trichloroethane, 1,1,1-	639	12100	5.3%	640	214000	640	214000	12800
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	3360	49300	6.8%	3360	-	3360	-	49300
Cumene	262	2840	9.2%	268	10700	268	10700	3860
Styrene	834	8650	9.6%	867	21400	867	21400	14500
Ethyl Chloride	2120	20100	11%	2120	-	2120	-	20100
Toluene	746	6810	11%	818	8550	818	8550	33300
Dichlorobenzene, 1,2-	362	2640	14%	376	9620	376	9620	3630
Mercury (elemental)	3	16	19%	3	-	3	-	16
Xylenes	256	856	30%	260	21400	260	21400	892
Methyl Methacrylate	2320	6580	35%	2360	150000	2360	150000	6890
Trimethylbenzene, 1,3,5-	156	391	40%	182	1070	182	1070	616
Trimethylbenzene, 1,2,4-	181	437	41%	219	1070	219	1070	738
Trimethylbenzene, 1,2,3-	230	483	48%	293	1070	293	1070	880
Methyl Ethyl Ketone (2-Butanone)	19700	38300	51%	28400	64200	28400	64200	94800
Carbon Disulfide	691	1130	61%	738	10700	738	10700	1270
Acetone	52300	83900	62%	114000	96200	114000	96200	656000
Diisopropyl Ether	2260	3330	68%	2260	-	2260	-	3330
Propylene Glycol Monomethyl Ether	43900	57200	77%	106000	74900	106000	74900	243000
Bromobenzene	379	408	93%	679	855	679	855	780

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[24] Risk-based soil concentrations, before rounding to 2 significant figures.

TSD Table 12: Soil RAGs for Petroleum Hydrocarbon Fractions, Selection of Volatilization Model

	Infinite source VF, C_{sat} substitution	Infinite Source VF	Mass Limited VF 3M source depth	Maximum	Soil RAG[25] (mg/kg)
Resident					
C5-C8 Aliphatics	153	246	1660	1660	1700
C9-C12 Aliphatics	21.8	1120	2520	2520	2500
C9-C10 Aromatics	174	385	663	663	660
C11-C22 Aromatics	2550	2550	2550	2550	2600
C19-C36 Aliphatics	100000	100000	100000	100000	100000
C9-C18 Aliphatics	13.7	2030	2520	2520	2500
Commercial Worker					
C5-C8 Aliphatics	161	1090	11000	11000	11000
C9-C12 Aliphatics	21.8	5210	13600	13600	14000
C9-C10 Aromatics	188	1830	3480	3480	3500
C11-C22 Aromatics	32800	32800	32800	32800	33000
C19-C36 Aliphatics	100000	100000	100000	100000	100000
C9-C18 Aliphatics	13.7	10400	13600	13600	14000
Park User					
C5-C8 Aliphatics	158	3510	7540	7540	7500
C9-C12 Aliphatics	21.8	12200	16700	16700	17000
C9-C10 Aromatics	184	3850	4720	4720	4700
C11-C22 Aromatics	7250	7250	7250	7250	7300
C19-C36 Aliphatics	100000	413000	413000	413000	410000
C9-C18 Aliphatics	13.7	15600	16700	16700	17000
Recreator Sediment					
C5-C8 Aliphatics	9520	9520	9520	9520	9520
C9-C12 Aliphatics	23800	23800	23800	23800	23800
C9-C10 Aromatics	6950	6950	6950	6950	6950
C11-C22 Aromatics	8370	8370	8370	8370	8370
C19-C36 Aliphatics	100000	100000	100000	100000	100000
C9-C18 Aliphatics	23800	23800	23800	23800	23800

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[25] Risk-based value not rounded to 2 significant figures.

	Infinite source VF, C_{sat} substitution	**Infinite Source VF**	**Mass Limited VF 3M source depth**	**Maximum**	**Soil RAG[25] (mg/kg)**
Construction Worker					
C5-C8 Aliphatics	157	157	432	432	430
C9-C12 Aliphatics	21.8	2300	1300	2300	2300
C9-C10 Aromatics	189	2640	1070	2640	2600
C11-C22 Aromatics	73600	73600	73600	73600	74000
C19-C36 Aliphatics	100000	100000	100000	100000	100000
C9-C18 Aliphatics	13.7	4820	1300	4820	4800

7.6 Construction Worker Parameters for Particulate Emission Factor

The RSL Construction Worker scenario considers inhalation of dust kicked up from truck traffic and earthwork. Specifically, the Construction Worker RSL calculator uses a particulate emission factor (PEF) based on mechanical disturbance of the soil with vehicle traffic as opposed to a default weather-driven PEF, as used for the other receptor exposure scenarios. As explained in the RSL Guidance, the equation to calculate the subchronic PEF for the Construction Worker (PEFsc) focuses exclusively on emissions from truck traffic on unpaved roads, typically the major contribution of dust emissions during construction. The PEFsc equation requires estimates of parameters such as the number of days with at least 0.01 inches of rainfall, the mean vehicle weight, and the sum of fleet vehicle distance traveled during construction. Derivation of the days with total precipitation of at least 0.01 inches is discussed in Section 3.2.2 above. The input parameters for the Construction Worker PEF are presented in TSD Table 13.

TSD Table 13: Construction Worker Soil Exposure Parameters for Particulate Emission Factor

Parameter	**Abbreviation**	**Value**	**Source**
Days worked (days/week)	DWcw	5	RSL Default
Overall duration of construction (weeks/year)	EWcw	50	RSL Default
Number of cars	-	20	RSL Default
Number of trucks	-	10	RSL Default
Tons/car	-	2	RSL Default
Tons/truck	-	20	RSL Default
Days per year with at least 0.01” precipitation	p	131	GHCN dataset for Portland, ME

7.7 Soil Leaching to Groundwater

7.7.1 Introduction: RSL Calculator for Soil to Groundwater

Contaminated soil that does not pose a direct contact risk can still pose a health risk from contamination leaching from the soil, contaminating the underlying aquifer, and people drinking water from a well in the contaminated aquifer. The RSL calculator estimates screening levels in soil (SSLs) that are protective of groundwater by back calculating the amount of chemical allowed in soil before groundwater will exceed the Tap Water RSL (aka Residential Groundwater RAG, see 4.1 above). This calculation is computed with a soil-water partition equation that uses chemical-specific parameters, such as Henry's Law constants and organic carbon partition coefficients (K_{oc}), and system-specific parameters such as water-filled porosity, air-filled porosity, and bulk soil density.

The partition equation models the migration of chemicals from the soil to the groundwater at the source. A generic dilution attenuation factor (DAF), rather than a contaminant-specific DAF, is used to account for dilution that occurs during migration of the chemical through the groundwater from the source to the receptor. EPA suggests using a DAF of 1 (i.e., no dilution) or 20. MEDEP has ascertained that a DAF of 55 is more appropriate based on Maine-specific data and previous modeling results, as detailed in Section 7.7.1.1.

7.7.1.1 Derivation of the Dilution Attenuation Factor (DAF)

The DAF used in the EPA RSL calculator is defined as the groundwater concentration at the source divided by the groundwater concentration at the receptor. Multiplying this factor by the groundwater criteria accounts for the attenuation of the chemical as it migrates through the groundwater from the groundwater at the source to the receptor. In developing the 2016 Leaching to Groundwater RAGs for 37 common contaminants, DEP used a modeling program, SEVIEW which incorporated an unsaturated soil transport model (SESOIL) and a groundwater transport model (AT123D). These models estimated the groundwater concentrations at the source and the groundwater concentrations at the receptor based on a Maine-specific spill scenario, Maine-specific climate data, and Maine-specific hydrogeologic data. These groundwater concentrations were used to calculate chemical-specific DAFs for each of the 37 chemicals, which produced a range of DAFs from 38.6 to 1420, with a mean of 119 and a median of 56.1. A histogram of these DAFs shows that there are two outliers, bis (2-ethylhexyl) phthalate and fluoranthene. The removal of the outliers results in a range of 38.6 to 88.1, with a mean of 58.6 and a median of 55.7, so although the mean value changes with the removal of outliers, the median value is very similar. The Agencies rounded the median value of these modeled DAFs for a DAF of 55.

The transport of chemicals in the groundwater from the source area to the receptor is dependent on certain chemical properties, such as Henry's Law constant and the K_{oc}, so the use of a single DAF to account for this attenuation for all chemicals is a simplification that will result in the overestimate of the RAG for some chemicals and the underestimate of the RAG for others. Using a DAF of 55 is supported by the fact that it is based on model results from the same models that were used to establish the previous leaching to groundwater RAGs. Further, site specific information from Maine sites indicates that the 2016 Leaching to Groundwater RAGs were protective of groundwater resources, so the Agencies thought it made reasonable sense to calibrate the RSL leaching to groundwater model with the detailed 2016 RAG modeling.

7.8 Soil PFAS

In general, soil concentrations for PFAS were derived as discussed in the sections above. Note that additional PFAS guidance numbers must be consulted.[26]

8 Lead Modeling

8.1 Departure from RSL Model

The RAGs for lead could not be modeled with the RSL calculator because there is no toxicity value for lead. Since there is no "safe level" of lead exposure to young children, lead does not present a classic "threshold," which is needed to develop a noncancer toxicity value. Therefore, to derive a guidance value for lead in soil the EPA recommends the use of two biokinetic models: the Integrated Exposure Uptake Biokinetic (IEUBK) model for residential scenarios; and the Adult Lead Methodology (ALM) for non-residential scenarios. The IEUBK model estimates a blood lead level from the combined exposure of soil, indoor dust, water, air, and diet in children from infancy up to 84 months (7 years old). The ALM estimates a fetal blood lead level in a pregnant female worker exposed to lead from soil and dust in a non-residential, workplace setting. Using EPA guidance, CDC ran both the IEUBK and ALM models to establish the soil RAG at which there was a 5% or less probability that a typical child's blood lead level, or fetal blood lead level of a pregnant female worker, would not exceed 5 micrograms per deciliter (5 µg/dL). The model inputs (TSD Table 15 and TSD Table 16) were based on the most recent EPA default values, except as described below. The 5 µg/dL target blood level reflects the current US Centers for Disease Control and Prevention

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[26] Maine PFAS Screening Levels: https://www1.maine.gov/dep/spills/topics/pfas/Maine-PFAS-Screening-Levels-Rev-6.28.21.pdf

(USCDC) recommendation,[27] Maine's statutory definition of a "Lead Poisoned" child,[28] and EPA guidance.[29]

8.2 Lead Residential Soil

For the Residential Soil RAG, CDC iteratively ran the IEUBK model using EPA default parameter inputs for a 12 to 72-month age range. The resulting soil concentration was 200 mg/kg.

8.3 Lead Park User Soil

The soil lead RAG for the Park User scenario is based on the IEUBK modeling results, since the concern at a park will be lead exposure in children, especially the younger 1- to 5-year-old age group with typically more hand to mouth activity. For a child exposed intermittently at a non-residential site, the EPA recommends the use of a time weighting approach whereby exposure is apportioned between the park soil and residential yard soil as presented in equation 1.[30]

$$PbS_{total} = (PbS_{yard} \text{ x } f_{yard}) + (PbS_{park} \text{ x } f_{park}) \quad \text{(eq. 1)}$$

where:

PbS_{total} = Total lead soil concentration (mg/kg) goal corresponding to less than a 5% probability of exceeding a blood lead level of 5 µg/dL

PbS_{yard} = Background soil lead concentration (mg/kg) in a residential yard

f_{yard} = Fraction of weekly time spent in the yard (days in yard/7 days per week)

PbS_{park} = Park soil lead concentration (mg/kg)

f_{park} = Fraction of weekly time spent at the park (days at park/7 days per week)

Equation 1 can be rearranged to solve for PbS_{park} where:

$$PbS_{park} = (PbS_{total} - (PbS_{yard} \text{ x } f_{yard}))/f_{park} \quad \text{(eq. 2)}$$

The 200 mg/kg soil lead concentration was selected as the total soil level goal as this concentration corresponds to less than a 5% probability of exceeding a blood lead level of 5 µg/dL for a 1 to 5-year-old child. A value of 38 mg/kg was selected for the background soil lead concentration in a Maine yard (see

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[27] USCDC blood lead reference level from USCDC website, Childhood Lead Poisoning Prevention from: https://www.cdc.gov/nceh/lead/acclpp/blood_lead_levels.htm.

[28] 22 M.R.S. §§ 1315 (5-C)

[29] EPA Hazard Standards and Clearance Levels for Lead in Paint, Dust and Soil (TSCA Section 402 and 403) from: https://www.epa.gov/lead/hazard-standards-lead-paint-dust-and-soil-tsca-section-403 and EPA Memo Updated Scientific Considerations for Lead in Soil Cleanups, https://semspub.epa.gov/work/08/1884204.pdf. December 22, 2016.

[30] EPA, Assessing Intermittent or Variable Exposures at Lead Sites (Downloaded December 11, 2020 from: https://semspub.epa.gov/work/HQ/176288.pdf). Undated.

background metal soil levels documentation section). The fraction of weekly time spent at the park is the Maine Park User exposure frequency of 3 days per week expressed as a fraction (i.e., 3 days/7 days). The remaining 4 days per week is used as the weekly time spent in the yard. Using these input values, the time-weighted Park User soil RAG is 416 mg/kg rounded to 420 mg/kg.

8.4 Lead Commercial Worker and Construction Worker Soil

The ALM was used to develop the non-residential soil RAGs for the Commercial and Construction Worker scenarios. The CDC used the EPA recommended default exposure factors (ingestion rate and exposure frequency) for the ALM, which represent non-residential exposure scenarios occurring at a workplace. The default soil ingestion rate of 50 mg/day is a central tendency estimate for a non-contact intensive indoor worker. As the RAGs for the Commercial and Construction Worker scenarios are intended to be protective of soil contact during intensive work at a site, such as grounds-keeping for a Commercial Worker or digging/excavating for a Construction Worker, a 100 mg/day ingestion rate was used for these two exposure scenarios. A 100 mg/day ingestion rate is recommended by the EPA to be more representative of soil contact during intensive work for the ALM.[31]

The ALM default exposure frequency of 219 days/year was adjusted to better model RAG Commercial and Construction Worker scenarios. For the Commercial Worker, the RAG default exposure frequency of 183 days/year was used. This exposure frequency is based on Maine climate-specific data for days per year where the ground is neither frozen nor snow covered (256 days/year) and adjusted for a 5 day/week work week. As this exposure frequency is approximately half a year, the default averaging time of 365 days/year in the ALM was adjusted to 256 days/year to prevent an effect of diluting out the exposure over a full year. With the 100 mg/day ingestion rate, 183 days/year exposure frequency, 256 days/year averaging time, and the remaining parameters at the most recent EPA recommended default values (TSD Table 16), the Commercial Worker lead soil RAG is 441 mg/kg rounded to 440 mg/kg.

For the Construction Worker scenario, the same default parameters used for the Commercial Worker scenario were used except for exposure frequency, which was set at the RAG default value of 250 days/year, and averaging time set at the ALM default of 365 days/year. The ALM model with these adjustments results in a soil lead RAG of 460 mg/kg for a Construction Worker scenario.

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[31] EPA Website, Lead at Superfund Sites: Frequent Questions from Risk Assessors on the Adult Lead Methodology from: https://www.epa.gov/superfund/lead-superfund-sites-frequent-questions-risk-assessors-adult-lead-methodology#ingestion%20rate.

8.5 Lead Recreational Sediment

Recreational exposure to sediment accounts for sediment exposure while wading or swimming for 3 days per week from May through October (26 weeks) based on observances of Maine weather. The Recreational sediment RAG for lead is 420 mg/kg. This is the same as the Park User soil RAG for lead derived using a weekly time-weighted approach. Since the Park User soil and Recreational sediment scenarios are both based on a 3 day per week exposure, the weekly time-weighted approach produces equivalent RAGs for these scenarios.

8.6 Lead Residential Groundwater

The residential lead groundwater RAG of 1 µg/L was developed using the IEUBK model where approximately no more than 5% of children would have a blood lead level greater than 5 µg/dL. The soil lead concentration was set at the residential soil RAG of 200 mg/kg (see Section 8.2) and all other parameters set at EPA defaults (TSD Table 14). Model iterations were run, gradually increasing the contribution from lead in water above the EPA default value of 0.9 µg/L. Increasing the water lead level to 1 µg/L, while the soil level remains constant at 200 mg/kg, the model predicts that 5.1% of children age 1 to 5 years old would have a blood lead level > 5 µg/dL. At 1 µg/L the predicted percent of children with a blood lead level greater than 5 µg/dL is slightly above the goal of no more than 5%. It is important to note in the IEUBK model that the dominant exposure source contributing to blood lead levels at the 200 mg/kg residential soil RAG is in fact soil. At a background soil lead level of 38 mg/kg, water lead levels could be as high as 12 µg/L with less than 5% of children exceeding a 5 µg/dL blood lead level.

TSD Table 14: IEUBK Input Parameters for 2021 Residential Soil Lead

Parameter	**Units**	**Values**				
		Age groups (years)				
Soil and dust		1-2	2-3	3-4	4-5	5-6
Soil and dust intake, age-specific (Prev. default)	g/day	0.094	0.067	0.063	0.067	0.052
Soil to dust ingestion weighting factor	%	45				
Soil relative bioavailability	%	30				
Soil to household dust lead level conversion factor	unitless	0.7				
Air to household dust lead level conversion factor	unitless	100				
Indoor dust lead concentration	*µg/g*	*Calculated from outdoor soil and air lead contributions*				
Dust relative bioavailability	%	30				
Water						
Drinking water intake, age-specific (prev. default)	L/day	0.43	0.51	0.54	0.57	0.60
Drinking water lead concentration (prev. default)	µg/L	0.9				
Water relative bioavailability	%	50				
Air						
Time spent outdoors	hours/day	2	3	4	4	4

Ventilation rate (prev. default)	m^3/day	4.97	6.09	6.95	7.68	8.32
Outdoor air lead	µg/m^3	0.1				
Indoor air lead concentration (percent of outdoor air concentration)	%	30				
Lung absorption	%	32				
Diet						
Dietary lead intake (prev. default)	g/day	5.03	5.21	5.38	5.64	6.04
Diet relative bioavailability	%	50				
Maternal						
Maternal blood lead level	µg/dL	0.6				
Blood lead reference value						
Child blood lead level	µg/dL	5				

TSD Table 15: Commercial and Construction Worker Inputs for the Adult Lead Model

Parameter	**Description**	**Units**	**Value**
BLL fetal goal	Target fetal blood lead level	µg/dL	5
fetal/maternal BLL ratio	Ratio of fetal blood lead to maternal blood lead	unitless	0.9
GSD adult $^{1.645}$	Geometric standard deviation for the adult population used to calculate the 95th percentile blood lead level	unitless	1.8
BLL adult baseline	Adult population, female of childbearing age, background blood lead level	µg/dL	0.6
Averaging time	Total days per year	days/year	- [a]
Biokinetic slope factor	Factor relating lead uptake per day to a blood lead level in adults	µg/dL per µg/day	0.4
Ingestion rate	Total soil/dust ingestion rate	g/day	0.1
Absorption fraction	Fraction of lead absorbed in the GI tract	unitless	0.12
Exposure frequency	Duration of time in days per year spent at a site	days/year	- [a]

[a] Values are scenario specific. See text for commercial and Construction Worker scenario parameter values.

8.7 Soil Lead Leaching to Groundwater

The RSL calculator does not provide an output for lead in the Leaching to Groundwater calculator. It does calculate an MCL-based value,[32] for the EPA

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[32] Maximum Contaminant Levels (MCLs) are standards that are set by the United States Environmental Protection Agency (EPA) for drinking water quality. An MCL is the legal threshold limit on the amount of a substance that is allowed in public water systems under the Safe Drinking Water Act (SDWA). Downloaded April 22, 2020 from: https://en.wikipedia.org/wiki/Maximum_Contaminant_Level.

Lead MCL of 15 µg/L. The Lead Leaching to Groundwater value presented in the RAGs is calculated in the same way, but based on residential lead water RAG of 1 µg/L, the Maine DAF of 55, and default RSL parameters, as presented in TSD Table 16.

TSD Table 16: Lead Input Factors for Leaching to Groundwater

Lead water conc. (ug/L)	DAF	Kd (L/kg)	Water filled soil Porosity (L/L)	Soil bulk density (kg/L)	Lead RAG (mg/kg)
1	55	900	0.3	1.5	50

9 Soil Background Concentrations

9.1 Metals

To assist with determining site-specific clean-up goals at Maine sites, DEP added background concentrations for select metals to the soil RAGs table. These values have been updated for the 2023 RAGs. Background Threshold Values (BTVs) included in the RAGs for metals prior to 2023 were calculated using data collected in Maine as part of Smith, D.B., Cannon, W.F., Woodruff, L.G., Solano, Federico, Kilburn, J.E., and Fey, D.L., 2013, Geochemical and mineralogical data for soils of the conterminous United States: U.S. Geological Survey Data Series 801, 19 p (https://pubs.usgs.gov/ds/801/). This data has been called into question for comparison to typical environmental data due to the analytical method used. As described in the supporting document, Sanborn Head, Statistical Evaluation Comments, Metals and Polycyclic Aromatic Hydrocarbons Background Threshold Values, State of Maine, May 25, 2023, the USGS project used an analytical method which included grain size reduction (grinding) and a much more aggressive extraction than typical methods used for environmental sample analysis. Due to this difference in the analytical methods, the USGS results may overestimate the concentrations of metals in Maine background soils compared to typical environmental analysis results.

TSD Table 17: Summary of Comparative Assessment Results, Metals Soil Data – USGS Maine Background Soil Data vs. 2021 MEDEP Resample Data

	USGS Data Statistics				MEDEP 2021 Data Statistics				Comparative Assessment Results					
Parameter	Number of Detects	Minimum Value	Maximum Value	Mean	Number of Detects	Minimum Value	Maximum Value	Mean	Visual Screening	Wilcoxon Signed-Rank Result	ProUCL Mann-Whitney (95%) Result	ProUCL ANOVA/Kruskal-Wallis Result	Data Set Recommendation	Notes:
AS	30	1.0	15.0	7.30	29.0	0.0	79.0	11.22	Good	Good	Equal	Similar	**USGS & MEDEP Data**	
BA	30	89.0	531.0	331.10	30.0	14.0	86.0	38.77	Poor	NA	Not Equal	Different	**MEDEP 2021 Data**	
BE	30	0.2	10.7	1.91	8.0	0.0	1.1	0.15	Poor	Not Equal	Not Equal	Different	**None**	Do not include background value
CD	17	0.1	1.0	0.25	2.0	0.0	0.5	0.03	NA	Equal	Not Equal	Different	**None**	Do not include background value
CO	30	0.9	19.4	8.13	30.0	1.0	13.0	5.26	Fair	Not Equal	Not Equal	Different	**MEDEP 2021 Data**	
CU	30	3.9	54.4	15.46	29.0	0.0	83.0	13.18	Good	Marginal	Equal	Similar	**MEDEP 2021 Data**	
MN	30	103.0	1250.0	596.80	30.0	34.0	860.0	300.10	Poor	Not Equal	Not Equal	Different	**MEDEP 2021 Data**	
MO	30	0.4	1.3	0.67	NA	NA	NA	NA	NA	NA	NA	NA	**USGS Data**	No results from 2021 sampling
NI	30	4.6	46.4	21.90	30.0	3.2	39.0	14.86	Fair	Not Equal	Not Equal	Different	**MEDEP 2021 Data**	
PB	30	12.2	210.0	35.79	30.0	2.2	12000.0	427.90	Fair	Marginal	Not Equal	Different	**MEDEP 2021 Data**	
SB	30	0.1	0.8	0.42	1.0	0.0	250.0	8.33	NA	NA	NA	NA	**None**	Do not include background value
SE	13	0.2	0.9	0.36	0.0	ND	ND	ND	NA	NA	NA	NA	**None**	Do not include background value
V	30	12.0	119.0	58.33	30.0	4.0	49.0	18.90	Poor	NA	Not Equal	Different	**MEDEP 2021 Data**	
ZN	30	21.0	218.0	68.10	30.0	16.0	99.0	52.70	Good	Not Equal	Equal	Similar	**MEDEP 2021 Data**	

Notes: 1- USGS Data is the results of 30 selected soil samples collected by the USGS in Maine for the Geochemical and mineralogical data for soils of the conterminous United States: U.S. Geological Survey Data Series 801, 19 p.
2- MEDEP 2021 Data is the results of resampling of the 30 selected USGS soil sample locations, collected for the Maine DEP in 2021.
3- Visial Assessment is a rough qualitative assessment of approximate similarity of box plots and pair-wise comparison using scatter plots for the USGS and MEDEP 2021 data sets.
4- Wilcoxon Signed-Rank test was preformed by Sanborn Head & Associates for the MEDEP as part of the Statistical Evaluation Comments, Metals and PAH Background Threshold Values, Statewide, Maine, May 25, 2023.
5- ProUCL comparative tests were conducted using ProUCL version 5.2.0.
6- Data Set Recommendation is the suggested data set to use for calculation of State-wide background values, based on the assessment results.

To evaluate the useability of the USGS data for determining BTVs, 30 of the Maine USGS sample locations were resampled. A DEP contractor visited each of the 30 locations and collected a single surficial soil sample for metals analysis from each location. The samples were analyzed by Alpha Analytical Lab by U.S. EPA. 1996. “Method 3050B: Acid Digestion of Sediments, Sludges, and Soils,” Revision 2. Results of these samples as a population were compared to the corresponding USGS data using several statistical comparison methods (see TSD Table 17).

Conservatively, if any individual assessment indicated poor or marginal agreement between the two data sets, just the 2021 DEP data set was used. The comparative assessment indicated good agreement between the USGS and MEDEP 2021 data sets for arsenic, and the two data sets were combined for calculating the arsenic BTV. The 0-5 cm interval data was found to be statistically redundant with the A-horizon soil data; therefore, the 0-5 cm data was omitted for calculation of the arsenic BTV.

The comparative analysis results indicated that the two data sets are significantly different for all other metals, suggesting a bias in the USGS data due to the analytical method used. Based on this conclusion, the decision was made to use just the MEDEP 2021 data for calculation of the State-wide BTVs. The decision was made to not calculate and publish BTVs for antimony, beryllium, and selenium due to the limited number of positive detects in the MEDEP 2021 data sets and the uncertainty in the applicability of the USGS data. Resample data for molybdenum is not available; therefore, the USGS data was used for calculation of the molybdenum BTV.

The metals data set was screened for outliers using Q-Q plots on both a normal and log normal scale (see Sanborn Head Statistical Evaluation Comment report).[33] Upper outliers were removed from the arsenic, copper, and molybdenum data sets, based on Q-Q plot review.

ProUCL version 5.2.0 was used to calculate the metals BTVs. The 95% Upper Tolerance Limit on the 95th percentile of the data (ULT 95-95) was selected as the BTV for each metal. In general, statistics were selected based on the following data distribution hierarchy, from most preferred to least preferred: Normal, Gamma, Lognormal, No Discernable Distribution. For data sets including nondetect results, statistics incorporating Kaplan-Meier estimation were selected.

TSD Table 18: 2023 Metals Background Threshold Values

Compound	Data Distribution	Number of Outliers Removed	Summary Statistics						BTV		
			Number of Results	Number of Detects	Percent Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Mean (mg/kg)	UTL95-95 (mg/kg)	Statisitc	**RAGs BTV (mg/kg)**
AS	Gamma	2	125	124	99.2	0.94	43	11	28.1	95% Approx. Gamma UTL with 95% Coverage KM (WH)	**28**
BA	Normal	0	30	30	100.0	14.00	86	38.8	79.2	95% UTL with 95% Coverage	**79**
CD	None discernable	0	30	2	6.7	0.36	0.5	0.43	0.62	Nonparametric 95% UTL with 95% Coverage	**0.6**
CO	Normal	0	30	30	100.0	1.00	13	5.26	12.1	95% UTL with 95% Coverage	**12**
CU	Normal	1	29	29	100.0	0.00	25	10.8	23.4	95% UTL with 95% Coverage	**23**
MN	Normal	0	30	30	100.0	34.00	860	300	765	95% UTL with 95% Coverage	**770**
MO	Lognormal	5	92	92	100.0	0.21	1.48	0.65	1.31	Lognormal 95% UTL with 95% Coverage	**1.3**
NI	Normal	0	30	30	100.0	3.20	39	14.9	34.6	95% UTL with 95% Coverage	**35**
PB	Gamma	2	28	28	100.0	2.20	44	17.7	52.3	95% WH Approx. Gamma UTL with 95% Coverage	**52**
V	Normal	0	30	30	100.0	4.00	49	18.9	40.2	95% UTL with 95% Coverage	**40**
ZN	Normal	0	30	30	100.0	16.00	99	52.7	97.9	95% UTL with 95% Coverage	**98**

The decision was made, with Sanborn Head recommendation, to include a BTV for cadmium despite the low number of detections (2). The two cadmium detections in the Maine DEP 2021 data set are less than the highest concentrations detected in the USGS data, suggesting that the Maine DEP 2021 detections are

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[33] Sanborn Head & Associates, Inc., Statistical Evaluation Comments, Metals and Polycyclic Aromatic Hydrocarbons Background Threshold Values, State of Maine, File No. 5654.00, May 25, 2023.

within a reasonably anticipated range for background. The resulting nonparametric BTV is an upper end statistical projection.

9.2 PAHs

To establish the background concentration of Polycyclic Aromatic Hydrocarbons (PAHs), in 2011 DEP commissioned a study of typical background concentrations of PAHs in Maine. The study compiled background data from investigations in Maine, determined data gaps, and then obtained samples to fill those data gaps. The researchers evaluated key sources of PAHs, and determined that asphalt and urban fill materials, such as coal ash, are prime contributors to PAH concentrations found in Maine soil. After evaluating multiple possibilities, DEP ultimately determined that a consistent, statistically valid split in PAH sample results was correlated with the definition of urban and rural areas that is used by the Department of Transportation’s compact urban zones program. These zones are geographically located in GIS layers. Additional information is available in the PAH study.[34]

The updated 2023 State-wide BTVs for PAHs were calculated using the data set used for calculation of the 2018 PAH BTVs with additional PAH data collected during the 2021 Maine PFAS Background Study. The PAH data was separated into Urban and Rural data sets based on Maine DOT Urban Compact Area mapping. All samples collected within the mapped urban compact areas are considered urban and all samples located outside of the urban compact areas are considered rural. The Urban data set was further separated into an Urban Developed data set and an Urban Fill data set. This separation was based on soil sample material descriptions and known site characteristics. Any samples containing or suspected to contain brick, cement, wood, wood ash, coal, coal ash, boiler ash, clinkers, other ash, asphalt, glass, plastic, metal, demolition debris, and/or roadside ditch materials; or samples located in an area known or suspected to contain large quantities of urban fill material (e.g. the Bayside area of Portland); was removed from the Urban Developed data set and included in the Urban Fill data set.

The data sets were screened for outliers by Sanborn Head and the DEP by reviewing samples with the highest concentrations across multiple PAHs. Two samples in the Rural data set (Bridges Property, Calais BK-104(1’) and Bridges Property Calais, BK-104(2’)) and one sample from the Urban Developed data set (HA-5-6-14) were identified as clear upper outliers. These samples were removed from the respective data sets. Additional outlier screening was performed using Q-Q plots on both normal and lognormal scales. In general, the individual PAHs data appears to fit a lognormal distribution and no additional outliers were identified.

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[34] MEDEP, Summary Report for Evaluation of Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Background Soils in Maine (Prepared for Maine DEP, Augusta, Maine; Prepared by AMEC Environment & Infrastructure, Inc., Portland, Maine project no. 361211, October 14, 2011.

BTVs for each scenario (Rural Developed, Urban Developed, Urban Fill) were calculated using ProUCL version 5.2.0. The 95% Upper Tolerance Limit on the 95th percentile of the data (ULT 95-95) was selected as the BTV for each PAH for each scenario. In general, statistics were selected based on the following data distribution hierarchy, from most preferred to least preferred: Normal, Gamma, Lognormal, No Discernable Distribution. For the Urban Fill BTVs, the UTL 95-95 values based on a Lognormal distribution were selected over those based on a Gamma distribution due to the fact that the Lognormal BTVs are anticipated to more closely mimic real-world conditions. For data sets including nondetect results, statistics incorporating Kaplan-Meier estimation were selected.

TSD Table 19: 2023 PAH Background Threshold Values

2023 PAH Rural Developed Background Threshold Values

Compound	Data Distribution	Number of Outliers Removed	Summary Statistics						BTV		
			Number of Results	Number of Detects	Percent Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Mean (mg/kg)	UTL95-95 (mg/kg)	Statisitc	**RAGs BTV (mg/kg)**
2-METHYLNAPHTHALENE	Lognormal	2	87	28	32.2	3.10E-03	2.2	0.148	0.147	Lognormal 95% KM UTL 95% Coverage	**0.15**
ACENAPHTHENE	Lognormal	2	92	25	27.2	0.0034	11	0.624	0.222	Lognormal 95% KM UTL 95% Coverage	**0.22**
ACENAPHTHYLENE	Lognormal	2	92	51	55.4	0.0016	3.94	0.44	1.885	Lognormal 95% KM UTL 95% Coverage	**1.9**
ANTHRACENE	Lognormal	2	92	54	58.7	8.50E-04	12	0.617	2.252	Lognormal 95% KM UTL 95% Coverage	**2.3**
BENZO(A)ANTHRACENE	Lognormal	2	92	75	81.5	1.10E-03	38	1.836	17.07	Lognormal 95% KM UTL 95% Coverage	**17**
BENZO(A)PYRENE	Gamma	2	92	69	75.0	9.20E-04	21	1.562	5.386	95% Approx. Gamma KM UTL 95% Coverage	**5.4**
BENZO(B)FLUORANTHENE	Gamma	2	90	74	82.2	9.10E-04	74	1.799	6.905	95% Approx. Gamma KM UTL 95% Coverage	**6.9**
BENZO(G,H,I) PERYLENE	Gamma	2	92	67	72.8	8.20E-04	11	0.896	2.978	95% Approx. Gamma KM UTL 95% Coverage	**3.0**
BENZO(K)FLUORANTHENE	Gamma	2	92	63	68.5	1.10E-03	24	1.23	3.557	95% Approx. Gamma KM UTL 95% Coverage	**3.6**
CHRYSENE	None discernable	2	92	78	84.8	6.80E-04	32	1.627	32	Nonparametric 95% UTL 95% Coverage	**32**
DIBENZO(A,H)ANTHRACENE	Gamma	2	88	44	50.0	0.001	3.2	0.32	0.728	95% Approx. Gamma KM UTL 95% Coverage	**0.73**
FLUORANTHENE	None discernable	2	92	81	88.0	5.40E-04	59	2.693	59	Nonparametric 95% UTL 95% Coverage	**59**
FLUORENE	Lognormal	2	92	38	41.3	0.001	9	0.475	0.67	Lognormal 95% KM UTL 95% Coverage	**0.67**
INDENO(1,2,3-CD)PYRENE	Lognormal	2	90	66	73.3	9.20E-04	15	1.05	7.322	Lognormal 95% KM UTL 95% Coverage	**7.3**
NAPHTHALENE	None discernable	2	92	36	39.1	0.0017	5	0.24	5	Nonparametric 95% UTL 95% Coverage	**5.0**
PHENANTHRENE	None discernable	2	92	73	79.3	7.80E-04	54	2.056	54	Nonparametric 95% UTL 95% Coverage	**54**
PYRENE	Lognormal	2	92	81	88.0	5.80E-04	58	2.893	32.56	Lognormal 95% KM UTL 95% Coverage	**33**

2023 PAH Urban Developed Background Threshold Values

Compound	Data Distribution	Number of Outliers Removed	Summary Statistics						BTV		
			Number of Results	Number of	Percent Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Mean (mg/kg)	UTL95-95 (mg/kg)	Statisitc	**RAGs BTV (mg/kg)**
2-METHYLNAPHTHALENE	None discernable	1	40	16	40.0	3.60E-03	0.9	0.0854	0.9	Nonparametric 95% UTL 95% Coverage	**0.90**
ACENAPHTHENE	Gamma	1	40	33	82.5	0.0023	0.609	0.0947	0.206	95% Approx Gamma KM UTL 95% Coverage	**0.2**
ACENAPHTHYLENE	Lognormal	1	40	30	75.0	0.0021	4.74	0.344	1.95	Lognormal KM 95% UTL 95% Coverage	**2.0**
ANTHRACENE	Lognormal	1	40	31	77.5	6.60E-04	2.18	0.236	2.173	Lognormal KM 95% UTL 95% Coverage	**2.2**
BENZO(A)ANTHRACENE	Gamma	1	40	35	87.5	1.30E-03	8.7	0.949	4.58	95% Approx Gamma KM UTL 95% Coverage	**4.6**
BENZO(A)PYRENE	Gamma	1	40	36	90.0	1.10E-03	10.7	0.94	4.584	95% Approx Gamma KM UTL 95% Coverage	**4.6**
BENZO(B)FLUORANTHENE	Lognormal	1	40	37	92.5	1.40E-03	16.4	1.207	18.65	Lognormal KM 95% UTL 95% Coverage	**19**
BENZO(G,H,I) PERYLENE	Lognormal	1	40	36	90.0	7.20E-04	7.15	0.546	8.222	Lognormal KM 95% UTL 95% Coverage	**8.2**
BENZO(K)FLUORANTHENE	Lognormal	1	40	34	85.0	8.60E-04	5.1	0.555	6.578	Lognormal KM 95% UTL 95% Coverage	**6.6**
CHRYSENE	Lognormal	1	40	37	92.5	1.00E-03	10	0.844	13.43	Lognormal KM 95% UTL 95% Coverage	**13**
DIBENZO(A,H)ANTHRACENE	Lognormal	1	40	33	82.5	0.00091	1.2	0.148	1.421	Lognormal KM 95% UTL 95% Coverage	**1.4**
FLUORANTHENE	Lognormal	1	40	39	97.5	1.60E-03	12.8	1.337	21.95	Lognormal KM 95% UTL 95% Coverage	**22**
FLUORENE	Lognormal	1	40	26	65.0	0.001	0.676	0.0875	0.466	Lognormal KM 95% UTL 95% Coverage	**0.5**
INDENO(1,2,3-CD)PYRENE	Lognormal	1	40	36	90.0	8.20E-04	8.18	0.632	9.395	Lognormal KM 95% UTL 95% Coverage	**9.4**
NAPHTHALENE	None discernable	1	40	24	60.0	0.0015	2.9	0.178	2.9	Nonparametric 95% UTL 95% Coverage	**2.9**
PHENANTHRENE	Lognormal	1	40	36	90.0	5.80E-04	6.45	0.653	10.55	Lognormal KM 95% UTL 95% Coverage	**11**
PYRENE	Lognormal	1	40	38	95.0	1.50E-03	14.4	1.307	19.87	Lognormal KM 95% UTL 95% Coverage	**20**

2023 PAH Urban Fill Background Threshold Values

Compound	Data Distribution	Number of Outliers Removed	Summary Statistics						BTV		
			Number of Results	Number of Detects	Percent Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Mean (mg/kg)	UTL95-95 (mg/kg)	Statisitc	**RAGs BTV (mg/kg)**
2-METHYLNAPHTHALENE	Normal	0	24	6	25.0	2.50E-03	0.11	0.0323	0.0796	KM 95% UTL 95% Coverage	**0.08**
ACENAPHTHENE	Lognormal	0	29	5	17.2	0.0093	1.12	0.262	0.289	Lognormal KM 95% UTL 95% Coverage	**0.29**
ACENAPHTHYLENE	Normal	0	29	11	37.9	0.0069	0.699	0.214	0.485	KM 95% UTL 95% Coverage	**0.49**
ANTHRACENE	Lognormal	0	29	12	41.4	2.00E-03	1.77	0.285	3.666	Lognormal KM 95% UTL 95% Coverage	**3.7**
BENZO(A)ANTHRACENE	Lognormal	0	29	23	79.3	2.00E-03	5.56	0.656	16.18	Lognormal KM 95% UTL 95% Coverage	**16**
BENZO(A)PYRENE	Lognormal	0	29	23	79.3	2.40E-03	5.44	0.689	15.85	Lognormal KM 95% UTL 95% Coverage	**16**
BENZO(B)FLUORANTHENE	Lognormal	0	29	24	82.8	3.60E-03	8.68	1.058	34.04	Lognormal KM 95% UTL 95% Coverage	**34**
BENZO(G,H,I) PERYLENE	Lognormal	0	29	20	69.0	1.80E-03	2.07	0.31	6.011	Lognormal KM 95% UTL 95% Coverage	**6.0**
BENZO(K)FLUORANTHENE	Lognormal	0	29	19	65.5	1.20E-03	2.75	0.439	13.7	Lognormal KM 95% UTL 95% Coverage	**14**
CHRYSENE	Lognormal	0	29	23	79.3	0.00E+00	6.74	0.757	21	Lognormal KM 95% UTL 95% Coverage	**21**
DIBENZO(A,H)ANTHRACENE	Normal	0	29	13	44.8	0.005	0.41	0.206	0.456	KM 95% UTL 95% Coverage	**0.46**
FLUORANTHENE	Lognormal	0	29	27	93.1	2.00E-03	14.9	1.223	30.26	Lognormal KM 95% UTL 95% Coverage	**30**
FLUORENE	Lognormal	0	29	8	27.6	0.0014	1.38	0.216	0.643	Lognormal KM 95% UTL 95% Coverage	**0.64**
INDENO(1,2,3-CD)PYRENE	Lognormal	0	29	24	82.8	2.00E-03	2.8	0.39	9.724	Lognormal KM 95% UTL 95% Coverage	**9.7**
NAPHTHALENE	Normal	0	29	10	34.5	0.0017	0.26	0.0665	0.198	KM 95% UTL 95% Coverage	**0.20**
PHENANTHRENE	Lognormal	0	28	25	89.3	2.00E-03	12.1	0.863	18.38	Lognormal KM 95% UTL 95% Coverage	**18**
PYRENE	Lognormal	0	29	26	89.7	3.00E-03	11.7	1.094	28.08	Lognormal KM 95% UTL 95% Coverage	**28**

9.3 PFAS

In 2021, the Maine DEP commissioned a study of background concentrations of PFAS in Maine soils. Shallow soil samples were collected from 64 locations across the state and analyzed for a list of 28 PFAS. The resulting data was used to derive BTVs. This resulted in recommended BTVs for a list of 9 PFAS (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, and PFOS). Two PFAS, PFOS and PFDA, displayed statistically significant differences in the urban vs. rural (non-urban) datasets suggesting a difference in concentrations of these compounds in urban vs. rural soils; therefore, BTVs were derived for PFOS and PFDA for both urban and rural environments. The recommended BTV for all PFAS, except PFOS rural, is the 95% Upper Tolerance Limit with 95% coverage. The recommended BTV for PFOS rural is the 90% Upper Tolerance Limit with 95% coverage. The 2023 RAGs include BTVs for those PFAS for which risk-based guidelines were included in the RAGs tables and for which a statistically supportable BTV was calculated. These PFAS are PFBA, PFBS, PFHxA, PFHxS, PFNA, PFOA, PFOS (urban and rural), and HFPO-DA (GenX). Derivation and selection of the PFAS BTVs is described in detail in the Background Levels of PFAS and PAHs In Maine Shallow Soils report and accompanying Department memorandum.[35]

9.4 UCLs

BTVs based on upper threshold values, such as UTLs are not generally appropriate for comparison to samples that represent a mean or average concentration in soil in a specified area, such as Incremental Samples. To provide a set of BTVs for comparison to samples that represent average concentrations, a separate set of BTVs were calculated based on Upper Confidence Limit on the Mean (UCL) statistics. These values are referred to as the RAGs UCLs. The same datasets, the same rationale, and the same methodology were used for calculating the metals and PAH UCLs as is described above for the UTL based BTVs. ProUCL was used to determine the 95% UCL for each compound and the values recommended by ProUCL were selected as the RAGs UCLs. The UCLs are provided in a separate, standalone table in the RAGs main document.

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[35] MEDEP, Background Levels of PFAS and PAHs in Maine Shallow Soils Study Report (Prepared for the Maine Department of Environmental Protection; Prepared by Sanborn, Head & Associates, Inc., File No. 5060.00, April 2022.

TSD Table 20: 2023 UCLs for Comparison to ISM Sample Results

2023 Metals UCLs For Comparison To ISM Sample Results

			Summary Statistics						UCLs		
Compound	Data Distribution	Number of Outliers Removed	Number of Results	Number of Detects	Percent Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Mean (mg/kg)	95% UCL (mg/kg)	Statisitc	**RAGs UCL (mg/kg)**
AS	Gamma	2	125	124	99.2	0.94	43	10.96	12.1	95% KM Approximate Gamma UCL	**12**
BA	Normal	0	30	30	100.0	14.00	86	38.77	44.42	95% Student's-t UCL	**44**
CD	None discernable	0	30	2	6.7	0.36	0.5	0.43	0.246	95% KM (t) UC	**0.25**
CO	Normal	0	30	30	100.0	1.00	13	5.26	6.213	95% Student's-t UCL	**6.2**
CU	Normal	1	29	29	100.0	0.00	25	10.77	12.55	95% Student's-t UCL	**13**
MN	Normal	0	30	30	100.0	34.00	860	300.1	365	95% Student's-t UCL	**370**
MO	Gamma	5	92	92	100.0	0.21	1.48	0.653	0.7	95% Approximate Gamma UCL	**0.70**
NI	Normal	0	30	30	100.0	3.20	39	14.86	17.62	95% Student's-t UCL	**18**
PB	Gamma	2	28	28	100.0	2.20	58	17.71	22.37	95% Adjusted Gamma UCL	**22**
V	Normal	0	30	30	100.0	4.00	49	18.9	21.88	95% Student's-t UCL	**22**
ZN	Normal	0	30	30	100.0	16.00	99	52.7	59.02	95% Student's-t UCL	**59**

2023 PAH Rural Developed UCLs For Comparison to ISM Sample Results

Compound	Data Distribution	Number of Outliers Removed	Summary Statistics						BTV		
			Number of Results	Number of Detects	Percent Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Mean (mg/kg)	95% UCL (mg/kg)	Statistic	**RAGs UCLs (mg/kg)**
2-Methylnaphthalene	Lognormal	2	87	28	32.2	3.10E-03	2.2	0.148	0.0382	KM H-UCL	**0.038**
Acenaphthene	Lognormal	2	92	25	27.2	0.0034	11	0.624	0.0596	KM H-UCL	**0.060**
Acenaphthylene	Lognormal	2	92	51	55.4	0.0016	3.94	0.44	0.796	KM H-UCL	**0.80**
Anthracene	Lognormal	2	92	54	58.7	8.50E-04	12	0.617	1.162	KM H-UCL	**1.2**
Benzo(a)anthracene	Lognormal	2	92	75	81.5	1.10E-03	38	1.836	12.83	KM H-UCL	**13**
Benzo(a)pyrene	Gamma	2	92	69	75.0	9.20E-04	21	1.562	1.999	95% KM Approximate Gamma UCL	**2.0**
Benzo(b)fluoranthene	Gamma	2	90	74	82.2	9.10E-04	74	1.799	2.437	95% KM Approximate Gamma UCL	**2.4**
Benzo(g,h,i) perylene	Gamma	2	92	67	72.8	8.20E-04	11	0.896	1.118	95% KM Approximate Gamma UCL	**1.1**
BENZO(K)FLUORANTHENE	Gamma	2	92	63	68.5	1.10E-03	24	1.23	1.751	95% KM Approximate Gamma UCL	**1.8**
CHRYSENE	None discernable	2	92	78	84.8	6.80E-04	32	1.627	2.123	95% KM (t) UCL	**2.1**
DIBENZO(A,H)ANTHRACENE	Gamma	2	88	44	50.0	0.001	3.2	0.32	0.301	95% KM Approximate Gamma UCL	**0.30**
FLUORANTHENE	None discernable	2	92	81	88.0	5.40E-04	59	2.693	3.723	95% KM (t) UCL	**3.7**
FLUORENE	Lognormal	2	92	38	41.3	0.001	9	0.475	0.233	KM H-UCL	**0.23**
INDENO(1,2,3-CD)PYRENE	Lognormal	2	90	66	73.3	9.20E-04	15	1.05	4.482	KM H-UCL	**4.5**
NAPHTHALENE	None discernable	2	92	36	39.1	0.0017	5	0.24	0.198	95% KM (t) UCL	**0.20**
PHENANTHRENE	None discernable	2	92	73	79.3	7.80E-04	54	2.056	2.836	95% KM (t) UCL	**2.8**
PYRENE	Lognormal	2	92	81	88.0	5.80E-04	58	2.893	26.96	KM H-UCL	**27**

2023 PAH Urban Developed UCLs For Comparison to ISM Sample Results

Compound	Data Distribution	Number of Outliers Removed	Summary Statistics						BTV		
			Number of Results	Number of Detects	Percent Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Mean (mg/kg)	95% UCL (mg/kg)	Statisitc	**RAGs UCLs (mg/kg)**
2-Methylnaphthalene	None discernable	1	40	16	40.0	3.60E-03	0.9	0.0854	0.0784	95% KM (t) UCL	**0.078**
Acenaphthene	Gamma	1	40	33	82.5	0.0023	0.609	0.0947	0.0967	95% KM Adjusted Gamma UCL	**0.10**
Acenaphthylene	Lognormal	1	40	30	75.0	0.0021	4.74	0.344	0.639	KM H-UCL	**0.64**
Anthracene	Lognormal	1	40	31	77.5	6.60E-04	2.18	0.236	0.977	KM H-UCL	**1.0**
Benzo(a)anthracene	Gamma	1	40	35	87.5	1.30E-03	8.7	0.949	1.62	95% KM Adjusted Gamma UCL	**1.6**
Benzo(a)pyrene	Gamma	1	40	36	90.0	1.10E-03	10.7	0.94	1.813	95% KM Adjusted Gamma UCL	**1.8**
Benzo(b)fluoranthene	Lognormal	1	40	37	92.5	1.40E-03	16.4	1.207	10.49	KM H-UCL	**10**
Benzo(g,h,i) perylene	Lognormal	1	40	36	90.0	7.20E-04	7.15	0.546	4.332	KM H-UCL	**4.3**
BENZO(K)FLUORANTHENE	Lognormal	1	40	34	85.0	8.60E-04	5.1	0.555	3.321	KM H-UCL	**3.3**
CHRYSENE	Lognormal	1	40	37	92.5	1.00E-03	10	0.844	7.397	KM H-UCL	**7.4**
DIBENZO(A,H)ANTHRACENE	Lognormal	1	40	33	82.5	0.00091	1.2	0.148	0.495	KM H-UCL	**0.50**
FLUORANTHENE	Lognormal	1	40	39	97.5	1.60E-03	12.8	1.337	11.01	KM H-UCL	**11**
FLUORENE	Lognormal	1	40	26	65.0	0.001	0.676	0.0875	0.146	KM H-UCL	**0.15**
INDENO(1,2,3-CD)PYRENE	Lognormal	1	40	36	90.0	8.20E-04	8.18	0.632	4.933	KM H-UCL	**4.9**
NAPHTHALENE	None discernable	1	40	24	60.0	0.0015	2.9	0.178	0.235	95% KM (t) UCL	**0.24**
PHENANTHRENE	Lognormal	1	40	36	90.0	5.80E-04	6.45	0.653	5.977	KM H-UCL	**6.0**
PYRENE	Lognormal	1	40	38	95.0	1.50E-03	14.4	1.307	10.47	KM H-UCL	**10**

2023 PAH Urban Fill UCLs For Comparison to ISM Sample Results

			Summary Statistics						BTV		
Compound	Data Distribution	Number of Outliers Removed	Number of Results	Number of Detects	Percent Detects	Minimum Detect (mg/kg)	Maximum Detect (mg/kg)	Mean (mg/kg)	95% UCL (mg/kg)	Statisitc	**RAGs UCLs (mg/kg)**
2-Methylnaphthalene	Normal	0	24	6	25.0	2.50E-03	0.11	0.0323	0.0294	95% KM (t) UCL	**0.029**
Acenaphthene	Lognormal	0	29	5	17.2	0.0093	1.12	0.262	0.0845	95% H-UCL	**0.085**
Acenaphthylene	Normal	0	29	11	37.9	0.0069	0.699	0.214	0.179	95% KM (t) UCL	**0.18**
Anthracene	Lognormal	0	29	12	41.4	2.00E-03	1.77	0.285	2.398	95% H-UCL	**2.4**
Benzo(a)anthracene	Lognormal	0	29	23	79.3	2.00E-03	5.56	0.656	8.867	95% H-UCL	**8.9**
Benzo(a)pyrene	Lognormal	0	29	23	79.3	2.40E-03	5.44	0.689	8.014	95% H-UCL	**8.0**
Benzo(b)fluoranthene	Lognormal	0	29	24	82.8	3.60E-03	8.68	1.058	20.78	95% H-UCL	**21**
Benzo(g,h,i) perylene	Lognormal	0	29	20	69.0	1.80E-03	2.07	0.31	2.779	95% H-UCL	**2.8**
BENZO(K)FLUORANTHENE	Lognormal	0	29	19	65.5	1.20E-03	2.75	0.439	10.14	95% H-UCL	**10**
CHRYSENE	Lognormal	0	29	23	79.3	0.00E+00	6.74	0.757	12.58	95% H-UCL	**13**
DIBENZO(A,H)ANTHRACENE	Normal	0	29	13	44.8	0.005	0.41	0.206	0.176	95% KM (t) UCL	**0.18**
FLUORANTHENE	Lognormal	0	29	27	93.1	2.00E-03	14.9	1.223	16.29	95% H-UCL	**16**
FLUORENE	Lognormal	0	29	8	27.6	0.0014	1.38	0.216	0.238	95% H-UCL	**0.24**
INDENO(1,2,3-CD)PYRENE	Lognormal	0	29	24	82.8	2.00E-03	2.8	0.39	4.044	95% H-UCL	**4.0**
NAPHTHALENE	Normal	0	29	10	34.5	0.0017	0.26	0.0665	0.0734	95% KM (t) UCL	**0.073**
PHENANTHRENE	Lognormal	0	28	25	89.3	2.00E-03	12.1	0.863	10.03	95% H-UCL	**10**
PYRENE	Lognormal	0	29	26	89.7	3.00E-03	11.7	1.094	15.13	95% H-UCL	**15**

10 Multi-Contaminant Risk

Risk Assessment theory holds that the risk from multiple contaminants that are below their respective RAGs could, when summed, exceed the risk targets in Maine (a HI=1 and ILCR=10^{-5}; see Section 1.2). Prior to the 2010 RAGs, risks from multi-contaminants were not routinely considered in remedial decisions made with the RAGs. Beginning with the 2010 RAGs, the Agencies developed multi-contaminant risk calculators to assess residual risk from sites once all contaminants were below their respective RAGs. However, their use did not result in any additional remediation when the individual contaminants each met its respective RAG. This is because the contaminants were co-located such that the remediation addressed all of them and/or because one recalcitrant contaminant typically drives a clean-up; by the time the RAG is achieved for this risk-driver, the other contaminants are well below their respective RAGs. Since maintenance and use of the risk calculators had resource costs with no associated risk reduction, DEP ended their use in 2018. That is, no multi-contaminant calculations will be required to demonstrate that cumulative risks do not exceed a Hazard Index of 1 or an ILCR of 10^{-5} when the RAGs are met, even though the RAGs individually are set at a hazard quotient of 1 and an ILCR of 10^{-5}.

TSD Table 21: Default Exposure Assumptions for Maine Remedial Action Guidelines and Site-Specific Risk Assessments

Exposure Factor	Medium	Receptor	Value	Units	Notes	Maine or RSL
Ingestion Rate	Soil	Resident Adult/Older Child	100	mg/day	U.S. EPA 1991a (pg. 15)	RSL default
	Soil	Resident Young Child <6	200	mg/day	U.S. EPA 1991a (pg. 15)	RSL default
	Soil	Outdoor Commercial Worker	100	mg/day	U.S. EPA 1991a (pg. 15)	RSL default
	Soil	Indoor Commercial Worker	50	mg/day	U.S. EPA 1991a (pg. 15)	RSL default
	Soil	Construction Worker	330	mg/day	U.S. EPA 2002 Exhibit 5-1	RSL default
	Sediment	Recreator Adult/Older Child	100	mg/day	U.S. EPA 1991a (pg. 15)	RSL default
	Sediment	Recreator Young Child <6	200	mg/day	U.S. EPA 1991a (pg. 15)	RSL default
	Surface Water	Swimmer - Child	49	ml/hour	U.S. EPA 2011, Table 3-5 Mean value for water ingestion while swimming - children	Maine
	Surface Water	Swimmer - Adult	21	ml/hour	U.S. EPA 2011, Table 3-5 Mean value for water ingestion while swimming - adults	Maine
	Drinking Water	Resident Adult	2.5	L/day	U.S. EPA 2011, Table 3-33; 90th percentile of consumer-only ingestion of drinking water (>= 21 years)	RSL default
	Drinking Water	Resident Young Child <6	0.78	L/day	U.S. EPA 2011, Tables 3-15 and 3-33; weighted average of 90th percentile consumer-only ingestion of drinking water (birth to <6 years)	RSL default
	Drinking Water	Commercial Worker	2.5	L/day	U.S. EPA 2011, Table 3-33; 90th percentile of consumer-only ingestion of drinking water (>= 21 years)	RSL default

Exposure Factor	Medium	Receptor	Value	Units	Notes	Maine or RSL
	Groundwater	Construction Worker	15	ml/day	U.S. EPA 2011, Table 3-93 Mean ingestion while wading/splashing (3.7 milliliter per hour, 4 hours per day)	Maine
	Fish	Adult	32400	mg/day	One 8-oz. fish meal/week; upper estimate of sport fish consumption	Maine
	Homegrown Produce exposed fruit	Resident	1.8	g/kg-day	U.S. EPA 2011, Table 9-18 Mean values for households in the Northeast (exposed fruit)	Maine
	Homegrown Produce exposed vegetables	Resident	1.4	g/kg-day	U.S. EPA 2011, Table 9-20 Mean values for households in the Northeast (exposed vegetables)	Maine
	Homegrown Produce root vegetables	Resident	1.1	g/kg-day	U.S. EPA 2011, Table 9-22 Mean values for households in the Northeast (root vegetables)	Maine
Exposure Frequency	Soil	Resident Child/Adult	256	days/year	Climate-specific data for days when ground is neither frozen nor snow covered in the Portland area	Maine
	Soil	Park User Child/Adult	90	days/year	3 days/week, 30 weeks/year (April-October)	Maine
	Soil	Trespasser - Older Child (6>16)	52	days/year	2 days/week, 26 weeks/year (May-October)	Maine
	Soil	Outdoor Commercial Worker	183	days/year	Climate-specific data for days when ground is neither frozen of snow covered in the Portland area, adjusted to 5 days/week	Maine
	Soil	Indoor Commercial Worker	183	days/year	Climate-specific data for days when ground is neither frozen of snow covered in the Portland area, adjusted to 5 days/week	Maine

Exposure Factor	Medium	Receptor	Value	Units	Notes	Maine or RSL
	Soil	Construction Worker	250	days/year	USEPA RSL default value - 1-year construction period adjusting for 5 days/week workweek out of 350 days/year	RSL default
	Sediment	Recreator - Child/Adult	78	days/year	3 days/week, 26 weeks/year (May-October)	Maine
	Surface Water	Swimmer - Adult	40	days/year	4 days/week, 10 weeks/year (2 weeks of June, all of July & August)	Maine
	Surface Water	Swimmer - Child	40	days/year	4 days/week, 10 weeks/year (2 weeks of June, all of July & August)	Maine
	Surface Water	Wader - Child/Adult	78	days/year	3 days/week, 26 weeks/year (May-October)	Maine
	Tap Water	Resident Child/Adult	350	days/year	U.S. EPA 1991a (pg. 15)	RSL default
	Drinking Water	Commercial Worker	250	days/year	U.S. EPA 1991a (pg. 15)	RSL default
	Groundwater	Construction Worker	52	days/year	1 day/week, 52 weeks/year	Maine
	Homegrown Produce	Resident	182	days/year	7 days/week, 26 weeks (May-October)	Maine
	Air	Resident Child/Adult	350	days/year	U.S. EPA 1991a (pg. 15)	RSL default
Exposure Frequency (continued)	Air	Indoor Commercial Worker	250	days/year	U.S. EPA 1991a (pg. 15)	RSL default
	Air	Construction Worker	250	days/year	U.S. EPA 2002 Exhibit 5-1	RSL default
Exposure Time	Surface Water	Swimmer - Adult	3.2	hours/day	U.S. EPA 2011, Table 3-92 95th UCL of mean value for swimming duration in freshwater or seawater - male and female adults	Maine
	Surface Water	Swimmer - Child	4.3	hours/day	U.S. EPA 2011, Table 3-92 95th UCL of mean value for swimming duration in freshwater or seawater - children	Maine
	Surface Water	Wader	3.2	hours/day	Assumed to be the same as swimming.	Maine

Exposure Factor	Medium	Receptor	Value	Units	Notes	Maine or RSL
	Surface Water	Wader	4.3	hours/day	Assumed to be the same as swimming.	Maine
	Household Water	Resident Bathing - Child	0.54	hour/bath	U.S. EPA 2011, Table 16-28; weighted average of 90th percentile time spent bathing (birth to <6 years)	RSL default
	Household Water	Resident Showering - Adult	0.71	hour/shower	U.S. EPA 2011, Tables 16-30 and 16-31; weighted average of adult (21 to 78) 90th percentile of time spent bathing/ showering in a day, divided by mean number of baths/showers taken in a day.	RSL default
	Groundwater	Construction Worker	4	hours/day	USEPA 2002 Section 4.2.3	Maine
	Air	Resident Child/Adult (Indoors)	24	hours/day	The whole day	RSL default
	Air	Resident Child/Adult (Outdoors)	2.3	hours/day	USEPA 2011 Mean of Time Outdoors at a residence (Table 16-1, ages 0<26 years)	Maine
	Soil	Resident	24	hours/day		RSL default
	Soil	Park User	3	hours/day	U.S. EPA 2011, Table 16-20 Mean time, 184.9 minutes per/day (3.08 hours), spent at park or golf course in the Northeast	Maine
	Sediment	Recreator	3.7	hours/day	U.S. EPA 2011, Table 16-20 Mean time, 220.7 minutes per/day (3.68 hours), spent outdoors at a pool/river/lake in the Northeast	Maine
	Air	Commercial Worker (Indoors)	8	hours/day	The workday	RSL default
	Air	Commercial Worker (Outdoors)	8	hours/day	The workday	RSL default
	Air	Construction Worker	8	hours/day	The workday	RSL default

Exposure Factor	**Medium**	**Receptor**	**Value**	**Units**	**Notes**	**Maine or RSL**
Exposed Surface Area	Soil	Adult - Resident/Park User	6032	cm2	U.S. EPA 2011, Tables 7-2 and 7-12; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, 21+ years) (forearm and lower leg-specific data used for males and female lower leg; ratio of male forearm to arm applied to female arm data.	RSL default
	Soil	Young Child <6 - Resident/Park User	2373	cm2	U.S. EPA 2011a, Tables 7-2 and 7-8; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, birth to < 6 years) (forearm and lower leg-specific data used when available, ratios for nearest available age group used elsewhere)	RSL default
	Soil	Trespasser - Older Child (6>16)	3749	cm2	USEPA 2011 mean value for head, hands, forearms, and lower legs. The forearm-to-arm ratio (0.45) and lower leg to-leg ratio (0.4) were obtained from the EPA RAGs Part E dermal guidance (EPA 2004).	Maine
	Soil	Indoor Commercial Worker	3527	cm2	US EPA 2011a, Table 7-2; weighted average of mean values for head, hands, and forearms (male and female, 21+years)	RSL default
	Soil	Outdoor Commercial Worker	3527	cm2	ibid.	RSL default
	Soil	Construction Worker	3527	cm2	ibid.	RSL default

Exposure Factor	**Medium**	**Receptor**	**Value**	**Units**	**Notes**	**Maine or RSL**
	Sediment	Recreator Adult	6032	cm2	U.S. EPA 2011, Tables 7-2 and 7-12; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, 21+ years)(forearm and lower leg-specific data used for males and female lower leg; ratio of male forearm to arm applied to female arm data.	RSL default
	Sediment	Recreator Young Child <6	2373	cm2	U.S. EPA 2011a, Tables 7-2 and 7-8; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, birth to < 6 years) (forearm and lower leg-specific data used when available, ratios for nearest available age group used elsewhere)	RSL default
Exposed Surface Area (continued)	Surface Water	Adult - Swimming	19652	cm2	U.S. EPA 2011, Tables 7-9; weighted average of mean values for male and female adults.	RSL default
	Surface Water	Young Child <6 - Swimming	6365	cm2	U.S. EPA 2011, Table 7.9, weighted average of mean values for children <6 years.	RSL default
	Surface Water	Adult - Wading	6032	cm2	U.S. EPA 2011, Tables 7-2 and 7-12; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, 21+ years)(forearm and lower leg-specific data used for males and female lower leg; ratio of male forearm to arm applied to female arm data.	RSL default

Exposure Factor	Medium	Receptor	Value	Units	Notes	Maine or RSL
	Surface Water	Young child <6 - Wading	2373	cm^2	U.S. EPA 2011a, Tables 7-2 and 7-8; weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, birth to < 6 years) (forearm and lower leg-specific data used when available, ratios for nearest available age group used elsewhere)	RSL default
	Surface Water	Trespasser - Older Child (6>16)	3749	cm^2	Assumed to be the same as soil	Maine
	Household Water	Bathing - Child	6365	cm^2	U.S. EPA 2011, Table 7.9, weighted average of mean values for children <6 years.	RSL default
	Household Water	Showering - Adult	19652	cm^2	U.S. EPA 2011, Tables 7-9; weighted average of mean values for male and female adults.	RSL default
	Groundwater	Construction Worker	3527	cm^2	US EPA 2011a, Table 7-2; weighted average of mean values for head, hands, and forearms (male and female, 21+years)	RSL default
Adherence Factors	Soil	Adult - Resident/Park User	0.07	mg/cm^2	U.S. EPA 2002 (Exhibit 1-2)	RSL default
	Soil	Young Child - Resident/Park User	0.2	mg/cm^2	U.S. EPA 2002 (Exhibit 1-2)	RSL default
	Soil	Outdoor Commercial Worker	0.12	mg/cm^2	U.S. EPA 2011, Table 7-20 and Section 7.2.2; arithmetic mean of weighted average of body part- specific (hands, forearms, and face) mean adherence factors for adult commercial/industrial activities	RSL default
	Soil	Construction Worker	0.3	mg/cm^2	U.S. EPA 2002 (Exhibit 5-1)	RSL default
	Sediment	Recreator Adult	0.07	mg/cm^2	U.S. EPA 2002 (Exhibit 1-2)	RSL default

Exposure Factor	**Medium**	**Receptor**	**Value**	**Units**	**Notes**	**Maine or RSL**
	Sediment	Recreator Young Child <6	0.2	mg/cm^2	U.S. EPA 2002 (Exhibit 1-2)	RSL default
	Sediment	Recreator Older Child 11-<18	0.07	mg/cm^2	U.S. EPA 2002 (Exhibit 1-2)	RSL default
Body Weight	All	Young Child <6	15	kg	U.S. EPA 1991a (pg. 15)	RSL default
	All	Adult (>18)	80	kg	U.S. EPA 2011, Table 8-3; weighted mean values for adults 21 - 78	RSL default
	All	Worker	80	kg	ibid.	RSL default
	All	Young Child - Resident/Park User	6	years	U.S. EPA 1991a (pg. 15)	RSL default
	All	Adult - Resident/Park User	20	years	EDres (26 years) - EDres-c (6 years)	RSL default
	All	Trespasser - Older Child (6>16)	10	years	Ages 6>16 years USEPA Region 4 2017	Maine
	All	Commercial Worker	25	years	U.S. EPA 1991a (pg. 15)	RSL default
	All	Construction Worker	1	years	U.S. EPA 2002 Exhibit 5-1	RSL default
	Air	Resident	26	years	EPA 2011, Table 16-108; 90th percentile for current residence time.	RSL default
	Soil	Park User	26	years	ibid.	RSL default
	Homegrown Produce	Resident	26	years	ibid.	RSL default
Averaging Period	All	Carcinogenic Effects	70	years	U.S. EPA 1989 (pg. 6-23)	RSL default
	All	Non-Carcinogenic Effects	Equal to exposure duration			RSL default
	All	Young Child - Resident/Park User	6	Years	U.S. EPA 1989 (pg. 6-23)	RSL default
	All	Adult - Resident/Park User	26	Years	U.S. EPA 1989 (pg. 6-23)	RSL default

Exposure Factor	Medium	Receptor	Value	Units	Notes	Maine or RSL
	All	Trespasser - Older Child (6>16)	10	Years	Averaging period = exposure duration	Maine
	All	Commercial Worker	25	Years	U.S. EPA 1989 (pg. 6-23)	RSL default
	All	Construction Worker	1	Years	U.S. EPA 1989 (pg. 6-23)	RSL default
Particulate Emission Factor	Soil	All	1.36E+09	m^3/kg	USEPA 2002 Equations 4-3 and 4-4	Maine
Number of days with ≥0.01” precipitation	Soil	Construction worker	1.31E+02	days/year	Maine-specific climate data based on the Portland area	Maine

Abbreviations

mg - milligram
kg - kilograms
ml - milliliters
L - liter
cm^2 - square centimeter

References

U.S. EPA 1989. RAGs Volume I: Human health evaluation manual (Part A). Interim Final. Office of Emergency and Remedial Response. EPA/540/1-89/002. U.S. EPA 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard default exposure factors". OSWER Directive 9285.6-03.

U.S. EPA. 1996a. Soil Screening Guidance: User's Guide. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4-23

U.S. EPA. 1996b. Soil Screening Guidance: Technical Background Document. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4-17A

U.S. EPA. 1997a. Exposure Factors Handbook. Office of Research and Development, Washington, DC. EPA/600/P-95/002Fa.

U.S. EPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. December 2002.

U.S. EPA 2004. RAGs Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). OSWER 9285.7-02EP.July 2004.

U.S. EPA 2009. RAGs Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). OSWER 9285.7-82. January 2009.

U.S. EPA 2011. Exposure Factors Handbook 2011 Edition (Final). National Center for Environmental Assessment, Office of Research and Development. Washington D.C.

U.S. EPA 2018. Region 4 Human Health Risk Assessment Supplemental Guidance March 2018 available at: https://rais.ornl.gov/documents/hhra_regional_supplemental_guidance_report-march-2018_update.pdf

TSD Table 22: Physical/Chemical Properties and Toxicity Values for Manual Entry into RSL Calculator

	Acenaphthylene	Benzo[g,h,i]perylene	Carbazole	Dichlorobenzene, 1,3-			Phenanthrene	Phthalic Acid	2-Methylbenzene sulfonamide	4-Methylbenzene sulfonamide	Chlorendic acid	C5-C8 Aliphatics	C9-C12 Aliphatics	C9-C10 Aromatics	C11-C22 Aromatics	C19-C36 Aliphatics	C9-C18 Aliphatics
CAS Number	208-96-8	191-24-2	86-74-8	541-73-1			85-01-8	88-99-3	88-19-7	70-55-3	115-28-6	DEP2038	DEP2039	DEP2040	DEP2041	DEP2042	DEP2043
Chronic Oral Reference Dose (mg/kg-day)	0.06	0.03	-	0.09			0.03	2	0.04	0.114		0.04	0.1	0.03	0.03	2	0.1
Chronic Inhalation Reference Concentration (mg/m3)	-	-	-	0.2			-	0.02	NV	NV		0.2	0.2	0.05	0.05	0	0.2
Subchronic Oral Reference Dose (mg/kg-day)	0.2	0.3	-	0.6			0.3	2	0.04	0.114		0.4	1	0.3	0.3	6	1
Subchronic Inhalation Reference Concentration (mg/m3)	-	-	-	2			-	0.02	NV	NV		0.2	0.6	0.5	0.5	0	0.6
Oral Slope Factor (mg/kg-day)-1	-	-	0.028	-			-				0.091	-	-	-	-	-	-
Inhalation Unit Risk (µg/m3)-1	-	-	-	-			-				2.60E-05	-	-	-	-	-	-
RAGS Part E Dermal Absorption Factor	**Physical/chemical properties in the RSL**								0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.2

	Acenaphthylene	Benzo[g,h,i]perylene	Carbazole	Dichlorobenzene, 1,3-			Phenanthrene	Phthalic Acid	2-Methylbenzene sulfonamide	4-Methylbenzene sulfonamide	Chlorendic acid	C5-C8 Aliphatics	C9-C12 Aliphatics	C9-C10 Aromatics	C11-C22 Aromatics	C19-C36 Aliphatics	C9-C18 Aliphatics
CAS Number	**208-96-8**	**191-24-2**	**86-74-8**	**541-73-1**			**85-01-8**	**88-99-3**	**88-19-7**	**70-55-3**	**115-28-6**	**DEP2038**	**DEP2039**	**DEP2040**	**DEP2041**	**DEP2042**	**DEP2043**
RAGS Part E Gastrointestinal Absorption Factor GIABS	**Physical/chemical properties in the RSL**								1	1	1	1	1	0.92	0.92	1	1
Relative Bioavailability (RBA)	**Physical/chemical properties in the RSL**								1	1	1	1	1	1	1	1	1
Henry`s Law Constant (atm-m3/mol)	**Physical/chemical properties in the RSL**								4.70E-07	4.70E-07	1.12E-13	1.296	1.56	0.008	7.2E-04	-	1.656
Henry`s Law Constant	**Physical/chemical properties in the RSL**								1.92E-05	1.92E-05	4.58E-12	53	63.8	0.324	0.029		67.72
Log of Octanol-Water Partition Coefficient logP	**Physical/chemical properties in the RSL**								0.84	0.82	2.255	3.85	5.52	3.93	5.09	11	5.94
Molecular Weight (g/mol) MW	**Physical/chemical properties in the RSL**								171.2	171.2	388.9	93	149	120	152	0	170
Vapor Pressure (mm Hg) VP	**Physical/chemical properties in the RSL**								6.00E-05	9.60E-05	3.04E-08	76	0.661	2.204	0.024	0	0.106
Organic Carbon Partition Coefficient (L/kg) Koc	**Physical/chemical properties in the RSL**								68	66	2404	2265	1.5E+05	1778	5000	-	6.80E+05
Soil-Water Partition Coefficient (cm3/g) Kd	**Physical/chemical properties in the RSL**								0.136	0.132	4.808	4.53	300	3.556	10	-	1360

	Acenaphthylene	Benzo[g,h,i]perylene	Carbazole	Dichlorobenzene, 1,3-			Phenanthrene	Phthalic Acid	2-Methylbenzene sulfonamide	4-Methylbenzene sulfonamide	Chlorendic acid	C5-C8 Aliphatics	C9-C12 Aliphatics	C9-C10 Aromatics	C11-C22 Aromatics	C19-C36 Aliphatics	C9-C18 Aliphatics
CAS Number	208-96-8	191-24-2	86-74-8	541-73-1			85-01-8	88-99-3	88-19-7	70-55-3	115-28-6	DEP2038	DEP2039	DEP2040	DEP2041	DEP2042	DEP2043
Skin Permeability Constant (cm/hr) Kp	**Physical/chemical properties in the RSL**								6.25E-04	6.06E-04	3.24E-04	0.166	-	0.132	-	-	-
Absorbed Chemical Fraction FA (unitless)	**Physical/chemical properties in the RSL**								1	1	1	1	1	1	1	1	1
Water Solubility (mg/L) S	**Physical/chemical properties in the RSL**								1620	3160	3500	11	0.07	51	5.8	-	0.01
Volatile	**Physical/chemical properties in the RSL**								N	N	N	Y	Y	Y	N	Y	Y
Inside EPD?	**Physical/chemical properties in the RSL**								Y	Y	Y	Y	N	Y	N	N	N
Liquid or solid	**Physical/chemical properties in the RSL**								S	S	S	L	L	L	S	L	L

Notes

The constants for chlorendic acid were obtained from the Risk Assessment Information System (RAIS) (Downloaded December 11, 2020 from: https://rais.ornl.gov)

The constants for 2-Methylbenzene sulfonamide and 4-Methylbenzene sulfonamide were obtained from National Institute of Health’s National Library of Medicine and the National Center for Biotechnolgy Information (Available December 11, 2020 from: https://pubchem.ncbi.nlm.nih.gov/

The toxicity values for 2-Methylbenzene sulfonamide and 4-Methylbenzene sulfonamide were derived by Maine CDC.

The constants for the petroleum hydrocarbon fractions were obtained from the Massachusetts Department of Environmental Protection.

"Updated Petroleum Hydrocarbon Fraction Toxicity Values for the VPH/EPH/APH Methodology" MassDEP 2003 and "Characterizing Risks Posed by Petroleum Contaminated Sites" MassDEP 2002.

Attachment B: Supplemental Guidance for Conducting Site-Specific Risk Assessments in Maine

Effective Date: November 15, 2023

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
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Contents

1 Disclaimer

This guidance provides an approach for determining risk to human health at remediation sites that is accepted by the Maine Department of Environmental Protection (DEP) and the Maine Center for Disease Control (CDC, together "the Agencies"). These guidelines are not rules and are not intended to have the force of law. This guidance does not create or affect any legal rights of any individual, all of which are determined by applicable law. This guidance does not supersede statutes or rules.

2 Introduction

2.1 Current Guidance

This document replaces the Supplemental Guidance for Conducting Site-Specific Risk Assessments in Maine, May 1, 2021. This guidance is current until a revised guidance is posted on DEP's website.[1]

2.2 Purpose

The Agencies have produced this Supplemental Guidance for Conducting Site-Specific Risk Assessments in Maine. This revision is intended to supplement the United States Environmental Protection Agency's (EPA) Risk Assessment Guidance for Superfund (EPA RAGS): Parts A through F.[2] EPA RAGS are used at contaminated sites to:

1. Establish baseline human health risk from contaminants at a site;
2. Provide the basis for preparation of preliminary remediation goals (PRGs); and
3. Assist in the site remediation decision-making process.

This supplemental guidance:

1. Fosters a consistent framework for conducting risk assessment at Maine sites;
2. Expedites Agency review of risk assessments;
3. Minimizes revision and resubmittal of risk assessment documents; and
4. Identifies when the Agencies and other Parties should be consulted.

In addition to EPA guidance, the Agencies recognized that the Interstate Technology Regulatory Council has compiled risk assessment guidance that is

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[1] See Maine DEP's web page, "Remediation Program Guidance: Guidance for the Investigation and Clean-up of Hazardous Substance Sites in Maine", from: http://www.maine.gov/dep/spills/publications/guidance/index.html.

[2] EPA Website "Risk Assessment Guidance for Superfund (RAGS): Part A" from: https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part.

useful in completing human health risk assessments and undertaking risk management based on the risk assessment.[3]

2.3 Acronyms and Abbreviations

For the purposes of this guidance, the following list of acronyms and abbreviations have the following meanings:

COPC – Chemical of Potential Concern
DEP - Maine Department of Environmental Protection
ED - Exposure Duration
EGAD – Maine Environmental and Geographic Analysis Database
EPA - U.S. Environmental Protection Agency
EPA RAGs – EPA's Risk Assessment Guidelines, parts A-F
m^3/kg – cubic meter per kilogram
Maine Agencies – DEP and MeCDC
Maine RAGs – Maine Remedial Action Guidelines for Hazardous Substance Sites
MCL – Maximum Contaminant Level
MeCDC - Maine Center for Disease Control
mg/kg - milligram per kilogram
mg/L - milligram per liter
ORNL - Oak Ridge National Laboratory
PCB – polychlorinated biphenyls
Project Lead- the Party that is undertaking the risk assessment. This may be DEP, a Potential Responsible Party, or other organization.
RBC – Risk Based Concentration
RME - Reasonably Maximum Exposure
RSL – EPA Regional Screening Level
SL – Screening Level
SVOCs – semi-volatile organic compounds
TEQ – toxicity equivalency
VF – Volatilization factor
VOCs – volatile organic compounds
ug/kg – microgram per kilogram
ug/l – microgram per liter

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[3] ITRC, Webpage "Decision Making at Contaminated Sites: Issues and Options in Human Health Risk Assessment" from: https://www.itrcweb.org/risk-3/.

2.4 RSL Calculator

The EPA’s "Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites" Guidance includes a tool for calculation of site-specific risks from exposures to soil, water, air, and fish consumption.[4] Use of this tool is acceptable to the Maine Agencies, to the extent that the relevant exposure pathways for the site are included in the tool. The risk assessor should consult with the DEP before using inputs that differ from those in the Maine RAGs Technical Support Document (TSD) Table 21 - Default Exposure Assumptions for Maine Remedial Action Guidelines and Site-Specific Risk Assessments.

2.5 Communication and Dispute Resolution

Timely, frequent, and clear communication is critical to efficient development of risk assessments and risk management. The intent of this guidance is to provide direction on issues that have arisen in the past on risk assessments. When development of a risk assessment is first contemplated, it is important to immediately establish project teams with appropriate interdisciplinary subject experts from the Maine Agencies and Project Lead organizations, and to clearly communicate (preferably in writing) the roles and responsibilities of each team member, and how communication will flow between project team members. For example: Will all communication flow to and from the Project Managers of the Lead Organization and Maine Agencies, or will risk assessors/geologists/engineers talk directly to each other? What iterative process for deliverables will be used: conceptual design, 30%, 90% and as built? Will routine weekly/monthly/quarterly check-in meeting or calls be held?

Inevitably, differences of opinion will arise that are not covered in this guidance as the team works through development of the risk assessment. The key to resolving conflicts is to talk them through with technical experts at the project team level as soon as possible, and if not resolved at that level, to quickly elevate the issue to decision makers. This should be done in a step-wise, tiered approach, where decisions are made at the lowest level possible. Often dispute resolution is spelled out in Administrative Orders or other agreements, such as the Defense-State Memorandum of Agreement. Those established processes should be used. If a process is not established, one should be established by the project team, ideally *before* the first dispute arises. The following is a typical dispute resolution process that may be used as a template.

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[4] EPA webpage, “Risk Assessment: Regional Screening Levels (RSLs)” from: https://www.epa.gov/risk/regional-screening-levels-rsls.

If a Party objects to any action taken or not taken pursuant to completing the risk assessment and the objections cannot be resolved informally at the project team level:

1. The aggrieved Party will notify DEP’s Director of the Division of Remediation, the Maine State Toxicologist, and their tier-I management equivalent for the Project Lead in writing of its objection(s) within 5 (five) days after such action. The tier-I Parties will have 14 (fourteen) days from receipt of the written objection(s) to resolve the dispute (the "Negotiation Period").
2. If the tier I Party representatives are unable to reach an agreement within the Negotiation Period, the DEP Remediation Division Director will, within 5 days of the end of the Negotiation Period, notify DEP’s Director of the Bureau of Remediation and Waste Management (“BRWM”), the Maine DHHS Director of the Maine Center for Disease Control and Prevention and their tier II equivalent for the Project Lead of the dispute. The tier II Party representatives will have a 14 (fourteen) day Negotiation Period from receipt of the written objection(s) to resolve the dispute.
3. If the tier II Party representatives are unable to reach an agreement within the Negotiation Period, DEP’s BRWM Director will, within 5 days of the end of the Negotiation Period, notify the DEP Commissioner, the Commissioner of the Maine Department of Health and Human Services, and their tier III equivalents for the Project Lead of the dispute. The Parties will have a 14 (fourteen) day Negotiation Period from receipt of the written objection(s) to resolve the dispute.
4. If the dispute is not resolved, the DEP Commissioner will make the final decision and issue a written Dispute Decision Document within thirty (30) days of the end of the tier III Negotiation Period. The Dispute Decision Document shall, upon signature, be incorporated into the Risk Assessment.
5. Any agreement reached by the Parties pursuant to this Dispute Resolution Process shall be in the form of a written Dispute Decision Document and will, upon signature by the Parties, be incorporated into the Risk Assessment.
6. The Negotiation Periods for each tier may be extended up to 30-days by mutual agreement of the parties. Such extension may be granted verbally but must be confirmed in writing.

3 Planning and Scope of The Risk Assessment

3.1 Work Plan

When a site-specific risk assessment is to be conducted, generally DEP Programs will require that Project Leads prepare and submit a Work Plan for the site-specific risk assessment. The Work Plan provides a platform for discussion between the Agencies and the Project Lead on the scope-of-work for the risk assessment. The Work Plan should include a schedule for completion, details concerning the content, format, and submittal of interim deliverables, and a dispute resolution process (section 2.5). Interim deliverables provide an opportunity to collaborate with the agencies as the risk assessment is being developed. To standardize and facilitate review of submitted risk assessments, risk assessors are encouraged to use the reporting format specified in the EPA Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part D).[5] Suggested interim deliverables that are submitted prior to the draft risk assessment report, include:

1. Conceptual Site Model (CSM) identifying the media, exposure points, receptors, and exposure pathways of concern (see Figure C-1);[6]
2. Selection of chemicals of potential concern (COPCs);
3. Receptor-specific exposure assumptions;
4. Exposure Units (see section 3.2);
5. Modeling reports when models are used to estimate risks or hazards, including any statistical programs, and fate and transport models;
6. Exposure point concentration (EPC) calculations (section 5.4); and
7. Draft risk and hazard calculations.

As discussed in EPA RAGS part D, the planning stage of a risk assessment should begin early in the site investigation and include a discussion of goals and expectations between the risk assessor and the Agencies. Persons performing the risk assessment should be involved with the preparation of the CSM as it relates to risk assessment. The use and grouping of exposure units should be discussed and agreed upon at this stage. The data necessary for the risk assessment should be considered when drafting the Sampling and Analysis Plan (SAP) for the site because the number, location, and analytical requirements for environmental

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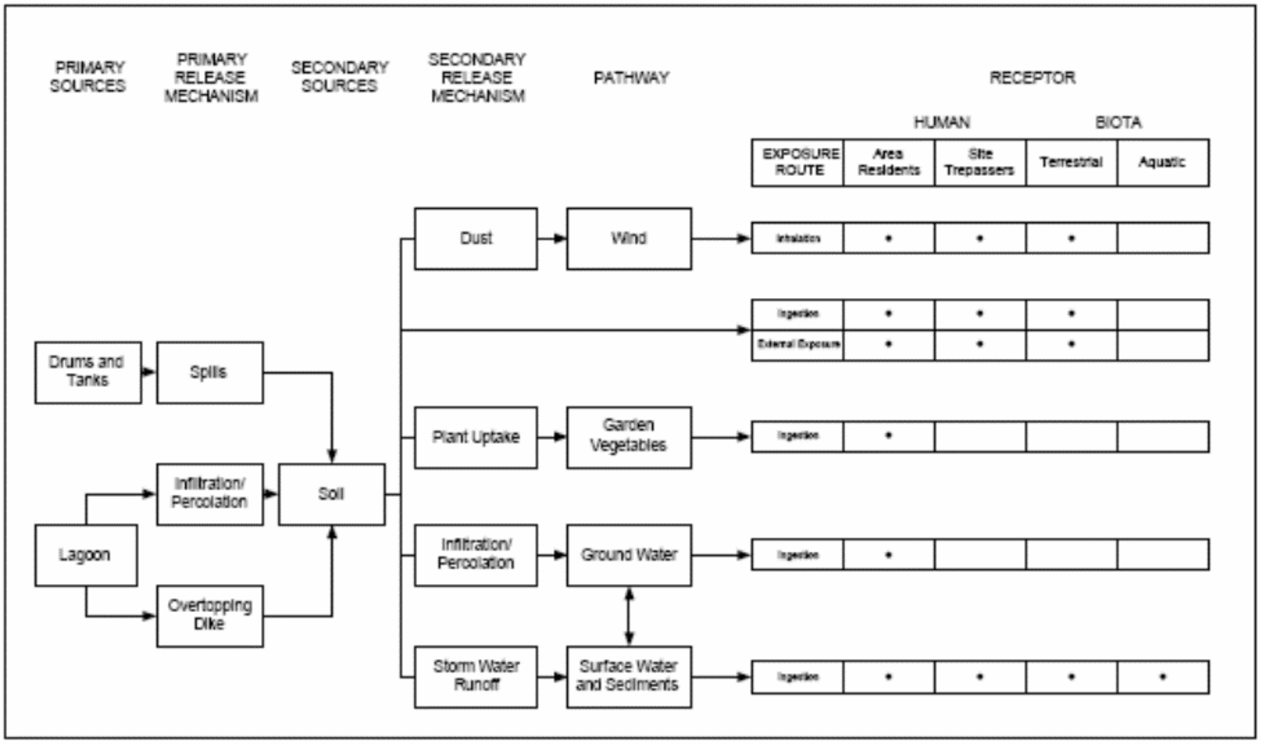
[5] EPA webpage, "Risk Assessment: Risk Assessment Guidance for Superfund (RAGS): Part D" (downloaded February 19, 2021 from: https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-d).

[6] EPA, Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model (OSWER, EPA 542-F-11-011, available at: https://www.epa.gov/sites/production/files/2015-04/documents/csm-life-cycle-fact-sheet-final.pdf) July 2011.

samples in each identified exposure unit will need to be able to support the risk assessment calculations.

Figure C-1: Example Conceptual Site Model Schematic
From: EPA/Techlaw PowerPoint Presentation, Conceptual Site Model from: https://archive.epa.gov/epawaste/hazard/web/pdf/csm.pdf), undated.



	HUMAN		BIOTA	
EXPOSURE ROUTE	Area Residents	Site Trepassers	Terrestrial	Aquatic
Inhalation	•	•	•	
Ingestion	•	•	•	
External Exposure	•	•	•	
Ingestion	•			
Ingestion	•			
Ingestion	•	•	•	•

3.2 Exposure Units

An exposure unit is the portion of the site where a Reasonably Maximum Exposed (RME) individual may be exposed to site contaminants. Exposure units are identified based on typical human activities, and the CSM's current and future site use. They are described by location, size and environmental media (e.g. soil, groundwater, etc.). In the quantitative risk assessment, data are grouped by exposure units to calculate exposure point concentrations. An example of an exposure unit is surficial soil over a proposed ¼-acre residential house lot. Typically, separate operable units or areas of concern at a site are evaluated as separate exposure units.

Exposure areas should not unnecessarily combine areas of high contamination with areas of low contamination. At sites with "hot-spots" or localized areas of high contamination, exposure points need to focus on these areas while considering typical exposure behavior. For example, quantify the exposure of a child to an identified hot-spot if a future sand box or swing is in that area, considering that the child will use other areas of a yard as well. Unimpacted portions of the site may not be appropriate for inclusion in an exposure point (but may be used to determine site-specific background conditions, if necessary).

Individual drinking water wells should be considered a unique exposure unit. However, it may be appropriate to group monitoring wells (see 5.4.1). Exposure units for sediment and surface water (e.g., rivers, ponds, lakes, estuaries, coastal, and wetland environments) should be proposed on a site-specific basis, while considering the distribution of contamination in depositional areas, tidal influence, and known human exposure patterns in the area.

3.3 Data Usability

Prior to use in the risk assessment, the quality of analytical data should be assessed using methods detailed in EPA guidance for data usability, including the collection and evaluation of appropriate blank and duplicate data. For data to be considered adequate for a risk assessment, the following criteria should be met:

1. There is sufficient analytical data to characterize the site;
2. Data collection methods are consistent with DEP and EPA guidance and an approved SAP that includes a Quality Assurance Project Plan (QAPP);
3. Sampling and analytical procedures give accurate, chemical-specific concentrations;
4. The data has been validated and found to meet project data quality objectives (DQOs) for the risk assessment; and
5. Method detection limits and sample quantitation limits, to the extent practicable, are below risk screening criteria (see section 4.1).

3.3.1 Reporting Limits

One goal for data usability is to set analytical detection limits such that reporting limits are at least three-fold less than the media-specific screening criteria appropriate for selecting COPCs (see section 4.1), as well as any applicable regulatory standards and guidelines. For highly toxic compounds with low screening criteria, this goal may not be achievable. In these cases, an analytical method should be selected that provides a reporting limit less than or as close as possible to the screening criteria.

3.3.2 Field Data

In general, field screening data are not recommended for use in a quantitative risk assessment unless the chemical-specific results correlate well with fixed laboratory analysis conducted in parallel with the collection of field screening data.

3.3.3 Tentatively Identified Compounds

Data for tentatively identified compounds (TICs), if available/identifiable, should be evaluated to determine the need for chemical/compound specific analysis. TICs detected at a concentration higher than the analytical equipment's background noise, and/or determined to exhibit a high degree of chemical-specific toxicity should be evaluated.

3.3.4 Qualified & Rejected Data

Qualified data should be appropriately used and explained in the uncertainty section of the risk assessment report (i.e., discussion on potential bias from qualified data and how it might result in the over or under estimation of risk). Rejected data should not be used for risk assessment purposes.

3.3.5 Data Usability Criteria

The risk assessment data usability criteria listed below should be assessed during scoping for the risk assessment. Consult DEP when discussing how to best address inadequate data.

1. Data Sources – Data should be from comparable sources (i.e., analytical methods, areas of concern, sampling methodologies).
2. Documentation – Deviations from the SAP and standard operating procedures (SOPs) should be documented so that risk assessors are aware of any potential limitations in the data.
3. Analytical Methods – Analytical methods should be capable of analyzing all COPCs at reporting limits that are at or below applicable screening levels, as well as applicable or relevant and appropriate requirements (ARARs).
4. Data Quality Objectives – EPA's DQOs Guidance for analytical data should be met.[7]
5. Data Review – Use of preliminary or partially reviewed data is not recommended. A full data quality review should be completed.
6. Reports – A data review report that includes evaluation of the adequacy of the analytical quantitation limits, demonstration that DQOs have been met as described above, and a narrative

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[7] EPA, Data Quality Objectives Process for Hazardous Waste Site Investigations (QA/G-4HW), January 2000, from: https://www.epa.gov/sites/production/files/2015-07/documents/g4hw-final.pdf;

EPA, Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4), February 2006, from: https://www.epa.gov/quality/guidance-systematic-planning-using-data-quality-objectives-process-epa-qag-4; and

EPA, EPA Guidance for Quality Assurance Project Plans, February 1998, from: https://clu-in.org/conf/tio/sysplan_031501/epaqag5.pdf.

discussing any qualified data and potential impacts resulting in uncertainties in the risk estimates should be provided.

4 Hazard Assessment

4.1 Selection of Chemicals of Potential Concern

If the number of chemicals detected at a site is large, it may be appropriate to narrow the list of chemicals to be quantitatively evaluated in the risk assessment. This is done by eliminating chemicals that could not pose, even when additive risks are considered, an unacceptable risk at the site (i.e. exceed an ILCR of 10^{-5} or a HI of 1). The retained chemicals are known as Chemicals of Potential Concern (COPCs). COPCs are selected by comparing maximum measured concentrations in a given media to the current media-specific RSL values set at a HQ=0.1 and an ILCR of 10^{-6}. Compounds that exceed the screening table values are COPCs. The intent of the COPC selection process is to generate a list of COCs for inclusion in the risk assessment evaluation. The screening criteria are intended to be conservative to prevent the omission of compounds that may impact cumulative risk calculations.

Do not eliminate chemicals based on frequency of detection alone since just one detection could be indicative of a localized contaminant “hot spot.”

If a chemical is not represented in the RSL table, the corresponding Maine RAG may be adjusted to the COPC selection Target Risk by multiplying the Maine RAG by 0.1. For site contaminants that are missing from the RSL tables and Maine RAGs, consult CDC on the appropriate value to be used. Additionally, retain lead as a COPC when a maximum exposure concentration exceeds its respective Maine RAG value.

In accordance with EPA Guidance, retain compounds for quantitative evaluation of risks that may stem from background contamination.[8] However, in accordance with EPA RAGS part A, eliminate low concentrations of essential human nutrients, which are chemicals denoted by EPA as essential human nutrients at low concentrations and toxic only at very high doses: namely magnesium, calcium, and potassium.

5 Exposure Assessment

The purpose of the exposure assessment is to estimate the pathways by which humans are potentially exposed, the magnitude of actual and/or potential exposures, and the frequency and duration of these exposures. This is specific to the environmental media (soil, groundwater, etc.) and receptor (residential, park user, etc.) for each exposure unit. When fate and transport models are used to estimate exposure, the report should present

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[8] Assessing risk contribution from background contaminants is described in Section 7.2 of the Maine RAGs narrative.

pertinent information needed to verify the model and to recreate the output. Required information includes input parameters and assumptions.

Consult with the Agencies prior to running calculations when departing from the default exposure assumptions used for the Maine RAGs as shown in TSD Table 21.

5.1 Receptors and Exposure Pathways

Generally, DEP programs require that the baseline risk assessment consider all current and future land uses at each exposure unit through the evaluation of all potentially complete exposure pathways. Applicable receptors and exposure pathways should be identified and justified as part of the CSM prepared for the site. Depending on the CSM, potential receptors could include residents, indoor commercial workers, outdoor commercial workers, various construction workers, excavation workers, recreators, farmers, gardeners, anglers, trespassers, etc. Figure C-1 depicts an example CSM with standard default exposure pathways of concern, by land use and receptor. Some additional pathways and/or receptors that may require consideration for evaluation include:

1. Ingestion of homegrown meat and dairy products for a home farm scenario;
2. Ingestion of game and waterfowl for hunters and their families;
3. Inhalation of volatiles from surface water;
4. Inhalation of particulates by dirt biking trespassers, residents, or recreational users; and/or
5. Ingestion of fish and shellfish as part of a regular subsistence diet for certain populations (e.g., Native American, off-shore island families, etc.)

DEP Programs almost always require that an unrestricted use (i.e. future residential) scenario for each site be included in the baseline risk assessment. Even if current and likely future site use and/or local zoning is non-residential, the unrestricted use scenario determines whether institutional controls are necessary on (part of) the site, the type of control, and how stringent such controls need to be.

The exposure pathways should be identified for all probable current and future site use scenarios. For example, there may not be a current complete exposure pathway for groundwater because there is not a potable well at or near the site, but there is a potential future pathway if a well can be installed in the future. Therefore, the groundwater pathway should be considered as a future complete pathway. If the COPCs include contaminants in soil vapor, then the vapor intrusion pathway should be considered for future occupied buildings, even if such buildings currently do not exist at the site. See the Maine RAGs for further discussion of excluding exposure pathways, implementation of institutional controls, and exposure to soil at depth.

5.2 Exposure Assumptions - RME

The selection of exposure assumptions to be used in Maine risk assessment should be consistent with the intent of a Reasonable Maximum Exposure (RME) scenario, defined by EPA as the highest exposure that is reasonably anticipated to occur at a site. Exposure parameters specific to the default exposure pathways for the State of Maine are listed in TSD Table 21. Deviation from these recommended values should be discussed beforehand with the Agencies and be based on well documented site-specific justification.

5.3 Exposure Models

For quantitative risk assessment, DEP recommends the use of site monitoring data rather than modeled results, whenever possible. For example, reported concentrations in indoor air are preferable to concentrations estimated by modeling subsurface migration and dilution into indoor air. However, when the use of monitoring data is not feasible, conservative application of modeling, within its limitations to derive EPCs, is acceptable. Specific models and associated parameters and assumptions should be discussed with DEP before implementation. Modeling of other media-specific environmental contaminant concentrations (e.g., contaminant uptake into edible fish or game) or the use of other available models should be proposed on a site-specific basis and likewise discussed with DEP before completion of the risk assessment.

Consult EPA's latest guidance for modeling Exposure Point Concentrations,[9] which provides assessment models and tools by media, including air, water, sediment, soil, dust, food, aquatic biota and consumer products. ITRC also lists exposure models that may be useful.[10] Additionally, the following sections provide general guidance relative to the use of some specific models to estimate EPCs.

5.3.1 Soil and Groundwater to Indoor Air

Direct measurement of soil gas concentrations is a much better tool to evaluate Vapor Intrusion than available models. To evaluate the subsurface migration of volatile compounds to the indoor air of occupied buildings, (known as Vapor Intrusion or VI), DEP has developed Vapor

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[9] EPA webpage ExpoBox (A Toolbox for Exposure Assessors), which provides models and other tools by media, from: https://www.epa.gov/expobox.

[10] ITRC webpage, "Decision Making at Contaminated Sites, Issues and Options in Human Health Risk Assessment, Chapter 6- Exposure Assessment," from https://projects.itrcweb.org/risk-3/#6.%20Exposure%20Assessment.htm#6._Exposure_Assessment%3FTocPath%3D6.%2520Exposure%2520Assessment%7C_____0 and Appendix C- Models Routinely Used to Estimate Exposure Concentrations for Different Exposure Scenarios and Exposure Pathways," fromhttps://projects.itrcweb.org/risk-3/#Appendix%20C.%20Models%20Routinely%20Used%20to%20Estimate%20Exposure%20Concentrations%20for%20Different%20Exposure%20Scenarios%20and%20Exposure%20Pathways.htm%3FTocPath%3D_____18, January 2015.

Intrusion Guidance,[11] which Supplements EPA's recent VI guidance. DEP's VI supplemental guidance should be followed to determine whether impacts to indoor air require investigation, and if so, how to conduct these evaluations. When direct measurement is not possible, consult DEP on the value of modeling, and whether preemptive remedies will be more cost-effective. The EPA Vapor Intrusion Screening Level (VISL) calculator identifies chemicals that are considered to be sufficiently volatile and toxic to warrant an investigation of the soil gas intrusion pathway when they are present as subsurface contaminants.

5.3.2 Shower Model

The RSL calculator residential tap water scenario includes exposure to contaminants from volatilization while showering and can be used to model this exposure.

5.3.3 Inhalation of Volatiles in a Trench

The Virginia Department of Environmental Quality (VDEQ) trench air models are used to assess the inhalation pathway for workers in an excavation trench impacted by volatiles in groundwater.[12] Two distinct models have been developed by VDEQ for groundwater greater than 15 feet below ground surface and groundwater less than 15 feet below ground surface. Again, maximum groundwater concentrations should be used to model trench air concentrations for COPC selection. Once COPCs are selected, groundwater EPCs (e.g., 95% UCLs) may be used to generate trench air EPCs.

5.4 Exposure Point Concentrations

The Exposure Point Concentrations (EPCs) are the concentrations of the COPCs in the environmental media at the point of human exposure, such as groundwater in a drinking water well or soil in a residential yard. Consistent with EPA guidance,[13] the 95th percentile upper confidence limit (UCL) on the arithmetic mean concentration is recommended for use as the EPC for soil, sediment, and surface water exposure points. DEP recommends the use of EPA's ProUCL software to calculate the 95% UCL. Other statistical software should be preapproved by DEP. Please use the current version of ProUCL available from

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[11] See DEP's **Vapor Intrusion Guidance:** Investigation procedures to determine if contaminants have volatilized from contaminated soil or water into indoor air, & associated risk-based evaluation guidance. This guidance is available from DEP's webpage entitled Remediation Program Guidance: Guidance for the Investigation and Clean-up of Hazardous Substance Sites in Maine, available at: http://www.maine.gov/dep/spills/publications/guidance/index.html#vi.)

[12] Virginia Department of Environmental Quality, Virginia Unified Risk Assessment Model – VURAM Users Guide for Risk Assessors, updated October 2018, from: https://www.deq.virginia.gov/home/showpublisheddocument?id=4068.

[13] EPA, Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites, December 2002, from: https://www.epa.gov/sites/production/files/2016-03/documents/upper-conf-limits.pdf..

EPA as a free, downloadable program. The ProUCL output pages should be included in the Risk Assessment report. The ProUCL input files should be submitted in digital format.

The maximum concentration may be used as the EPC when there is an insufficient number of samples to calculate a 95% UCL or if the calculated 95% UCL exceeds the maximum value. The most current ProUCL version recommends a minimum of eight samples to calculate a reliable UCL on the arithmetic mean for an exposure point in soil.

In the case of Multi-Incremental Sampling (a.k.a. Incremental Sampling Methodology), the Decision Unit may represent the Exposure Unit and therefore the Incremental Sampling result would be the EPC. If an Exposure Unit is represented by multiple Decision Units, then the 95% UCL of the mean of the Decision Unit sample results must be calculated to determine the EPC.

5.4.1 EPCs for Groundwater

EPCs for groundwater should be at a potential future RME receptor such as a resident consuming drinking water from a well near the most contaminated part of the plume at the site. This is a conservative approach but generally the remedial action selected for sites where there is no current drinking water receptor is an institutional control, such as a covenant on the property deed restricting groundwater use. Whether an active groundwater remedy is needed should be evaluated under certain criteria and will be determined following a feasibility study.

Consistent with EPA guidance,[14] for monitoring well data being evaluated for the household water use pathway, the groundwater EPC should be the 95% UCL on the arithmetic mean based on at least 10 data points from the core of a contaminant plume (or the maximum value if the 95% UCL exceeds the maximum value). For evaluating risk at an existing drinking water well, typically the maximum concentration is used as the EPC.

For direct contact with groundwater by an excavation worker, it may be appropriate to use UCLs for groundwater COPCs for each exposure point with appropriate justification provided. For sites with multiple rounds of groundwater data, temporal averaging may be used prior to the identification of maximum concentrations as long as enough data have been collected to adequately characterize seasonal variability (e.g., quarterly sampling).

5.4.2 EPCs for Surface Water

EPCs for groundwater discharging at a surface water body near the site should be determined through direct measurement of surface water

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[14] EPA, Exposure Point Concentrations in Groundwater, February 2014, from: https://www.epa.gov/risk/exposure-point-concentrations-groundwater.

concentrations. Failing that, modeling for groundwater to surface water loading calculations may be conducted.

5.4.3 Data Handling

Total water analytical results, rather than filtered results, are recommended for use in EPC estimation because unfiltered samples yield a better representation of what would be consumed by residents or contacted by construction workers. Prior to EPC estimation, duplicate sample results should be averaged. Estimated values (e.g., "J" qualified results) should be used without adjustment. Non-detects in the dataset should be treated as recommended in the ProUCL User's Guide.

6 Toxicity Assessment

6.1 Toxicity Hierarchy

Maine uses the EPA toxicity hierarchy and the chronic and subchronic toxicity values selected by EPA for use in the RSL calculators.[15]

6.2 Toxicity Equivalence Factors for Dioxins and Coplanar PCBs

For chlorinated dibenzo-p-dioxin, chlorinated dibenzofuran and co-planar polychlorinated biphenyl (PCB) data, the relative potencies of the isomers and congeners should be addressed through the use of toxicity equivalency factors (TEFs). Maine RAGs, Section 7.5.3-Dioxins and Co-Planar PCBs, provides guidance on how to evaluate dioxin and dioxin-like compound data, including a table of TEFs (Table 3). The raw analytical data should be adjusted using the TEFs prior to the estimation of EPCs. EPCs should be expressed as Toxicity Equivalents (TEQs) and evaluated as 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD).

6.3 Petroleum Hydrocarbon Fractions

As discussed in the RAGs TSD, EPA RSL guidance for petroleum contamination uses fractions for which analytical methods have not been developed. Therefore, DEP continues to use the Massachusetts Department of Environmental Protection's (MassDEP's) volatile petroleum hydrocarbon (VPH), extractable petroleum hydrocarbon (EPH) and air-phase petroleum hydrocarbon (APH) analytical methods for petroleum hydrocarbon fractions and MassDEP's toxicity values for these fractions for use in Maine risk assessments.[16] TSD Table 22: Physical/Chemical Properties and Toxicity Values for Manual Entry into RSL

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[15] EPA, Memorandum for Human Health Toxicity Values in Superfund Risk Assessments (OSWER Directive 9285.7-53, December 5, 2003, from: https://www.epa.gov/sites/production/files/2015-11/documents/hhmemo.pdf..

[16] Specific details concerning the MassDEP petroleum methods can be found at https://www.mass.gov/lists/risk-assessment-information#petroleum-.https://www.mass.gov/lists/policies-guidance-technical-support-for-site-cleanup

Calculator, of the Maine RAGs TSD, includes default toxicity values to be used for assessing VPH, EPH and APH exposure risk.

6.4 Chemical Isomers xylene, 1,2 dichloroethylene and 1,3-dichloropropane

Unless otherwise agreed to by MeCDC, handle the risk of these parameters as follows:

1. Compare the sum of all xylene isomers to the total xylenes RAG.
2. Compare 1,2 dichloroethylene results to the cis-1,2-dichloroethylene RAG.
3. Compare the sum of cis and trans 1,3-dichloropropane to the 1,3-dichloropropane RAG.

6.5 Pesticide Classes

Unless otherwise agreed to by MeCDC, total each of the following pesticides in the following pesticide classes and assess risk using the toxicity factors for the parent compound:

Total DDT: The terms “DDT,” “DDE,” and “DDD” are used to refer to the sum of isomer concentrations of p,p'-DDT and o,p'-DDT, p,p'-DDE and o,p'-DDE, and p,p'-DDD and o,p'-DDD, respectively. “DDTs” refers to any or all of the six compounds identified above, as well as the metabolites and degradation products of these six compounds. “Total DDT” refers to the sum of the concentrations of p,p'-DDT, o,p'-DDT, p,p'-DDE, o,p'-DDE, p,p'-DDD, and o,p'-DDD.

Total Endosulfan is the sum of α- and β-isomers, endosulfan diol, endosulfan ether, endosulfan sulfate, and endosulfan lactone.

Total Chlordane is the sum of cis and trans-chlordane, heptachlor, heptachlor epoxide, oxychlordane and cis-nonachlor, trans-nonachlor.

Total Endrin is the sum of endrin, endrin aldehyde, endrin ketone, heptachlorobicycloheptene, hexachloronorbornadiene, and isodrin.

6.6 Chemicals without Toxicity Values

If no risk-based concentration is available for a given chemical in a given media, that chemical should be retained in the quantitative risk assessment, unless a risk-based concentration for a conservative surrogate compound is selected for screening and its maximum detected concentration is less than the conservative surrogate screening value. The use of surrogate screening values should be identified in footnotes on the COPC screening table.

Surrogate assignments recommended by the Agencies include:

Compound Lacking Toxicity Criteria in RSL	**Toxicity Surrogate Compound**
PCBs (noncancer)	Aroclor 1254

Acenaphthylene	Acenaphthene
Phenanthrene	Pyrene
Benzo(g,h,i)perylene	Pyrene
Dibromochlormethane	Bromochloromethane
Dichlorobenzene, 1,3-	Dichlorobenzene, 1,2-

Some per- and polyfluoroalkyl substances (PFAS) do not have toxicity values. As part of the PFAS Strategic Road Map, EPA has taken steps to build the evidence base for PFAS and define categories of PFAS to establish toxicity values.[17] Several other States have developed toxicity factors for several PFAS compounds, and Maine CDC is assessing this information. Until toxicity values are released, PFAS will be assessed on a site-specific basis.

Toxicity Factors for compounds may underestimate the risk of the compounds if the compounds are in Nano form (less than 100 nanometers in at least one direction). To assess the toxicity of nanomaterials, consult the latest EPA guidance.[18]

6.7 Risk Assessment for Lead

If lead is found to be a COPC, site-specific risk models such as the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) and the Adult Lead Model (ALM) should be used to determine lead cleanup levels. In a residential scenario, the most sensitive receptor is a child exposed to lead and, therefore, the IEUBK should be used to determine appropriate cleanup levels. In a non-residential setting, such as a commercial or industrial scenario, the most sensitive receptor is the fetus of a worker who develops a body burden as a result of non-residential exposure to lead. The ALM should be used in this instance.

The IEUBK attempts to predict blood-lead (PbB) concentrations for children exposed to lead in their environment. The model allows the user to input relevant absorption parameters (e.g., the fraction of lead absorbed from water) as well as intake and exposure rates. Using these inputs, the IEUBK model rapidly calculates and recalculates a complex set of equations to estimate the potential concentration of lead in the blood for a hypothetical child (6 months to 7 years of age).

The United States Center for Disease Control and Prevention (USCDC) has determined that childhood PbB concentrations at or above 5 micrograms of lead

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[17] EPA webpage, “EPA Actions to Address PFAS,” from: https://www.epa.gov/pfas/epa-actions-address-pfas.

[18] EPA webpage, “Exposure Assessment Tools by Chemical Classes – Nanomaterials,” from: https://www.epa.gov/expobox/exposure-assessment-tools-chemical-classes-nanomaterials.

per deciliter of blood (µg Pb/dL) present a potential risk to children's health,[19] and the Maine Legislature in 2015 effectively adopted this level as the definition of lead poisoning.[20]

The ALM should be used to assess exposure to lead in a non-residential setting. The ALM assesses non-residential adult risks utilizing a methodology that relates soil lead intake to blood lead concentrations in women of childbearing age. The ALM estimates the soil lead concentration at which the probability of blood lead concentrations exceeding 10 µg Pb/dL in fetuses of women exposed to environmental lead is no greater than 5%.

The default parameters incorporated in the IEUBK and the ALM can be found in EPA guidance.[21, 22]

If alternate bioavailability values are proposed (based either on in vivo studies, blood lead studies, or other studies) for use in the IEUBK model or the ALM, the proposed values should be submitted to MeCDC and the Technical Review Workgroup (TRW) for Lead for review. The proposed values should be compared to current guidance regarding use of the IEUBK, blood lead studies, and other studies.

7 Risk Characterization

The information from the exposure assessment and the toxicity assessment is integrated to form the basis for the characterization of human health risks. The risk characterization presents qualitative and quantitative descriptions of potential risks with a discussion of the assumptions and uncertainties. The risk characterization serves as the bridge between risk assessment and risk management.

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[19] U.S. Centers for Disease Control and Prevention website, “Blood Lead Reference Value,” from: https://www.cdc.gov/nceh/lead/acclpp/blood_lead_levels.htm.

[20] 22 M.R.S, §1315 §§ 5-C, which states: “**Lead poisoning.** "Lead poisoning" means a confirmed elevated level of blood lead that is equal to or exceeds 5 micrograms per deciliter,” from: http://legislature.maine.gov/statutes/22/title22sec1315.html.

[21] EPA Website, “Lead at Superfund Sites: Software and Users' Manuals,” from: https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals.

[22] EPA website, “Lead at Superfund Sites: Guidance,” from: https://www.epa.gov/superfund/lead-superfund-sites-guidance, including:

- Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (1994)
- IEUBK model (2009)
- Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil (2003) and
- ALM Spreadsheet (USEPA, 2003)

The risk characterization should include the following elements in the final discussion:

1. Confidence that key site-related contaminants have been identified, and their nature and extent fully characterized;
2. Description of known or predicted health risks;
3. Confidence in the toxicity information supporting the risk estimates;
4. Confidence in the exposure assessment estimates;
5. Magnitude of the cancer and noncancer risks relative to the site-remediation goals; and
6. Major factors driving the risks including contaminants, pathways, and scenarios.

For more information regarding risk characterization, refer to EPA RAGs Step 4, Risk Characterization.

For each receptor, cancer risks and hazard quotients should be summed across all contaminants and media of concern to estimate the cumulative cancer risk and hazard index for that receptor. Cancer risk should additionally be summed across age groups (e.g., adult plus child resident cancer risks) to generate a total receptor cancer risk, as applicable. The Agencies use a benchmark Incremental Lifetime Cancer Risk (ILCR) level of 1×10^{-5} and a benchmark Hazard Index (HI) of 1. These benchmarks are compared with the cumulative HI (added across all contaminants and media of concern) and the total ILCR for each receptor. Where the cumulative HI exceeds 1, consider providing a target organ segregation rationale to demonstrate that the COPCs contributing to the HI in excess of 1 act through distinct mechanisms of action and on different target organs. Use this information to calculate target organ-specific hazards. The DEP uses the benchmark HI and ILCR above to determine when remedial action or mitigation is necessary to protect public health.

When conducting risk assessments for petroleum compounds, be careful to avoid double counting risks from target analytes and petroleum ranges. For example, analyzing for both VOCs and VPH/APH will cause reporting of the substituted benzenes (trimethylbenzene, butylbenzenes) twice, once as the pure compounds and a second time as part of the C9-C10 mixture of compounds. The risks from these two analyses should not be added together. The risks from the VPH/APH will be the most accurate because they account for the risk posed by the full mixture, rather than the small number of individual compounds that fall within that range that are picked up by the VOC analysis.

The toxicity values for the petroleum ranges were developed to best represent the toxicity of each ranges’ mixture overall, based on the toxicity of the most toxic individual compound or on mixtures studies. So, while the RfD and CPF of each range may not be as conservative as those for some of the individual non-BTEX substituted benzene compounds, they capture the risk of the entire range. If a site was sampled for VOCs only (and not VPH/APH) and the results show the benzene substitutes to be present, then the site will need to be resampled for VPH/APH to determine the actual risk posed by petroleum.

8 Acute Toxicity Values

When the risk assessment indicates that there is a significant exceedance of chronic risk endpoints, then acute health risk should be assessed to determine if emergency or early actions are needed. As with subchronic toxicity values, there is no centralized database for acute toxicity values. ATSDR develops MRLs for acute exposures ranging from 1 to 14 days in duration.[23] For inhalation exposures, EPA maintains a website with acute toxicity values from a variety of sources and for a variety of exposure durations (generally ranging from 1-hour to 8-hour exposures).[24]

Risk assessors are encouraged to work closely with CDC toxicologists to select acute toxicity values most applicable to the exposure scenario of interest. However, use of Acute Exposure Guideline Levels (AEGLs) is inappropriate for assessing acute air exposure risk at remediation sites since AEGLs were developed to assess the risk resulting from a once-in-a-lifetime exposure to airborne chemicals from catastrophic events.

9 Development of Alternative Cleanup Levels

Consult the latest EPA guidance on calculating Preliminary Remediation Goals (PRGs).[25]

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[23] ATSDR Webpage: Toxic Substances Portal, Minimal Risk Levels (MRLs) – For Professionals, from: http://www.atsdr.cdc.gov/mrls/index.html.

[24] EPA webpage “Dose-Response Assessment for Assessing Health Risks Associated With Exposure to Hazardous Air Pollutants,” from: https://www.epa.gov/fera/dose-response-assessment-assessing-health-risks-associated-exposure-hazardous-air-pollutants.

[25] EPA, “Calculating Preliminary Remediation Goals (PRGs),” from: https://www.epa.gov/risk/calculating-preliminary-remediation-goals-prgs.

Attachment C: Maine 2023 Remedial Action Guidelines Addendum for Petroleum Remediation

Effective Date: November 15, 2023

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Contents

1 Introduction and Disclaimer

This document presents the 2021 Maine Remedial Action Guidelines (RAGs) for sites Contaminated with Hazardous Substances and Petroleum, Addendum for Petroleum Remediation (petroleum addendum). Together, the petroleum addendum and the RAGs provide a DEP-accepted approach for determining human health risk and clean-up goals at petroleum remediation sites.

The petroleum addendum and RAGs are guidelines not rules and are not intended to have the force of law. This addendum does not create or affect any legal rights of any individual, all of which are determined by applicable law. This guidance does not supersede statutes or rules. Specifically, applicable standards in *Rules for Underground Oil Storage Facilities*, 06-096 C.M.R. ch. 691 (effective date September 16, 1991, amended September 26, 2018-filing 2018-205), *Identification of Hazardous Matter*, 06-096 C.M.R. ch. 800 (effective date February 3, 1981, amended September 3, 2013-filing 2013-215) and *Beneficial Use of Solid Wastes*, 06-096 C.M.R. ch. 418 (last revised July 8, 2018) supersede any conflict with this guidance.

The petroleum addendum is specific to the investigation and remediation of petroleum only sites directly related to petrogenic hydrocarbons with the exception of the Marine Terminal Facilities, which have their own cleanup criteria established in *Oil Discharge Prevention and Pollution Control*, 38 M.R.S. §542 (4-B)(E) (1/1/2021). Section 3 below provides additional details on the applicability of the petroleum addendum.

The petroleum addendum identifies specific sections where petroleum remediation guidelines require clarification on how the RAGs are applied to petroleum remediation (e.g. Section 3.2, Applicable Pollutants) and sections that don’t align with the RAGs (e.g. Section 3.3, Applicable Media, Scenarios, and Routes of Exposure). The petroleum addendum defaults to the RAGs when there are no specific details provided in this addendum (e.g. Section 3.5 of the RAGs, Not Applicable to Selection of COPCs for Full Risk Assessment, Section 8, Technical Help & Technical Basis for the RAGs, and Section 9, RAG Tables).

This addendum utilizes the same risk-based criteria supported by the Maine Center for Disease Control and Prevention (CDC). Section 4 of the RAGs provides the risk protocols used to develop the petroleum addendum. This addendum is supported by Attachment A and Attachment B of the RAGs and is included as Attachment C to the RAGs.

As discussed in section 6.2 of the RAGs, the RAGs apply only after emergency removal actions have been completed. Many petroleum release sites involve a recent discharge of petroleum. DEP’s Division of Response Services is responsible for emergency actions to resolve imminent threats to human health and the environment. Emergency actions include stopping the discharge, mitigating the spread of the discharge to receptors, and removing the discharge at the receptor (residential home, commercial building, wetland, marsh, surface waters, and marine environment). Prompt emergency response actions to eliminate the discharge condition and control the released petroleum from migrating to a receptor, into the environment, or soaking further into building materials is the top priority for emergency response action.

This addendum applies to the following programs within BRWM including Uncontrolled Sites (RAGs Section 3.1.1), VRAP (RAGs Section 3.1.2), Brownfields (RAGs Section 3.1.3), Superfund/CERCLA (RAGs Section 3.1.4), RCRA subpart I (RAGs Section 3.1.5), and Beneficial Reuse of Remediation Debris (RAGs Section 3.1.8).

Standard Operating Procedures (SOPs) for implementation of the RAGs Petroleum Addendum are provided on the DEP website at: https://www.maine.gov/dep/spills/petroleum/index.html.

Remedial actions completed or overseen by DEP staff must follow required funding approval requirements and supervisor notifications.

When petroleum remediation sites need state liability protections as defined in law (*Voluntary Response Action Program*, 38 M.R.S §343-E), application should be made to the Voluntary Response Action Program (VRAP) at : https://www.maine.gov/dep/spills/vrap/index.html.

Petroleum Remediation sites that do not require VRAP liability protections but need an opinion from the DEP related to contamination present (i.e. comfort letter) should contact the Technical Services Director for assistance. Contact information is available on the DEP website: https://www.maine.gov/dep/spills/petroleum/index.html

1.1 DEP Petroleum Program

Widespread use, storage, and transportation of petroleum products, and their frequent discharges to the environment in Maine (averaging 2 per day) make the petroleum program a diverse program. The scope of the petroleum remediation program includes, but is not limited to, operating and former gas stations, home and commercial heating oil tanks, transportation accidents (trucks, cars, and boats), bulk oil storage facilities, unlicensed and/or illegal storage of petroleum, above ground tanks, underground storage tanks, piping, and dispensers.

The majority of petroleum remediation cases come through a report of a discharge to the Division of Response Services and are assigned a Spill Number. However, there are many other petroleum remediation sites that get reported to the Maine DEP through various other sources, including assessment reporting required under 06-096 C.M.R. ch. 691, through other BRWM programs, and through other points of contact within the Department. The petroleum addendum addresses the applicability of the RAGs to oil discharges.

The Maine petroleum program includes staff from:

- Maine Department of Public Safety, Office of the State Fire Marshal
- Office of Commissioner, Collections, Claims, and Recovery Unit
- Bureau of Remediation and Waste Management
- Bureau of Air Quality, Division of Licensing and Compliance

The DEP petroleum program includes, but is not limited to:

- UST Management and Compliance
- Oil Compliance
- Bulk Oil Storage
- Petroleum Remediation

Federal and state laws, statues, and rules that provide the foundation to the Remedial Action Guideline Addendum for Petroleum Remediation are outlined below.

The USEPA RCRA Subtitle I (RCRA §§9001-9010) includes requirements for the Underground Storage Tank (UST) Program for storing petroleum including:

- Protecting groundwater from leaking underground storage tanks
- Requiring owners and operators to prevent, detect, and cleanup releases
- Bans the installation of unprotected steel tanks and piping
- Considerations for UST cleanup include:
  - Protect human health and the environment
  - Ensure that wastes are managed in an environmentally sound manner

Protection and Improvement of Waters, 38 M.R.S. §§361 - 571 includes two subchapters that set the foundation for the petroleum program and establish differences between it and the other programs in BRWM. The two subchapters are:

- Oil Discharge Prevention and Pollution Control, 38 M.R.S. §§541-560
- Oil Storage Facilities and Ground Water Protection, 38 M.R.S.§§561-570-N

Four sections of Title 38 establish the petroleum remediation program including:

- Pollution and Corruption of Waters and Lands of the State Prohibited, 38 M.R.S. §543
- Removal of Prohibited Discharges, 38 M.R.S. §548
- Maine Ground and Surface Clean-up and Response Fund, 38 M.R.S. §551
- Cleanup and Removal of Prohibited Discharges, 38 M.R.S. §568

38 M.R.S. §551 satisfies the EPA requirement for financial assurance for UST facility owners and provides funding for required cleanup.

There are several rule chapters for the Board of Underground Storage Tank Installers (06-481) and DEP (06-096) related to different aspects of the petroleum program (https://www.maine.gov/sos/cec/rules/06/chaps06.htm). Rules specifically related to this Petroleum Addendum to the RAGs include:

- *Rules for Underground Oil Storage Facilities*, 06-096 C.M.R. ch. 691 (effective date September 16, 1991, amended September 26, 2018-filing 2018-205)
- *Siting of Oil Storage Facilities*, 06-096 C.M.R. ch. 692 (effective date August 7, 2019-filing 2019-116)

38 M.R.S. §543 states that any person who causes or is responsible for a discharge in violation of §543 is not subject to any fines or civil penalties if that person reports

the discharge within 2 hours and promptly removes the discharge in accordance with the rules and orders of the Board of Environmental Protection or Commissioner of the DEP (38 M.R.S. §550). There is no minimum quantity stated in the law or in any DEP rules.

1.2 DEP Petroleum Remediation

Petroleum remediation is one of several components of the DEP Petroleum Program. The remediation program focuses on releases associated with home and commercial heating oil spills, that result in a direct human health risk, at the same time the remediation program continues to address releases at UST, AST, and transportation related releases that are attributable to equipment failure, human error, and accidents. Threats to environmental resources and human health have been significantly reduced at UST and bulk oil AST facilities due to advancements in technology, reporting requirements, and siting criteria. However, continual releases from home and commercial heating oil tanks have not been reduced over the same time period and often result in completed exposure pathways to human occupants and adjacent properties. This document and associated Standard Operating Procedures (SOPs) are based on more than 40 years of DEP staff experience in successfully remediating petroleum contamination in Maine.

The petroleum program successfully opens and closes petroleum remediation cases based on the Conceptual Site Model (CSM) for the site that includes evaluation of human health risks and risks to surface water bodies. Several factors have contributed to the success of the petroleum program that are unique to the program, including:

1. The establishment of the Maine Ground and Surface Waters Clean-up and Response Fund for petroleum releases makes the petroleum program function differently than all other programs by establishing cleanup funding and rules related to fund expenditures and reimbursements (38 M.R.S. Section 551 and Section 568-A).

2. Technology advancements in leak detection and facility design has reduced legacy releases that were the focus of remedial resources in the 1990’s.

3. Siting criteria for oil storage facilities has reduced the risk to water supplies and groundwater resources.

4. Improved reporting of petroleum releases has allowed DEP staff to focus on source reduction in a timely fashion, which reduces the length of a project.

5. Resources to remediate contaminated soil and water and eliminate vapor risks in a timely manner, which facilitates site closure within months of a release.

6. Funding and resources to monitor the effects of source reduction and evaluate human health risks. Follow-on monitoring facilitates the ability to leave remaining contamination in place after the source reduction activities are complete and to make sure human health is protected.

7. Understanding unique physical properties affecting the fate and transport of petroleum in the environment. Specifically, the ability of petroleum to biodegrade, attenuate, and float on water, in most instances, allows DEP staff to make risk management decisions that are not possible with other contaminant types.

8. The ability to close sites, in accordance with the CSM and follow-on monitoring, even when remaining contamination is present and institutional controls are not established.

2 Purpose

The purpose of this addendum is to specify unique aspects of the petroleum remediation guidelines that are different from the hazardous substance sites and mixed substance (petroleum and hazardous substance) sites as presented in Section 3.1 of the RAGs. The differences between petroleum and hazardous substances provide the basis for this addendum and set the basis for how the RAGs are applied to petroleum sites. This addendum prioritizes long-term remediation resources in the following order of importance, in accordance with the site-specific CSM:

1. Sites where the human health pathway is complete from the source to receptor;
2. Removal of petroleum product from the environment before it partitions into air and water and migrates away from the area of release in the vapor phase, dissolved phase or light non-aqueous phase liquid (LNAPL) phase;
3. Sites where the Conceptual Site Model (CSM) demonstrates that human health is at-risk because the migration pathway between the source and the receptor is contaminated;
4. Sites where the environmental resource pathway is complete from the source to the receptor (i.e. surface water); and
5. Sites where the CSM demonstrates that the surface water receptor is at-risk because the migration pathway between the source and the surface water receptor is contaminated.

The CSM is the tool used to determine if a risk pathway is complete or at-risk. For sites covered under items 3 through 5 above, where the existing contamination has been in place for sufficient time (relative to the fate and transport of petroleum contamination along the migration pathway) to reach a receptor and the receptor is not impacted above an applicable guideline (as determined by the CSM), the Environmental Professional, in consultation with DEP staff and the Director of Technical Services, must consider the environmental footprint (Section 4 below) of the cleanup as part of the remedy selection process. The environmental footprint includes but is not limited to the presence and function of wetlands and natural stream and river embankments as well as consideration of the carbon footprint of the selected remedy. The evaluation will be consistent with the ITRC Green and Sustainable Remediation work group (https://www.itrcweb.org/Team/Public?teamID=7). The determination of sufficient time is based on site specific measurements of travel times and attenuation rates between the source and the receptor.

For short-term emergency response cases, such as those administered by the Division of Response Services, the priority of actions is to eliminate the discharge condition and control the released petroleum from migrating to a receptor, into the environment, or soaking further into building materials as explained in Section 1 above.

The petroleum remediation program does not use institutional controls in the form of a declaration of environmental covenant to control exposures. Therefore, clean-up of petroleum sites should meet the ASTM definition of a historic recognized environmental condition (Section 4 below) that allows for unrestricted site use without subjecting the property to any required activity and use limitations (AUL). AULs in the form of a Declaration of Environmental Covenant in compliance with the *Uniform Environmental Covenants Act*, 38 M.R.S.A. §§ 3001-3013 (UECA) are permitted and may be used as part of a risk-based decision that is protective of human health and the environment where remediation is not practicable.

2.1 Consistency

This addendum is consistent with 06-096 C.M.R. ch. 691, 06-096 C.M.R. ch. 800, and 06-096 C.M.R. ch. 418 §3(O) and §3(R).

2.2 Site Specific Risk Assessment

This addendum is administered by the Technical Services Director in BRWM. Therefore, any petroleum only site administered under the petroleum program must have written approval from the Technical Services Director to develop and implement a site-specific risk assessment.

3 Applicability

This addendum is applicable to staff in the DEP’s petroleum program and other Environmental Professionals (EP) completing investigation, remediation, or mitigation in accordance with the commissioner’s satisfaction. This includes:

- Petroleum sites requiring DEP approval under 06-096 C.M.R. ch. 691,
- Reimbursement for eligible expenses under 38 M.R.S.§562-A,
- Fund coverage under 38 M.R.S.§568-A and 38 M.R.S.§569-A.

The following summarize the applicability of this addendum:

- Applicable to petroleum only
- Applicable to pure motor oil
- Applicable to pure hydraulic oil
- Applicable to hydrocarbons with petrogenic origin
- Not Applicable to hydrocarbons with pyrogenic origin
- Not Applicable to waste oil discharge
- Not Applicable to DEP Licensed Marine Oil Terminals, 38 M.R.S. §542 (4-B)(E) (1/1/2021)

- Not Applicable to mixtures

3.1 Applicable Programs

This addendum applies to all programs within BRWM including Uncontrolled Sites (RAGs Section 3.1.1), VRAP (RAGs Section 3.1.2), Brownfields (RAGs Section 3.1.3), Superfund/CERCLA (RAGs Section 3.1.4), RCRA subpart I (RAGs Section 3.1.5), and Beneficial Reuse of Remediation Debris (RAGs Section 3.1.8). As stated previously, this addendum does not apply to DEP licensed Marine Oil Terminal Facilities, which have their own defined cleanup criteria, 38 M.R.S. §542 (4-B)(E) (1/1/2021). Additionally, Chapter 691, notification levels, rather than the RAGs, determine when the Department must be notified of a petroleum discharge. The current laws, rules, and policies for Underground Oil Storage Tanks can be found at https://www.maine.gov/dep/waste/ust/lawsrules.html.

This addendum may be applicable to portions of an Uncontrolled Site, VRAP, Brownfield, Superfund/CERCLA, or RCRA, sites where the petrogenic hydrocarbon contamination is directly related to a tank (UST or AST) that contained heating oil or petrogenic hydrocarbon contamination that is not co-mingled with hazardous substances including waste oil, stoddard solvents, lubricants, or coatings.

Remediated soils or other debris may qualify for a subsequent reuse, such as construction fill, even though pollutants in the material may exceed normal background concentrations. The beneficial reuse of petroleum contaminated material that is not classified as a hazardous waste is subject to the DEP's Solid Waste Program rules. Specifically, if the material is to be beneficially used for agronomic utilization, such as for topsoil, fertilizer, soil amendment, or for any other plant growth purpose, then the reuse is subject to the solid waste rules at *Agronomic Utilization of Residuals*, 06-096 C.M.R. ch. 419. If the material is to be used for any other purpose, such as construction fill or a building material, that activity would be subject to *Beneficial Use of Solid Wastes*, 06-096 C.M.R. ch. 418. These rules generally have exemptions to allow the storage and reuse of materials on the site of generation, if DEP is the Project Lead, as defined in 06-096 C.M.R. ch. 418 (last revised July 8, 2018), §3(O) and §3(R). See the rules and discuss with the DEP's solid waste staff (aka Division of Materials Management staff) (207- 287-7688) any intended storage or reuse of materials from a remediation project to determine if it is an exempt activity or if a license under 06-096 C.M.R. ch. 418 or 06-096 C.M.R. ch. 419. When DEP is the Project Lead, surplus soils excavated during a UST replacement can be managed in accordance with SOP-PP-012 per 06-096 C.M.R. ch. 418§3(O) and §3(R).

3.2 Applicable Pollutants

This addendum is applicable to media that are contaminated with petroleum only such as motor fuel, jet fuel, heating oil (including kerosene), or their additives (i.e. MTBE).

MTBE is a gasoline additive used in Maine as part of the reformulated gasoline formula to replace lead and lead scavengers. The State of Maine, Department of Health and Human Services, Maine Center for Disease Control and Prevention, Division of Environmental Health, Drinking Water Program has set an enforceable drinking water standard (MCL) for MTBE of 35 ug/L (10-144 C.M.R., ch. 231, §7(D)(2)(b)). The RAG for residential groundwater exposure is 140 ug/L based on the USEPA RSL Calculator. This addendum for petroleum remediation will default to the MCL of 35 ug/L for all drinking water supplies. The groundwater RAG values for MTBE are appropriate for groundwater that is not associated with drinking water supplies within the context of an approved CSM (RWM-PP-006). Site specific risk assessments may be used in accordance with The RAGs, Attachment B which are reviewed by the DEP and Maine CDC to determine site specific health risks associated with the presence of MTBE in private drinking water supplies.

Where historic use of the site includes potential storage of leaded gasoline, this procedure applies and includes the evaluation of the presence of lead, and lead scavengers; including, 1,2-dichloroethane (1,2-DCA) and 1,2 dibromoethane (i.e. ethylene dibromide or EDB), in accordance with 06-096 C.M.R. ch. 691.

This addendum is applicable where fire-fighting foam, including fire-fighting foam with PFAS, was used to extinguish or prevent a petroleum-based fire and there is documented evidence of a petroleum release. Therefore, this addendum applies to PFAS compounds associated with the fire-fighting foam.

3.3 Applicable Media, Scenarios, and Routes of Exposure

This addendum does not apply to establishing clean-up guidelines for public drinking water supplies, or any other media/scenarios/routes-of-exposure that are not included in Table 1 of the RAGs, except for surface water.

In accordance with 06-096 C.M.R. ch. 691, this addendum does apply to surface water as defined in Section 3 above. For surface water, petroleum hydrocarbons and additives related to leaded gasoline analytical results should be compared to Surface Water Quality Criteria for Toxic Pollutants, 06-096 C.M.R. ch.584 (effective date July 29, 2012-filing 2012-211), MCLs, MEGs, Health Advisories, and Drinking Water Equivalent Levels to determine if an ongoing discharge is adversely affecting surface water quality.

4 Definitions

In addition to the definitions presented in the RAGs, Section 4.2, the following definitions are unique to Petroleum Remediation:

4.1 Contamination

Contamination means a site with any of the following conditions:

1) The presence of LNAPL;
2) The presence of petroleum hydrocarbon constituents at concentrations exceeding the RAGs or MCLs adopted by the Maine Department of Health and Human Services under 22 M.R.S. §2611;
3) A statistically significant increase in the concentration of measured parameters at on-site or down-gradient locations by comparison with representative background values, as demonstrated by statistical methods and procedures using a 95 percent level of confidence, approved by the Commissioner and consistent with the provisions of Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 C.F.R. §264.97 as amended up to July 1, 2018 (except that where the "Regional Administrator" is referred to, the "Commissioner" is meant);
4) Contamination includes soil and water where petroleum hydrocarbons are detected above the laboratory practical quantitation level using the MADEP VPH or EPH analyses;
5) Contamination includes soil and water where motor fuel additives are detected above the laboratory practical quantitation level using the appropriate laboratory methods to detect the additives at levels consistent with the appropriate RAGs and are associated with the presence of motor fuels; and
6) Soils visibly stained or discolored by the presence of heavy oil or present above a notification level (06-096 C.M.R. ch. 691, Appendix Q).

4.2 Discharge

Discharge means any spilling, leaking, pumping, pouring, emitting, escaping, emptying, or dumping of oil (38 M.R.S. §562-A).

4.3 Environmental Footprint

The term is broad and includes all impacts to the natural environment. Specifically, the effect that an activity has on the environment, which includes the amount of natural resources impacted by the action (excavation, investigation) and the amount of harmful gases that the activity produces (excavation, trucking, treatment, etc.). The term includes but is not limited to the carbon footprint of an activity.

4.4 Environmental Professional

An Environmental Professional (EP) is person meeting the educational, training, and experience requirements as set forth in 40 CFR Section 312.10(b). 40 CFR Section 312.10(b) includes (1) a person who possesses sufficient specific education, training, and experience necessary to exercise professional judgment to develop opinions and conclusions regarding conditions indicative of releases or threatened releases on, at, in, or to a property, sufficient to meet the objectives and performance factors in Section 312.20(e) and (f). (2) Such a person must: (i) hold a current Professional Engineer’s or Professional Geologist’s license or registration from a state, tribe, or US territory and have the equivalent of three (3) years of full-time relevant experience; or (ii) be licensed or certified by the federal government, a state, tribe, or U.S. territory to perform environmental inquiries territory and have the equivalent of three (3) years of full-time relevant experience; or (iii) have a Baccalaureate or higher degree from an accredited institution of higher education in a discipline of engineering or science and the equivalent of five (5) years of full-time relevant experience; or (iv) have the equivalent of ten (10) years of full-time relevant experience. (3) An EP should remain current in his or her field through participation in continuing education or other activities.

4.5 Fund Insurance Program

The Fund Insurance Program is the State program established under 38MRS, §568-A, to cover eligible costs associated with the clean-up of discharges from oil storage facilities. The program uses public funds from the Maine Ground and Surface Water Clean-up and Response Fund to cover eligible clean- up costs and third-party damages.

4.6 Gross Contamination

Presence of Free Product LNAPL, heavily contaminated soil, heavily contaminated groundwater, heavily contaminated surface water, or heavily contaminated indoor air. Petroleum is readily apparent through visual or olfactory senses.

4.7 Historic Recognized Environmental Condition

As defined in the ASTM Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process, ASTM E- 1527-13, a past release of any hazardous substances or petroleum products is one that has occurred in connection with the property and has been addressed to the satisfaction of the applicable regulatory authority or meeting unrestricted use criteria established by a regulatory authority, without subjecting the property to any required controls. (For example, property use restrictions, activity and use limitations, institutional controls, or engineering controls.) Before calling the past release a historic recognized environmental condition, the environmental professional must determine whether the past release is a recognized environmental condition at the time the Phase I Environmental Site Assessment is conducted (for example, if there has been a change in regulatory criteria). If the EP considers the past release to be a recognized environmental condition at the time the Phase I ESA is conducted, the condition should be included in the conclusions section of the (Phase I ESA) report as a recognized environmental condition.

4.8 LNAPL Light Non-Aqueous Phase Liquid

A liquid having a specific gravity less than one and is composed of one or more organic compounds that are immiscible or sparingly soluble in water and is observable to be separate from water. The term encompasses all potential occurrences of LNAPL including free, residual, mobile, entrapped, and visible petroleum sheen.

4.9 Oil

As defined in statue, 38 MRS, §562-A, means oil, additives, petroleum products, and their by-products of any kind and in any form including, but not limited to: petroleum, fuel oil, sludge, oil refuse, oil mixed with other non-hazardous waste, crude oils, and other liquid hydrocarbons regardless of specific gravity.

4.10 Oil Storage Facility

As defined in 38 MRS, § 562-A, and oil storage facility means tanks together with associated piping, transfer and dispensing facilities, used to store or supply oil at a fixed location for more than 4 consecutive months per year. If less than 10% of the facility capacity is beneath the surface of the ground, the facility is an above ground oil storage facility, or AST. All other storage facilities are underground storage tanks (UST) facilities, including facilities with tanks located wholly above the ground surface if associated underground piping contains 10% or more of the facility’s total capacity.

4.11 Petrogenic Hydrocarbons

Hydrocarbons produced from pure petroleum sources including refined and unrefined petroleum products like crude oil, gasoline, heating oil, and pure petroleum based asphalt coatings.

4.12 Pyrogenic Hydrocarbons

Hydrocarbons produced by incomplete combustion of organic material and is not directly related to pure petroleum sources. Pyrogenic hydrocarbons may be found in ash, coal ash, rubber products (tires), asphalt, coal tar, and coal tar based products (some asphalt coatings).

4.13 Surface Water

The State of Maine classifies three types of surface water: Fresh Surface Water, Lakes and Ponds, and Estuarine and Marine Waters. Fresh Surface Water has four classifications: AA, A, B and C. Lakes and Ponds has one GPA. Estuarine and Marine Waters has three classifications SA, SB, and SC.

Additionally, the State of Maine designates Surface Water of Special Considerations including waters that are classified as sustenance fishing including sections of the Penobscot River Basin, St. Croix River Basin, and St. John River Basin and some lakes and ponds including, Conroy Lake in Monticello; Grand Lake Metagaming in Trout Brook Township and T6R8 W.E.L.S; Mattamiscontis Lake in T3R9 N.W.P. and T2R9 N.W.P; Grand Falls Flowage, Berry Brook Flowage, George Brook Flowage, Huntley Brook Flowage, Lewey Lake, The

Basin, The Narrows, Long Lake and Big Lake, adjacent to Indian Township; and Sysladobsis Lake in T5 N.D.

An updated map of the Classification of Maine Waters is found on the Maine DEP GIS website for GIS Maps and Other Data Files at www.maine.gov/dep/gis/datamaps.
A link to the ArcGIS Online map is: https://maine.maps.arcgis.com/apps/webappviewer/index.html?id=397738f1d21d42589ab7ac989e2db568

4.14 Waste Oil

A petroleum or synthetic oil that, through use or handling, has become unsuitable for its original purpose due to the presence of hazardous substances or other impurities, or loss of its original properties (38 MRS, §1301-C).

4.15 Water Shake Test

A field method for determining the presence of LNAPL in soils or sediments. The method is described in DEP SOP TS004, and it includes placing soil into a clear glass jar and pouring clean water into the jar to cover the soil in water. Securing the water tight lid and shaking the soil and water sufficiently to break-up the soil particles and liberate any LNAPL present in the soil pores. The presence of LNAPL is observed as a layer on the water surface after shaking is stopped and the lid is removed.

4.16 Water Supply Well

A well that supplies potable water for human consumption. This may be a private well, or a public water supply. It could be a drilled bedrock well, a driven point overburden well, a dug well, or a spring that supplies water.

5 Responsibilities

5.1 Project Leader

The project leader of a petroleum remediation site should develop media specific remediation goals for DEP's consideration that are consistent with the RAGs, including this petroleum supplemental guidance or the site-specific risk assessment guidance provided in the RAGs Attachment B.

The project leader shall have the responsibility of establishing and maintaining communications with the Project Team and all parties involved with and affected by the release of petroleum including:

- Property Owner
- Tenant/Occupant
- Potential Responsible Party and their representatives

The Project Leader must communicate to their supervisor (DEP-lead case) or to the Director of the Division of Technical Services, or their designee (non-DEP lead case) who will complete the tasks necessary to remediate/mitigate the petroleum release, accurately document the progress, document decisions made, track costs, and provide updates all parties involved with and affected by the release of petroleum (see above).

5.2 BRWM Staff

DEP program staff should encourage adherence to the RAGs through the development of a Conceptual Site Model to facilitate site clean-up. Staff should alert their supervisors when alternative approaches are proposed for a site.

5.3 BRWM Unit Supervisors

Unit supervisors should ensure that remediation decisions are consistent within their unit-specific standard operating procedures or protocols. Unit supervisors must receive pre-approval from the Division or Bureau Director before recommending any remediation approvals that vary from this addendum.

5.4 BRWM Division Directors

Division Directors are responsible for ensuring that the staff in their division are trained in how to apply this addendum and that the RAGs are consistently applied within the Division's programs and between other divisions to which this procedure is applicable. Division Directors will consult with each other on variances to this guidance in their respective programs, generally through a project specific management review meeting.

6 Where RAGS fit in the Petroleum Program Site Assessment and Remediation Process

6.1 Introduction

Section 6 of the RAGs provides a summary of where the RAGs fit into the site assessment and remediation process. The Petroleum Program SOPs provide guidance for site assessment and remediation that together with this addendum define the Commissioner's satisfaction. As stated above the Petroleum Program SOPs are provided on the DEP website at: https://www.maine.gov/dep/spills/petroleum/index.html

Determination of risks at petroleum release sites require laboratory analyses that quantify the mass of petroleum mixture present and individual target compounds for the more toxic compounds present within the petroleum mixture. The Massachusetts Department of Environmental Protection petroleum hydrocarbon fraction analytical methods for Volatile Petroleum Hydrocarbons (VPH) and Extractable Petroleum Hydrocarbons (EPH) are needed to determine the risks at a petroleum release site. The VPH and EPH analyses, including the target compounds are needed to apply the RAGs to petroleum release sites. VPH and

EPH analyses are needed when individual petroleum compounds are detected by compound specific analytical methods, such as EPA methods 524.4, 8260, and 8270 in order to quantify the risks of the total petroleum mass present.

6.2 Conceptual Site Model

The project lead will be responsible for development of the CSM for DEP review and approval at non-DEP lead sites. The CSM can be submitted to the DEP Project Manager, Hydrogeologist, or Engineer. If none of these are assigned, the CSM can be submitted to the Director of the Technical Services Division. The CSM should follow Section 6.3 of the RAGs, DEP SOP RWM-PP-006, and applicable guidance such as ASTM Standard Guide for Developing Conceptual Site Models for Contaminated Sites, and Standard Guide for Development of Conceptual Site Models and Remediation Strategies for Light Nonaqueous-Phase Liquids Released to the Subsurface.

6.3 Groundwater Resource and Drinking Water Protection

The supplemental petroleum guidance is protective of groundwater supplies and groundwater resources for public and private water supplies by applying the Residential Groundwater Exposure RAGs, MCLs, and MEGs to groundwater remediation sites where groundwater or surface water is the primary drinking water resource within the migration pathway of the petroleum plume. SOP RWM-PP-010 provides procedures to be used to meet the Commissioners satisfaction when groundwater is contaminated at a petroleum site.

6.4 Sampling Investigation and Remediation

The supplemental petroleum guidance encourages simultaneous sampling, investigation, and remediation to take place, especially during the early stages of a remediation project when some risk pathways are complete (i.e. soil and air), while others require additional information (i.e. groundwater, surface water). All steps taken must be supported by the CSM. A site sampling plan is needed when investigations and sampling involve laboratory analysis to assure appropriate detection levels and data quality objectives are met. When remedial actions are finished, appropriate documentation of the completeness of the remedial actions and remaining contamination must be documented in accordance with SOP RWM-PP-017.

6.5 Field Instrument Calibration

Investigations and remedial actions must use and document the use of calibrated field instrumentation. SOP RWM-PP-007 and RWM-PP-008 provide additional guidance.

6.6 Site-Specific Sampling Plan and Site Safety Plan

Investigations and remedial actions must follow a site-specific sampling and analysis plan and a site safety plan. SOP RWM-PP-007 (Development of a

Sampling and Analysis Plan), RWM-PP-014 (Water Sampling at Petroleum Sites), and RWM-PP-071 (Site Safety Plan) provide additional guidance.

6.7 Detection Levels & Data Quality Objectives

It is important to consider the site's clean-up goals when establishing the Data Quality Objectives (DQOs) for a site sampling plan (see Section 6.4.1 of RAGs). For example, ethylene dibromide (EDB, 1,2 dibromoethane) must be analyzed using EPA method 504.1 to meet the appropriate detection limit for the groundwater RAG for residential exposure.

6.8 Assessing Petroleum Vapor Intrusion

Petroleum vapor intrusion (VI) is the volatilization of petroleum related substances from NAPL, contaminated soil, or groundwater into buildings. DEP has adopted the EPA Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites, June 2015. SOP RWM-PP-009 provides additional information.

DEP Technical Services notification is required under the following conditions:

a. Vapors are detected within 100-feet of an occupied building; and
b. When a sensitive receptor (i.e. school, day care, or elderly housing) is at risk of vapor intrusion. DEP Technical Services staff are required to notify Technical Services Division Director to determine if CDC assistance is warranted.

6.9 Lead and Lead Scavengers

Lead continues to be used in high octane fuels and certain aviation fuels. However, lead was prohibited in gasoline as of January 1, 1996. According to public testimony given by DEP Commissioner Sullivan dated September 16, 1998, leaded gasoline in Maine was replaced by reformulated gasoline with MTBE by January 1, 1995. DEP detected MTBE in Maine groundwater as early as 1985, indicating that reformulated gasoline was used at least 11-years before the lead prohibition.

Where historic use of leaded gasoline was potentially stored prior to the prohibition of leaded gasoline, lead scavengers; including, 1,2-dichloroethane (1,2-DCA) and 1,2 dibromoethane (i.e. ethylene dibromide or EDB) should be considered potential contaminants of concern, in accordance with Chapter 691. EDB in water should be analyzed using EPA method 504.1 to meet the appropriate DQOs.

6.10 Soil Sampling Depths

Appropriate soil depths at a petroleum site will be based on the CSM and in accordance with any institutional controls that may or may not be used to manage the risks.

6.11 Exposure Point Concentrations

See RAGs, Section 6.5 and Section 7.5.1 for handling of chemical isomers of xylene.

7 Determining Target Clean-up Levels Using RAGs

The six steps outlined in Section 7.1 of the RAGs (provided below) are potentially applicable to large historic petroleum releases where decades have passed since the petroleum release occurred. This was the type of site that the petroleum program remediated in the 1980's and 1990's. There are large historic release sites that DEP handles on occasion that could benefit from following the six-step process.

1. Exclude background contaminants that were not released by site activities in accordance with Section 7.2;
2. Based on the Site's CSM, determine which media are contaminated and the applicable scenario, and then select the appropriate table (see Table 2: Media to RAG Table Cross-walk);
3. Determine the appropriate land use scenario for the site, considering current and potential future land uses. The descriptions of the scenarios are found in Section 7.3, and the criteria for exclusion of scenarios in Section 7.4;
4. The lowest applicable value in the column of the table that you are using is the applicable RAG;
5. Plan and undertake the clean-up, if necessary;
6. Following remedial action, confirmation sampling needs to show that the target clean-up goals have been met and the site may be closed-out, or if further action is needed.

Oftentimes Step 6 of the six-step process can be achieved within days of the reported release and the petroleum program can begin the collection of confirmation sampling to confirm that the remedial actions have addressed the risk to human health and the environment. Using this approach, sites can be successfully closed after monitoring a site (i.e. vapor and groundwater) for an appropriate amount of time (i.e. 4 quarters) based on the 40-year program experience. With supervisor approval or approval from the Technical Services Division Director, this can be done, even when contamination remains on-site that exceeds the RAGs as explained in Section 1.2 above.

As explained in Section 1.2 of this addendum, several factors facilitate more efficient remedial actions when spill volumes are small, reporting times are short relative to the fate and transport of petroleum contamination along the migration pathway, and aggressive source removal is completed before sensitive resources are impacted. Therefore, the CSM is a vital tool to making appropriate remedial decisions and establishing clean-up goals.

In situations where contamination has been present for sufficient time relative to the fate and transport of petroleum contamination along the migration pathway and no receptors (human or surface water) have been impacted above a guideline or criteria, an evaluation of the environmental footprint should be completed to evaluate the benefit of completing remedial actions.

7.1 Application of Exposure Pathways and Scenarios

7.1.1 Groundwater

Groundwater remediation goals using residential exposure criteria and soil remediation goals using the leaching to groundwater criteria will be followed at sites where public water is not provided and where the site meets the definition of a sensitive geologic area defined in 06-096 C.M.R. ch. 691. This includes mapped (1) Significant Sand and Gravel Aquifers; (2) locations within 1,000 feet of a public drinking water supply; (3) locations within 300-feet of a private drinking water supply; (4) surface water bodies within 1000-feet of the intake point of a public water system, except on rivers and streams where it will only include the upstream side on both shores. See 06-096 C.M.R. ch. 691, §3 (EEE and FFF) for additional details. The Department may allow for site specific data to be used to modify the use of the leaching to groundwater criteria that is supported by the Conceptual Site Model. All modifications need to be approved by the Director of the Technical Services Division or their designee.

Groundwater remediation goals using the Construction Worker scenario should not be used as a groundwater cleanup guideline. The groundwater Construction Worker scenario should be used as a risk management tool to protect Construction Workers as part of a groundwater management plan during remedial actions, UST replacement, or property redevelopment. DEP SOP RWM-PP-012, Managing Non-Hazardous Petroleum Contaminated Groundwater and Soil at UST Sites, provides guidance for managing contaminated groundwater.

The Ground Water Resource and Drinking Water Protection SOP (RWM-PP-010) provides procedures for notification of the Department of Health and Human Services, Drinking Water Program when appropriate in accordance with a DWP/DEP Memorandum of Agreement.

7.1.2 Surface Water

To be consistent with 06-096 C.M.R. ch. 691, the petroleum addendum includes criteria for surface water, as defined in Section 3 above. For petroleum sites, the contaminants of concern in the dissolved phase must be protective of human health and the aquatic environment of the surface water body. However, it is beyond the scope of this addendum to include a full ecological risk assessment. Based on DEP experience, leaded and unleaded motor fuel facilities within 300-feet of a water body have the potential to impact surface water and pore water quality above acceptable levels. Beyond 300-feet the potential for impact declines below measurable levels due to the ability of petroleum to attenuate.

Water Classification Program, 38 M.R.S. §464 (1 and 2) specify that Class AA and Class A surface waters must be of such quality that they are suitable for designated uses of drinking water after disinfection. Subsections 3 and 4 specify that Class B and C surface waters must be of such quality that they are suitable for the designated uses of drinking water after standard treatment required under the Safe Drinking Water Act (and not more advanced treatment that might be necessary to meet the 'water and organisms' or 'organisms only' criteria of Maine's Surface Water Quality Criteria).

For risks to the aquatic environment, the discharge of the plume must not degrade the water quality below the designated uses as stated in Water Classification Program, 38 M.R.S. §465. This can be evaluated by comparing the porewater concentrations to the 06-096 C.M.R Ch. 584, Appendix A, Criterion Continuous Concentration (CCC) as a screening criterion. Surface water samples should be evaluated against the applicable drinking water criteria (MCL, MEG, RAG).

7.1.3 Lead in Soil

06-096 C.M.R. ch. 691requires total lead concentrations exceeding 100 mg/kg to be analyzed by TCLP. Therefore, all soils with lead concentrations directly related to leaded gasoline must be analyzed for lead and if the total lead concentration exceeds 100 mg/kg, the soil needs to be analyzed for TCLP lead. Soil cleanup actions will be based on the presence of petroleum hydrocarbon contamination, not the extent of lead contamination in the soil.

7.1.4 MTBE in Drinking Water

MTBE is a gasoline additive used in Maine as part of the reformulated gasoline formula to replace lead and lead scavengers. The State of Maine, Department of Health and Human Services, Maine Center for Disease Control and Prevention, Division of Environmental Health, Drinking Water Program has set an enforceable drinking water standard (MCL) for MTBE of 35 ug/L (10-144 CMR, Chapter 231, Section 7(D)(2)(b)). The RAG for residential groundwater exposure is 140 ug/L based on the USEPA RSL Calculator. This addendum for petroleum remediation will default to the MCL of 35 ug/L for all drinking water supplies. The groundwater RAG values for MTBE are appropriate for groundwater that is not associated with drinking water supplies within the context of an approved CSM (RWM-PP-006). Site specific risk assessments may be used in accordance with The RAGs, Attachment B which are reviewed by the DEP and Maine CDC to determine site specific health risks associated with the presence of MTBE in private drinking water supplies.

7.2 Assessing Risk Contribution from Background Contaminants

Section 7.2 of the RAGs addresses the Background Concentrations Policy (Section 7.2.1), Determining Background Concentrations (Section 7.2.2) Arsenic Background Concentrations vs. Man-made Sources (Section 7.2.3), Background Concentration of Polycyclic Aromatic Hydrocarbons (Section 7.2.4), and Addressing Risk Due to Background (Section 7.2.6).

At many UST sites the background concentrations of PAHs at a site are elevated due to the presence of pyrogenic PAHs present in the pavement. Therefore, the CSM needs to address the background concentrations of pyrogenic hydrocarbons and the sampling and analysis plan should include provision for distinguishing between PAHs related to petrogenic hydrocarbons and PAHs related to background pyrogenic hydrocarbon sources.

Appendix E

STATE OF MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Remediation and Waste Management
LUST Program

QUALITY ASSURANCE PLAN LOG SHEET

The following Staff have reviewed Version 8, LUST Program Quality Assurance Plan.

Augusta Office [CMRO] Ray Building:

Name	Position	Signature	Date
Molly King	PSM II		
Kelly Perkins	Chemist III		
Colin Williams	Chemist I		
Robert Leighton	ES III		
Jessica Whitney	Planning and Research Assistant		
Sean Dougherty	HydroGeo Mgr		
Matt Burke	Sr HydroGeo		
Jamie Popejoy	Env HydroGeo		
Charles Rodda	Env HydroGeo		
Janet Gorman	ES II		
Robbie Knowles	GeoTech II		
Tim MacMillan	EESM		
David McCaskill	Sr EE		
Racheal French	AEE		

Rebecca Poole AEE ______________________________

Ed Cousins Sr EE ______________________________

Pat Locklin EE ______________________________

Chris Fournier PSM II ______________________________

Butch Bowie ES IV ______________________________

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Dan Courtemanch OHMS II ______________________________

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Dan Wehr ES II ______________________________

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Name	Position	Signature	Date
John Woodard	OHMR III		
Nate Thompson	OHMR II		
Brandon Wright	OHMR II		
Jazmyn Atteberry	OHMR I		
Stuart Blanchard	OHMR I		
Nathan Tower	OHMR I		

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Name	Position	Signature	Date
Bob Shannon	OHMR III		
John Selleck	OHMR II		
Darian Higgins	OHMR II		
Paul Nichols	OHMR I		
Tiffany LeClair	OHMR I		
Jared Meklin	OHMR I		
Jason Langley	Sr HydroGeo		
Jim Lavoie	EngTech III		
Sam Spizzuoco	GeoTech II		
Becky Doore	AEE		

Presque Isle Office [NMRO]

Name	Position	Signature	Date
Jesse Clark	OHMR II		
Kelly Langley	OHMR I		
Mason Moro	OHMR I		

Portland Office [SMRO]

Name	Position	Signature	Date
Greg O'Brien	OHMR III		
John Luongo, Jr.	OHMR II		
David Cherry	OHMR II		
David Adams	OHMR I		
Oakley Farnham	OHMR I		
April Bloodsoe	OHMR I		
Mark Woodruff	Sr HydroGeo		
Kristen Babcock	GIS Coordinator		
Pete Eremita	Sr EE		
Donald White	EES		

Appendix F

Accredited Laboratories Certified by the Maine Laboratory Certification Program

Lab	Address	City	State	Zip	Phone
A & L Laboratory - A Division of Granite State Analytical Services, LLC.	155 Center Street, Building C	Auburn	ME	04210	(207) 784-5354
Absolute Resource Associates	124 Heritage Ave, Unit 16	Portsmouth	NH	03801	(603) 436-2001
Acheron Inc. dba ClearWater Laboratory	153 Main Street, Suite A	Newport	ME	04953	(207) 368-5700
Aerobiology Laboratory Associates, Inc., A Pace Analytical Laboratory	22 Cummings Park	Woburn	MA	01801	(781) 935-3212
Alpha Analytical - Westborough	8 Walkup Drive	Westborough	MA	01581	508-898-9220
Alpha Analytical- Mansfield Laboratory	320 Forbes Blvd.	Mansfield	MA	02048	(508) 822-9300
ALS Environmental - Rochester	1565 Jefferson Road, Bldg 300, Suite 360	Rochester	NY	14623	(585) 288-5380
ALS Environmental - Simi Valley	2655 Park Center Drive, Suite A	Simi Valley	CA	93065	(805) 526-7161
ALS Group USA Corp., DBA ALS Environmental (WA)	1317 South 13th Avenue	Kelso	WA	98626	(360) 577-7222
ALS Laboratory Group, Environmental	10450 Stancliff, Suite 115	Houston	TX	77099	(281) 530-5656
Bangor Water District	614 State Street	Bangor	ME	04401	(207) 947-4516
Battelle Analytical Chemistry Services	141 Longwater Drive, Suite 202	Norwell	MA	02061	(781) 681-5400
Chemtech	284 Sheffield Street	Mountainside	NJ	07092	(908) 789-8900
City of Brewer Water Dept. Water Testing Laboratory	257 Hatcase Pond Road	Eddington	ME	04428	(207) 843-7182
City of Rockland -WWTF	40 Tillson Ave.	Rockland	ME	04841	(207) 584-0324
Con-test, A Pace Analytical Laboratory	39 Spruce Street	East Longmeadow	MA	01028	(413) 525-2332
Eastern Analytical, Inc.	51 Antrim Avenue	Concord	NH	03301	(603) 228-0525
EMSL Analytical, Inc.	200 Route 130 North	Cinnaminson	NJ	08077	(800) 220-3675
Environmental Hazards Services LLC	7469 Whitepine Rd	Richmond	VA	23237	(800)-347-4010
ESS Laboratory	185 Frances Avenue	Cranston	RI	02910	(401) 461-7181
Eurofins Buffalo	10 Hazelwood Drive	Amherst	NY	14228	(716) 691-2600
Eurofins CEI, Inc.	730 SE Maynard Road	Cary	NC	27511	(919) 481-1413
Eurofins Eaton Analytical, LLC	110 South Hill Street	South Bend	IN	46617	(574) 233-4777
Eurofins Eaton Analytical, LLC	941 Corporate Center Drive	Pomona	CA	91768	626-386-1100
Eurofins Environment Testing Northeast, LLC	646 Camp Avenue	North Kingstown	RI	02852	413-789-9018
Eurofins Lancaster Laboratories Environment, LLC	2425 New Holland Pike	Lancaster	PA	17601	(717) 656-2300
Eurofins Pittsburgh	301 Alpha Drive	Pittsburgh	PA	15205	(412) 963-7058
Eurofins Sacramento	880 Riverside Parkway	West Sacramento	CA	95605	(916) 373-5600
Eurofins Savannah	5102 LaRoche Avenue	Savannah	GA	31404	(912) 354-7858
Eurofins Seattle	5755 8th Street East	Tacoma	WA	98424	(253) 248-7032
GEL Laboratories, LLC	2040 Savage Rd.	Charleston	SC	29407	(843) 556-8171
Granite State Analytical Services, LLC	22 Manchester Road, Unit 2	Derry	NH	03038	(603) 432-3044
Health and Environmental Testing Laboratory	221 State Street	Augusta	ME	04330	(207) 287-2727
Health and Environmental Testing Laboratory	47 Independence Drive	Augusta	ME	04330	(207) 287-1717
Katahdin Analytical Services	600 Technology Way	Scarborough	ME	04074	(207) 874-2400
Kennebec Water District	462 Main Street	Vassalboro	ME	04989	(207) 923-3358
KNL Environmental Testing, LLC	3202 N. Florida Avenue	Tampa	FL	33603	(813) 229-2879
Lewiston Water Division - Auburn Water District	167 Pumping Station Road	Auburn	ME	04210	207-513-2622
Maine Coast Lab dba Water Quality and Compliance Services, Inc.	47 Gardiner Road	Wiscasset	ME	04578	(207) 882-5476
Maine Environmental Laboratory	1 Main Street	Yarmouth	ME	04096	(207) 846-6569
Maine Laboratories LLC	25 Main Street	Norridgewock	ME	04957	207-518-8030
Mi'Kmaq Environmental Laboratory	8 Northern Road	Presque Isle	ME	04769	207-764-4011
National Testing Laboratories, Ltd.	556 S. Mansfield Street	Ypsilanti	MI	48197	(440) 449-2525
Nelson Analytical - Manchester	490 East Industrial Park Drive	Manchester	NH	03109	(603)622-0200
Nelson Analytical Lab - Maine	120 York Street	Kennebunk	ME	04043	(207) 467-3478
Northeast Laboratory Services	227 China Road	Winslow	ME	04901	(207) 873-7711
Nova Analytical Labs, LLC	65 Milliken St., Unit C	Portland	ME	04103	207-446-4661
Nova Biologicals, Inc.	1775 N. Loop 336 E, Ste. 4	Conroe	TX	77301	(800) 282-5416
Pace Analytical National Center for Testing & Innovation	12065 Lebanon Road	Mount Juliet	TN	37122	(615) 758-5858
Pace Analytical Services, LLC	106 Vantage Point Drive	West Columbia	SC	29172	803-791-9700
Pace Analytical Services, LLC - Greensburg	1638 Roseytown Road Suites 2, 3 & 4	Greensburg	PA	15601	(724) 850-5600
Pace Analytical Services, LLC - Minneapolis, MN	1700 Elm Street SE, Suite 200	Minneapolis	MN	55414	(612) 607-6400
Pace Analytical Services, LLC Ormond Beach FL	8 E. Tower Circle	Ormond Beach	FL	32174	386-672-5668
Phoenix Environmental Laboratories, Inc.	587 Middle Turnpike East	Manchester	CT	06040	(800) 827-5426
Portland Water District (East End)	500 Marginal Way	Portland	ME	04101	(207) 523-5402
Portland Water District (Sebago Lake)	2 White Rock Rd	Standish	ME	04084	(207) 523-5402
Portsmouth Naval Ship Yard Materials Testing Laboratory	Portsmouth Naval Shipyard (Code 134, BLDG 20/3)	Kittery	ME	03904	(207) 438-3530
Presque Isle Utilities District	126 Dyer Street	Presque Isle	ME	04769	(207) 764-1329
Regional Water Authority	90 Sargent Drive	New Haven	CT	06511	203-401-2700
Seacoast Analytical Services	72 Pinkham Road	Lee	NH	03861	(603) 868-1457
SGS AXYS Analytical Services Ltd.	2045 Mills Road West	Sidney	CN	V8L 5X2	(250) 655-5800
SGS North America Inc.	5500 Business Drive	Wilmington	NC	27516	(910) 350-1903
SGS North America Inc.	2235 Route 130	Dayton	NJ	08810	(800) 329-0204
SGS North America, Inc. - Orlando	4405 Vineland Rd., Ste C-15	Orlando	FL	32811	407-425-6700
Summit Environmental Technologies, Inc.	3310 Win Street	Cuyahoga Falls	OH	44223	(330) 253-8211
The Marine Water Quality Laboratory	193 Clarks Cove Road	Walpole	ME	04862	(207) 563-8124
Vista Analytical Laboratory, Inc.	1104 Windfield Way	El Dorado Hills	CA	95762	(916) 673-1520

List current as of May 29, 2024

Appendix G

06-096
Maine Department of Environmental Protection

Chapter 691
RULE FOR UNDERGROUND OIL
STORAGE FACILITIES

Effective: September 16, 1991
Amended: December 24, 1996
Amended: June 13, 2002
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Amended: September 26, 2018 – filing 2018-205

TABLE OF CONTENTS

Chapter 691 RULE FOR UNDERGROUND OIL STORAGE FACILITIES

SUMMARY: This Chapter requires registration of all new and existing underground petroleum tanks. It establishes standards for installation of new facilities, and for the operation, maintenance and closure of all types of underground oil storage facilities. This Chapter also outlines requirements for reporting and investigating evidence of a possible leak and clean up of leaks, discharges or other oil pollution at underground storage facilities, certain wastewater treatment units, and certain aboveground oil storage tanks associated with field constructed underground oil storage tanks or airport hydrant systems and aboveground tanks with underground piping.

1. **Legal Authority.** This Chapter is authorized under the *Oil Storage Facilities and Ground Water Protection Law*, 38 M.R.S. §§ 561-570-M. These sections of Maine law authorize and direct the development of rules for the registration, siting, design, installation, replacement, operation and closure of underground oil storage facilities and tanks, except tanks used to store propane, and the procedures, methods, means and equipment to be used in the investigation of discharges and the removal of oil and petroleum pollutants.

2. **Preamble.** It is the purpose of this Chapter, consistent with legislative policy, to provide necessary controls over underground oil storage facilities to ensure the protection of Maine's ground water resources from oil discharges and leaks and of public health, safety, welfare, and the overall environment. It is also the purpose of this Chapter to require the investigation and cleanup of oil discharges from aboveground oil storage tanks associated with field constructed underground oil storage tanks and airport hydrant systems.

NOTE**:** This Chapter incorporates by reference certain industry codes and standards. Appendix R lists those codes and standards that are incorporated by reference and the specific amended date for each section.

3. **Definitions.** The following terms as used in this Chapter have the following meaning:

   A. **A/B Operator.** “A/B Operator” means the owner, employee or agent who has either primary responsibility for operation and maintenance of the facility or responsibility for the day-to-day on-site operation and maintenance of the facility.

   B. **Ancillary equipment.** "Ancillary equipment" means devices including but not limited to, piping fittings, flanges, valves and pumps used to distribute, meter or control the flow of oil to or from an underground oil storage tank.

   C. **Board.** "Board" means the Maine Board of Environmental Protection.

   D. **Cathode.** "Cathode" means the electrode of an electrochemical cell at which the chemical process of reduction occurs.

   E. **Cathodic protection tester.** "Cathodic protection tester" means an underground oil storage tank installer or inspector certified by the Maine Board of Underground Storage Tank Installers (BUSTI), who also meets the requirements of Appendix M of this Chapter.

   F. **Cathodically protected.** "Cathodically protected" means the use of a technique to prevent the corrosion of a metal surface by making that surface the cathode of an electrochemical cell. For example, a tank system can be protected against corrosion through the application of either a galvanic or an impressed current cathodic protection system. Cathodic protection techniques are those that are consistent with the National Association of Corrosion Engineers (NACE) International publication, “Standard Practice, External Corrosion Control of Underground Storage Tank Systems by Cathodic Protection,” NACE S P 0285, or “Standard Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems”, NACE SP 0169.

G. **Cathodic protection monitoring.** "Cathodic protection monitoring” means a process of measuring the structure to electrolyte potential to determine whether a cathodically protected structure is being adequately protected against corrosion. Cathodic protection monitoring shall be performed according to the requirements of Appendix A.

H. **Class I liquids.** "Class I liquids” means liquids having a flash point below 100 degrees F.

I. **Commissioner.** "Commissioner" means the Commissioner of the Department of Environmental Protection, or his or her designee.

J. **Compatible.** “Compatible” means the ability of two or more substances to maintain their respective physical and chemical properties upon contact with one another for the design life of the tank system under conditions likely to be encountered in the underground storage tank.

K. **Containment sump.** “Containment sump” means a liquid-tight container that protects the environment by containing leaks and spills of oil from piping, dispensers, pumps and related components in the containment area. Containment sumps may be single walled or secondarily contained and include sumps located at the top of tank (tank top or submersible turbine pump sump), underneath the dispenser (under-dispenser containment sump), or at other points in the piping run (transition or intermediate sump), and spill buckets.

L. **Contamination.** "Contamination" for the purposes of this Chapter only and only as applied to ground water, surface water, sediment and soils, means oil pollution attributable to an underground oil storage facility or the underground piping of an aboveground oil storage facility and exceeding any one of the following standards:

(1) The presence of free product, an oil sheen or oil saturated soils;

(2) Primary drinking water standards adopted in rule by the Maine Department of Health and Human Services, *Rules Relating to Drinking Water*, 10-144 C.M.R. ch. 231;

(3) *Maximum Exposure Guidelines (MEG) for Drinking Water* published on December 31, 2016 by the Maine Center for Disease Control and Prevention in the Department of Health and Human Services;

(4) A statistically significant increase in the concentration of measured parameters at on-site or down-gradient locations by comparison with representative background values, as demonstrated by statistical methods and procedures using a 95 percent level of confidence, approved by the Commissioner and consistent with the provisions of *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,* 40 C.F.R. §264.97 as amended up to July 1, 2018 (except that where the "Regional Administrator" is referred to, the "Commissioner" is meant);

(5) Water where volatile or extractable petroleum hydrocarbon fractions or target compounds are documented;

(6) Soils visibly stained or discolored by heavy oil; or

(7) Soils where volatile or extractable petroleum hydrocarbon fractions or target compounds equal or exceed reporting levels in Table 1 of Appendix Q of this Chapter.

M. Continuous electronic monitoring. "Continuous electronic monitoring" means the use of a monitoring device capable of automatic, continuous unattended operation, which will provide a clear, audible or visual indication of the presence of liquid hydrocarbons or hydrocarbon vapors outside of a primary hydrocarbon container or the loss of the primary containment structure's integrity.

N. Corrosion expert. "Corrosion expert" means a person who is certified by the Commissioner pursuant to 38 M.R.S. §567-A and Appendix N of this Chapter, as qualified to engage in the practice of corrosion control on buried or submerged metal piping systems and metal tanks.

O. Corrosion-induced leak. "Corrosion-induced leak" means any discharge of oil from an underground oil storage facility or tank caused by the deterioration of materials that comprise the facility or tank because of a reaction with the internal or external environment of the facility or tank.

P. Daily inventory. "Daily inventory" means accounting practices for oil stock control, including at a minimum: (1) a record of all bulk liquid receipts; (2) a record of all liquid dispersed from the facility; (3) a daily reconciliation between sales, use, receipts and inventory-on-hand; and (4) a monthly summary of inventory results maintained in accordance with the requirements of section 5(D)(1) of this Chapter.

Q. Department. "Department" means the Maine Department of Environmental Protection composed of the Board and the Commissioner.

R. Dispenser. “Dispenser” means equipment located aboveground that supplies product from the underground oil storage facility.

S. Dispenser system. “Dispenser system” means the dispenser and the equipment necessary to connect the dispenser to the underground oil storage facility.

T. Discharge. "Discharge" means any spilling, leaking, pumping, pouring, emitting, escaping, emptying, or dumping.

U. Double-walled tank. "Double-walled tank" means an underground oil storage tank providing no less than 300-degree secondary containment, interstitial space monitoring and secondary containment for pressurized product delivery pipe connections.

V. Emergency situation. "Emergency situation" means any unforeseen circumstances where the installation or replacement of an underground oil storage facility or tank is required to protect the public health, safety, and welfare.

W. Existing underground oil storage facility or existing underground oil storage tank. "Existing underground oil storage facility" or "existing underground oil storage tank" means any facility or tank, as defined in subsections OOO and PPP, that was fully installed as of April 19, 1990, and the location of which has not changed.

X. Facilities used for consumption on the premises. "Facilities used for consumption on the premises” means underground oil storage facilities not used to store motor fuels or waste oil, or in the marketing and distribution of oil to others. This includes underground heating oil storage facilities where the product is consumed on the premises or by the owner or operator of the facility.

Y. Facilities used for marketing and distribution. "Marketing and distribution facility" means any underground oil storage facility where oil is stored for eventual resale.

Z. Electrical equipment tank. Electrical equipment tank" means a tank that is a piece of underground equipment that contains dielectric fluid that is necessary for the operation of the equipment such as transformers or buried electrical cable.

AA. Equipment or machinery tank. "Equipment or machinery tank" means a tank that contains oil that is used for operational purposes such as a hydraulic lift tank or electrical equipment tank.

BB. Field constructed tank. "Field constructed tank" means a tank constructed in the field, including a tank constructed of concrete that is poured in the field, or a steel or fiberglass tank primarily fabricated in the field.

CC. Free product. "Free product" means nonaqueous phase liquid oil or petroleum.

DD. Gallon. "Gallon" means a unit of volume in the U.S. Customary System, used in liquid measure, equal to four (4) quarts, or 3.785 liters.

EE. Gasoline. "Gasoline" means a volatile, highly flammable liquid with a flash point of less than 100 degrees F obtained from the fractional distillation of petroleum.

FF. Heavy oil. "Heavy oil" means forms of oil that must be heated during storage, including, but not limited to #5 and #6 oils.

GG. Impressed current cathodic protection system. "Impressed current cathodic protection system" means a cathodic protection system that relies on direct current supplied by a power source external to the electrode system.

HH. In service. "In service" means that a tank or facility has had product added or removed for its intended purpose.

II. Leak. "Leak" means a loss or gain of:

(1) 0.1 gallons or more per hour as determined by a precision test or other facility integrity test methods approved by the Commissioner capable of detecting a 0.1 gallon or more per hour product loss or gain; or

(2) fluid to or from an underground oil storage facility, including, but not limited to, interstitial spaces and containment sumps.

JJ. Manifolded piping system. "Manifolded piping system" means a system where two or more pipes are merged into a single pipe. This includes vapor vent pipes from two or more tanks merging into one vent pipe, or pressurized product pipes from two or more tanks merging into one pressurized product pipe.

KK. Master tank. "Master tank" means a tank containing a submersible turbine pump that delivers product to fuel dispensers through a pressurized product pipe, and passively receives fuel from a subordinate tank through a siphon bar connecting the two tanks.

LL. Monitoring well. "Monitoring well" means a dug or drilled, cased well or other device used to detect oil in ground water and appropriately constructed.

MM. Motor fuel. "Motor fuel" means a complex blend of petroleum hydrocarbons and additives typically used in the operation of a motor engine such as motor gasoline, aviation gasoline, #1 fuel, or #2 diesel fuel or any blend containing one or more of these substances, such as gasoline blended with alcohol.

NN. Occurrence. "Occurrence" means a contamination incident or prohibited discharge associated with one or more tanks or piping at an underground oil storage facility or an aboveground oil storage facility within one year.

OO. Oil. "Oil" means oil, oil additives, petroleum products and their by-products of any kind and in any form including, but not limited to, petroleum, fuel oil, sludge, oil refuse, oil mixed with other nonhazardous waste, crude oils. and all other liquid hydrocarbons regardless of specific gravity. For the purposes of this Chapter, oil does not include propane.

PP. Operator. "Operator" means any person who is in control of, or having responsibility for, the daily operation of an underground oil storage facility or tank.

QQ. Out-of-service underground oil storage facility or tank. "Out-of-service underground oil storage facility" and "out-of-service underground oil storage tank" means any such facility or tank, as defined in subsections OOO and PPP, which is neither receiving nor dispensing oil, but to be returned to service or awaiting abandonment pursuant to section 11 of this Chapter.

RR. Owner. "Owner" means any person whom alone, or in conjunction with others owns an underground oil storage facility.

SS. Person. "Person" means any natural person, firm, association, partnership, corporation, trust, the State and any agency of the State, governmental entity, quasi-governmental entity, the United States and any agency of the United States and any other legal entity.

TT. Piping line tightness test. "Piping line tightness test" means a test to determine the presence of a leak in the piping components of a facility. Volumetric and non-volumetric tests may be used. All piping tightness tests must be conducted in accordance with the requirements of Appendix B.

UU. Pneumatic test. "Pneumatic test" means an air pressure test, performed in accordance with the requirements of Appendix C of this Chapter.

VV. Precision test. "Precision test" means a tank or piping line tightness test, approved by the Commissioner, that is capable of detecting a leak, a loss or gain of 0.1 gallons per hour with a probability of detection of at least 95 percent and a probability of false alarm of five (5) or less percent as determined by an independent testing laboratory using protocols approved by the U.S. Environmental Protection Agency (EPA) or a nationally recognized independent testing organization, including, but not limited to, the American Society for Testing and Materials (ASTM) and the National Work Group on Leak Detection Evaluations. A precision test method specifically for testing the integrity of the interstitial space of a double-walled tank, and that lacks an independent third party approval of its protocols, must be reviewed and approved by the Commissioner prior to use. For the purpose of this Chapter, precision test also means test methods approved by the Commissioner to determine the integrity of spill buckets, dispenser, tank top, piping and other containment sumps.

WW. Private water supply. "Private water supply" means any dug, drilled or other type of well or spring or other source of water, which collects water for human consumption and is not a public water supply.

XX. Public drinking water supply. "Public drinking water supply" means any well or other source of water that furnishes water to the public for human consumption for at least 15 connections, regularly serves an average of at least 25 individuals daily at least 60 days out of the year, or that supplies bottled water for sale.

YY. Repair. “Repair” means to restore to proper operating condition a tank, piping, containment sump, corrosion prevention equipment, leak detection equipment or other underground oil storage tank system component that has failed to function properly or that has caused or may cause a release of product from the underground oil storage tank system.

ZZ. Replace. “Replace” means to remove a tank and install another tank, or to remove and replace 25 percent or more of a single underground piping run that does not meet the design standards for new installations in section 5(B).

AAA. Replacement facility. “Replacement facility” means an underground oil storage facility where one or more of the following major components are replaced: a tank; piping; leak detection equipment; or overfill prevention or containment equipment. Minor repairs to a facility component, or other repairs conducted in accordance with the requirements of this Chapter, do not trigger the definition of a replacement facility.

NOTE: Except where specified otherwise in the rule, only the major component replaced will need to meet the rule’s design and installation requirements for new and replacement facilities. It is not the intent of this definition to require the upgrade of an entire facility in the event one component is replaced. An example of a specific section in the rule that requires an upgrade is when an existing dispenser and the equipment used to connect the dispenser to the underground piping are removed and replaced with a new dispenser. In this example the continuous electronic monitoring and under-dispenser containment requirements are triggered. See section 5(C)(5) and (6).

BBB. Safe Suction piping. “Safe suction piping” also known as European safe suction, means underground product piping connected to a suction pump that continuously slopes back to the tank at least 1/8 inch per foot, and has a single check valve located as close to the pump as possible, such that product will drain back to the tank, if the integrity of the piping is compromised.

CCC. Secondary containment. "Secondary containment" means a system installed so that any material that is discharged or has leaked from the primary containment is prevented from reaching the soil or ground water outside the system for the anticipated period of time necessary to detect and recover the discharged material. Such a system may include double-walled tanks and piping, double-walled sumps or another method approved by the Commissioner that is technically feasible and effective, and meets the requirements of section 5(B)(2).

DDD. Self-structural systems. “Self-structural systems” means a retrofit system that is designed to meet equivalent structural requirements of an underground tank standard, without any structural contribution from the host tank.

EEE. Sensitive geologic area. "Sensitive geologic area" means any of the following: (1) significant ground water aquifers, as defined in subsection FFF below; (2) locations within 1,000 feet of a public drinking water supply; or (3) locations within 300 feet of a private drinking water supply. Sensitive geologic areas around surface water bodies shall include all areas within 1000 feet of the intake point of a public water system, except on rivers and streams where it will only include areas within a 1000 feet of the intake point and upstream on either shore. All areas within 300 feet of the intake point in a lake, pond or other surface water body used for a private water supply system shall be considered a sensitive geological area, except on rivers and streams where it will only include areas 300 feet upstream on either shore of the intake point. For the purpose of this Chapter, a well or other source of water that is a public drinking water supply solely because the water is used to make beverages for public sale or consumption is deemed to be a private drinking water supply.

FFF. Significant ground water aquifer. "Significant ground water aquifer" means a porous formation of ice-contact and glacial outwash sand and gravel, as identified by the current Maine Geological Survey maps, that contains significant recoverable quantities of water which is likely to provide drinking water supplies.

NOTE: Significant Sand and Gravel Aquifer Maps are available from the Maine Geological Survey, Department of Agriculture, Conservation and Forestry, 22 State House Station, Augusta, Maine 04333-0022. http://www.maine.gov/dacf/mgs/pubs/online/aquifers/aquifers.htm

GGG. Siphon bar. “Siphon bar” means piping that connects two tanks and allows fuel to be drawn from the tank that contains a higher product level to equalize the product level of both tanks.

HHH. Site assessment. "Site assessment" means a determination at the time of facility or tank closure, of the occurrence of a prohibited leak or discharge of oil, and of the presence or absence of oil contamination in the soils or the waters of the State.

III. Spill bucket. “Spill bucket” means a liquid tight spill container for each tank chamber, which is sealed around the fill pipe and will collect any spillage during product delivery.

JJJ. Statistical inventory reconciliation. "Statistical inventory reconciliation” means a process of evaluating the various sources of errors present in daily inventory records and capable of detecting a leak or discharge of 0.1 gallons per hour with a 95 percent probability and a 5 percent chance of a false alarm as determined by an independent vendor using EPA's approved standardized test procedures, conducted in accordance with the requirements of section 5(D)(2).

KKK. Subordinate tank. “Subordinate tank” means a tank that is connected to an adjacent “master” tank via a siphon bar and does not distribute fuel to a dispenser.

LLL. Tank tightness test. "Tank tightness test" means a precision test, as defined under subsection VV. Tank tightness tests may include volumetric tank tightness tests or non-volumetric tank tightness tests. Tank tightness tests must be conducted in strict accordance with Appendix B and the manufacturer's test instructions and any protocols identified by an independent testing laboratory as required to meet the performance standards of subsection VV.

MMM. Tank Warranty. “Tank warranty” means the length of time the manufacturer guarantees the tank against corrosion or structural failure.

NNN. Under-dispenser containment. “Under-dispenser containment” or “dispenser sump” means a liquid tight container under the dispenser designed to prevent the intrusion of water and that prevents leaks from the associated dispenser and piping from reaching soil or ground water.

OOO. Underground oil storage facility. "Underground oil storage facility" also referred to as "facility," means any underground oil storage tank or tanks, as defined in subsection PPP, together with associated piping, ancillary equipment, containment systems, and dispensing facilities located under any land at a single location and used, or intended to be used, for the storage or supply of oil, as defined in this Chapter. Underground oil storage facility also includes piping located under any land at a single location associated with above ground storage tanks and containing 10 percent or more of the facility's volume capacity.

NOTE: Underground piping associated with an aboveground oil storage facility, regardless of percent of facility volume, must be installed, operated, maintained and abandoned in accordance with this Chapter and other requirements of 38 M.R.S. §570-K governing aboveground oil storage facilities. Piping associated with oil terminals, most aboveground home heating oil facilities, and liquefied petroleum and natural gas facilities are exempt.

PPP. Underground oil storage tank. "Underground oil storage tank" also referred to as "tank," means any container, 10 percent or more of its volume being beneath the surface of the ground and which is used, or intended to be used, for the storage, use, treatment, collection, capture or supply of oil as defined in this subchapter, but does not include any tanks situated in an underground area if these tanks or containers are situated upon or above the surface of a floor and in such a manner that they may be readily inspected. For the purpose of this Chapter, "underground oil storage tank" does not include underground propane storage tanks, wastewater treatment tank systems such as underground oil water separators that are regulated by the *Clean Water Act* §§ 402 or 307(b) (1972) (33 U.S.C., §1317(b) or §1342 (2016)), storm water and emergency catch basins, and equipment or machinery tanks such as hydraulic lift tanks and electrical equipment tanks. Overflow tanks associated with oil-water separators are still considered an underground oil storage tank.

QQQ. Underground oil storage tank inspector. Any person certified under the *Underground Oil Storage Tank Installers Law*, 32 M.R.S. §§ 10001-10016 and *Certification of Underground Oil Storage Tank Inspectors*, 06-481 C.M.R. ch. 6 (last amended February 15, 2015) to inspect underground oil storage tanks and facilities.

RRR. Underground oil storage tank installer. Any person certified under 32 M.R.S. §§ 10001-10016 and *Certification of Underground Oil Tank Installers*, 06-481 C.M.R. ch. 3 (last amended February 15, 2015) to install underground oil storage tanks and facilities.

NOTE: BUSTI, 06-481 C.M.R. ch. 3, refers to underground oil storage tank installers as underground oil tank installers. These terms apply to the same types of individuals.

SSS. Volumetric tank tightness test. "Volumetric tank tightness test" means a hydrostatic tank tightness test or precision test conducted at constant hydrostatic pressure at the bottom of the tank; where instrumentation noise is 3 to 5 times less than the minimum detectable leak rate; where temperature sensors provide adequate spatial coverage of tank; and where calibration of all instrumentation can be field checked. A volumetric or hydrostatic tank tightness test must be performed in accordance with Appendix B of this Chapter.

TTT. Waste oil. "Waste oil" means petroleum-based oil which, through use or handling, has become unsuitable for its original purpose due to the presence of impurities or loss of original properties. It must have sufficient liquid content to be free flowing. Waste oil is further defined in the Department's *Waste Oil Management Rules*, 06-096 C.M.R. ch. 860, §4.

UUU. Waste oil dealer. "Waste oil dealer" means any person in the business of transporting or handling more than 1,000 gallons of waste oil for the purpose of resale in a calendar month. A person, who collects or stores waste oil on the site of generation, whether or not for the purpose of resale, is not a waste oil dealer.

VVV. Waste oil tank. "Waste oil tank" means an underground oil storage tank used for the collection and storage of waste oil.

WWW. Wastewater treatment tank. “Wastewater treatment tank” means a tank that is designed to receive and treat an influent wastewater through physical, chemical, or biological methods.

4. Registration of Underground Oil Storage Facilities

A. All underground oil storage tanks and facilities must be registered regardless of use, size or type of petroleum product stored therein and regardless of whether the tanks and facilities are in service or out of service.

B. A person may not install, or cause to be installed, a new or replacement underground oil storage tank, piping or facility without first having: (1) filed registration materials with the Commissioner in accordance with subsection I, which materials have been deemed complete by the Commissioner at least 10 business days but no more than 2 years prior to installation; (2) sent a copy of the materials and any subsequent amendments to the chief administrative official of the municipality having jurisdiction, or in the case of an unorganized township to the Maine Land Use Planning Commission (LUPC); (3) retained a copy to be made available on site to Department employees, agents or authorized representative and to municipal officials; and (4) paid the registration fee in accordance with subsection J.

C. No person may retrofit an existing underground oil storage facility with leak detection, overfill prevention equipment or other design or installation changes without first having filed a registration amendment in accordance with subsection M.

D. Registration materials that are not in conformance with this Chapter will not be accepted by the Commissioner.

E. Written acknowledgment from the Commissioner is acceptable evidence that a new, retrofitted or replacement tank or facility has been properly registered. The Commissioner will determine the completeness of the registration materials and notify the registrant within 10 business days of receipt.

F. A person who installs, or causes to be installed, a new or replacement underground storage facility, or retrofits an existing facility, after 10 business days of the Commissioner's receipt of the registration form, without first having received confirmation that the registration is complete, does so at the person’s own risk. If it is determined that the facility was not installed in accordance with the regulations, the tank owner shall bring the facility into conformance with these regulations.

G. When an emergency situation occurs, the time requirement of subsection B may be waived by the Commissioner upon petition of a facility registrant if: (1) the registrant can demonstrate to the Commissioner that an emergency situation exists; and (2) the municipality or LUPC having jurisdiction has been notified by the registrant that the facility is being installed without the 10 day notice due to an emergency situation.

H. For existing facilities, the information required for registration must be submitted to the Commissioner and a copy provided to the chief administrative official of the municipality having jurisdiction, or in the case of an unorganized township to LUPC in accordance with this section. No person may operate, maintain or store oil in an underground oil storage facility, unless each underground oil storage tank at that facility has been properly registered with the Commissioner and a copy of the registration materials has been received by the chief administrative official of the municipality having jurisdiction, or in the case of an unorganized township to LUPC.

I. Registrations must be submitted on forms developed by the Commissioner and containing the following information:

(1) The name, mailing address and telephone number of the owner;

(2) The name, mailing address and telephone number of the operator;

(3) The name, street address and telephone number of the facility;

(4) The name, mailing address and telephone number of an individual to contact with questions on the registration materials submitted;

(5) The location of the facility compatible with the State of Maine Geographic Information System (GIS). If a new facility or a facility expansion, adequate GIS location information to determine if the facility meets the siting restrictions of the *Wellhead Protection Law,* 38 M.R.S. §§ 1391-1400 and *Siting of Oil Storage Facilities*, 06-096 C.M.R. ch. 692;

(6) The location of the facility relative to a sensitive geologic area, including: (a) whether a private water supply exists within 300 feet of the tanks; (b) if any person owns, operates, or utilizes any private water supply within 300 feet of the tanks; (c) whether a public water supply exists within 1,000 feet of the tanks; and (d) whether the facility is located on a significant ground water aquifer, as defined by this Chapter;

(7) The location of the facility relative to a 100 year flood plain as mapped by the Federal Emergency Management Agency (FEMA), or in the absence of such maps, as indicated by the presence of flood plain soils or the flood of record;

NOTE: FEMA maps are available at most municipal offices.

(8) The size of each tank and each internal storage compartments (if more than one) measured in gallons;

(9) The type of tank(s) and piping, including the materials used for construction and the type of pumping system;

(10) The type of product(s) stored in each tank;

(11) For a new or replacement facility or retrofitting of an existing facility, the installer's name, signature and certification number assigned by BUSTI;

(12) For a new or replacement facility, a site drawing of the facility containing the location of all new or replacement tanks, including: (a) distance and direction measurements in the Universal Transverse Mercator (UTM) map projection using the North American Datum (NAD83) coordinate units in meters or in Latitude/Longitude decimal degree coordinates (not degrees in minutes and seconds) and have sub-meter accuracy and precision and that are sufficient to locate all underground portions of the facility; (b) details of secondary containment and interstitial space leak detection monitoring equipment; (c) locations of any monitoring wells; (d) all piping associated with the new or replacement facility; (e) the depth to ground water that would be encountered during the tank installation, if known; and (f) the depth to bedrock that would be encountered during the tank installation, if known;

NOTE: The Maine Geological Survey Surficial Materials Map contains helpful information on determining likely depth to bedrock. The Department of Environmental Protection project files for underground storage tank sites and neighboring sites also contain helpful information on likely depth to groundwater and bedrock. These two sources should be consulted prior to filing a registration form for a new installation in order to assist the Maine

Certified Underground Oil Storage Tank Installer with water management and excavation planning.

(13) The best estimate of the date of installation for each existing tank and its warranty expiration date, if available;

(14) For new and replacement tanks, the expiration date of the tank manufacturer's warranty;

(15) For retrofitting an existing underground oil storage facility, the information required in paragraphs 1, 2, 3, 4, 8, 9, 11 and 12 above must be provided on the required registration amendment, as well as information on the type of leak detection, overfill prevention, or other equipment to be installed;

(16) Any other information required by federal law or regulation; and

NOTE: The Federal *Resource Conservation and Recovery Act*, 42 U.S.C. §§ 6991-6991a requires an underground tank notification program and specifies informational requirements for that program. Registration forms meeting all federal and state informational requirements are available from the Department. A tank owner is not required to send a copy of the completed form to EPA in addition to the Commissioner.

(17) Certification of the accuracy of the information by the tank owner or the owner's permanent full time employee. The certification cannot be signed by the installer or other subcontractor, unless the tank is owned by the installer.

J. Registration fees. The owner or operator of an underground oil storage facility shall pay a registration fee every three years to the Commissioner of $100 for each tank located at the facility, except that single family homeowners are not required to pay a fee for a tank at their personal residence. Registration payments must be paid on or before January 1st of every third calendar year upon receipt of a bill from the Commissioner in order to maintain an effective registration for the upcoming three years. Registrations for new tanks shall include payment of the three year registration fee. Registration of a replacement facility shall not require that an additional fee be paid or accompany the registration amendment if the registration fee has been previously paid.

K. It is the responsibility of the facility owner to register all tanks. Where the facility owner cannot be determined, or is disputed, it is the responsibility of the property owner to register all facilities and tanks located on the property.

L. Registration number. The Commissioner will assign a unique registration number to each facility and to each tank at a facility. These registration numbers shall be provided to the owner or operator and shall be used for re-registration every three years and in all subsequent correspondence regarding registered facilities and tanks. The owner or operator shall post the registration number or certificate in a prominent location at the facility.

M. Registration amendments. The owner or operator of an underground oil storage tank shall file an amended registration form with the Commissioner and LUPC or municipality having jurisdiction whenever there is a change in the information required pursuant to section 4(I). Such amendments must be received by the Commissioner within 10 business days of the change, except that amendments for installation of leak detection, overfill and spill protection, other underground oil storage facility equipment, the reinstallation of tanks, or the retrofitting of secondary containment in an existing tank must be submitted at least 10 business days before installation. No amendment is required for repairs. No amendment is required for facility abandonment or closure but instead notice must be provided to the Commissioner in accordance with section 11 of this Chapter. There is no fee for filing an amended registration.

NOTE: A change in the facility ownership or operator requires the submission of a registration amendment. See section 4(P) regarding filing amended registration forms.

N. Supplier notification requirement. Any person who sells a tank intended to be installed as an underground oil storage tank shall notify the purchaser in writing of the purchaser's registration obligations under this section.

O. Wherever these rules require that information or notice be submitted to the Commissioner or Department, failure to provide such notice or information in the manner required by this Chapter or providing false information constitutes a violation of this Chapter.

P. Notifications at time of facility sale or transfer. Prior to the sale or transfer of any real estate where an underground oil storage facility is located, the owner of the real estate shall file a written notice with the purchaser or transferee. The notice shall disclose the existence of the underground oil storage facility, its registration number or numbers, the real estate where the facility is located, whether or not the facility has been abandoned in place and that the facility is subject to this Chapter, including the registration requirements of this section. A change in facility ownership requires the new owner or operator to amend the facility registration within 10 business days of the transfer of ownership by providing the Commissioner written notice of the change, including the facility name and registration number; and the name, mailing address and telephone number of the new owner.

5. Regulation of underground oil storage facilities used to store motor fuels or used in the marketing and distribution of oil

A. Applicability

(1) This section and its requirements apply to all facilities and tanks used to store motor fuels or used in the marketing and distribution of oil to others, except where noted below.

(2) Tanks supplying fuel to a generator are considered a motor fuel tank and are governed by this section.

(3) This section does not apply to field constructed tanks and airport hydrant systems, which must comply with sections 8 and 10 of this Chapter, respectively.

NOTE: All new and replacement underground piping associated with aboveground storage tanks must be installed, operated, maintained and removed in accordance with these rules and 38 M.R.S. §570-K.

B. Design and installation standards for new and replacement facilities

(1) General design requirements

(a) All new and replacement tanks must be constructed of fiberglass reinforced plastic (hereafter "fiberglass"), cathodically protected steel, or other equally noncorrosive material approved by the Commissioner. Piping and below ground ancillary equipment in contact with soil or water must be constructed of fiberglass, cathodically protected steel or other corrosion-resistant or noncorrosive materials approved by the Commissioner.

(i) It is the responsibility of the facility owner to demonstrate to the satisfaction of the Commissioner that the materials are noncorrosive or corrosion resistant and meet or exceed the performance standards listed below.

(ii) All new or replacement facilities must be listed and constructed in accordance with the standards contained in the following:

- Fiberglass Tanks –
    - Underwriters Laboratories (UL) Standard 1316, Glass-Fiber- Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols and Alcohol-Gasoline Mixtures; or
    - Underwriters Laboratories of Canada (ULC) S615, Standard for Fibre Reinforced Plastic Underground Tanks for Flammable and Combustible Liquids;
- Cathodically Protected Steel Tanks -
    - Steel Tank Institute (STI) STI-P3®, Specification and Manual for External Corrosion Protection of Underground Steel Storage Tanks;
    - UL Standard 1746, External Corrosion Protection Systems for Steel Underground Storage Tanks;
    - ULC S603, Standard for External Corrosion Protection for Steel Underground Tanks for Flammable and Combustible Liquids, and S631, Standard for Isolating Bushings for Steel Underground Tanks Protected with External Corrosion Protections Systems;
    - Steel Tank Institute (STI) Standard F841, Standard for Dual Wall Underground Steel Storage Tanks;
    - NACE International, SP0 285-2 011, External Corrosion Control of Underground Storage Tank Systems by Cathodic Protection, and UL Standard 58, Standard for Steel Underground Tanks for Flammable and Combustible Liquids; or
    - Petroleum Equipment Institute (PEI) RP-100, Recommended Practices for Installation of Underground Liquid Storage Systems;
- Steel Clad or Jacketed Tanks –
    - UL 1746, External Corrosion Protection Systems for Steel Underground Storage Tanks, STI F894;
- Composite Tank Standard –
    - STI F894, ACT-100 ® Specification of External Corrosion Protection of FRP Composite, or STI Specification F922, STI Specification for Permatank;
- Non-Metallic and Fiberglass Piping – UL Standard 971, Non-metallic Underground Piping for Flammable Liquids, or ULC Standard S660, Standard for Non-metallic Underground Piping for Flammable Liquids and Combustible Liquids; Pipe Connectors –
    - UL Standard 567, Standard for Emergency Breakaway Fitting, Swivel Connectors and Pipe Connectors for Petroleum Products and LP Gas;

- Flexible Connectors –
    - CAN/ULC -S633, Flexible Underground Hose Connectors for Flammable and Combustible Liquids; and
- Steel Piping -
    - National Fire Protection Association (NFPA) Standards 30, Flammable and Combustible Liquids Code, 30-A, Code for Motor Fuels Dispensing Facilities and Repair Garages, or 31, Standard of the Installation of Oil Burning Equipment;
    - American Petroleum Institute (API) Publications 1632, Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems;
    - NACE International Standard SP0169, Control of External Corrosion on Underground or Submerged Metallic Piping Systems or NACE SP0285, External Corrosion Control of Underground Storage Tank Systems by Cathodic Protection; or
    - STI Recommended Practice R892, Recommended Practice for Corrosion Protection of Underground Piping Networks Associated with Liquid Storage and Dispensing Systems.

NOTE: Fiberglass clad steel and other steel composite tanks need not be provided with galvanic or impressed current cathodic protection if constructed with secondary containment and interstitial space monitoring in accordance with the standards of this subsection.

(iii) Impressed current cathodic protection systems must be designed by a corrosion expert and according to the standards described in the NACE International SP0285 and SP0169, and installed under the supervision of a corrosion expert and by a Maine Certified Underground Oil Storage Tank Installer.

(b) All facility construction materials must be chemically and physically compatible with the product to be stored. For facilities storing gasoline with more than 10 percent ethanol or storing diesel with more than 20 percent biodiesel or any other regulated substance identified by the Department, the facility owner must demonstrate that the facility is compatible with these oil products by one of the following methods:

(i) UL or other nationally recognized independent testing laboratory certification or listing approved by the Commissioner;

(ii) A written statement of compatibility from the equipment or component manufacturer that indicates an affirmative statement of compatibility and specifies the range of biofuel blends the equipment or component is compatible with; or

(iii) Another method demonstrating compatibility of facility components and equipment with the oil product to be stored approved by the Commissioner.

Documentation of facility and oil product compatibility shall be maintained at the owner's place of business for the life of the facility component or equipment.

NOTE: Gasoline underground oil storage facilities with a monthly throughput of 10,000 gallons or more in any one month are required to install vapor control equipment in accordance with *Gasoline Dispensing Facilities Vapor Control*, 06-096 C.M.R. ch. 118 of the Department's air quality rules.

(2) Leak detection

(a) All new and replacement facilities must be designed to provide secondary containment for all facility components routinely containing product, including tanks, product piping, other below ground ancillary equipment and product dispensers. New and replacement tanks and product piping must have continuous interstitial space monitoring. All piping sumps including dispenser sumps and pans shall be provided with continuous leak detection monitoring.

(b) Interstitial space monitoring of tanks and piping must be able to detect a loss or gain in the interstitial space from a leak in the primary or secondary containment structure.

(c) Safe suction piping and siphon bars designed and installed in accordance with this Chapter are not required to have secondary containment.

(3) Overfill and spill prevention equipment. Facility owners and operators shall take measures to prevent releases due to spilling or overfilling. New and replacement facilities must include:

(a) For a new facility, a liquid tight double walled spill bucket with electronic or mechanical interstitial space monitoring, of a minimum capacity of 15 gallons for each tank fill, which is sealed around the fill pipe and will collect any spillage during product delivery. For replacement facilities, when only the spill bucket is retrofitted or replaced, the largest capacity double walled spill bucket with electronic or mechanical interstitial space monitoring feasible from 5 to 15 gallons must be installed.

(b) Overfill prevention equipment that will:

(i) Automatically shut off flow into the tank when the tank is no more than 95 percent full; or

(ii) Alert the transfer operator when the tank is no more than 90 percent full by restricting flow into the tank or triggering a high-level audible alarm (vent whistles are not considered a high-level alarm).

(c) A ball float valve, also known as a ball float vent valve, may not be installed after October 13, 2018.

(d) Dispenser s umps or pans of adequate dimensions must be located and installed under all product dispensers in such a manner as to collect all product leaks and discharges from dispenser piping and equipment to prevent oil reaching the environment. Dispenser sumps must be liquid tight and allow for visual inspection and access to the components in the containment system. Dispenser sumps must be equipped with continuous leak detection equipment including leak detection sensors and alarms. If the facility operates unattended at any time, then the dispenser sump sensor(s) must shut down all submersible pumps.

NOTE: Because double walled containment sumps with continuous monitoring do not require triennial sump testing, owners should carefully consider the initial costs of this design as compared to the anticipated cost associated with triennial sump testing.

(e) Bulk plants and other distribution facilities where oil is transferred to tank trucks or railroad tank cars must include a system to prevent oil spills and overfills from reaching the environment. Installation of a system to catch or direct the flow of loading area spills and overfills is required. Any such system must be able to hold at least the maximum capacity of the largest single compartment of a tank car or tank truck loaded or unloaded at the facility, and must include one of the following:

(i) An impermeable curbed loading or unloading pad sloped or connected to a catchment basin, an underground oil storage tank or other containment system which in combination provide sufficient containment capacity to meet this Chapter;

(ii) An impermeable curbed loading or unloading pad sloped or connected to an oil water separator discharging to a public wastewater treatment facility or the waters of the State, licensed by the Department pursuant to the law on waste discharge licenses, the *Pollution Control Law*, 38 M.R.S. §413 and the *Oil Discharge Prevention and Pollution Control Law*, 38 M.R.S. §543; or

(iii) Other loading or unloading rack overfill containment system approved by the Commissioner.

Subsurface discharges of potentially oil contaminated storm water are prohibited unless licensed by the Department in accordance with 38 M.R.S. §§ 413 and 543.

(4) General facility installation requirements

(a) No person may install an underground oil storage facility or a portion thereof unless that person is a properly Certified Underground Oil Storage Tank Installer with the appropriate class of certification and has paid the required certification fee. A Maine Certified Underground Oil Storage Tank Installer shall be present and supervising all aspects of the UST facility installation.

(b) An underground oil storage tank installer may not install an underground storage facility if the installer has been placed on inactive status or if the installer’s certification has been suspended or revoked under 32 M.R.S., §10015, and has not been reinstated.

(c) An underground oil storage facility may not be installed unless the entire facility has been registered in accordance with section 4 of this Chapter.

(d) An underground oil storage tank or piping may not be installed within one foot of the closest bedrock. In sensitive geologic areas with known contamination, bedrock may not be blasted without the Department’s prior approval.

NOTE: Blasting in contaminated sensitive geologic areas can spread contamination to drinking water supplies where contamination is not currently present.

(e) All phases of the installation of an impressed current cathodic protection system must be conducted under the direct supervision of a corrosion expert. The tank, piping and other portions of the facility other than the impressed current system may be installed by a Maine Certified Underground Oil Storage Tank Installer without such supervision.

(f) All new and replacement steel tanks and piping with cathodic protection must be monitored within 6 to 12 weeks of completion of installation by a cathodic protection tester in accordance with Appendix A of this Chapter.

(g) Owners of new and replacement facilities shall ensure that the installer(s) provides certification of proper installation to the Commissioner within 30 days of completion of installation that the facility's materials, design and installation are in compliance with the requirements of this Chapter. This certification shall be provided in writing on a form provided by the Commissioner and signed by the Certified Underground Oil Storage Tank Installer responsible for the installation. The certification shall be submitted to the Department before fuel is dispensed from the tank for consumption or resale, unless an alternate schedule for submitting the Certificate of Proper Installation is agreed to by the Department, the Maine Certified Underground Oil Storage Tank Installer and the tank owner.

(h) For all new installations and replacements of tanks and piping the facility owner shall maintain a to-scale, as-built drawing of the facility at the facility or the owner’s primary place of business. The drawing is to show the location of tanks, piping, dispensers and other major underground facility components to facilitate safe facility maintenance, repairs, replacement and remediation.

(i) No used or previously installed double-walled fiberglass, cathodically protected steel, or other tank meeting the requirements of section 5(B) may be reinstalled, unless the owner has supplied the Commissioner with satisfactory documentation that the manufacturer will warranty that tank against internal and external corrosion and structural failure for a period of at least 10 years, after which the tank and piping must be properly abandoned in accordance with section 11. Reinstallation of a tank requires an amendment of the facility registration in accordance with section 4(M). The warranty documentation shall accompany the submission of the registration amendment. Used piping may not be reinstalled. A tank that has been reinstalled cannot operate beyond 30 years from the original date of installation unless the tank owner receives written permission from the Department pursuant to section 5(F).

(j) The facility owner shall ensure that no permanent structures, underground utilities or other objects are installed or constructed in proximity to the tank, so as to impede the ability to safely remove the tank as determined by a Maine Certified Underground Oil Storage Tank Installer or a Maine registered engineer,

(k) After July 1, 2019, a Certified Underground Oil Storage Tank Installer overseeing a tank removal must be trained in best management practices for erosion and sedimentation control by the Department or through an equivalent program approved by the Department.

(5) Installation requirements for new and replacement tanks

(a) New and replacement tanks and facilities must be installed in conformance with the requirements of Appendix D, except field constructed tanks which must be installed in accordance with section 8 of this Chapter.

(b) If a tank is replaced, all associated underground piping not meeting the design requirements of this Chapter shall be replaced. Underground piping meeting the requirements of this chapter must be precision tested in accordance with Appendix B prior to continued use. If product piping is replaced and structural damage to the associated tank has occurred, impairing its physical integrity, the tank also must be replaced or repaired. Any replacement tank must be designed and installed in accordance with this Chapter. Repairs of damaged fiberglass, cathodically protected steel and other Commissioner approved noncorrosive material tanks may only be made if conducted in accordance with sections 5(D) (13) or (14). Tanks that cannot be repaired must be abandoned in accordance with section 11.

(6) Installation requirements for new and replacement piping

(a) All underground piping must be designed and installed in conformance with the requirements of Appendix E, except airport hydrant piping, which must comply with section 10. If replacement piping is installed for 25 percent or more of a non-compliant piping run, the entire piping run must be replaced.

(b) All underground piping in contact with soil or water must be constructed of fiberglass or cathodically protected steel. Other noncorrosive materials may be used when approved by the Commissioner.

(i) It is the responsibility of the tank owner to demonstrate to the satisfaction of the Commissioner that the materials are noncorrosive.

NOTE: Galvanized piping does not meet the requirement for corrosion protection of tanks or piping, and does not meet the criteria for cathodic protection as stated in the NACE International, Standard Practice SP0285.

(ii) All new or replacement non-metallic product piping must be listed by UL for underground use. Cathodically protected piping must be constructed and installed in conformance with the NACE International, Standard Practice, SP0169, or PEI Recommended Practice RP100.

(iii) Other than field coating limited to vertical fill pipes, vertical vent risers and piping joints, field coating of steel pipe for product delivery lines is prohibited except where supervised and inspected by a corrosion expert.

(c) Product lines must be installed in a single trench between the tank area and each pump island. Underground vent lines must be installed in a single trench. All product and vent lines shall slope toward the tank or a sump with leak detection at a minimum slope of 1/8 inch per foot, or in accordance with the manufacturer's instructions.

NOTE: The Department recommends placing colored, plastic tape in the excavation trench for fiberglass reinforced piping and plastic piping runs to warn excavator operators and to help locate piping in the future.

(d) Secondary containment and cathodic protection of vertical, direct drop fill pipes is not required if the fill pipe is constructed of Schedule 40 steel and is uniformly coated with a minimum of 1/8 inch of fiberglass resin, bitumastic coating or epoxy coating. The pipe surface must be properly prepared and the coating allowed to cure. Offset fill pipes require secondary containment and interstitial leak detection.

(e) Piping shall be installed such that in-line piping leak detectors and overfill prevention equipment operate in accordance with manufacturers' specifications and the requirements of this Chapter.

(6-A) Replacement of the flexible primary product piping in a double-walled piping system. Primary piping that is part of double-walled piping may be replaced without excavation and removal of the entire piping run when there is no evidence of a possible piping discharge and when the following conditions and requirements are met:

(a) Flexible primary piping can be removed by pulling the entire length of old piping through the four (4) inch diameter secondary containment or chase piping, and can be replaced with new double-walled piping fed through the existing chase piping;

(b) The original chase piping may only be used as the conduit for the replacement piping, not as secondary containment;

(c) The facility is equipped with dispenser, tank top and piping containment sumps installed in accordance with section 5(B);

(d) The replacement piping is double-walled with an interstitial space for leak monitoring, and is installed in accordance with all applicable requirements of this Chapter, including Appendix E;

(e) The facility registration is amended in accordance with section 4(M); and

(f) A modified site assessment is conducted and submitted to the Commissioner in accordance with section 11(A) and Appendix P of this Chapter.

(7) Installation requirements for leak detection and overfill/spill prevention equipment

(a) Leak detection and overfill/spill prevention alarms and shutoff equipment must be installed and operating prior to the start of the facility's operation and in accordance with manufacturer specifications, including proper calibration of electronic equipment. Installation of a ball float valve for overfill prevention is prohibited after October 13, 2018.

(b) Piping, tank and dispenser containment sumps and pans must be liquid tight. New and replacement piping, tank and dispenser containment sumps must be tested to 4 inches above the highest penetration or seam in the sidewall.

(c) Penetrations of a containment sump for piping or other sump entrance must be liquid tight and must be at least three (3) or more inches above the leak detection sensor activation level. The three (3) inch penetration location requirement does not apply to the bottom access hole in a tank sump for the installation of a pressurized product pump or to provide access to the tank for suction dispenser piping. The bottom access hole must be liquid tight.

NOTE: The Department recommends that sump penetrations be at least 4 inches or more above the leak detection sensor whenever possible to facilitate low level sump testing.

C. Retrofitting requirements for existing facilities

(1) Existing facility owners shall retrofit or institute a leak detection method, capable of detecting a leak in the tank, product piping and other portions of the facility normally containing product. Such leak detection must be capable of detecting a leak within 30 days of occurrence with a probability of detection of at least 95 percent and a 5 percent or less probability of a false positive as determined by an independent testing laboratory, using EPA approved testing protocols. Leak detection methods found to meet the above performance standards and tested using other protocols approved by nationally recognized independent testing organizations may be used. Examples include, but are not limited to, the American Society of Testing and Materials and the National Work Group on Leak Detection Evaluations.

Acceptable methods are listed in section 5(C)(2) below. Facility owners shall have leak detection in operation by December 1, 1990, for facilities with pressurized piping and by December 1, 1991, for facilities with safe suction piping.

Existing facilities with secondary containment with interstitial space monitoring for all tanks, product piping and associated below ground ancillary equipment are considered to meet this requirement.

Facilities with suction piping installed such that the piping is sloped so that the contents of the pipe will drain back into the tank if suction is lost, and only one check valve is located in a piping line with the check valve located directly below and as close as possible to the pump, may have until December 1, 1993 to implement leak detection.

Where an existing tank has leak detection meeting the requirements of this Chapter, the associated product piping must be provided leak detection in accordance with the time schedule and other provisions of this subsection. If the mandatory removal date for a nonconforming facility under 38 M.R.S., section 563-A, precedes the leak detection compliance schedule outlined above, the facility owner shall comply with the removal schedule in section 563-A.

(2) Acceptable leak detection methods for tanks installed before September 16, 1991 are any one of the following:

(a) Monthly statistical inventory reconciliation of daily product inventory data in accordance with Appendix I and an annual precision test of all tanks and piping. All facilities using this method must install drop tubes in the fill pipes. An annual statistical inventory reconciliation, conducted in accordance with section 5(D)(2) or other Commissioner approved methods of facility leak detection capable of detecting a leak rate of 0.1 gallons per hour with a 95 percent probability of detection and 5 percent probability of false alarm, may be substituted for a precision test for the purposes of this paragraph. In addition, all pressurized piping must be retrofitted with an automatic in-line leak detector capable of detecting a leak of 3 or more gallons per hour at 10 pounds per square inch line pressure within 1 hour of its occurrence with a 95 percent probability and a 5 percent probability of false alarm.

(b) Automatic tank gauging, that can detect a 0.2 gallon per hour loss, conducted at least once every 30 days, and monitoring of associated existing piping, by implementing one of the leak detection methods listed below in paragraph C(2)(c) of this section.

(c) When an existing tank is to be monitored for leaks by automatic in-tank gauging, associated existing piping must be monitored for leaks using one of the following methods:

(i) Secondary containment with continuous interstitial space monitoring;

(ii) For pressurized piping, either an automatic mechanical in-line leak detector and an annual piping line tightness test; or an electronic in-line leak detector capable of detecting a piping leak of 0.1 gallons per hour; or

(iii) Replacement with safe suction piping designed and installed in accordance with requirements for new and replacement piping in this section and Appendix E.

(d) Where only existing piping requires leak detection, one of the following methods must be used:

(i) Secondary containment with continuous interstitial space monitoring;

(ii) For pressurized piping, an automatic mechanical in-line leak detector, and an annual piping line tightness test; or an electronic in-line leak detector capable of detecting a 0.1 gallon per hour leak;

(iii) Replacement with safe suction piping designed and installed in accordance with requirements for new and replacement piping in this section and Appendix E.

(e) Other facility leak detection systems approved by the Commissioner that can detect at least a 0.2 gallon per hour leak rate with at least a 95 percent probability and a 5 percent or less chance of false alarm, as determined by an independent testing laboratory using EPA approved testing protocols, or by other testing protocols approved by a nationally recognized independent testing organization.

(3) Overfill and spill prevention equipment must be retrofitted at all facilities constructed of fiberglass, cathodically protected steel or other noncorrosive materials approved by the Commissioner in accordance with section 5(B) by December 22, 1998.

(4) Facilities that do not comply with the retrofitting requirements of this subsection shall cease operation on the date upon which retrofitting was required, and close in accordance with section 11 of this Chapter.

(5) A dispenser system is considered new when both the dispenser and the equipment needed to connect the dispenser to the underground oil storage facility are installed. The equipment necessary to connect the dispenser to the underground oil storage facility includes check valves, shear valves, unburied risers or flexible connectors, or other transitional components that are underneath the dispenser and connect the dispenser and the underground piping.

(6) The replacement of the dispenser and the equipment needed to connect the dispenser to the underground oil storage facility triggers the requirement to install a dispenser sump and continuous leak detection equipment, including leak detection sensors and alarms.

D. Monitoring, maintenance, operating and inspection requirements

(1) Daily inventory requirements. The owner or operator of a facility with single-walled tanks that do not have an automatic gauge system for leak detection shall maintain and reconcile daily inventory for each day that oil is being added to or withdrawn from the facility or tank.

(a) Daily inventory must be conducted so as to be able to detect a leak or discharge of at least 1 percent of throughput on a monthly basis and must include all the following:

(i) The daily measurement of product and water levels in each tank for each day product is added or removed. Measurement of product levels may be made by a stick gauge reading. Water level measurements may be made by using water paste and a gauge stick. Electronic or mechanical level measuring devices which measure product and water levels are also acceptable. Product level and water levels are to be measured to the nearest one-eighth of an inch (1/8").

(ii) The measurement of product levels, before and after any deliveries.

(iii) Product dispensing is metered and recorded within Maine Department of Agriculture, Conservation and Forestry's weight and measure standards or an accuracy of six (6) cubic inches for every five (5) gallons of product withdrawn.

(iv) Daily reconciliation of tank measurements and pump meter readings shall be performed to determine daily loss or gain of product. The reading of pump meter readings and product delivery receipts shall not in itself constitute adequate inventory records.

(v) A log book shall be kept at the facility which includes each measurement and the initials of the individual taking and recording the pump meter readings and the actual product and water level measurements.

(b) All inventory data must be summarized monthly and must include the total cumulative loss or gain for the preceding month.

NOTE: See Appendix I for an example of a daily inventory data sheet. Practices described in the API Publication 1621, "Recommended Practice for Bulk Liquid Stock Control at Retail Outlets", may be used, where applicable, as guidance in meeting the daily inventory requirements of this Chapter.

(2) Statistical Inventory Reconciliation

(a) On or before October 13, 2018, the owner of each single-walled tank that does not have an automatic tank gauge system for leak detection shall be responsible for having a monthly statistical inventory reconciliation performed for each of the owner’s tanks, and reporting the results of the reconciliation to the Commissioner on or before the 1st day of each month. The reconciliation must include an evaluation of the various sources of error present in daily inventory records, including the following:

(i) Identifying and removing large measurement errors;

(ii) Identifying unrecorded additions or removals of oil;

(iii) Detecting errors in metering oil from the tank;

(iv) Estimating the potential for temperature differential to induce spurious trends or conceal real trends;

(v) Establishing that residual errors contain no systematic components and reflect the normal errors of measurement;

(vi) Evaluating the quality of the data provided and the adequacy of operator procedures to detect leaks if present;

(vii) Identifying persistent daily physical loss which could be consistent with leakage; and

(viii) Determining values and dates for any delivery errors and any unexplained one time gains or losses.

(b) The report of the reconciliation results also must contain the following facility information:

(i) Name of the facility;

(ii) Municipality in which the facility is located;

(iii) Name of the owner;

(iv) Registration numbers assigned by the Commissioner to the facility and to the tanks;

(v) Certification by tank owner and the agent conducting the reconciliation that the results are true and accurate to the best of his or her knowledge; and

(vi) Dates of inventory data used in the reconciliation.

(c) The requirement for statistical inventory reconciliation must be met only if the inventory records submitted are capable of being analyzed with conclusive results. The following attributes constitute cause for invalidation of a reconciliation:

(i) Excessively large and other clearly erroneous measurements of inventory-on-hand;

(ii) Excessively large unexplained removals or additions of product;

(iii) Failure to take daily readings of inventory-on-hand;

(iv) Excessive data recording errors; or

(v) Evidence of the use of an incorrect conversion chart or persistent faulty gauging.

(d) A statistical inventory reconciliation resulting in an inconclusive finding due to poor quality product inventory readings, pump error, tank tilt or other reasons, must be redone following correction of likely errors, using new daily inventory data and submitted to the Commissioner within 30 days of receipt of the initial statistical reconciliation.

(e) All tank owners shall maintain the results of all statistical inventory reconciliation for each underground storage tank in accordance with section 5(D) (16). Only statistical inventory reconciliation by methods meeting the definition and performance standards of section 3(JJJ) shall be accepted by the Commissioner.

(3) Operation and Monitoring Requirements for Galvanic Cathodic Protection Systems

(a) All galvanic cathodic protection systems must be operated and maintained to continuously provide adequate corrosion protection to the underground metal components of the facility routinely storing or containing oil, and in a manner that ensures no leaks occur during the operational life of the facility. Adequate corrosion protection is indicated by a cathodic protection test reading of at least negative 0.85 volts. Steel composite tanks without secondary containment and continuous interstitial space monitoring must comply with this requirement.

(b) Cathodically protected steel underground storage tanks or piping that fail to achieve the minimum level of adequate corrosion protection of negative 0.85 volts or less within six (6) months after a failing reading shall be properly abandoned in accordance with section 11 of this Chapter.

(c) All cathodically protected tanks and piping must have an accurate structure to soil potential reading performed upon installation or repair and annually thereafter. The cathodic protection testing must be conducted by a qualified Certified Underground Oil Storage Tank Installer or Inspector who is approved as a cathodic protection tester in accordance with Appendix M.

(d) When repairs to cathodic protection systems are made or underground work is performed at the site, the cathodic protection shall be monitored 6 to 12 weeks after such work has been completed, to assure that the system is functioning properly. Repairs must be conducted in accordance with Appendix A and must be documented on a form developed by the Commissioner and submitted to the Department within 30 days.

(e) Monitoring must be performed in accordance with the requirements of Appendix A.

(f) Repairs of a galvanic cathodic protection system must be completed by a Maine Certified Underground Oil Storage Tank Installer within 180 days of a failed test, and in accordance with section 5(D)(14). If anodes are added to a tank, the owner shall ensure that the Maine Certified Underground Oil Storage Tank Installer submits written documentation that all repairs were conducted in accordance with the recommended practices of STI or NACE, as applicable.

(g) The results of all monitoring and repairs must be kept in a logbook in accordance with section 5(D)(16).

(4) Monitoring Requirements for Impressed Current Cathodic Protection Systems

(a) All impressed current cathodic protection systems must be operated and maintained to continuously provide adequate corrosion protection to all underground metal components of the facility routinely storing or containing oil, and in a manner that ensures that no leaks occur during the operating life of the facility. Adequate corrosion protection is indicated by cathodic protection tests, conducted in accordance with Appendix A.

(b) A monthly voltage reading and inspection of the rectifier meter on all facilities must be performed using the impressed current system of corrosion protection. All readings, inspection results and repairs must be recorded in a logbook, which must be kept in accordance with the record keeping requirements of 5(D)(16).

(c) A certified installer, or a certified inspector who has also been certified in accordance with Appendix M of this Chapter as a cathodic protection tester, shall measure the structure to soil and structure-to-structure potentials, the rectifier voltage and current output as part of an on-site test and inspection at least once per year.

(d) Repairs to an impressed current cathodic protection system must be supervised by a corrosion expert and adhere to NACE International Standards SP0285 and SP0169.

(5) Operation, maintenance and testing of in-line leak detectors. In-line leak detection devices must be maintained to properly operate in accordance with this Chapter at all times while the piping contains oil. The facility owner or operator shall ensure all in-line leak detectors are tested for proper operation in accordance with manufacturer instructions upon installation and at least once each calendar year thereafter. This test must include an assessment of proper operation by simulating a leak. Tests of in-line leak detectors must be conducted by a Certified Underground Oil Storage Tank Installer, or Inspector who is also certified by the manufacturer of the equipment, where such manufacturer certification is available. Improperly operating leak detectors must be repaired or replaced by a Certified Underground Oil Storage Tank Installer, within 30 days. A log of all tests, maintenance, and repairs must be maintained by the owner in accordance with the record keeping requirements of section 5(D)(16).

(6) Overfill and spill prevention

(a) The facility owner or operator shall ensure that a representative of the owner, operator or oil transporter is physically present during and monitors all product deliveries or transfers. The owner or operator or oil transporter must ensure that the volume available in the tank is greater than the volume of product to be transferred to the tank before the transfer is made.

(b) Operation, maintenance and testing of overfill and spill prevention equipment. All overfill and spill prevention equipment must be maintained to properly operate at all times while the facility is in operation, and in accordance with the requirements of this Chapter. Overfill and spill prevention alarms and shutoff systems must be tested at least annually and recalibrated, if necessary, in accordance with manufacturer's instructions. Testing and recalibration must be conducted by a Maine Certified Underground Oil Storage Tank Installer, or Inspector who is also certified by the manufacturer of the equipment, if such manufacturer certification is available. Repairs of automatic overfill and spill prevention alarm and shutoff systems must be done by a Maine Certified Underground Oil Storage Tank Installer, or for certain minor repairs an Inspector in accordance with section 5(D)(14)(d), within 30 days. A log recording all tests, maintenance and repairs must be maintained by the owner in accordance with section 5(D)(16). Spill buckets must be kept clean of water and debris such that the spill buckets' full capacity is maintained and available to catch overfills. Spill buckets must be inspected and, if necessary, cleaned before and after each product delivery.

Loading rack catchment and containment systems at new and replacement bulk plants or other distribution facilities shall be maintained by the owner or operator in accordance with API Standard 2610 and to capture an overfill or spill incident of at least the largest single compartment of a tank car or tank truck loaded or unloaded at the facility.

(c) All tanks may only be filled by way of a liquid tight connection from the delivery vehicle in accordance with National Fire Protection Association (NFPA) 30-A section 9.2.

(d) The use of fuel delivery equipment or methods that bypass or prevent overfill equipment from functioning properly is prohibited.

(e) Containment sumps must be tested every three years in accordance with section 5(D)(18) by either a Maine Certified Underground Oil Storage Tank Installer or Inspector who is also certified by the manufacturer of the equipment, if such manufacturer certification is available. Testing must be conducted in accordance with manufacturer's instructions, or in accordance with PEI/ RP 1200 Recommended Practices for the Testing and Verification of Spill, Overfill, Leak Detection and Secondary Containment Equipment at UST Facilities, or an alternate procedure approved by the Commissioner.

The following containment sumps are not required to be tested:

(i) Double walled dispenser, piping sumps, and spill buckets that are installed and maintained with continuous monitoring of the interstitial space of both walls (mechanical or electronic) that are checked for alarms at least weekly by an A/B operator, and annually by a Maine Certified Underground Oil Storage Tank Installer or Inspector;

(ii) Single-wall spill buckets located in a single or double wall sump which provides secondary containment for the spill bucket, and when the sump is monitored at least weekly by an A/B operator, and annually by a Maine Certified Underground Oil Storage Tank Installer or Inspector; and

(iii) Vapor recovery buckets.

(f) Liquids used in the testing must be managed and disposed of in accordance with Appendix T and all applicable local, state and federal requirements.

(7) General operation, maintenance and testing of leak detection equipment requirements

(a) All leak detection equipment must be maintained to operate at all times while the facility contains oil, and in accordance with the performance standards of this Chapter and the manufacturer's instructions.

(b) The owner or operator must perform weekly inspections. The weekly inspections must be performed in accordance with *Operator Training for Underground Oil and Hazardous Substance Storage Facilities*, 06-096 C.M.R. ch. 693, §5.

(c) The owner or operator of a facility with electronic leak detection equipment for tanks or piping must check for alarms at least weekly, and must maintain a log of the results at the facility in accordance with section 5(D)(16).

(d) Continuous automated or electronic leak detection equipment must be tested, including a determination that all leak detection sensors are functioning properly, at least annually and recalibrated if needed. All leak detection sensors must be individually tested for proper operation following the manufacturer’s instructions. Sensors must be visually inspected for any damage. Each sensor must trip the alarm on the console to demonstrate the leak detection system is functioning properly. At least annually, conduct an inspection to determine that the probes and sensors are free of residue, the floats move freely, that the shaft is not damaged, and ensure that cables are free of kinks and breaks. Testing and recalibration must be conducted in accordance with the manufacturer's instructions by either a Maine Certified Underground Oil Storage Tank Installer, or Inspector who is also certified by the manufacturer of the equipment, if such manufacturer certification is available.

(e) Repairs of continuous, automated or electronic leak detection equipment must be conducted within 30 days by a Maine Certified Underground Oil Storage Tank Installer, or for certain minor repairs an Inspector in accordance with section 5(D)(14)(d). If the leak detection system is not properly operating within 30 days of discovery of a problem, the Commissioner must be notified in writing by the owner or operator.

(f) A log of all tests, maintenance and repairs must be maintained by the owner in accordance with section 5(D)(16).

(g) Test records must include at a minimum the following information: facility name, address and registration number, tank(s) and piping tested (tank number), test method used, test date(s), test's leak detection threshold, date and time of last product delivery, length of any applicable waiting period, product level during test, and the length of time of the test.

(8) Automatic tank gauging (ATG) systems

(a) Testing must be conducted at a tank capacity or a range of tank capacities as specified in the equipment manufacturer's instructions.

(b) ATG systems must monitor at the tank bottom for water level gains of more than 1/2 inch.

(c) ATG systems must be operated with a back-up system to preserve test data in the event of a power outage.

(d) ATG systems must print or record test results at least once every 30 days. Test records must be maintained in accordance with section 5(D)(16) and must include the test dates; the tests' leak detection threshold; water levels; the date and time of the last prior product delivery; the length of any applicable waiting period; product level; and test length. Annually the ATG and other controllers must be tested for proper operation, and the test must at a minimum include the following components and criteria: test alarm, verify system configuration, and test battery backup.

NOTE: Care should be taken to ensure that settings are not lost. It is a good practice to print out the ATG settings and keep them in a safe place in case power is ever lost or if they are accidentally erased. This would allow the settings to be easily reentered in accordance with manufacturer's instructions.

(9) Precision testing

(a) Results of all annual precision tests conducted to meet the annual leak detection requirements of section 5(C)(2)(a) for an existing facility and the requirements of section 5(F) for operating beyond the tank warranty, must be submitted to the Commissioner or the Commissioner's representative by the facility owner by July 1 of each year. Precision test results must also be maintained and be available for inspection in accordance with section 5 (D)(16) of this Chapter. Each test record must contain the following information: facility name, address, and registration number; tank(s) and piping tested (tank number); tank volume and product stored; test method used; test date; test's threshold; length of waiting period; product level during test; the actual length of time to conduct test; and the name and certification number of the supervising certified installer, if required to be present by Appendix B.

(b) The Commissioner may require precision testing as defined in this Chapter of all tanks and piping at a facility showing evidence of a possible leak, as defined in section 5(D)(10) below, or where an actual oil discharge has been discovered.

(c) Results of precision tests conducted in follow-up to evidence of a possible leak and in accordance with section 12(B) of this Chapter, must also be submitted to the Commissioner by the person conducting the test.

(10) Evidence of a possible leak or discharge

(a) Evidence of a possible leak or discharge requires further investigation to determine if an actual discharge or leak has occurred, and includes, but is not limited to, any one of the following:

(i) Monitoring results from a facility's leak detection equipment or method indicating a possible leak, release or discharge.

(ii) Any unexplained loss or gain of 1.0 percent of the throughput of each storage system over a 30-day period, as indicated by the recording and reconciliation of daily inventory records.

(iii) Failure of a piping line tightness test, as defined in section 3(TT) or a tank tightness test as defined in section 3(LLL), which indicate a leak of 0.1 gallons per hour or greater.

(iv) Failure of a precision test as defined in section 3 (VV), other than a piping or tank tightness test which indicates a loss or gain of 0.1 gallons per hour or greater.

(v) Unexplained losses detected through a statistical reconciliation of inventory records or an indication in the statistical inventory reconciliation that the inventory data provided were insufficient to perform an accurate reconciliation.

(vi) The excessive accumulation of water in a tank evidenced by a rise in water level of greater than one-half inch (1/2") for an 8 to 12 hour period, except where the cause of the water accumulation is storm water runoff intrusion and is promptly corrected.

(vii) Presence of water-product phase separation in a single-walled tank containing ethanol.

(viii) Reduced flow in a remote pumping system equipped with an in-line leak detector, unless the system returns to normal operating flows within one hour of the first discovery that day.

(ix) Pump hesitation, vibration, meter stripping or air elimination, attributable to a loss of prime for product lines, which operate under a suction system.

(x) Evidence of the presence of oil or water entering into the interstitial space of a secondary containment facility, or a significant drop in the liquid level of a hydrostatically monitored interstitial space as specified by the tank or leak detection equipment manufacturer's instructions.

(xi) Discovery of oil or an oil sheen in a piping sump or dispenser sump, whether or not cleaned up.

(xii) A failing precision or tightness test of a spill bucket, piping sump or dispenser sump.

(11) Leak or discharge reporting requirements

(a) A tank owner or operator shall report to the Commissioner as soon as possible, but no later than within 24 hours any evidence of a possible leak or discharge of oil, including but not limited to those listed in section 5(D)(10).

(b) A Certified Underground Oil Storage Tank Installer or Inspector finding evidence of a possible leak or discharge of oil must report it to the facility owner or operator, and the Commissioner, as soon as possible, but no later than within 24 hours of discovery.

(c) Actual oil leaks and discharges, whether or not cleaned up, shall be reported to the Commissioner by the facility owner or operator, and the Certified Underground Oil Storage Tank Installer or Inspector within two (2) hours of discovery. This 2 hour reporting requirement applies to, but is not limited to, the reporting of the following:

(i) Overfills not fully captured or contained by a spill bucket or sump;

(ii) Other spills;

(iii) Visual or olfactory evidence of oil in soil or water including, but not limited to, in a tank or piping excavation, nearby surface waters, or facility ground water monitoring well;

(iv) Oil or oil vapors on or under abutting properties, including nearby utility conduits, sewer lines, buildings, and drinking water supplies; and

(v) Soil and water contamination as defined in section 3(L) , setting forth the definition of "contamination".

NOTE: TO REPORT A LEAK, SPILL OR OTHER DISCHARGE OF OIL, CALL TOLL FREE 1-800-482-0777.

(d) Notwithstanding the above, discharges of 10 or less gallons of oil that occur on the facility premises and above the surface of the ground onto a concrete or asphalt paved surface, and not reaching ground water or surface waters of the State need not be reported to the Commissioner if the owner or operator complies with all of the following requirements:

(i) The discharge is fully cleaned up within 24 hours of discovery.

(ii) A written log is maintained at the facility or the owner's place of business in accordance with section 5(D)(16), recording for each discharge the date of discovery, its source, the general location of the discharge on the facility, the date and method of cleanup, and the signature of the facility owner or operator certifying the accuracy of the log.

(iii) The spill log must be made available upon request within 24 hours for inspection by personnel and authorized agents of the Commissioner and the municipality.

(e) Under 38 M.R.S. §568(4)(A), any person who causes or is responsible for a discharge from an underground oil storage facility is not subject to any fines or civil penalties for the discharge if the person promptly reports and removes that discharge in accordance with the rules and orders of the Commissioner and the Board, except that a person who violates any laws or rules administered by the Department under 38 M.R.S. §§ 561-570-M is subject to fines and penalties.

(12) Product compatibility. Only oil and petroleum products chemically and physically compatible with the materials, from which the tank, piping and other components of the facility routinely containing product are constructed, may be stored.

A facility owner who intends to store gasoline with more than 10 percent ethanol or diesel with more than 20 percent biodiesel or any other regulated substance identified by the Department, must provide written notification to the Commissioner at least 30 days before switching products. The facility owner must maintain documentation demonstrating that the facility is compatible with these oil products by one of the following methods:

(a) UL or other nationally recognized independent testing laboratory certification or listing approved by the Commissioner;

(b) A written statement of compatibility from the equipment or component manufacturer that indicates an affirmative statement of compatibility and specifies the range of biofuel blends the equipment or component is compatible with; or

(c) Another method demonstrating compatibility of facility components and equipment with the oil product to be stored and approved by the Commissioner.

Written documentation of facility and oil product compatibility shall be maintained at the owner’s place of business for the life of the facility component or equipment.

(13) Interior relining of new and existing facilities

(a) Tanks may be relined provided that, prior to lining, the tank has passed a precision test and is free of perforations, except fiberglass tanks that have failed may be relined or repaired if the cause of failure will be completely repaired to the satisfaction of the Commissioner and a warranty is provided by the person performing the repairs. The warranty must be for a minimum of 10 years and must warranty the tanks against internal and external corrosion and structural failure. A fiberglass tank that once failed a precision test, and was subsequently lined, must be precision tested prior to be placed back in operation. If a fiberglass tank with a leak is lined, the tank must be properly abandoned pursuant to section 11 of this Chapter upon expiration of the warranty.

(b) The following requirements also apply to relining activities:

(i) After relining, fiberglass tanks must pass a precision test.

(ii) The material used as a liner must be compatible with the product to be stored in the tank.

(iii) The lining procedure must be performed in accordance with the procedures outlined in API Recommended Practice No. 1631.

(iv) Piping may not be relined.

(v) The owner of the facility shall amend the facility's registration in accordance with section 4(M) of this Chapter and maintain records of relining for the remaining operating life of the lined tank that demonstrate compliance with section 5(D)(13).

(14) Repairs other than relining

(a) Repairs are allowed in accordance with this paragraph to tanks and piping constructed of fiberglass, cathodically protected steel and other noncorrosive materials approved by the Commissioner.

(b) Repairs of corrosion induced or product incompatibility caused leaks are prohibited. Tanks and piping with corrosion or chemical reaction induced leaks must be closed in accordance with section 11.

(c) Repairs, other than those prohibited in paragraph (b) above, to fiberglass, cathodically protected steel and other approved noncorrosive material tanks and piping must be properly conducted by a BUSTI Certified Underground Oil Storage Tank Installer who is also certified by the manufacturer, or by the manufacturer's authorized representative under the supervision of a Maine Certified Underground Oil Storage Tank Installer. A Maine Certified Underground Oil Storage Tank installer must also be certified by the tank or piping manufacturer, when such manufacturer certification is available, to conduct a repair on a tank or piping without a representative of the manufacturer, so not o void the manufacturer warranty.

(d) Repairs of a facility leak detection system, overfill prevention equipment or other ancillary equipment including containment sumps must also be conducted by an underground oil storage tank installer certified by the BUSTI and by the manufacturer of the equipment being repaired, when such manufacturer certification is available.

The following minor repairs of existing equipment or components, when not requiring excavation, may be conducted by an underground oil storage tank inspector certified by the BUSTI and by the manufacturer of the equipment being repaired, when such certification by the equipment manufacturer is available:

(i) Replacement of a defective mechanical or electronic line leak detector with one of the same design;

(ii) Replacement of a drop tube;

(iii) Replacement of a drop tube overfill prevention device with one of the same design; and

(iv) Replacement of a leak detection system sensor or control panel with one of the same make and model.

(e) Containment sumps must be tested for tightness immediately following a repair in accordance with *Recommended Practices for the Testing and Verification of Spill, Overfill, Leak Detection and Secondary Containment Equipment at UST Facilities,* PEI RP 1200, the manufacturer’s instructions, or an alternative procedure approved by the Commissioner. If the repair consists only of replacement of a lid, sump testing is not required.

(f) Tank and piping repairs are to be conducted in accordance with manufacturer specifications or in accordance with the National Fire Protection Association Standard 30, "Flammable and Combustible Liquids Code".

(g) Repairs jeopardizing the manufacturer's original warranty are prohibited.

(h) Repaired tanks and piping must be tested before going back into operation, in accordance with the manufacturer's instructions.

(i) Repairs to a cathodic protection system must be conducted in accordance with the NACE International Standard Practices SP0285 and SP0169, and in accordance with the following requirements:

  (i) Field coated cathodically protected steel underground piping may not be repaired and must be properly abandoned in accordance with section 11, except for broken wiring;

  (ii) Repairs to a galvanic cathodic protection system must be conducted by a Certified Underground Oil Storage Tank Installer; and

  (iii) Repairs to an impressed current, cathodic protection system must be supervised by a corrosion expert and a Maine Certified Underground Oil Storage Tank Installer.

(j) Within 6 to 12 weeks of a repair to a cathodic protection system, the owner or operator shall have the system tested by a Certified Underground Oil Storage Tank Installer, or Certified Inspector also certified as a cathodic protection tester in accordance with Appendix A.

(k) Owners must maintain records of each repair of the type listed in section 5(D)(14) for the remaining life of the facility.

(15) Financial responsibility requirements

(a) The owner or operator of a new, replacement or existing tank or facility shall demonstrate to the Commissioner that the owner or operator has the ability to assure the costs of corrective action and for compensating third parties for bodily injury, property damage and loss of income caused by sudden and non-sudden releases, leaks or discharges from an underground oil storage facility. For the purposes of (b) and (c) below, an underground oil storage tank means a single containment unit and does not mean combinations of single containment units.

(b) Owners or operators shall maintain an ability to assume financial responsibility in accordance with this Chapter in at least the following per-occurrence amounts.

  (i) Owners or operators of all marketing or distribution facilities and motor fuel facilities that handle an average of more than 10,000 gallons of oil per month based on the previous year's throughput shall maintain $1 million.

  (ii) All other owners or operators of marketing, distribution and motor fuel underground oil storage facilities shall maintain $500,000.

(c) Owners or operators shall maintain an ability to assume financial responsibility in accordance with this Chapter in at least the following annual aggregate amounts.

  (i) For owners or operators of one (1) to 100 tanks, $1 million; and

  (ii) For owners or operators of 101 or more tanks, $2 million.

(d) The amounts of assurance required under this section exclude legal costs.

(e) All references below to the EPA’s financial responsibility regulations are from the July 1, 2018 version of *Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)*, 40 C.F.R. pt. 280. The definitions contained in 40 C.F.R. §280.92 as well as the drawing on financial assurance mechanisms of 280.112 are also incorporated. The definition for “occurrence” in section 3(NN) of this chapter is adopted in lieu of the definition of “occurrence” in 40 C.F.R. §280.92.

(f) A facility owner or operator may use any one or combination of the financial responsibility mechanisms listed below in meeting the requirements of paragraphs a through d above and EPA's financial responsibility requirements for underground storage tanks containing petroleum:

(i) Self insurance meeting the financial test of self insurance under 40 C.F.R. §280.95;

(ii) Guarantee meeting the requirements of 40 C.F.R. §280.96;

(iii) Liability insurance or risk retention group coverage meeting the requirements of 40 C.F.R. §280.97;

(iv) Surety bond meeting the requirements of 40 C.F.R. §280.98;

(v) Letters of credit meeting the requirements of 40 C.F.R. §280.99;

(vi) Trust fund meeting the requirements of 40 C.F.R. §280.102; or

(vii) The Maine Ground and Surface Waters Cleanup and Response Fund in accordance with the eligibility requirements and financial assurance limits of the *Oil Discharge Prevention and Pollution Control Law,* 38 M.R.S. §551 and the *Oil Storage Facilities Groundwater Protection Law,* 568-A, in combination with one or more of the other above mechanisms to assure full coverage of third party damage liability in accordance with the minimum financial assurance requirements of sections 5(D)(15)(a) and 5(D)(15)(b) above.

(viii) Standby trust fund meeting the requirements of 40 C.F.R. §280.103 when an owner or operator uses any one of the mechanisms authorized by 40 C.F.R. §§ 280.96 (guarantee), 280.98 (surety bond), or 280.99 (letter of credit). This standby trust fund must be established when the financial assurance mechanism is acquired. The trustee of the standby trust fund must be an entity that has the authority to act as a trustee and whose trust operations are regulated and examined by a federal agency or an agency of the state in which the fund is established.

(g) Municipalities, counties, school administrative districts and Indian tribes may use, in addition to the mechanisms listed in paragraph (f) above, any one or combination of the following financial assurance mechanisms:

(i) Local government bond rating test in accordance with 40 C.F.R. §280.104;

(ii) Self insurance when meeting the local government financial test and the provisions of 40 C.F.R. §280.105;

(iii) Local government guarantee meeting the requirements of 40 C.F.R. §280.106; and

(iv) A local government dedicated trust fund meeting the requirements of 40 C.F.R. §280.107.

(h) An owner or operator may replace one financial assurance mechanism for another, provided that at all times the owner or operator maintains an effective financial assurance mechanism or combination of mechanisms that satisfy the requirements of this section 5(D)(15).

(i) Financial assurance mechanisms may be canceled or not renewed in accordance with 40 C.F.R. §280.109.

(j) The facility owner or operator shall maintain financial responsibility records at the facility or at the owner's place of business in accordance with 40 C.F.R. §280. 111.

(k) In the event of bankruptcy or other financial responsibility incapacity of the facility owner or operator, or a provider of financial assurance; the notification and financial responsibility replacement requirements of 40 C.F.R. §280.114 must be met.

(l) An owner or operator is no longer required to maintain financial responsibility under this Chapter after a tank or facility has been properly and permanently closed in accordance with section 11 of this Chapter, and if corrective action is required by the Commissioner, after the corrective action has been completed to the Commissioner's satisfaction and in accordance with section 12 and other rules or orders of the Commissioner and Board.

(m) If at any time a standby trust is funded upon the instruction of the Department with funds drawn from a guarantee, local government guarantee with standby trust, letter of credit, or surety bond, and the amount in the standby trust is reduced below the full amount of coverage required, the owner or operator shall replenish the value of financial assurance to equal the full amount of coverage required or acquire another financial assurance mechanism for the amount by which funds in the standby trust have been reduced.

(n) An owner or operator may use self insurance in combination with a guarantee only if, for the purpose of meeting the requirements of the financial test under this Chapter, the financial statements of the owner or operator are not consolidated with the financial statements of the guarantor.

(o) The Commissioner may require an owner or operator to submit evidence of financial assurance as described in 40 C.F.R. §280.110 and 280.111(b) or other information related to compliance with the financial responsibility requirements at any time.

(16) Maintenance of records. All logs, monitoring results and other records required by this section must be maintained for a minimum of three (3) years. Except where specifically stated otherwise, facility records must be kept at the facility or the owner’s primary place of business, and made readily available to the Commissioner, the Commissioner’s representatives and agents, and municipal officials within 48 hours.

(17) Annual compliance inspection requirements. The owner of a facility is responsible for ensuring that the entire facility is inspected annually for compliance with the applicable requirements of this Chapter, 38 M.R.S. §§ 561-570-M, and Department rules regarding stage I gasoline balance systems contained in *Gasoline Dispensing Facilities Vapor Control,* 06-096 C.M.R. ch. 118, where applicable. The owner shall have any deficiencies detected during an inspection corrected as necessary to bring the facility into compliance with the requirement cited above.

The first annual inspection for a new facility must be conducted no later than 12 months after the date the installation is certified as complete.

For all existing facilities, the facility owner shall submit annual inspection results to the Commissioner on each July 1st, unless the Department agrees to an alternate schedule for submittal that is no less frequent than once every 12 months.

The inspection results must be recorded on a form provided by the Commissioner and must include a certification statement, signed by an underground oil storage tank installer or inspector certified by BUSTI. The statement must certify that the entire facility was inspected and any deficiencies discovered have been corrected. Inspection and correction records must also be maintained in accordance with section 5(D)(16). The owner shall submit the completed form to the Department no more than 30 days after the date on which the inspection was completed.

At least once every 3 years thereafter, the annual inspection of each tank must be performed by a Certified Underground Oil Storage Tank Installer or Inspector who is not the tank owner or operator, an employee of the tank owner or operator or a person having daily on-site responsibility for the operation and maintenance of the tank.

(18) Containment sump testing requirements. The owner of a facility is responsible for ensuring that all sumps are tested every 3 years. In addition, a sump must be tested upon installation and completion of any repairs to ensure the containment sump is liquid tight. Containment sumps must be tested in accordance with *Recommended Practices for the Testing and Verification of Spill, Overfill, Leak Detection and Secondary Containment Equipment at UST Facilities,* PEI RP 1200, the manufacturer's instructions, or an alternative procedure approved by the Commissioner. The compliance schedule as specified below shall be based upon the date of the oldest tank at the facility. The owner shall have any failures detected during testing corrected as necessary within 30 days to ensure the containment sump is liquid tight except as provided in 5(D)(18)(e) below.

The facility owner shall submit all containment sump test results to the Commissioner within 30 days after the date on which the testing was completed. If an individual passing containment sump test was completed within 6 months of the 3-year testing schedule, this early test may satisfy the 3-year containment sump testing requirement. The sump test results for all containment sumps (including any completed 6 months previous to the 3-year testing timeframe) must be reported on a single 3-year containment sump test results form. The 3-year testing timeframe will remain unchanged irrespective of any early testing of an individual containment sump.

(a) Test results for containment sumps that were installed before October 13, 2018 must be submitted on the following schedule and every 3 years thereafter:

(i) For tanks installed in sensitive geologic areas prior to January 1, 1995, submit results for containment sump testing by December 1, 2019;

(ii) For tanks installed in non-sensitive areas prior to January 1, 1995, submit results for containment sump testing by December 1, 2020;

(iii) For tanks installed in sensitive geologic areas between January 1, 1995 and October 13, 2018, submit results for containment sump testing by August 1, 2021; and

(iv) For tanks installed in non-sensitive areas between January 1, 1995 and October 13, 2018, submit results for containment sump testing by December 1, 2021.

(b) Containment sumps for tanks installed after October 13, 2018 must be tested upon installation and at least every three years after the installation is complete. The sensor, must be programmed to sound an alarm, and a sensor may be installed that will shut off the relevant dispenser.

NOTE: When all tanks are removed at a site and new tanks are installed, a new 3 year containment sump testing schedule would begin in accordance with section 5(D)(18)(b) above.

(c) The test results must be recorded on a form provided by the Commissioner and must include a certification statement, signed by an underground oil storage tank installer or inspector certified by BUSTI. Such certification must certify that all containment sumps were tested and any deficiencies discovered have been corrected. Inspection and repair records must be maintained in accordance with section 5(D)(16). All repairs must be completed prior to the reporting deadline.

(d) The Department may on a case by case basis require low level tightness testing (sump floor to 4 inches above the sensor) or high level tightness testing (sump floor to 1 ½ inches below the top of spill bucket or 4 inches above the highest penetration or seam in the sidewall for other sumps) of containment sumps, and/or may require single-wall containment sumps to be equipped with leak detection sensors that will shut off electrical power to the dispenser of any containment sump that is not being properly monitored, or is not liquid tight.

(e) If a tank top, dispenser, or piping containment sump cannot pass the high level tightness test and repairs or replacement cannot occur within 30 days, a low level tightness test must be conducted. The low level test is conducted in accordance with PEI RP 1200, except that the sump test fluid is added to 4 inches above the sensor. An electronic sensor must be installed that is tied to a pump interface to shut down the relevant submersible pumps (pressure systems) or the suction pumps (suction systems) in the event that a leak is detected. This sensor must shut down all submersible/suction product pumps entering the affected containment sump. If the containment sump does not pass a low level tightness test, the sump must be repaired or replaced within 30 days or an alternative schedule approved by the Department.

A containment sump operating under a passing low level tightness test must be:

(i) repaired within 120 days of the failing high level tightness test, or

(ii) replaced within 180 days or an alternate schedule approved by the Department, of the failing high level tightness test.

NOTE: Under 38 M.R.S. §565-A, the Commissioner may issue an administrative order to enforce the annual inspection requirements above. Such orders may include ceasing receipt of product deliveries to, and the overall operation of, the portion of the facility in violation of this requirement.

(19) Safe excavation requirements

(a) This section applies to excavation activities on the facility premises and associated with its operation and maintenance.

(b) To ensure adequate protection of public safety and the maintenance of the structural integrity of the facility in accordance with the requirements of this Chapter, the owner of a facility shall have a Certified Underground Oil Storage Tank Installer present to supervise the excavation and replacement of a concrete pad, back fill, or soil within 10 feet of an underground oil storage tank or facility product piping. The Certified Underground Oil Storage Tank Installer shall be present at all times when such work is being performed. No person other than a Certified Underground Oil Storage Tank Installer may supervise the above activities.

(c) The underground oil storage tank installer shall have the appropriate class of certification in accordance with 32 M.R.S. §§ 10001-10016.

(d) In accordance with NFPA 30 and 30-A, no excavation, or other activities that may act as a source of ignition of flammable vapors at a Class 1 liquid dispensing facility shall occur within 20 feet of the fueling dispenser hose and nozzle when fully extended, unless the electrical power supply to the dispenser has first been turned off and all fueling operations from that dispenser have ceased.

(e) A written record must be maintained by the facility owner of the excavation date(s) and location, and the name and certification number of the supervising underground oil storage tank installer.

NOTE: Any discharge caused by or discovered in the course of an excavation must be reported in accordance with section 5(D)(11).

E. Facility closure and abandonment. The closure, abandonment or temporary discontinuance of service of a facility or any part thereof must be conducted in accordance with section 11.

F. Mandatory facility closure upon expiration of warranty. In accordance with 38 M.R.S. §564(5), a tank and its associated piping must be taken out of operation and properly abandoned in accordance with section 11 upon the expiration date of the tank warranty unless the tank, its associated piping and other facility components meet the requirements of this section. For the purpose of this subsection, when the length of the tank warranty is either unknown or the tank was installed after January 1, 2008, the tank will be deemed to have a tank warranty of 30 years from the date of installation.

NOTE: Many steel USTs sold and installed after January 1, 2008 only have a 10 year tank warranty unless the owner purchased an additional 20 years of warranty from manufacturer.

(1) Double-walled tanks. A double-walled tank may remain in service up to 10 years beyond the expiration date of its original tank warranty if the facility meets the following requirements:

(a) The tank interstitial space and its associated piping, spill bucket and sumps pass a precision test in the 6 months immediately prior to the expiration of the warranty. Testing must be conducted in accordance with the requirements of Appendices B and T;

(b) Single-walled pressurized piping connected to the tank is replaced with single-walled safe suction piping or with double walled piping and leak detection meeting the requirements of sections 5(B) and (D);

(c) The tank and its associated piping and other facility components are equipped and operated in accordance with the requirements for leak detection monitoring, overfill protection and spill protection in accordance with sections 5(B) and 5(D);

(d) A passing annual inspection report has been submitted to the Commissioner in accordance with section 5(D)(17) in the 12 months immediately preceding the expiration date of the tank's original manufacturer warranty, and there is no continuing unexplained evidence of a possible leak;

(e)The facility registration is amended in accordance with section 4(M**);** and

(f) The tank interstitial space and associated piping, spill bucket and sumps pass an annual precision test in the 6th, 7th, 8th and 9th year following the expiration of the tank warranty.

(2) Corrosion-resistant single-walled tanks. A single-walled tank constructed of fiberglass, cathodically protected steel or another equally noncorrosive material approved by the Commissioner and has not been out of service for more than 12 consecutive months may remain in service up to 10 years beyond the expiration date of the original tank warranty when the tank is retrofitted with secondary containment and meeting the following requirements:

(a) The original tank and its associated piping, spill bucket and sumps pass a precision test in the 6 months immediately prior to the expiration of the tank warranty;

(b) A passing annual inspection report has been submitted to the Commissioner in accordance with section 5(D)(17) in the 12 months immediately preceding the expiration date of the tank's original manufacturer warranty, and there is no continuing unexplained evidence of a possible leak;

(c) The facility registration is amended in accordance with section 4(M);

(d) Prior to submitting the registration amendment and initiating the required tank retrofit, a site assessment is conducted in accordance with the below items to determine whether oil contamination from historical discharges underlies the tank:

(i) A soil boring is installed into the ground water table or to first refusal, whichever is shallower, and as close as feasible to, but no further than 10 feet from the tank, on all four sides;

(ii) A Maine Certified Underground Oil Storage Tank Installer must be present to supervise the installation of the borings in accordance with section 5(D)(19);

(iii) As the borings are advanced, soil samples must be collected and screened continuously using a field analytical method for oil in soils approved by the Commissioner;

(iv) One soil sample from above the ground water table with the highest screening result must be collected for laboratory analysis using the Massachusetts Department of Environmental Protection Petroleum Hydrocarbon Fractions Analytical Method, Version 1.1, 2004, for volatile and extractable petroleum hydrocarbons, as applicable, based on which types of oil were historically stored in the tank;

(v) A ground water sample must be collected from each boring in which ground water is encountered for field evaluation for the presence of free product;

(vi) Evidence of a possible leak or discharge of oil is reported by the facility owner or operator within 24 hours of discovery in accordance with Appendix P; and

(vii) Submission of the testing results and their interpretation by a Maine certified geologist or licensed professional engineer with the facility registration amendment.

(e) The secondary containment retrofit system is constructed and installed in accordance with UL Standard 1316 or UL 1856;

(f) The tank secondary containment retrofit system is installed in accordance with the manufacturer's specifications and by a manufacturer certified installer or representative in collaboration with a Maine Certified Underground Oil Storage Tank Installer;

(g) The tank and its associated piping and other facility components are equipped and operated in accordance with the requirements for leak detection monitoring, overfill prevention and spill prevention under sections 5(B) and 5(D);

(h) The cathodic protection system of steel tanks continues to be maintained and monitored in accordance with section 5(D) except for self-structural retrofit systems;

(i) Prior to the expiration of the original tank warranty, single-walled pressurized piping connected to the tank is replaced with piping and leak detection monitoring meeting the requirements of section 5(B) and 5(D); and

(j) The tank interstitial space and associated piping, spill bucket and sumps pass an annual precision test in the 6th, 7th, 8th and 9th year following the expiration of the original tank warranty.

(3) Precision testing required to allow a tank to remain in service after the expiration of the original manufacturer warranty must be conducted and the results reported to the Commissioner in accordance with section 5(D) and Appendix B. Passing precision test results must be submitted as part of the facility registration amendment. Precision testing as specified in paragraphs 1 or 2 above is not required of a double-walled tank monitored by a continuous hydrostatic or vacuum leak detection system meeting the requirements. The piping, however, must be tested as required above.

(4) Delayed facility closure and abandonment. Upon expiration of the extended tank operating life provided under this subsection, the tank and the associated piping installed 10 or more years prior are to be abandoned in accordance with section 11 of this Chapter.

6. Regulation of heating oil facilities used for consumption on the premises or by the owner or operator

A. Applicability

(1) This section applies to all underground heating oil or process oil storage facilities used for consumption on the premises or by the owner or operator of the facility.

(2) This section does not apply to motor fuel, marketing, distribution facilities, waste oil facilities, field constructed tanks or heavy oil facilities except where specifically stated otherwise.

B. Design and installation requirements for new and replacement facilities

(1) General design requirements

(a) The installation of new or replacement tanks and piping constructed of bare steel or asphalt coated steel is prohibited.

(b) All new and replacement tanks must be constructed of fiberglass reinforced plastic (hereafter referred to as fiberglass), cathodically protected steel, or other noncorrosive material approved by the Commissioner. Piping and other below ground ancillary equipment in contact with soil or water must be constructed of fiberglass, cathodically protected steel or other equally noncorrosive materials approved by the Commissioner.

(i) It is the responsibility of the facility owner to demonstrate to the satisfaction of the Commissioner that the materials are noncorrosive and meet or exceed the required performance standards listed below in this paragraph.

(ii) All new or replacement facilities must be listed and constructed in accordance with the standards contained in the following:

- Fiberglass Tanks –
  - UL Standard 1316, Glass-Fiber- Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols and Alcohol-Gasoline Mixtures; or
  - ULC S615, Standard for Reinforced Plastic Underground Tanks for Flammable and Combustible Liquids;
- Cathodically Protected Steel Tanks–
  - STI sti-P3® Specification and Manual for External Corrosion Protection of Underground Storage Tanks;
  - UL Standard 1746, Standard for External Corrosion Protection Systems for Steel Underground Storage Tanks;
  - ULC S603, Standard for Steel Underground Tanks for Flammable and Combustible Liquids, and S631, Standard for Isolating Bushings for Steel Underground Tanks Protected with External Corrosion Protections Systems;
  - (STI Standard F841, Standard for Dual Wall Underground Steel Storage Tanks;
  - NACE International, SP0285, Corrosion Control of Underground Storage Systems by Cathodic Protection, and UL Standard 58, Standard for Steel Underground Tanks for Flammable and Combustible Liquids; or
  - PEI RP-100.
- Steel Clad or Jacketed Tanks –
  - UL 1746;

    - STI Composite Tank Standard (F894-02); or
    - STI Specification F922, STI Specification for Permatank;

- Non-Metallic and Fiberglass Piping – UL Standard 971, Standard for Non-metallic Underground Piping for Flammable Liquids, or ULC Standard S660, Standard for Non-metallic Underground Piping for Flammable Liquids. Pipe Connectors - UL Standard 567.
- Flexible Connectors - ULC Standard ULC/CAN -S633.
- Steel Piping –
    - NFPA 30 or 31;
    - API Publications 1632, Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems;
    - NACE International Standard SP 0169, Control of External Corrosion on Underground or Submerged Metallic Piping Systems or NACE SP0285, External Corrosion Control of Underground Storage Tank systems by Cathodic Protection;
    - STI R982, Recommended Practice for Corrosion Protection of Underground Piping Networks Associated with Liquid Petroleum Storage and Dispensing Systems; or
    - API Publications 1632, Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems.

NOTE: Fiberglass clad steel and other steel composite tanks need not be provided with galvanic or impressed current cathodic protection if designed and constructed with secondary containment and interstitial space monitoring in accordance with standards of this subsection.

(iii) Impressed current cathodic protection systems shall be designed by a corrosion expert and according to standards described in the NACE Standard Practices SP0285 and SP0169, and installed under the supervision of a corrosion expert. Other portions of the facility may be installed by a Maine Certified Underground Oil Storage Tank Installer without such supervision.

(c) Used or previously installed fiberglass or cathodically protected tanks may not be re-installed unless the owner has supplied the Commissioner with satisfactory documentation that the manufacturer will warranty the tanks against internal and external corrosion and structural failure, for a period of at least 10 years, after which the tanks must be properly abandoned in accordance with section 11. Reinstallation of a tank requires an amendment of the facility registration in accordance with section 4(M). The warranty documentation shall accompany the submission of the registration amendment. Used piping may not be reinstalled.

(d) All facility construction materials must be chemically and physically compatible with the product to be stored.

(2) Leak detection. All new and replacement facilities must be provided with secondary containment for all facility components routinely containing product, including tanks, product piping (including supply and return lines) and below ground ancillary equipment. New and replacement tanks and product piping must have continuous interstitial space monitoring. Interstitial space monitoring for heating oil facilities must be able to detect a loss or gain in the interstitial space from a leak in primary or secondary containment structure. Leak detection probes are to be installed at the lowest point of each leak monitoring location.

(3) Overfill and spill prevention equipment. New and replacement tanks with a capacity in excess of 1,100 gallons must have the following spill and overfill prevention equipment:

(a) A liquid tight spill catchment basin, sealed around each tank fill pipe and having a minimum capacity of 15 gallons to collect spillage during product delivery; and

(b) Overfill prevention equipment that will automatically shut off flow into the tank when the tank is no more than 95 percent full, or alert the transfer operator when the tank is no more than 90 percent full by restricting flow into the tank or triggering a high-level audible alarm. The use of ball float valves for overfill prevention is prohibited on a tank that will receive pressurized oil deliveries because of the danger of rupturing the tank or overfilling the fill pipe. The installation of ball float valves is prohibited after October 13, 2018.

(c) All tanks may only be filled by way of liquid tight connection from the delivery vehicle.

(d) The use of fuel delivery equipment or methods that bypass or prevent overfill equipment from functioning properly is prohibited.

(4) General installation requirements for new and replacement facilities

(a) No underground oil storage facility or tank may be installed unless the facility has been registered in accordance with section 4.

(b) No person may install an underground oil storage facility or a portion thereof unless that person is a properly Certified Underground Oil Storage Tank Installer with the appropriate class of certification in accordance with 32 M.R.S. §§10001 - 10016 and has paid the required certification fee.

(c) A Certified Underground Oil Storage Tank Installer may not install an underground storage tank if the installer has been placed on inactive status or if the installer's certification has been suspended or revoked under 32 M.R.S. §10015, and has not been reinstated.

NOTE: No person may connect an underground storage tank used to store heating oil to a boiler or furnace unless that person is a master oil burner technician or a journeyman oil burner technician working under the supervision of a master oil burner technician licensed by the *Maine Fuel Board,* 32 M.R.S. §§ 18131-18144, and rules administered by the Maine Fuel Board.

(d) If a tank is replaced, all associated underground piping not meeting the design requirements of this Chapter must be replaced. Any replacement piping must be designed and installed in accordance with this Chapter. If product piping is replaced and structural damage to the associated tank has occurred, impairing its physical integrity, the associated tank must also be replaced if not constructed of fiberglass, cathodically protected steel, or other noncorrosive materials approved by the Commissioner. Repairs of damaged fiberglass, cathodically protected steel, and other Commissioner approved noncorrosive material tanks may only be made if conducted in accordance with sections 5(D)(13) or (14). Tanks that cannot be repaired must be abandoned in accordance with section 11.

(e) An accurate structure to soil potential measurement must be performed by a Certified Underground Oil Storage Tank Installer or a certified cathodic protection tester in accordance with Appendix A upon installation of all galvanic cathodic protection systems.

(f) All phases of the installation of an impressed current cathodic protection system must be supervised on-site by a corrosion expert. The tank, piping and other portions of the facility other than the impressed current system may be installed by a Maine Certified Underground Oil Storage Tank Installer without such supervision.

(g) No underground oil storage tank or piping may be installed within 1 foot of the bedrock surface.

(h) Leak detection and overfill/spill prevention alarms and shutoff equipment must be installed and operational prior to the start of the facility's operation and in accordance with manufacturer specifications, including proper calibration of electronic equipment.

(i) Certification of installation. Owners of new and replacement facilities shall ensure that the installers certify to the Commissioner, within 30 days of completion of installation, that the facility materials, design and installation comply with the requirements of this Chapter. This certification must be provided in writing on a form provided by the Commissioner.

(j) The facility owner shall ensure that no permanent structures, underground utilities or other objects are installed or constructed in proximity to the tank if such structures, utilities or other objects will impede safe removal of the tank as determined by a Maine Certified Underground Oil Storage Tank Installer or a Maine registered engineer.

(k) After July 1, 2019, a Certified Underground Oil Storage Tank Installer overseeing a tank removal must be trained in best management practices for erosion and sedimentation control by the Department or through an equivalent program approved by the Department.

(5) Installation requirements for new and replacement tanks.

(a) All tanks must be installed in conformance with the requirements of Appendix D.

(b) All tanks must be installed in accordance with the manufacturer's instructions.

(6) Installation requirements for new and replacement piping.

(a) All underground piping in contact with soil or water must be installed in conformance with Appendix E.

(b) All underground piping in contact with soil or water must be constructed of fiberglass, cathodically protected steel or other noncorrosive materials approved by the Commissioner.

(i) For #1 and #2 heating oil facilities, copper piping meeting, the requirements of National Fire Protection Association Code 31, Installation of Oil Burning Equipment, may be used for supply and return lines. All connections between a cathodically protected steel tank and the copper piping must incorporate dielectric fittings that electrically isolate the tanks from the piping.

(ii) Schedule 40 polyvinyl chloride (PVC) piping may be used for secondary containment for #2 heating oil facilities if it is at least twice the diameter of the internal piping.

(iii) When installing copper piping inside fiberglass, PVC or other piping to provide secondary containment, supply and return lines must be provided with spacers to separate the lines and prevent wear due to vibration and friction.

NOTE: Primary pipe spacers can be provided by using 6-inch lengths of 1/4 inch thick polyethylene foam tubing insulation placed every 10 feet of pipe.

(iv) It is the responsibility of the facility owner to demonstrate to the satisfaction of the Commissioner the materials are noncorrosive.

(v) All new or replacement non-metallic piping must be listed by UL and installed in accordance with manufacturer instructions. Cathodically protected piping must be constructed and installed in conformance with the National Association of Corrosion Engineers, Standard Practice, Publication No. SP0285, or STI Standard RP 892.

(vi) Secondary containment and cathodic protection of vertical, direct drop fill pipes is not required if the fill pipe is constructed of Schedule 40 steel and is uniformly coated with a minimum of 1/8 inch of fiberglass resin, bitumastic coating or epoxy coating. The pipe surface must be properly prepared and the coating allowed to cure. Offset fill pipes require secondary containment and interstitial space monitoring. Where secondary containment with interstitial space monitoring is not technically feasible, another leak detection system may be used upon prior approval of the Commissioner.

C. Operation, maintenance, testing and inspection requirements for new, replacement and existing facilities

(1) The owner or operator shall report any evidence of a possible leak or discharge, as defined in section 5(D)(10) to the Commissioner within 24 hours of discovery. A Certified Underground Oil Storage Tank Installer or Inspector finding evidence of a possible leak or oil discharge must report it to the facility owner or operator, and the Commissioner, as soon as possible, but no later than within 24 hours of discovery. Actual oil leaks and discharges as defined in section 5(D)(11) shall be reported to the Commissioner by the facility owner or operator, and the Certified Underground Oil Storage Tank Installer or Inspector within two (2) hours of discovery.

Notwithstanding the above, discharges of 10 or less gallons of oil that occur on the premises and above the surface of the ground onto a concrete or asphalt paved surface, and that do not reach ground water or surface waters of the State need not be reported to the Commissioner if the owner or operator complies with all of the following requirements:

(a) The discharge is cleaned up within 24 hours of discovery.

(b) A written log is maintained at the facility or the owner's place of business recording for each discharge the date of discovery, its source, the general location of the discharge on the facility, the date and method of cleanup, and the signature of the facility owner or operator certifying the accuracy of the log.

(c) The log is readily available for inspection upon request by personnel and authorized agents of the Commissioner within 24 hours.

NOTE: To report a leak or discharge at any time 24 hours a day, 7 days a week, call 1-800-482-0777.

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(2) If a facility has a cathodic protection system, it must be operated, monitored and maintained in accordance with section 5(D)(3) or (D)(4).

(3)(a) For existing facilities with ground water monitoring wells for leak detection, the monitoring wells must be checked weekly by withdrawing a sample from each monitoring well on site and examining the sample visually for a sheen or other evidence of oil, and by smelling the sample for the odor of "oil." Weekly sampling shall be performed in accordance with the procedures required in Appendix H, and the results recorded in a logbook.

NOTE: A sample log sheet is provided in Appendix H.

(b) Upon discovery of any evidence of a possible leak or discharge as defined in section 5(D)(10) of this Chapter, the owner of the tank shall notify the Commissioner as soon as possible but not later than 24 hours from the time of discovery. The tank owner shall then obtain samples from all ground water monitoring wells for laboratory analysis in accordance with the procedures required in Appendix H. Investigation and corrective action requirements of section 12 of this Chapter must be followed.

(c) Where laboratory analysis is required, all monitoring wells must be sampled and the samples analyzed in accordance with the requirements of Appendix S of this Chapter. The results of all hydrocarbon analysis must be maintained in accordance with section 5(D)(16). The detection of hydrocarbons in concentrations exceeding the laboratory reporting limits must be reported to the Commissioner by the facility owner or operator as soon as possible, but not later than 2 hours from the time of discovery.

(4) The owner or operator of a facility with electronic leak detection equipment for tanks or piping shall check for alarms at least monthly, and maintain a log at the facility, including the date, the presence or absence of evidence of a leak or discharge and the name of the individual conducting the test.

(5) Continuous interstitial space or other continuous leak detection monitoring equipment must be maintained in accordance with section 5(D).

(6) The owner or operator shall operate and maintain the spill prevention and overfill prevention equipment to ensure it is operating properly at all times in accordance with the requirements of section 5(D).

(7) The owner or operator shall operate and maintain the cathodic protection systems in accordance with the requirements of section 5(D).

(8) Tanks only may be relined in accordance with section 5(D)(13). Other facility repairs must be conducted in accordance with section 5(D)(14).

(9) Oil product may not be stored in a facility of a design or construction with which it is not chemically or physically compatible.

(10) The owner shall conduct an annual compliance inspection of the facility, correcting any deficiencies found, in accordance with section 5(D)(17).

(11) Underground oil storage tanks connected to a heating system that also uses an alternative fuel must be designed and operated in accordance with this Chapter including the annual inspection requirement, and must be ready to operate. The underground oil storage tank system must be connected to the burner and the burner must be operated at least once per year to remain in service.

(12) Maintenance of records. All facility records and logs required by this Chapter must be maintained and available in accordance with section 5(D)(16).

D. Facility closure and abandonment. Closure, abandonment, or temporary discontinuance of service of a facility or any part thereof must be in accordance with section 11.

7. Regulation of facilities for the underground storage of waste oil

A. Applicability

This section applies to any person, except a waste oil dealer, who stores or proposes to store waste oil in underground tanks. Waste oil dealers are subject to the Maine *Waste Oil Management Rules,* 06-096 C.M.R. ch. 860.

B. Design and installation standards for new and replacement facilities

(1) All tanks and associated piping used for the underground storage of waste oil must be registered in accordance with section 4.

(2) The installation of new and replacement tanks constructed of bare steel or asphalt coated steel is prohibited.

(3) All new and replacement tanks must be installed by an underground oil storage tank installer who has been properly certified pursuant to 32 M.R.S. §§ 10001-10016.

(4) New and replacement waste oil tanks, associated piping and other facility components routinely containing oil must be equipped with secondary containment with continuous interstitial space monitoring, designed and installed in accordance with section 5(B) except as provided below.

(5) Piping for a new or replacement waste oil facility supplying a waste oil furnace or boiler may not use PVC piping for secondary containment but instead must be constructed of fiberglass, cathodically protected steel or other noncorrosive materials approved by the Commissioner.

(6) Fill and removal pipes at new and replacement facilities must be installed with a spill bucket with a capacity of at least 15 gallons with a liquid tight seal around the fill pipe that will collect spillage during product delivery or withdrawal.

(7) In addition to the siting restrictions of the Department's *Rules for Siting Oil Storage Facilities*, 06-096 C.M.R. ch. 692, and the *Wellhead Protection Law,* 38 M.R.S. §§ 1391 - 1400, new and replacement underground waste oil facilities may not be located in the following areas:

(a) Beneath a building or other permanent structure; or

(b) Within 25 feet of a classified body of surface water.

(8) No used or previously installed fiberglass, cathodically protected steel, or other tank meeting section 5(B) of this Chapter may be re-installed unless the owner has provided the Commissioner with satisfactory documentation that the manufacturer will warrant the tank or piping against internal and external corrosion and structural failure for a period of 10 years, after which the tank or piping must be properly abandoned in accordance with the requirements of section 11. Reinstallation of a tank or piping requires an amendment of the facility registration in accordance with section 4(M). The warranty documentation shall accompany the submission of the registration amendment. Used piping may not be reinstalled.

(9) Certification of proper installation. Owners of new and replacement facilities shall ensure that the installer(s) provides certification to the Commissioner within 30 days of completion of installation that the facility's materials, design and installation are in compliance with the requirements of this Chapter. This certification must be provided in writing on a form provided by the Commissioner.

(10) After July 1, 2019, a Certified Underground Oil Storage Tank Installer overseeing a tank removal must be trained in best management practices for erosion and sedimentation control by the Department or through an equivalent program approved by the Department.

C. Operation, maintenance, testing and inspection requirements for existing, new and replacement facilities

(1) All cathodically protected steel tanks, piping and other ancillary equipment must be operated, and maintained in accordance with section 5(D)(3) or (D)(4), and Appendix A.

(2) Leak detection and overfill and spill prevention systems must be operated and maintained in accordance with the requirements of section 5(D).

(3) The owner or operator shall report to the Commissioner any evidence of a possible leak or discharge, as defined in section 5(D)(10) within 24 hours from the time of discovery. A Certified Underground Oil Storage Tank Installer or Inspector finding evidence of a possible leak or oil discharge must report it to the facility owner or operator, and the Commissioner, as soon as possible, but no later than within 24 hours of discovery. Actual oil leaks and discharges as defined in section 5(D)(11) shall be reported to the Commissioner by the facility owner or operator, and the Certified Underground Oil Storage Tank Installer or Inspector within two (2) hours of discovery. All leaks and discharges must be cleaned up to the Commissioner’s satisfaction and in accordance with the requirements of section 12.

Notwithstanding the above, discharges of 10 or less gallons of oil, occurring above the surface of the ground onto a concrete or asphalt paved surface and not reaching ground water or surface waters of the State, do not need to be reported to the Commissioner if the owner or operator complies with all of the following requirements:

(a) The discharge is cleaned up within 24 hours of discovery.

(b) A written log is maintained recording for each discharge the date of discovery, its source, the general location of the discharge on the facility, the date and method of cleanup, and the signature of the facility owner or operator certifying the accuracy of the log.

(c) The log is readily available for inspection upon request by personnel and authorized agents of the Commissioner within 24 hours.

NOTE: To report a leak or discharge at any time, 24 hours a day, 7 days a week, call 1-800-482-0777.

(4) The owner or operator shall maintain a log at the facility, recording the date, results, and the individual conducting the annual tests of cathodic protection and leak detection systems.

(5) Only waste oil tanks constructed of cathodically protected steel, fiberglass or another noncorrosive material approved by the Commissioner may be relined. Such tanks must be relined in accordance with section 5(D)(13). Repairs other than relining must be conducted in accordance with section 5(D)(14).

(6) Waste oil may not be stored in a facility of a design and construction with which it is not chemically or physically compatible. Documentation demonstrating compatibility must be submitted to the Department and maintained in accordance with section 5(D)(12).

(7) Hazardous substances as defined in the *Uncontrolled Hazardous Substance Sites Law, 38* M.R.S. §1362(1), may not be added to or stored at a waste oil facility.

NOTE: The addition of degreasers, solvents and other hazardous substances to a waste oil tank may make the waste oil a hazardous waste. Hazardous wastes must be stored, manifested, transported and disposed in accordance with the Department's Hazardous Waste Management Regulations, 06-096 C.M. R. ch. 850 - 858.

(8) All owners or operators of waste oil facilities shall provide financial responsibility coverage in accordance with the requirements of section 5(D)(15).

(9) Maintenance of records. Required facility records and logs must be maintained and available in accordance with section 5(D)(16).

(10) The owner must conduct an annual facility compliance inspection, correcting any deficiencies found in accordance with section 5(D)(17).

D. Closure of waste oil storage facilities. Underground waste oil storage tanks and associated piping must be abandoned in accordance with section 11. All single-walled waste oil tanks and their associated piping must be taken out of operation and properly abandoned in accordance with section 11 by October 13, 2019.

8. Regulation of field constructed underground oil storage tanks

A. Applicability

This section applies to all field constructed underground oil storage tanks constructed of steel, concrete, fiberglass and other materials.

NOTE: Owners and operators of field constructed underground oil storage tanks should also review section 13 for additional requirements for any associated aboveground oil storage tanks.

B. Design and installation requirements for new and replacement tanks

(1) General design requirements

(a) Bare steel and asphalt coated steel tanks are prohibited.

(b) Concrete, fiberglass and riveted steel tanks are prohibited.

(c) All new and replacement steel tanks must be cathodically protected and coated with a suitable dielectric material. The cathodic protection system must be designed by a corrosion expert to adequately protect all parts of a tank from corrosion by maintaining a negative structure to soil potential of at least 0.85 volts. Cathodic protection systems must be designed in accordance with NACE SP0285 "External Corrosion Control of Underground Storage Tank Systems by Cathodic Protection".

(d) New and replacement steel tanks must be designed by a professional engineer in compliance with Maine's professional regulation statute, and constructed in accordance with UL Standard 1746, "Corrosion Protection Systems for Underground Storage Tanks", and API Standard 650 "Welded Steel Tanks for Oil Storage".

(e) Piping connected to field constructed tanks must be designed and constructed in accordance with the requirements of sections 5, 6, 7, 9 or 10 depending on type of facility and piping system proposed.

(f) Tank systems must be constructed of materials that are chemically and physically compatible with the products stored in accordance with section 5(B)(1)(b).

(g) In addition to the requirements and codes of practices listed in this section, owners and operators may use the military construction criteria, Unified Facilities Criteria (UFC) 3-460-01, Design: Petroleum Fuel Facilities when designing, constructing, and installing underground oil storage tank systems with field-constructed tanks.

(2) Leak detection. All new and replacement field constructed tanks must be provided with secondary containment and continuous interstitial space monitoring.

(3) Overfill and spill prevention equipment. New and replacement tanks must be installed with overfill and spill prevention equipment in accordance with section 5(B)(3) or section 6(B)(3) depending on facility type.

(4) General installation requirements

(a) No new or replacement field constructed underground oil storage tank may be installed unless the facility has been registered in accordance with section 4.

(b) New and replacement field constructed tanks shall be assembled and installed according to good engineering practices under the surveillance of a professional engineer licensed in Maine or otherwise working in compliance with the rules for Professional Engineers adopted pursuant to, 32 M.R.S. §§ 1351-1362. The engineer shall be responsible for supervising all phases of assembly and installation. At least 60 days prior to tank registration, design and installation plans must be submitted to the Commissioner for review and approval. The plan must include, at a minimum:

(i) Secondary containment and leak detection installation details;

(ii) Overfill and spill prevention equipment installation;

(iii) Anchoring;

(iv) Excavation and backfill specifications; and

(v) Cathodic protection system installation.

(c) Installation of the cathodic protection system must be supervised by a corrosion expert.

(d) If a tank is replaced, all associated piping not meeting the design and installation requirements of this section must be replaced except if the piping is part of an airport hydrant piping system. If product piping attached to a field constructed tank is replaced and structural damage to the associated tank has occurred impairing its physical integrity, the tank also must be replaced if not designed and installed in accordance with this section.

(e) Certification of proper installation. Owners of new and replacement facilities shall ensure that the project engineer certifies to the Commissioner, within 30 days of completion of installation; that the facility materials, design and installation are in compliance with the requirements of this Chapter. This certification must be provided in writing on a form provided by the Commissioner.

(f) After July 1, 2019, a Certified Underground Oil Storage Tank Installer overseeing a tank removal must be trained in best management practices for erosion and sedimentation control by the Department or through an equivalent program approved by the Department.

C. Operation, maintenance, testing, and inspection requirements for new, replacement and existing tanks

(1) Tanks that are part of a motor fuel, marketing or distribution facility must be operated in accordance with section 5(D), except that the requirements of sections 5(D)(1) and (2) do not apply.

(2) Tanks that are part of a heating oil facility for consumptive use by the owner or operator must be operated in accordance with section 6(C).

(3) Tanks that are a part of a waste oil facility must be operated in accordance with section 7(C).

(4) Notwithstanding the above, repairs must be conducted in accordance with sections 5(D)(13) and (14), except that a repair may be designed by and conducted under the surveillance of a professional engineer in accordance with Maine's professional regulation statutes.

(5) The owner shall conduct an annual facility compliance inspection and correct any deficiencies found in accordance with section 5(D)(17).

(6) The owner shall have designated, trained and certified operators as set forth in *Operator Training for Underground Oil and Hazardous Substance Storage Facilities*, 06-096 C.M.R. ch. 693.

(7) The owner or operator must ensure that a certified A/B operator inspects the facility for compliance at least weekly, and in addition conducts monthly and annual inspections in accordance with the schedule below. The owner or operator must maintain a log of these inspections in accordance with section 5(D)(16) and in accordance with 06-096 C.M.R. ch. 693, §5. The log must include a list of each area checked, whether each area checked was acceptable or needed action taken, and a description of any corrective actions taken. The inspections must at a minimum check the following equipment on the applicable schedule:

(a) Weekly check of spill prevention equipment including spill buckets-- visually check for damage; remove liquid or debris; check for and remove obstructions in the fill pipe; check the fill cap to make sure it is securely on the fill pipe; and

(b) Weekly check of leak detection equipment -- check to make sure the release detection equipment is operating with no alarms or other unusual operating conditions present; and ensure records of leak detection testing are reviewed and current; and

(c) Monthly check of double walled spill buckets with interstitial monitoring-- check for a leak in the interstitial area;

(d) Annual check of containment sumps by a Maine Certified Underground Oil Storage Tank Installer or Inspector -- visually check for damage, leaks to the containment area, or releases to the environment; remove liquid in contained sumps or debris; and for double walled sumps with interstitial monitoring, check for a leak in the interstitial area; and

(e) Annual check of hand held leak detection equipment by a Maine Certified Underground Oil Storage Tank Installer or Inspector -- check devices such as tank gauge sticks or ground water bailers for operability and serviceability.

D. Closure and abandonment of underground field constructed oil storage tanks

(1) Tanks must be abandoned in accordance with section 11, except that owners of concrete tanks larger than 20,000 gallon capacity may be granted a variance by the Commissioner from the requirement under the following conditions:

(a) An alternate method of closure or long term maintenance is proposed that is equally protective of the environment, public health, safety and welfare;

(b) Discharges of oil will be remediated to the satisfaction of the Commissioner;

(c) Public access is controlled;

(d) A notice of the presence of underground oil storage tanks is permanently attached to the deed of the parcel upon which the tanks are located, including at a minimum, a description of the tanks, their size, types of product stored, and their surveyed location; and

(e) Written notice has been provided to the local fire department having jurisdiction indicating that a variance is being sought from the requirements of section 11.

The Commissioner may approve, deny, or approve with conditions a variance under this paragraph.

(2) The owner or operator of a field constructed tank shall conduct a site assessment in accordance with section 11(A) and Appendix P prior to the completion of facility closure.

(3) The owner or operator of a previously closed underground oil storage facility that was not required to conduct a site assessment must assess the excavation zone of the tanks, piping and dispensers and must conduct an after-the-fact site assessment in accordance with Appendix P(11), if the Department determines releases from the underground oil storage tank pose a current or potential threat to human health or the environment.

9. Regulation of facilities for the underground storage of heavy oils

A. Applicability

(1) This section applies to all underground oil storage facilities intended for storing or containing heavy oil, oil that must be heated during storage, including but not limited to #5 and #6 oil.

(2) This section applies to # 4 oil storage facilities only when the oil must be heated during storage.

B. Design and installation requirements for new and replacement facilities

(1) General design requirements

(a) Facilities must be designed in accordance with section 6(B)(1) except where a field constructed tank is proposed at a heavy oil facility, then the general design requirements for heating oil facilities under sections 6(B)(1) or 8(B) must be followed.

(b) All facility construction materials must be physically and chemically compatible with the product to be stored, including the temperature at which the product is to be stored. Fiberglass or plastic jacketed components may not be installed in facilities where the oil temperature will exceed 150°F.

(2) Leak detection. New and replacement heavy oil facilities must provide leak detection in conformance with the leak detection requirements for other heating oils in section 6(B)(2) or field constructed tanks in section 8(B)(2), including secondary containment with continuous interstitial space monitoring.

(3) Overfill and spill prevention equipment requirements are the same as those for other heating oils under section 6(B)(3).

(4) Installation requirements for new and replacement heavy oil facilities.

(a) An underground oil storage facility or tank may not be installed unless the facility has been registered in accordance with section 4.

(b) No person may install an underground heavy oil storage facility unless that person is a properly certified Class 2 underground oil storage tank installer in accordance with 32 M.R.S. §§ 10001-10016 and has paid the certification fee.

(c) If a tank is replaced, all associated underground piping not meeting the design requirements of this Chapter must be replaced. Any replacement piping must be designed and installed in accordance with this Chapter. If product piping is replaced and structural damage to the tank has occurred, the associated tank also must be replaced if not constructed of fiberglass, cathodically protected steel, or other noncorrosive materials approved by the Commissioner. Repairs of damaged fiberglass, cathodically protected steel, and other Commissioner approved tanks may only be made if conducted in accordance with sections 5(D)(13) or (14). Tanks that cannot be repaired must be abandoned in accordance with section 11.

(d) New and replacement heavy oil facilities must be installed in accordance with National Fire Protection Association Code 31 and the requirements of section 6(B)(4), (5) and (6), except that the installation of copper and PVC piping is prohibited and the heating system must be electrically isolated from the cathodic protection system if the tank is steel.

(e) New and replacement fiberglass and plastic jacketed steel tanks must be provided with continuous product temperature monitoring equipment, installed in accordance with the manufacturer's specifications.

(f) After July 1, 2019, a Certified Underground Oil Storage Tank Installer overseeing a tank removal must be trained in best management practices for erosion and sedimentation control by the Department or through an equivalent program approved by the Department.

C. Operation, maintenance, testing and inspection of new, replacement and existing facilities

(1) Heavy oil facilities must be operated in accordance with the requirements for other heating oil facilities in section 6(C).

(2) The owner or operator of heavy oil facilities with fiberglass or plastic jacketed steel tanks or piping shall monitor representative product temperature within the tank daily to ensure it does not exceed tank and piping manufacturers' specifications or limits. Product temperature readings must be recorded, including date, temperature, and the initials of the person taking the measurements or readings. Temperature records must be maintained at the facility for 3 years and be available to Department personnel and representatives or municipal officials.

(3) Product temperature measurement equipment must be maintained in good operating condition. Such equipment must be tested and if necessary, calibrated, at least annually by a properly trained representative of the owner or operator, a Certified Underground Oil Storage Tank Installer or an authorized representative of the manufacturer.

(4) Fiberglass and jacketed steel facilities may not be operated above 150°F.

(5) The owner shall conduct an annual facility compliance inspection and correct any deficiencies found in accordance with section 5(D)(17).

D. Closure requirement. Heavy oil tanks must comply with the requirements of section 11.

10. Regulation of airport hydrant systems

A. Applicability

(1) This section applies to all airport hydrant systems that are part of an underground oil storage facility which fuels aircraft and operates under high pressure with large diameter piping that typically terminates into one or more hydrants.

(2) Underground tanks storing aviation fuel must comply with section 5 or 8, as applicable.

NOTE: Owners and operators of airport hydrant systems should also review section 13 for additional requirements for any associated aboveground oil storage tanks.

B. Design, construction and installation requirements for new and replacement systems

(1) General design and construction requirements

(a) Bare steel and asphalt coated steel piping are prohibited.

(b) All new and replacement steel piping in contact with soil or water must be cathodically protected and coated with a suitable dielectric material. The cathodic protection system must be designed by a corrosion expert to adequately protect all parts of the piping system from corrosion by maintaining a negative structure to soil potential of at least 0.85 volts. Cathodic protection systems shall be designed in accordance with NACE SP0285.

(c) Piping must be designed by a professional engineer in compliance with Maine professional regulation statutes, and constructed in accordance with American National Standards Institute (ANSI) standard for "Chemical Plant and Petroleum Refinery Piping", ANSI/ASME B 31.1.

(d) In addition to the requirements and codes of practices listed in this section, owners and operators may use the military construction criteria, Unified Facilities Criteria (UFC) 3-460-01, Design: Petroleum Fuel Facilities when designing, constructing, and installing airport hydrant systems.

(2) Leak detection. All new and replacement airport hydrant piping routinely containing oil must be provided with secondary containment and continuous interstitial space monitoring.

(3) General installation requirements

(a) No new or replacement airport hydrant piping may be installed unless the facility and piping have been registered in accordance with section 4.

(b) New and replacement airport hydrant piping must be installed according to good engineering practices using welded joints and under the supervision of a professional engineer licensed in Maine or otherwise working in compliance with 32 M.R.S. §§ 1351-1362. The engineer shall be responsible for surveillance of all phases of installation. Installation plans must be submitted for Department review and approval at least 60 days prior to new or replacement piping registration and must include at a minimum:

(i) Secondary containment and leak detection installation details;

(ii) Excavation and backfill specifications;

(iii) Pipe material specifications;

(iv) Welding specifications; and

(v) Cathodic protection system installation.

(c) Installation of the cathodic protection system must be supervised by a corrosion expert.

(d) If airport hydrant piping is replaced, any underground oil storage tank not constructed of fiberglass, cathodically protected steel, or other Commissioner approved noncorrosive materials in conformance with sections 5 or 8 must be replaced at the same time.

(e) New and replacement piping must be installed in accordance with NACE International SP0285, NACE International SP0169 or ANSI/ASME B31.3.

(f) Welded joints must be radiograph inspected.

(g) Hydrant pits must be liquid tight and must drain to an oil water separator, or other Commissioner approved collection and treatment system.

(h) Certification of installation. Owners of new and replacement facilities shall ensure that the project engineer certifies to the Commissioner, within 30 days of completion of installation, that the facility materials, design and installation meet the requirements of this Chapter. This certification must be provided in writing on a form provided by the Commissioner.

(i) After July 1, 2019, a Certified Underground Oil Storage Tank Installer overseeing a tank removal must be trained in best management practices for erosion and sedimentation control by the Department or through an equivalent program approved by the Department.

C. Retrofitting requirements for existing airport hydrant systems

(1) Existing airport hydrant systems without secondary containment and interstitial space monitoring or another form of leak detection in compliance with section 5(B)(2), shall retrofit or implement one of the following leak detection methods by December 1, 1991:

(a) An annual hydrostatic test of the entire piping line conducted at 150 percent of maximum design operating pressure, or maximum transient surge pressure, whichever is greater. Test shall be conducted for a minimum of four (4) hours and otherwise in accordance with API Recommended Practice 1110, "Pressure Testing of Liquid Petroleum Pipelines".

(b) Other leak detection systems approved by the Commissioner that can reliably detect a loss of at least 40 gallons per day.

(2) Existing airport hydrant systems constructed of steel may retrofit corrosion protection in accordance with 38 M.R.S. §563-A(l-A) as an alternative to abandonment or replacement, provided a corrosion induced leak has not occurred and the system is not located in a sensitive geological area. To be eligible for this exemption, the facility owner or operator must demonstrate to the Commissioner's satisfaction that the airport hydrant piping system does not leak. The test utilized to determine system integrity must be able to determine a leak rate of at least 40 gallons per day and that any leaks are not directly or indirectly due to corrosion. Cathodic protection must be designed by a corrosion expert and installed in accordance with the standards of section 10(B) above. Leak detection must be retrofitted at the same time cathodic protection is retrofitted.

D. Operation, maintenance, testing and inspection requirements for new, replacement and existing systems

(1) Airport hydrant systems must be operated in accordance with section 5(D), except that the requirements of 5(D)(1) and (2) do not apply.

(2) Repairs of new, replacement and existing piping must be in accordance with good engineering practice and under the surveillance of a Maine professional engineer. Upon completion, the repaired section must be tested for leaks and for proper operation of the cathodic protection system. A report describing the repairs made and test results must be submitted by the owner or operator to the Commissioner for approval.

(3) Annual inspection requirements. The owner shall conduct an annual facility compliance inspection and correct any deficiencies found in accordance with section 5(D)(17).

(4) The owner shall have designated, trained and certified operators as set forth in *Operator Training for Underground Oil and Hazardous Substance Storage Facilities*, 06-096 C.M.R. ch. 693.

(5) The owner or operator must ensure that a certified A/B operator inspects the facility for compliance in accordance with the schedule below. The owner or operator must maintain a log of these inspections in accordance with section 5(D)(16) and in accordance with 06-096 C.M.R. ch. 693, §5. The log must include a list of each area checked, whether each area checked was acceptable or needed action taken, and a description of actions taken to correct an issue. The inspections must at a minimum check the following equipment on a weekly, monthly and annual basis as applicable:

(a) Weekly check of spill prevention equipment including spill buckets -- visually check for damage; remove liquid or debris; check for and remove obstructions in the fill pipe; check the fill cap to make sure it is securely on the fill pipe;

(b) Weekly check of leak detection equipment -- check to make sure the release detection equipment is operating with no alarms or other unusual operating conditions present; and ensure records of leak detection testing are reviewed and current;

(c) Monthly check of double walled spill buckets with interstitial monitoring -- check for a leak in the interstitial area;

(d) Monthly check of hydrant pits and hydrant pit vaults that do not require a confined space entry permit per the Occupational Safety and Health Administration (OSHA) -- to visually check for any damage or leaks, and remove any liquid or debris;

(e) Annual check of hydrant pits and hydrant pit vaults if a confined space entry permit is required per the Occupational Safety and Health Administration (OSHA) -- to visually check for any damage or leaks, and remove any liquid or debris; and

(f) Annual check of containment sumps by a Maine Certified Underground Oil Storage Tank Installer or Inspector -- visually check for damage, leaks to the containment area, or releases to the environment; remove liquid in contained sumps or debris; and for double walled sumps with interstitial monitoring, check for a leak in the interstitial area.

E. Closure and abandonment. Closure and abandonment of airport hydrant piping systems must be in accordance with section 11.

11. Regulations for closure of underground oil storage facilities

A. Facility closure requirements

(1) The owner or operator of an underground oil storage facility or tank that has been or is intended to be out of service for a period of more than 12 months must close the facility or tank in accordance with this section unless the tank owner has received written permission from the Commissioner to remain temporarily out of service in accordance with the requirements of subsection B below. Closure must include:

(a) Proper abandonment of tanks, piping and other facility components;

(b) Emptying and cleaning tanks of all liquids and accumulated sludge;

(c) Storage or disposal of removed tanks in accordance with this section;

(d) Completion of a site assessment in accordance with the requirements of Appendix P for all types of facilities or a portion thereof, except on-site consumptive use heating oil facilities (other than heavy oil facilities), and farm and residential motor fuel tanks of 1,100 gallons or less capacity and where the product is used only by the tank owner or operator; and

(e) Clean up of discharges and leaks to the satisfaction of the Commissioner in accordance with section 12.

NOTE: A site assessment and site assessment report are required as part of facility or tank closure for heavy oil tanks but not for #2, kerosene and other heating oils when stored and consumed on the same premises. Only heating oils heated during storage meet the definition of heavy oil in this Chapter.

(2) When ownership of the facility or tank is unknown, the current landowner is responsible for facility closure.

NOTE: Maine law (see 38 M.R.S. §563-A) requires closure of nonconforming tanks in accordance with this Chapter no later than October 1, 1998.

B. Temporarily out of service facilities and tanks

(1) When a facility has been, or is intended to be temporarily out of service for a period exceeding 3 months and not exceeding 12 consecutive months, the owner or operator shall:

(a) Continue operation and maintenance of the corrosion protection system in accordance with the applicable requirements of this Chapter;

(b) Continue leak detection in accordance with the applicable requirements of this Chapter, unless all liquids including product and water are emptied from the tank with no more than one (1) inch of residual left;

(c) Leave vent lines open and functioning;

(d) Cap and secure all other lines, pumps, man-ways and ancillary equipment;

(e) Submit an annual compliance inspection report in accordance with section 5(D)(17) of this Chapter and 38 M.R.S. §563(9);

(f) Report and investigate evidence of a possible leak or discharge in accordance with section 12; and

(g) Perform a site assessment in accordance with section 12(B)(1)(c) prior to the tank owner requesting an extension to remain temporarily out of service for more than 12 months in accordance with section 12(B)(2).

(h) If after 12 months, the facility is brought back into service, it must meet the provisions of section 11(B)(3)(a)-(h).

(2) A tank owner may apply in writing for approval of the Commissioner to allow a facility to remain temporarily out of service for more than 12 consecutive months, if done so before the 12 months out of service expires, and when:

(a) The requirements of section 11(B)(1) above are met; and

(b) The facility is constructed in compliance with the applicable requirements of this Chapter.

Commissioner approval for a facility to remain temporarily out of service for more than 12 months must be in writing and is conditional upon continued compliance by the facility with the requirements of paragraph (1) above.

(3) If an underground oil storage facility has been out of service for a period of more than 12 consecutive months without written approval in accordance with subsection 11(B)(2) above, or remains out of service beyond an approved extension period under subsection 11(B)(2) of a facility's temporarily out-of-service status, the facility may not be brought back into service without the written approval of the Commissioner. The Commissioner may approve the return to service if the owner demonstrates to the Commissioner's satisfaction that:

(a) The tanks and piping are constructed of fiberglass, cathodically protected steel, or another equally non-corrosive material approved by the Commissioner;

(b) The tanks are of double walled construction and provided with continuous interstitial space monitoring for leak detection;

(c) The facility has safe suction or double walled pressurized product piping with continuous leak detection;

(d) The facility was installed or has been retrofitted with dispenser sumps that have continuous electronic leak detection;

(e) Facility tanks, piping, sumps and spill buckets have passed precision testing conducted in accordance with the requirements of this Chapter;

(f) The facility is in compliance with all other applicable requirements of this Chapter;

(g) The owner or operator performed a site assessment in accordance with section 12(B)(1)(c); and

(h) The return of the facility to service does not pose an unacceptable risk to ground water resources. In determining if the facility poses an unacceptable risk to ground water resources, the Commissioner may consider the age and maintenance history of the facility, the number and consequences of past oil discharges, and the proximity of the facility to sensitive geological areas, including, but not limited to, drinking water supplies, and significant sand and gravel aquifers mapped by the Maine Geological Survey and the results of the site assessment.

(i) The facility's registration must also be amended in accordance with section 4.

C. Permanently out of service facilities or tanks

(1) A tank that has failed a precision test or that has otherwise been determined to have compromised structural integrity may be allowed to remain out of service in accordance with the requirements of section 11(B) if removal would endanger other tanks that are being operated at the facility.

(2) A tank owner must apply in writing for approval of the Commissioner to allow a tank to remain permanently out of service. Approval may be given if the Commissioner deems that delaying removal will not put public health or the environment at risk. The owner or operator must:

  - (a) Ensure that all liquids including product and water are emptied from the tank with no more than one (1) inch of residual left;
  - (b) Leave vent lines open and functioning;
  - (c) Cap and secure all other lines, pumps, man-ways and ancillary equipment;
  - (d) Submit an annual compliance inspection report in accordance with section 5(D)(17) and 38 M.R.S. §563(9); and
  - (e) Amend the facility registration in accordance with section 4 of this Chapter.

(3) The permanently out of service tank(s) shall be removed when other tanks at the facility are removed.

D. Abandonment by removal

(1) Tanks, piping or facilities that have been out of service for 12 months must be removed within 60 days, unless a written request to remain out of service for more than 12 months under section 11(B)(2) above has been approved or has been made and is subsequently approved by the Commissioner.

(2) Removal of tanks and facilities must be conducted in accordance with API Recommended Practice 1604 and Appendix J to the satisfaction of the Commissioner. For facilities listed in section 11(A)(1)(d), a site assessment must be conducted at the time of removal in accordance with section 12(B)(1)(c) and Appendix P.

(3) As required under 38 M.R.S. §566-A(5), removal of tanks or facilities that have contained a Class 1 liquid at any time must be conducted under the direct, on-site supervision of an underground oil storage tank installer certified pursuant to 32 M.R.S. §§ 10001-10016.

NOTE: The above requirement applies to gasoline facilities and possibly other liquid petroleum products such as aviation fuel. Fire prevention requirements of this Chapter may also be enforced by State and local fire officials.

(4) After July 1, 2019, a Certified Underground Oil Storage Tank Installer overseeing a tank removal must be trained in best management practices for erosion and sedimentation control by the Department or through an equivalent program approved by the Department.

(5) If underground oil storage tanks that have been removed are stored, the following provisions apply:

  - (a) Areas chosen for storage may not be accessible to the general public.
  - (b) Inverted tanks may be stored with unplugged openings. While being transported, openings are to be tightly plugged, screwed plugs must be used and one plug must have a 1/8 inch vent hole to prevent the tank from being subjected to an excessive pressure differential caused by extreme temperature changes.

(c) All stored underground oil storage tanks must be labeled with the warning noted in section (6)(c) below.

(d) Any scale or sludge released by the tank prior to and during storage must be characterized and disposed of in accordance with the Maine Hazardous Waste Management Rules, *Standards for Generators of Hazardous Waste,* 06-096 C.M.R. ch. 851.

(6) If underground oil storage tanks that have been removed are sold or reused, the following provisions apply:

(a) Bare steel and asphalt coated steel tanks may not be re-installed for use as an underground oil storage facility;

(b) Fiberglass and cathodically protected double-walled tanks meeting the requirements of section 5(B) may be re installed, if the tank owner has supplied the Commissioner with satisfactory documentation that the manufacturer will warrant the tank for a period of at least 10 years for internal and external corrosion and structural failure, after which the tanks must be properly abandoned pursuant to this section. A written statement attesting to the validity of the warranty, signed by the tank manufacturer, and provided to the Commissioner constitutes the only proof of warranty coverage. A tank that has been reinstalled cannot operate beyond 30 years from the original date of installation unless the tank owner receives written permission from the Department pursuant to section 5(F).

(c) All transactions must be accompanied by a bill of sale indicating the former use of the tank. The bill of sale must contain the following warning:

Tank Has Contained Leaded Gasoline or Flammable Liquid

(use applicable designation)

Not Gas-Free

Not Suitable for Food or Drinking Water

(d) The tank must be clearly marked with the notice stated in paragraph (c) above, in legible letters not less than one (1) inch high, regardless of the condition of the tank.

(e) Abandoned underground oil storage tanks are prohibited from use for above ground storage of oil, except where approved by the Maine State Fire Marshal or where a Maine professional licensed engineer, or other person meeting the requirements of Maine professional regulation statutes and rules governing professional engineers practicing in Maine, certifies that the tank meets all applicable specifications and requirements in UL 142 and NFPA 30.

(7) The owner or operator of a previously closed underground oil storage facility that was not required to conduct a site assessment must assess the excavation zone of the tanks, piping and dispensers and must conduct an after-the-fact site assessment and closure in accordance with Appendix P(11), if the Department determines releases from the underground oil storage tank pose a current or potential threat to human health or the environment.

E. Abandonment by filling in place

(1) Abandoned facilities and tanks must be removed, except where the owner can demonstrate to the Commissioner that removal is not physically possible or practicable because the tank or other component of the facility to be removed is:

(a) Located beneath a building or other permanent structure that cannot be practically replaced;

(b) Of a size and type of construction that it cannot be removed;

(c) Inaccessible to heavy equipment necessary for removal; or

(d) Positioned in such a manner that removal would endanger the structural integrity of nearby tanks.

(2) A facility or tank owner may apply to the Commissioner for a variance to abandon a facility or tank in place rather than abandon the tank or facility by removal. The variance may be granted if the Commissioner finds that:

(a) Abandonment by removal is not possible or practicable due to circumstances other than those listed in paragraph 1 above; and

(b) The granting of a variance shall not pose a threat to a private or public drinking water supply or the quality of ground water, and is consistent with the intent of this Chapter.

(3) All facilities to be abandoned in place that receive written acknowledgment from the Department that the tank or piping meets one or more of the criteria listed in section 11(E)(1) or (2) must follow the notification requirements in section F below and follow the procedures outlined in API 1604 and Appendix K. For facilities listed in section 11(A)(1)(d), a site assessment must be conducted at the time of abandonment in accordance with section 12(B)(1)(c) and Appendix P.

(4) The owner or operator of a previously closed underground oil storage facility that was not required to conduct a site assessment must assess the excavation zone of the tanks, piping and dispensers and must conduct an after-the-fact site assessment in accordance with Appendix P(11), if the Department determines releases from the underground oil storage tank pose a current or potential threat to human health or the environment.

F. Notification requirements

(1) The owner or operator of a facility or tank, which is to be closed or abandoned in place, shall notify the Commissioner, the local fire department having jurisdiction, and where required by this Chapter, the underground oil storage tank installer overseeing the closure and the person conducting the site assessment. This notice must be in writing and received by the Commissioner at least 10 business days prior to abandonment, except that when ownership of the facility or tank is unknown, the current property owner is responsible for compliance with the requirements of this section. This notice must include:

(a) The name, mailing address, and telephone number of the owner;

(b) The mailing address and location of the facility;

(c) The size(s) of tank(s) to be abandoned or taken out of service;

(d) The type(s) of product(s) most recently stored in each tank;

(e) The registration number of the facility and tank(s) if registered under this Chapter;

(f) If the tank has contained a Class I liquid, the inerting procedure and, if applicable, the cleaning location;

(g) If the tank last contained a Class I liquid, or contained a Class I liquid in the 12 months prior to closure, the name and signature of the Maine Certified Underground Oil Storage Tank Installer supervising the facility closure and the person conducting the site assessment;

(h) If abandonment in place is planned, the criteria used for justifying abandonment in place, as listed in section 11(E)(1) above;

(i) The approximate age of the tank, if known;

(j) The date upon which the facility or tank is to be removed or when a variance has been granted pursuant to section 11(D) , the date on which the tank or facility will be properly abandoned on site; and

(k) The estimated date the tank was last used.

(2) The tank owner shall keep a permanent record of the tank location, the date of abandonment, and the method of conditioning the tank for abandonment.

(3) The tank owner is responsible for attaching, to the deed of the property on which the tank was located, a notice that an underground oil storage tank or underground piping has been abandoned in place pursuant to section 11(E). The deed notation must be executed within 30 days of completion of the abandonment and a copy of the executed notice from the county registry of deeds provided to the Commissioner.

NOTE: Siting of new underground oil storage facilities in wellhead protection zones is regulated under 38 M.R.S., §§ 1391 -1400. and the Department's *Rules for Siting Oil Storage Facilities,* 06-096 C.M.R. ch. 692. Pursuant to 38 M.R.S. §1393(2)(B) and 06-096 C.M.R. ch. 692, §3(A)(2) and 4(A)(2), i f intending to replace a tank or facility being abandoned in a wellhead protection zone, the facility owner must within 30 days of removal of the existing facility, notify the commissioner and the municipal code enforcement officer in writing of their intent to replace the facility. Construction of the replacement of the facility must commence within 2 years after the date of removal. A wellhead protection zone includes areas within 300 feet of a private well. In the case of public wells, the wellhead protection zone is the area within 1,000 feet of a public well, or on the source water protection area mapped by the Maine Drinking Water Program in the Department of Health and Human Services, whichever is greater. Without taking the above steps, siting restrictions on the installation of oil storage facilities in wellhead protection areas will apply.

12. Discharge and leak investigation, response and corrective action requirements

A. General requirements

(1) In accordance with 38 M.R.S. §568, any facility owner or operator or other responsible party, as defined in 38 M.R.S. §562-A(17), when a leak, spill or other prohibited discharge of oil occurs, shall immediately contain and undertake to remove that discharge to the satisfaction of the Commissioner, and in accordance with the requirements of this section. In determining the extent of a corrective action, the Commissioner and the Commissioner's staff shall consider the potential for human exposure and for adverse effects on public safety, health and welfare and the environment. The Commissioner will consider at a minimum the following factors in determining whether the corrective action plan is appropriate:

(a) The physical and chemical characteristics of the oil discharge, including its toxicity, persistence, and potential for migration;

(b) The hydrogeologic characteristics of the site and the surrounding areas;

(c) The proximity, quality, and current and future uses of nearby surface water and ground water, including the Maine water quality classification standards and objectives to restore and maintain the chemical, physical and biological integrity of the State's waters;

(d) The potential effects of residual contamination on nearby surface water and ground water;

(e) An exposure assessment; and

(f) Any information assembled in compliance with this section.

(2) Any evidence of a possible leak or discharge of oil as defined in section 5(D)(10) must be reported to the Commissioner by the facility owner or operator within 24 hours of discovery. Actual oil leaks and discharges as defined in section 5(D)(11) shall be reported to the Commissioner by the facility owner or operator, and the Certified Underground Oil Storage Tank Installer or Inspector within two (2) hours of discovery.

Notwithstanding the above, discharges of 10 or less gallons of oil that occur on the facility premises and above the surface of the ground onto a concrete or asphalt paved surface, and that do not reach ground water or surface waters of the State, need not be reported to the Commissioner if the owner or operator complies with all of the following requirements:

(a) The discharge is cleaned up within 24 hours of discovery.

(b) A written log is maintained at the facility or the owner's place of business in Maine recording for each discharge, the date of discovery, its source, the general location of the discharge at the facility, the date and method of cleanup, and the signature of the facility owner or operator certifying the accuracy of the log.

(c) The log must be made available upon request within 24 hours for inspection by Department personnel, authorized agents of the Commissioner, and municipal officials.

NOTE: Discharges of oil may be reported by calling the Department's toll free telephone number, 1-800-482-0777.

(3) Under 38 M.R.S. §568(4)(A), any person who causes, or is responsible for, a discharge from an underground oil storage facility in violation of 38 M.R.S. §543, is not subject to any fines or penalties for violation of 38 M.R.S. §543 for the discharge if that person promptly reports and removes that discharge in accordance with this Chapter as well as other rules or orders of the Commissioner and the B oard, except that a person who violates any laws or rules administered by the Department under 38 M.R.S. §§ 561-570-M is subject to fines and penalties.

(4) All hydrogeological or other investigation and corrective action plans required under this section must be certified and stamped by a Maine certified geologist, a licensed Maine professional engineer, or a geologist or engineer otherwise in compliance with the Maine professional regulation statutes for geologists or engineers. Implementation of corrective actions must be supervised by a Maine certified professional working in compliance with

Maine's professional regulation statutes. Individuals providing the above professional services should be knowledgeable in underground oil storage facility investigation and remediation.

(5) Any investigation of evidence of a possible leak or a discharge, and any removal or remediation of a discharge, that involves excavation, removal or replacement of soil material or a concrete pad, or the use of in situ techniques, above, under, or within 10 feet of a tank or piping, must be attended by an underground oil storage tank installer certified under 32 M.R.S. §§ 10001 -10016. In order to protect the structural integrity of the facility, to prevent further discharges, and to protect public safety and the environment, the certified installer shall supervise and be present at all times when work described above is being performed.

(6) Leaks and discharges of oil shall be investigated and corrected using techniques that are cost-effective, reliable and technically feasible.

(7) Upon determination that an oil discharge has occurred at a facility, that facility may resume partial or full operation while corrective action is taken unless the Commissioner determines that a return to operation would interfere with investigation and remediation efforts, and would therefore result in a threat to public health and safety and the environment. No excavation, drilling or soil removal may be undertaken on the facility premises within 5 feet of any pressurized Class 1 liquid (e.g. all gasolines) product lines until such lines have been drained of product. In accordance with NFPA 30 and 30 A, excavation, drilling, or other activities that may act as a source of ignition of flammable vapors at a Class 1 liquid dispensing facility may not be undertaken within 20 feet of a fueling dispenser and nozzle when fully extended, unless the electrical power supply to the dispenser has first been turned off and all fueling operations from that dispenser have ceased.

NOTE: Before undertaking excavation at a facility that will remain in operation, the owner or operator should notify the municipal fire chief in the event a local ordinance applies and a permit is required under NFPA 30 (7.9).

(8) The owners or operators of the following tanks must comply with the requirements of this section, except that they may meet the initial site characterization of 40 C.F.R. §280.63, as amended up to July 1, 2018, in lieu of conducting a site assessment in accordance with Appendix P:

(a) Aboveground oil storage tanks that are associated with field constructed underground oil storage tanks and airport hydrant systems; and

(b) Wastewater treatment tank systems that are not regulated by the *Clean Water Act* §§ 402 or 307(b) (1972) (33 U.S.C., §1317(b) or §1342 (2016)).

B. Discharge and leak investigation and confirmation requirements

(1) The facility owner or operator, or other responsible party shall immediately investigate and confirm all possible leaks, spills or other discharges of oil to the Commissioner's satisfaction within 7 business days of discovery, or another reasonable time period approved by the Commissioner, using the following steps or another procedure approved by the Commissioner:

(a) Leak detection check. If the facility has leak detection in accordance with this Chapter and it indicates a possible leak, a check for failures of the leak detection system may be conducted prior to precision testing if the check is concluded within 3 business days of the initial discovery of evidence of a possible leak or discharge. All components of the leak detection system for tanks and piping must be checked for proper operation, recalibrated if an automated or electronic system, and monitored in accordance with the requirements of this Chapter and if applicable, the manufacturer's instructions. Monitoring must be conducted for 5 consecutive days. For manual leak detection systems, monitoring must be conducted daily. Records of the findings of the leak detection check and monitoring must be provided to the Commissioner. If leak detection monitoring results are conclusive and do not indicate a leak, further investigation is not needed, unless there is other environmental contamination or physical evidence indicating a leak or discharge of oil. If the leak detection results indicate a leak, are inconclusive or the facility does not have leak detection meeting the requirements of this Chapter, the owner, operator or other responsible party shall conduct a precision test of the facility in accordance with paragraph (b) below. If leak detection indicates a leak, the owner, operator or other responsible party shall abandon, repair or replace facility components in accordance with appropriate sections of this Chapter. In addition the owner or operator of a motor fuel facility shall also comply with the testing and replacement procedures outlined in paragraph (d) below.

NOTE: Performing an additional statistical inventory reconciliation is not an acceptable option under the leak detection check requirements because of the delay to collect the 30 to 60 days of daily product inventory data required by this method.

(b) Precision test. When a possible leak is not attributed to a failure of the leak detection system under paragraph (a) above the owner, operator or other responsible party shall have a precision test conducted of the facility to determine whether and where a leak exists. This test shall be conducted by an independent third party. If an initial precision test is either inconclusive or indicates a failure, the owner or operator may recheck the results by re-testing within two weeks of receipt of the initial test results. A copy of all precision test results must be submitted to the Commissioner by the facility owner and the tester.

(i) If precision testing indicates a leak (2 test failures or a single uncontested test failure), the owner, operator or other responsible party shall abandon, repair or replace facility components in accordance with appropriate sections of this Chapter and initiate a site assessment in accordance with paragraph 1(c) below and undertake corrective actions as specified in subsection C below. In addition, the owner or operator of a motor fuel facility shall also comply with the replacement procedures outlined below in paragraph (d) of this section.

(ii) If results from a Commissioner-approved and properly conducted precision test of the facility conclusively indicates that a leak does not exist, and if no environmental contamination or other physical evidence is the basis for suspecting a leak or discharge, further investigation is not required. The Commissioner may, however, require additional precision testing or a site assessment in accordance with paragraph (c) below for environmental contamination by oil if initial precision tests are inconclusive or improperly conducted.

(iii) The facility owner, operator or other responsible party shall conduct a site assessment as described below in sub-paragraph (c) of this section if precision test results do not indicate a leak exists but evidence of environmental contamination or other physical evidence is the basis for suspecting a leak.

(c) Site assessment

(i) The objectives of the site assessment are as follows:

a. Determine the presence or absence of a leak, spill or oil discharge where contamination is most likely to be present on the facility site;

b. Identify the presence of free product, oil saturated soils and soils contaminated above the applicable notification levels in Appendix Q. At sites where leaded petroleum fuels were stored in underground oil storage facilities, the assessment must include an evaluation for total lead. If total lead is present in concentrations equal to or above 100 mg/kg, contaminated soils must be sampled for laboratory analysis and tested using EPA's Toxicity Characteristic Leaching Procedure, SW-846 Test Method 1311/6010C;

NOTE: Lead was prohibited in gasoline as of January 1, 1996, Lead continues to be used in high octane fuel and certain aviation fuel.

c. Evaluate the potential for vapor intrusion at the facility and nearby receptors if a leak, spill, or discharge is confirmed and/or free product and/or saturated soil is present;

d. Determine the degree of threat to ground water quality;

e. Consider the nature of the oils stored at a facility, the cause for suspecting a leak or discharge, the type of backfill and soils, the depth to ground water, the depth to bedrock, and other factors appropriate for identifying the presence and source of a leak or other discharge; and

f. Consider the potential effects of residual contamination on nearby surface water and ground water.

(ii) The site assessment must be conducted in accordance with procedures outlined in Appendix P. To verify the presence or absence of a leak or oil discharge at an operating facility in follow-up to the requirements of paragraphs (b) (ii) or (iii) above, the site assessment procedures outlined in paragraph 10 of Appendix P must be followed.

(iii) If site assessment results for the excavation and other areas of the facility site indicate that a leak, spill or other discharge of oil has occurred, the owner or operator shall properly abandon, repair or replace facility components and begin corrective actions in accordance with subsection C below.

(iv) If the site assessment results for the excavation and other areas of the facility site do not indicate a leak, spill or other discharge of oil has occurred, further investigation is not required.

(d) Within 30 business days, or another time period approved by the Commissioner, of discovery of evidence of a possible leak or discharge, the owner, operator or other responsible party shall submit a report on the steps taken and the findings of discharge and leak investigation and confirmation efforts. The report must include the name, address, and telephone number of the person to contact for more information, and a site assessment report meeting the requirements of Appendix P except that the reporting deadline is as specified above in this paragraph.

NOTE: 38 M.R.S. §568(6) allows for reimbursement by the Department of documented removal costs incurred by a tank owner or operator where a tank or facility was required by the Commissioner to be removed or closed upon evidence of a leak or discharge, but later determined by a site assessment or hydrogeological investigation not to be a source of a leak or oil discharge. The facility owner or operator under these circumstances also may apply for economic damages such as loss of income through the 3rd party damage claim process outlined in 38 M.R.S. §551.

C. Minimum corrective action requirements

(1) First response measures

(a) Identify and mitigate fire, explosion and acute vapor hazards to the satisfaction of the Commissioner and the local public safety agency having jurisdiction within 24 hours of discovery of a leak or discharge or another time period approved by the Commissioner.

(b) Take immediate action to prevent any further discharge of oil from the facility to the environment within 24 hours of discovery of leak or discharge, or another time period approved by the Commissioner. This includes ceasing use and removing from those tanks and associated piping suspected or tested to be leaking as much oil as necessary to entirely stop the discharge. All tanks and piping shall be abandoned in accordance with section 11.

(c) Remove the tanks and associated piping as soon as possible in accordance with section 11 of this Chapter except that compliance with the waiting period between notification and abandonment is hereby waived.

(d) Prevent further migration of oil into surrounding soils and ground water and surface water, including the removal of any free product in the vicinity of the tanks and piping or other source of leak or discharge. Recovery of free product shall be initiated immediately upon discovery and followed by submission of a free product abatement plan meeting the requirements of paragraph 3 below.

(e) Continue to monitor and mitigate any additional fire and safety hazards posed by vapors or free product that has migrated from the excavation zone and entered into structures, sewers and utility conduits.

(2) Initial public exposure assessment and abatement. The facility owner, operator or other responsible party shall complete initial public exposure assessment and abatement measures listed below and required by the Commissioner within 30 business days of confirmation of a leak, discharge or contamination, or within another time period approved by the Commissioner.

(a) Identification of impacted and potential human receptors. Existing and potential public health risks are to be identified for the purpose of establishing initial remediation objectives. Priority shall be given to the identification of human exposure to oil contaminated drinking water supplies and indoor air in occupied buildings, followed by an assessment of the potential for human exposure by way of ground water and drinking water contamination, vapor intrusion pathways, soil off-gassing and direct soil contact.

(b) Initial soil remediation. Remediate all oil saturated soils; contaminated soils that are deemed by the Commissioner to present a threat to public or private drinking water supply wells, or public health, safety or welfare and contaminated soils that are deemed by the Commissioner to present a contact risk to residents, recreation facility users, construction or commercial workers. Soil remediation decisions will be based on soil contamination concentrations measured in accordance with Appendix Q(1)(A) or (C) and the results of field or laboratory analysis for lead identified in §12(B)(c)(i)(b) above. Measurement of residual soil contamination concentrations following source removal are to be conducted by the same methods. Acceptable laboratory methods and performance standards to be used to analyze soil samples are found in Appendix S. Oil contaminated soils and uncontaminated soils are to be physically separated to the maximum extent possible to avoid unnecessary remediation costs.

(c) Soil treatment. The method and location of contaminated soil treatment or processing (in-situ or above ground) must be approved by the Commissioner and, if to be treated off the facility site, must comply with applicable regulations administered by the Commissioner.

(d) Soil disposal. Non-hazardous oil contaminated soils may be disposed at a Maine landfill that is specifically licensed by or otherwise has been approved by the Commissioner or Department for such disposal. This paragraph does not preclude disposal at a properly licensed out of state disposal or treatment facility.

(e) Identification and sampling of nearby drinking water supply wells. Identify, and using a Global Position System (GPS) receiver or other similar technology approved by the Commissioner, locate any water supply wells on the facility parcel, and the closest private and public water supply wells to the facility on abutting properties or within 500 feet of the facility. These wells are to be sampled and analyzed for petroleum hydrocarbons and other oil constituents in accordance with Appendix S and as required by the Commissioner. When wells are found contaminated, the Commissioner may require the sampling of additional wells to ensure all water supplies contaminated by a leak or discharge are identified. The Commissioner may require water supplies suspected to be at risk of contamination to be sampled, as site conditions warrant, including any public well whose mapped source water protection area includes a portion of the facility. Wells experiencing possible petroleum odor and taste problems and located in reasonable proximity to the facility shall also be sampled. The owners of all wells sampled shall be provided with a copy and explanation of the results within 10 business days of receipt. If a public drinking water supply is found to be contaminated, the Drinking Water Program in the Maine Department of Health and Human Services must be notified within 24 hours of discovery. Water samples must be analyzed in accordance with the requirements of Appendix S.

(f) Interim treatment of contaminated private water supply wells. Owners of private water supplies found to be contaminated with oil from a confirmed leak or discharge from a facility shall be offered and provided with point-of-entry water treatment within 10 business days of the discovery of contamination. Water supply wells contaminated with arsenic or other metals released from soil or bedrock by an oil discharge and exceeding a primary federal drinking water standard or State maximum exposure guideline shall be provided with treatment meeting with the satisfaction of the Commissioner. Such treatment shall reliably reduce the level of contamination below primary drinking water standards and Maine Department of Health and Human Services maximum exposure guidelines. For water supplies contaminated with total volatile or extractable petroleum hydrocarbons below 1 ppm and MTBE below 100 ppb, two granulated activated charcoal filters of adequate volume, installed in series may be used. Contamination above these levels requires treatment by aeration. Other point-of-entry treatment systems may be used when demonstrated to be effective and reliable in reducing oil contamination and approved by the Commissioner. If treatment does not reduce contamination levels below required health standards, the Commissioner may require different or additional interim remedial measures to avoid human exposure to oil contaminants or other contaminants present due to the oil contamination.

(g) Treatment of contaminated public water supplies. The Commissioner may require contaminated public water supply wells to be provided by the owner, operator or other responsible party with treatment adequate to reduce oil concentrations and other contaminant concentrations below primary drinking water standards and Maine Department of Health and Human Services maximum exposure guidelines. The treatment system must be designed by a professional engineer licensed in Maine or working in conformance with Maine professional regulation statutes and rules, and be approved by the Commissioner, the Maine Drinking Water Program and the public water supply owner.

(h) Water supply monitoring requirements. The following minimum water supply monitoring requirements must be met unless an alternate monitoring plan is agreed upon by the Commissioner.

(i) Contaminated water supplies must be monitored by sampling once every 3 months before, between and after treatment devices for as long as the system is operating. Water shall be analyzed for petroleum hydrocarbons, oil constituents and other applicable parameters as required by the Commissioner. Water supply sampling and analyses must be conducted in accordance with Appendix S.

(ii) Water supplies found to be contaminated with oil below established health standards and guidelines must be monitored every 3 months for petroleum hydrocarbons, oil constituents and other parameters required by the Commissioner. Water supplies located in close proximity to and adjoining to contaminated ones must, along with other wells deemed by the Commissioner to be at significant risk of contamination, also be monitored in accordance with the above requirements.

(iii) Monitoring of contaminated water supplies and supplies deemed at significant risk of contamination must continue until either use of the supply is discontinued, four (4) consecutive quarterly monitoring results do not detect contamination by oil or its components above a Commissioner established action level, or monitoring is suspended by the Commissioner because it is no longer needed for other reasons.

(iv) Monitoring results must be provided to the Commissioner and the water supply owner within 7 days of receipt.

(i) Water supply treatment systems must be maintained in proper operating condition until completion to Commissioner satisfaction of a potable replacement drinking water supply or the completion of long-term correction actions and settlement of third party damage claims under 38 M.R.S. §551.

(j) Within 30 days after confirmation of a leak or other discharge of oil or another time period approved by the Commissioner, the owner, operator or other responsible party shall submit a written report to the Commissioner for approval. This report shall summarize the initial public exposure assessment and abatement measures taken, their effectiveness, an assessment of impacted and threatened human receptors, supporting analytical data or laboratory analyses, documentation that affected parties and the Maine Drinking Water Program have been properly notified, and the need for investigation of the extent and severity of contamination or for additional human exposure abatement and remediation measures.

Upon consideration of the results and findings presented above, proximity to and potential effects of contaminated soil or ground water on important ground water or surface water resources or other relevant information developed by the Commissioner, the Commissioner may require an initial contamination investigation in accordance with paragraph 4 below as well as additional initial abatement measures.

(3) Free product recovery. Free oil product must be recovered or removed to the satisfaction of the Commissioner at all sites where found. A free product abatement plan shall be submitted for the review and prior approval of the Commissioner. The free product abatement plan must be submitted within 30 days of discovering free product or another time period approved by the Commissioner. Such a plan must include, at a minimum:

(a) Methods for product control. Control of free product migration and the removal or recovery of all free product that is technically feasible shall be the minimum objectives of any abatement plan. Free product removal or recovery must be conducted in a manner that minimizes the spread of contamination into previously uncontaminated zones using recovery and disposal techniques appropriate to the hydrogeological conditions of the site, and that properly treats, discharges or disposes of recovery byproducts in compliance with applicable local, state, and federal regulations;

(b) Methods to handle any flammable products in a safe and competent manner to prevent fires or explosions;

(c) The name of the person(s) responsible for implementing free product removal or recovery procedures;

(d) The estimated quantity, type and thickness of free product observed or measured in wells, bore holes and excavations;

(e) The location of any discharge of dissolved phase oil contaminated water. Any discharge of free oil product or a free product and water emulsion is prohibited;

(f) The type of treatment to be applied to and the effluent quality expected from any discharge;

(g) The recovery and treatment system design, including sizing of pumps and recovery wells, influence on ground water and capacity calculations;

(h) A plan to monitor the performance of the proposed recovery and treatment system, including monitoring scope, locations, parameters and frequency;

(i) A contingency and response plan for the loss of product control and recovery and treatment system failure;

(j) The disposition and handling of recovered free product; and

(k) If removal is to include soil gas venting, the quality and quantity of expected air emissions.

(4) Initial contamination investigation

(a) The objectives of the initial contamination investigation are to characterize the hydrogeology of the facility and the surrounding area; to determine the concentration and extent of soil and ground water contamination; to determine the direction of contamination movement; to identify what environmental resources, including nearby surface water resources, and receptors are at significant risk of contamination; to evaluate the potential of a vapor intrusion threat to nearby buildings; to develop a conceptual model of the contamination's fate, transport, and threat to receptors; and to determine the need for and the objectives of further investigation and long-term corrective actions. The initial contamination investigation study must cover the facility site and those areas known or suspected to be contaminated by oil from the facility discharge.

(b) The following existing data, where available, must be compiled and reviewed:

(i) Soils maps;

(ii) Aerial and satellite photographs;

(iii) Well logs for all contaminated wells and wells on properties abutting a parcel with a contaminated well and all other wells within 500 feet of the facility;

(iv) A suitable base map at a scale of 1"=500' or less showing the location of existing structures, private and public drinking water supply wells within 1000 feet of the facility, source water protection areas for public water supplies mapped by the Maine Drinking Water Program, significant sand and gravel aquifers mapped by the Maine Geological Survey, ground water monitoring wells (if any), current and past locations of oil storage facilities, location of subsurface waste disposal systems and dry wells, other potential contamination sources, property ownership, surrounding land uses, rights-of-way, roads, and existing underground utilities;

(v) Surface water bodies, including intermittent streams, wetlands and flood plains;

(vi) Regional bedrock geology; and

(vii) Surficial geology.

(c) Subsurface oil contaminated soils investigation. A subsurface investigation of oil contaminated soils on and off the facility property shall be conducted based on a sampling plan submitted for Commissioner approval and relying on geo-probing, soil test pits, or other in-situ methods approved by the Commissioner to determine the depth and areal extent of oil contaminated soil, contamination concentrations, physical soil properties, depth to ground water and bedrock if feasible, presence and depth of a confining strata, and ground water contamination concentrations. Products of the oil contaminated soil investigation are to include estimates of the volume of soil posing a threat to receptors, and the mass of the oil contained in those soils.

(d) When drinking water supplies or significant ground water sources are contaminated or at risk, a potential vapor intrusion risk to an occupied structure exists, the potential for contamination of a surface water body is present, or other site specific conditions require ground water quality and flow data for remediation decisions, the Commissioner may require the installation of ground water monitoring wells and submission of a ground water sampling plan. The following minimum data must be collected and logged during the boring and sampling of ground water monitoring wells:

(i) Soil and subsoil conditions and types (described using the unified soil classification system);

(ii) Presence and depth of confining strata;

(iii) Presence and depth of free oil products;

(iv) Depth of water table;

(v) Presence and depth of bedrock; and

(vi) Continuous split spoon logging screening for oil contaminated soils above the water table using the field methodology outlined in Appendix Q or another technique of comparable precision and reliability approved by the Commissioner.

(e) Water quality sampling and analyses requirements include:

(i) Each well must be properly developed and allowed to stabilize prior to sampling;

(ii) Water samples shall be collected and analyzed for petroleum hydrocarbon fractions and target chemicals using the Massachusetts Department of Environmental Protection’s volatile and extractable petroleum hydrocarbon laboratory methods. Other chemical analyses may be required by the Commissioner where needed to assess the extent of and the public health risk of contamination;

(iii) Laboratory analysis of water samples must be conducted in accordance with the requirements of Appendix S; and

(iv) At least 2 complete rounds of sampling are required from all monitoring points, including surrounding water supply wells, at least one month apart.

(f) Nearby surface water bodies likely to be affected must be sampled and analyzed for oil.

(5) Within 90 days of a Commissioner request to perform an initial contamination investigation, or another time period approved by the Commissioner, the owner, operator or other responsible parties shall submit a report of the findings and conclusions of the initial contamination investigation to the Commissioner for review and approval. The following data, results and conclusions must be included in the report:

(a) Data and sample collection and analysis methods used;

(b) Hydrogeological site description addressing the general geological setting of the site; potential and present contamination hazards; bedrock and overburden interconnection; extent and location of ground water and soil contamination; the direction and rate of contamination migration estimate of impacted aquifer properties including hydraulic conductivity, transmissivity and storativity; ground water and surface water resources at risk of contamination; identification of water supply wells contaminated or at imminent risk of contamination; and identification of receptors at risk of hydrocarbon vapor problems;

(c) Soil, soil gas and indoor air, ground water and surface water quality data, including all field and laboratory data, and the relationship of measured contaminant levels to State of Maine and federal allowable contaminant standards or guidelines;

(d) Minimum data and findings to be presented in tables, figures or appendices:

(i) Detailed site/locus map;

(ii) Geologic maps or cross sections to illustrate the site's geological setting;

(iii) Ground water contour map;

(iv) Geophysical survey map, if any;

(v) Table or map showing water quality sampling results;

(vi) Soil sampling results;

(vii) Boring logs and well installation details; and

(viii) All testing laboratory reports and results;

(e) A conceptual site model integrating the findings of investigation work to date, evaluating exposure pathways and the risks to public health and environmental receptors including nearby surface waters, and identifying critical information gaps needed for remediation decision-making; and

(f) Recommendations addressing the need and objectives for additional contamination investigation or monitoring, and the need for additional immediate abatement measures and/or corrective actions for long-term remediation of oil discharges.

(6) Upon review of the initial investigation report, the Commissioner may require the owner, operator or other responsible party to undertake further investigations to determine the need, objectives and feasibility of long-term corrective actions, or the Commissioner may require responsible parties to undertake long-term corrective action in accordance with paragraph D below.

D. Long-term corrective actions. The facility owner, operator or other responsible party may be required by the Commissioner to provide replacement potable drinking water, to mitigate the risk of contamination to private and public drinking water supplies or important ground water or surface water resources, to prevent human exposure to unhealthy petroleum vapors or soil contact, to control fire and explosion hazards, to protect or restore important biological resources, and to otherwise protect the public health, safety and the environment. Because of the site specific needs and objectives of long-term corrective actions, the owner, operator or other responsible party may be required by the Commissioner to submit for approval a long-term corrective action plan. In reviewing the corrective action plan the Commissioner will consider at a minimum the factors in section 12(A)(1). The schedule for submitting, the format, additional information needs, the overall contents and the objectives of the long-term corrective action plan will be determined by the Commissioner on a site by site basis. All required long-term remediation plans will identify feasible remediation alternatives and evaluate their long-term cost effectiveness in meeting the remediation objectives established by the Commissioner for an oil contamination site. Regardless of whether a facility owner or operator applies for and is eligible for coverage of their remediation costs from the Maine

Ground and Surface Waters Clean-up and Response Fund under 38 M.R.S. §568-A, a capital and annual operating budget and implementation schedule for the recommended remediation alternative shall be submitted for the Commissioner's review and approval as part of the long-term remediation plan.

Upon approval of the corrective action plan or as directed by the Commissioner, the facility owner, operator or other responsible party must implement the plan, including modifications to the plan made by the Commissioner. They must monitor, evaluate, and report the results of implementing the plan in accordance with the schedule and format established by the Commissioner.

E. Public information and participation requirements

(1) At the time of submission to the Commissioner, copies of the discharge and leak investigation and confirmation report, the initial response and abatement report, the free product abatement plan, the initial contamination investigation report and the long-term corrective action plan must be sent by certified mail by the owner, operator or other responsible party to the chief municipal officer with jurisdiction or the county commissioners if in an unorganized township, who are responsible for ensuring these documents are available to the public for inspection at the municipal or county offices. The discharge and leak investigation and confirmation report and free product abatement plan also must be provided to the local fire chief with jurisdiction.

(2) The owner, operator or other responsible party shall provide a copy of the discharge and leak investigation and confirmation report, and corrective action plan by certified mail to owners of land parcels abutting the facility, those members of the public directly affected by the release and those affected by the planned corrective action, and to holders of an easement or a right-of-way for an underground utility conduit on the facility or along a public or private road abutting the facility.

(3) Prior to approving a long-term corrective action plan, the Commissioner may hold a public meeting to inform and to solicit comments from impacted residents, abutting landowners and local officials. The Commissioner shall provide written notice 7 days in advance of such a meeting to affected parties, including at a minimum impacted residents and the chief municipal officer, and the responsible parties, if known. When a long-term corrective action effort is to be terminated prior to meeting the objectives of the long-term corrective action plan, the Commissioner shall provide written notice by certified mail to the chief municipal officer with jurisdiction or the county commissioners if an unorganized township, and to residents who have suffered oil contamination.

F. Environmental data analysis methods and quality assurance requirements

(1) Water, soil, soil gas and air samples are to be analyzed in accordance with Appendix S; and

(2) Samples are to be collected in accordance with laboratory method instructions, established environmental media sampling protocols, and a quality assurance plan approved by the Commissioner.

G. The Commissioner may require ground water, soil and other environmental sample locations and quality data to be submitted in an electronic form compatible with the Maine Environmental Geographic and Analysis Database (EGAD). The format shall be provided by the Commissioner.

H. Nothing in this section limits Department authority or discretion under 38 M.R.S. §568 to order or undertake immediate remedial or corrective action at sites where evidence of contamination by oil is present.

13. Regulation of wastewater treatment tank systems and aboveground oil storage tanks

A. Applicability

This section applies to the following types of tanks:

(1) A wastewater treatment tank system that meets the definition of an underground oil storage tank and that is not regulated by the *Clean Water Act* §§ 402 or 307(b) (1972) (33 U.S.C., §1317(b) or §1342 (2016)); and

(2) Aboveground oil storage tanks that are associated with field constructed underground oil storage tanks and airport hydrant systems.

B. Registration. The tanks regulated by section 13(A) must be registered in accordance with section 4.

C. Installation requirements

(1) All new and replacement tanks must be constructed and installed in accordance with 40 C.F.R. §280.11, as amended up to July 1, 2018.

(2) The underground oil storage facility or any portion thereof must be installed by a properly Certified Underground Oil Storage Tank Installer with the appropriate class of certification.

D. Financial assurance. The owner or operator of tanks regulated in section 13(A) of this Chapter must comply with the requirements of section 5(D)(15).

E. Discharge and leak investigation, response and corrective action requirements. The owners or operators must comply with the requirements of section 12 of this Chapter, except that the owners and operators may meet the initial site characterization requirements of 40 C.F.R. §280.63, as amended up to July 1, 2018, in lieu of conducting a site assessment in accordance with Appendix P.

14 Severability. If any provision of this Chapter is declared invalid or ineffective by a court decision, the decision does not invalidate any other provision of this Chapter.

Appendix A: Requirements for Cathodic Protection Monitoring

1. For Galvanic Cathodic Protection Systems

A. All measurements must be made by placing a saturated copper/copper sulfate reference electrode in direct contact with the soil electrolyte.

B. The copper/copper sulfate electrode must be placed over the center line of each tank and within 1 foot of each piping run. For single-walled tanks a minimum of three (3) measurements are to be made over the center line of each tank, one at each end and one at the tank's midpoint. For double-walled tanks, a minimum of one voltage measurement over each tank's midpoint is required.

C. All measurements must be recorded using a direct current voltage measuring device with a minimum of 10 megohms input impedance, accurate to at least + 1 percent at 1 volt.

D. A measurement of at least negative 0.85 volts must be recorded for each test location and each metallic facility component, including tanks, piping, and connectors that are cathodically protected.

E. When a negative voltage of at least 0.85 volts is not achieved upon installation of the tank or piping, the measurement must be repeated within 6 months. Upon failing to achieve a negative voltage of at least negative 0.85 volts after the 6-month period, the tank owner shall comply with paragraph F, below.

F. The tank owner shall repair or replace the system in accordance with the recommendations of the National Association of Corrosion Engineers, Standard Practice 0285- or STI Recommended Practice for the Addition of Supplemental Anodes to STI-P3® USTs, R972 and section 5(D)(14) of this Chapter whenever the system does not register a negative voltage reading of at least 0.85 volts for each tank or piping run within six (6) months of the first failed measurement, or properly abandon in accordance with section 11, except as provided for in paragraph E for a new installation.

G. The frequency of cathodic protection monitoring must be consistent with the requirements outlined in section 5(D)(3) and (4).

H. A cathodically protected steel tank or piping that continues to fail to achieve the minimum level of adequate corrosion protection of at least 0.85 volts within six (6) months of repair or replacement in accordance with paragraph F shall be properly abandoned in accordance with section 11.

2. For Impressed Current or Galvanic Cathodic Protection Systems

Test methods and criteria as described in the NACE TM 0101, Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Tank Systems, or TM 0497, Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems, are to be used to monitor impressed current systems. These methods for testing galvanic systems may be used with prior written approval of the Commissioner.

NOTE: Structure to soil potentials measured when the soil is frozen may be inaccurate because of the increased resistance of the soil electrolyte. Cathodic protection monitoring schedules should be planned to avoid frozen soil conditions.

Appendix B: Requirements for Tank, Piping and Containment Sump Tightness Tests

1. Volumetric tank tightness testing for single- walled tanks

A. For all tanks without overfill and spill prevention equipment installed in accordance with section 5(B)(3) or 6(B)(3) and properly operating, all tests must be conducted by overfilling the tank at least to grade level. For tanks with operating overfill and spill prevention equipment meeting the requirements of this Chapter, tests may be conducted if the tank is at least 60 percent full, provided the test is in accordance with manufacturer protocols and with any limitations determined by independent testing in accordance with EPA approved protocols, or other protocols approved by a nationally recognized independent testing organization, including but not limited to the ASTM and the National Work Group on Leak Detection Evaluations.

B. All tests must take into consideration all variables which may affect the determination of a leak rate, including, but not limited to, temperature, pressure, external water table elevation, vapor pockets and tank end deformation.

C. External water table elevation must be verified via a tank backfill ground water observation well at the time of testing for each tank location. The observation well is to be installed in accordance with paragraph 6(C) of this appendix.

D. All tests must be performed in strict conformity to all of the testing equipment manufacturer's operating procedures, and the following standard protocols:

(1) Tests must not be conducted during a fluctuating ground water table;

(2) Height-to-volume conversion factors must be measured rather than calculated;

(3) The test must be conducted under nearly constant hydrostatic pressure; and

(4) If the tank is less than 95 percent full during the volumetric test then the ullage space must also be tested using an appropriate tank tightness test method.

2. Non-volumetric tightness testing for single walled tanks

A. Non-volumetric and all other tank tightness tests must be performed in strict conformity to the manufacturer's protocols as used in the method's independent performance testing.

B. The ground water elevation must be measured at the time of testing via a ground water observation well installed in accordance with paragraph 6(C) of this appendix. If ground water is encountered in the observation well, a sample is to be taken and visually inspected for the presence of free product.

3. Tightness testing for single- walled piping

A. All pressurized product piping tests must be performed at 150 percent operating pressure, or if performed at a lower pressure, it must be able to obtain a leak rate equivalent or smaller than that determined by the piping test method's independent performance testing in accordance with EPA approved protocols.

B. All tests must be performed in strict conformity to all of the testing equipment manufacturer's standard operating procedures. In addition, the test must be run a minimum of one hour.

C. Tightness testing requirements for single-walled safe suction piping are considered to be met when a Maine Certified Underground Oil Storage Tank Installer or Inspector confirms in writing that each suction line is properly sloped back to the tank, and there is only one check valve in each line installed as close as practical to the pump.

4. **Tightness testing of tanks and piping with secondary containment.** For double walled tanks and piping, the integrity of both the inner and outer walls will be tested by testing the interstitial space rather than the primary containment. Tanks and piping with secondary containment shall be tested in accordance with sections 4 and 5 of the PEI Recommended Practice for Testing and Verification of Spill, Overfill, Leak Detection and Secondary Containment Equipment at UST Facilities, PEI 1200 or in accordance with protocols reviewed and approved by the Commissioner prior to use.

5. **Tightness testing of containment sumps.** Containment sumps will be tested by an alternative procedure approved by the Commissioner, or in accordance with testing procedures outlined in section 6 of the Petroleum Equipment Institute, Recommended Practices for Testing and Verification of Spill, Overfill, Leak Detection and Secondary Containment Equipment at UST Facilities, PEI 1200, or the manufacturer’s instructions.

6. **Other requirements**

A. Testing technicians shall be certified by the manufacturer of the testing equipment.

B. The additional requirements of this paragraph apply to the testing of single-walled tanks used to store ethanol blended gasoline.

(1) Tightness tests must be conducted with 10 or less inches of product in the tank using a test method approved for use with such product levels; and

(2) The tank must be tested manually for water and phase-separated gasoline.

C. Ground water elevation observation well installation. The observation well to determine the elevation of ground water is to be installed in the sand, gravel or pea stone backfill of the tank excavation to a depth of one (1) to two (2) feet below the tank bottom in accordance with EPI Recommended Practice 100. The observation well is to be a minimum of 1 inch in diameter and may be installed using direct push technology. The well is to be constructed of factory screened PVC pipe. Well screening is to start 5 feet above the ground water table and extend to the bottom of the well. Wells are to be installed flush with the ground surface and in a raised, limited access road box. The annulus around the well must be sealed with bentonite or a similar sealing material from 2 feet above the screen upward to the bottom of the road box. Permeable sand must be placed around the road box so that water can drain from the road box. A Maine Certified Underground Tank Installer must be present during the installation of the well to minimize the risk to the structural integrity of the facility.

D. Tank and piping tightness tests involving the removal and reinstallation of existing facility components, including but not limited to, leak detection or overfill prevention equipment, drop tubes, or vent valves, must have an Underground Oil Storage Tank Installer or Inspector present to supervise such facility equipment removals and repairs. The installer or inspector must be certified by BUSTI and by the manufacturer of the equipment being repaired, when such manufacturer certification is available. Tank testing involving excavation above, around or within 10 feet to tanks or piping also requires a Maine Certified Tank Installer to be present to supervise such excavation in accordance with section 5(D)(19) of this Chapter.

E. All test results must include the following information in order to be accepted by the Commissioner:

(1) Facility name, address, registration and tank number, and the product stored;

(2) Depth to ground water and whether free product was found in the ground water observation well;

(3) Whether the facility components tested passed or failed, and the measured leak rate;

(4) The method's threshold for declaring a leak; and

(5) Certification that the test method has been performed according to the manufacturer's protocols used in the third party evaluation, or a protocol for double-walled tanks approved by the Commissioner, and that ground water elevation was measured and taken into account in determining if a leak was present.

F. Written test results must be submitted to the Commissioner by the facility owner and the tester when conducted to verify evidence of a possible leak. Routine annual precision tests conducted to meet the requirements of section 5(C)(2)(a) or 5(F) of this Chapter need only to be submitted by the facility owner.

Appendix C: Requirements for Pneumatic (Air) and Other Pre-installation Tightness Testing

For Piping and Tanks

1. Air pressure testing of tanks and piping shall only be performed on new, empty tanks and piping, which have never contained product, and the manufacturer has not specified an alternate means of tightness testing.

2. When conducting an air pressure test on metallic tanks or piping, all external joints, seams and connections shall be soaped.

3. The test shall be maintained for a minimum of 1 hour, and all soaped areas shall be visually inspected for bubbles or any other indication of a leak.

4. Any loss of pressure or appearance of bubbles shall constitute failure of the test.

Piping

5. Underground piping shall be physically isolated from the tank prior to the test.

6. Underground primary piping shall be air tested to 150 percent of the maximum anticipated pressure of the system, but not less than fifty (50) pounds per square inch (psi) gauge at the highest point of the system.

7. Underground secondary piping must be tightness tested before being backfilled in accordance with manufacturers' instructions.

Tanks

8. Tanks shall be tested before being covered, enclosed or placed in service.

9. Primary tanks must be air tested at not less than three (3) pounds per square inch (psi) and not more than five (5) pounds per square inch (psi) gauge. Gauges used during air testing of tanks must have a maximum limit of 10-15 pounds per square inch (psi).

10. The interstitial space of double-walled tanks must be tightness tested following the manufacturer's instructions.

Appendix D: Installation Requirements Applicable to New and Replacement Tanks

1. All new and replacement tanks and associated leak detection and overfill and spill prevention equipment must be installed in accordance with manufacturer's instructions and the following nationally accepted codes of practice: API Publication 1615, "Installation of Underground Petroleum Storage Systems"; PEI Publication RP 100, "Recommended Practices for Installation of Underground Liquid Storage Systems"; and National Fire Protection Association Code 30, 30A or 31.

   NOTE: Tank installation instructions may require specific sized pea stone or gravel. Instructions also may specify mechanical compaction or layered placement of bedding and backfill. Always consult the installation instructions provided by the manufacturer, prior to installation.

2. Cathodically protected steel tanks must be set on a firm base and surrounded on all sides with at least 24 inches of noncorrosive inert material, such as clean sand, pea stone, or gravel, well tamped in place. The tanks must be placed in the hole with care, making sure not to scrape the protective coating off coated tanks, or damage attached cathodic protection components. Cathodic protection systems require electrical wiring connected to the tank at each end and at its centerline, and accessible for voltage readings at the ground surface as well as three (3) locations along the centerline of the tank to place a reference electrode in contact with the soil.

3. Cathodically protected steel underground tanks must be covered with a minimum of 2 feet of sand, pea stone or gravel, or with not less than 1 foot of sand on top of which is placed a slab of reinforced concrete not less than 4 inches thick. This fill must be free of debris, boulders, large rocks or other materials that may cause abrasions to the protective coating of the tank. When tanks are, or are likely to be, subjected to traffic, they must be protected from damage from vehicles passing over them by at least 3 feet of backfill or, 18 inches of well-tamped backfill plus 6 inches of reinforced concrete or 8 inches of asphalt paving. When asphalt or reinforced concrete paving is used as part of the protection, it must extend at least 1 foot horizontally beyond the perimeter of the tank in all directions.

4. All cathodically protected steel and nonmetallic fiberglass tanks must be installed in accordance with manufacturer instructions. The minimum depth of cover is as specified in section 3 above.

5. New underground tanks must be tested for tightness before being covered or placed in use by a test method approved by the manufacturer. If a pneumatic test is conducted, it should be done in conformance with the requirements of Appendix C.

   NOTE: Air pressure testing when petroleum vapors are present in the tank may result in explosion, and shall not be conducted after petroleum product has been placed in the tank.

6. All temporary supports must be removed prior to final backfilling.

7. All electrical wiring must be performed in accordance with the current State of Maine electrical code.

8. Anchoring is required when a tank is installed in an area where ground water will be in contact with the tank or in a 100 year flood plain as mapped by the FEMA, or if such mapping is unavailable, as determined by the flood of record or by the presence of flood plain soils. When anchoring tanks equipped with cathodic protection, the holddowns must be electrically isolated from the tank. Anchoring of all tanks must be performed in accordance with the tank manufacturer's specification or PEI Publication RP 100.

NOTE: FEMA flood plain maps are available for inspection at most municipal offices.

Appendix E: Installation Requirements for New and Replacement Piping

1. All new and replacement piping, sumps and associated leak detection must be installed in accordance with the manufacturer's instructions and the following nationally accepted codes of practice: API Publication 1615, "Installation of Underground Petroleum Storage Systems", PEI Publication RP 100, "Recommended Practices for Installation of Underground Liquid Storage Systems", STI Standard R 892, and NFPA 30, 30A and 31.

2. Before underground piping is installed, the trench must receive as a minimum a 6-inch deep bed of well compacted noncorrosive material such as clean sand, pea stone or gravel. All trenches must be wide enough to permit at least 6 inches of noncorrosive backfill material around all lines.

3. Prior to being covered or placed in service, all new and replacement piping must be tested for tightness by a method approved by the manufacturer. Air pressure tests are to be conducted in accordance with the requirements of Appendix C, and hydrostatic tests must be conducted in accordance with the requirements of Appendix B.

4. All temporary supports must be removed prior to final backfilling.

5. All vent piping for storage of Class I liquids must extend at least 12 feet above the ground surface and be positioned such that vapors will not pose a hazardous condition. Vent piping must slope back to the tank with a slope of at least 1/8 inch per foot.

6. Fill piping for storage of Class I liquids must be set back from any building opening in accordance with National Fire Protection Association Codes 30, 30A or 31.

7. Product supply lines used in conjunction with pressurized pumping systems must be installed with a product line leak detection device. All leak detection devices must be tested for proper operation before the remote pumping system is used after initial installation and once annually thereafter. All leak detectors must be capable of detecting a leak at a rate of at least 3 gallons per hour at a line pressure of 10 psi within one hour of occurrence with a 95 percent probability of detection and a 5 percent probability of false alarm.

8. A double-poppet crash valve must be installed under dispensers of pressurized pumping systems in accordance with the National Fire Protection Code 30A.

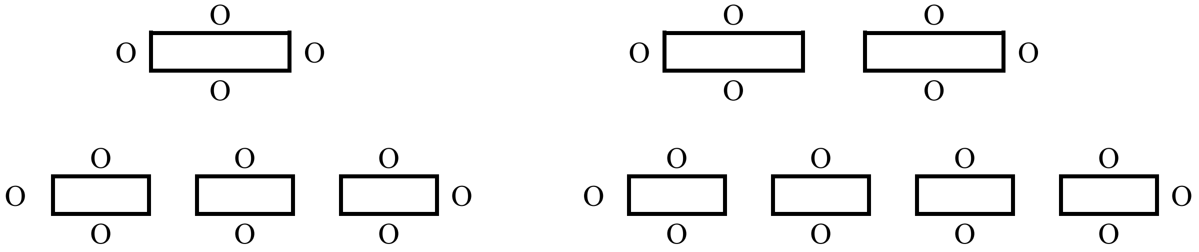
9. Safe suction systems must have no more than one check valve per pump. The check valve must be located as close to the pump as possible, such that any leaks in the line will result in a return of product to the tank. Safe suction piping must slope back to the tank with at least a 1/8 inch per foot slope. Supply and return piping for a facility storing oil for an emergency standby generator are exempt from this requirement if secondary containment with continuous interstitial space monitoring is provided in accordance with section 5(B)(2) of this Chapter.

10. When the product dispenser of a motor fuel facility is at a lower elevation than all or a portion of the tank height, an anti-siphon ("normally closed") valve must be installed as close as physically possible to the start of the down-gradient run of the product piping in order to prevent the loss of the tank contents in the event of a piping leak.

Appendix F: Specifications and Requirements for Vertical Ground Water Monitoring Wells at Existing Facilities

These requirements only apply to existing facilities, fully installed as of April 19, 1990.

1. Sufficient number of vertical ground water monitoring wells must be installed to detect a leak from every tank by including a minimum of four monitoring wells for each tank or where more than one tank is installed in the same continuous excavation, the minimum number of monitoring wells shall be installed as diagrammed below:



   When more than one tank is installed in a continuous excavation hole, alternate numbers and positioning of ground water monitoring wells may be used when determined by a Maine licensed professional engineer or Maine certified geologist as capable of detecting a leak or discharge from every tank and meeting the performance and installation requirements of section 5(C) of this Chapter. Such an alternate ground water monitoring plan must be certified by a Maine licensed professional engineer or Maine certified geologist, and submitted to the Commissioner as part of the facility's registration materials.

2. Monitoring wells must be a minimum of 2 inches in diameter.

3. The slotted zone must extend at least 5 feet into the water table and at least 5 feet above the ground water surface, as determined at the time of installation; or when installed within a secondary containment liner, the slotted zone must extend to within 6 inches of the low point of the liner.

4. The screened portion of the well must be a minimum of 10 feet in length and must be factory slotted with a slot size of .010 inch.

5. Monitoring wells must be installed with a cap at the bottom of the slotted section of the well.

6. Monitoring wells must not be constructed of schedule 20 PVC "sewer" or leach field piping.

7. Monitoring wells must be constructed of flush joint, threaded schedule 40 PVC or other materials and designs approved by the Commissioner.

8. Monitoring wells must be numbered such that all monitoring and testing results are easily correlated to a specific monitoring well location.

9. All monitoring wells must be equipped with liquid-proof lockable caps.

10. Monitoring wells must be properly distinguished from fill pipes.

11. The area around the screened portion of the well shall be surrounded by a porous medium (e.g. sand, gravel or pea stone).

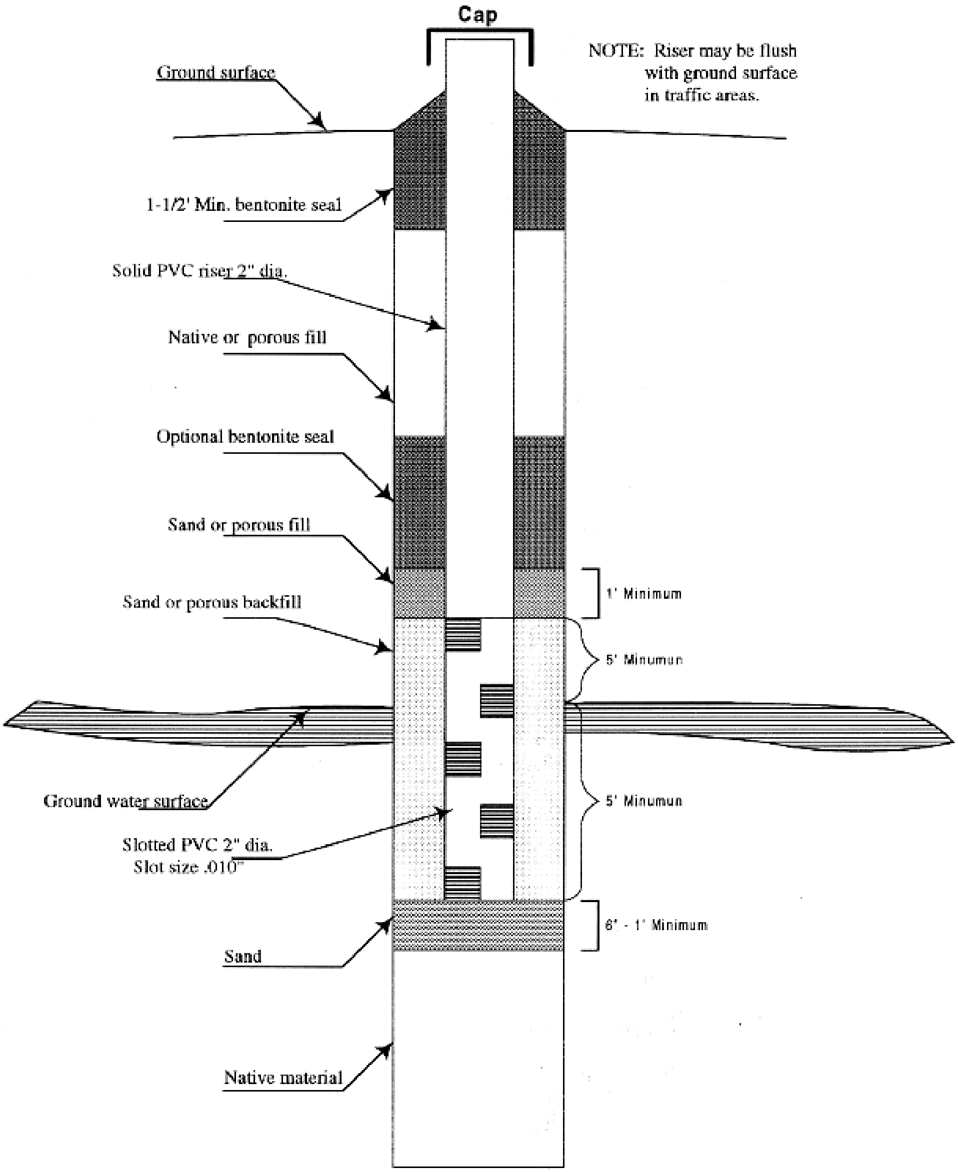
12. The outside of the monitoring wells risers must be sealed using bentonite or a similar product to a depth of 1 1/2 feet below ground surface.

13. Monitoring wells located in traffic areas must be cut off at ground level, clearly marked, and fitted with a limited access cover in accordance with PEI Publication RP 100 or properly protected from vehicles.

14. Any damaged monitoring well must be repaired or replaced as soon as possible after discovery of the damage, but at least within 45 days.

FIGURE I

VERTICAL MONITORING WELL



Not to scale

Appendix G: *Repealed*

Appendix H: Procedures for Weekly Monitoring, Handling, and Obtaining Samples for Laboratory Analysis

These procedures are specifically for manual sampling of ground water monitoring wells used as leak detection to meet the requirements of section 6(C)(3) of this Chapter.

NOTE: Due to the extreme sensitivity of laboratory analytical equipment, it is very important that all bailers, pumps and sample vials be kept clean. A contaminated pump or bailer may cross-contaminate monitoring wells or falsely indicate the presence of hydrocarbons in the ground water. It is also important that the person taking the sample have clean hands free of any grease, oil or gas.

For Weekly Monitoring, Perform Steps 1 through 7.

1. All equipment used shall be washed with a detergent soap and triple rinsed with water which is known to be uncontaminated to ensure the device is clean. The individual(s) performing the sampling shall wash their hands thoroughly prior to sampling.

2. Measure and record the distance from the top of the casing to the water surface.

3. Measure and record the distance from the top of the casing to the bottom of the well.

4. After checking for free product using a clear bailer and when the volume of water in the well is sufficient remove several bailer volumes of water.

5. Lower the bailer into the well and remove a sample. Pour the contents of the bailer into a clear container.

6. Inspect the sample for free product or an oily sheen. Smell the sample for olfactory evidence of oil.

7. Record the results in a logbook which, shall be kept at the facility. A sample log sheet is attached in Figure 3.

   NOTE: Commercially available pastes, which change color upon contact with hydrocarbons can be spread on a weighted, plastic tape measure or measuring stick and lowered the depth of the well. Pastes are also available which will change color upon contact with water. The use of these pastes is an acceptable method of determining water levels and detecting product in monitoring wells for the purpose of complying with weekly monitoring requirements. The use of an oil/water interface probe is also acceptable.

8. Prior to obtaining samples for laboratory analysis, remove 3 well volumes of water from each well. The water may be removed by bailing or pumping the well. For 2-inch wells, remove about 2.5 gallons of water for every 5 feet of well water.

9. After a sufficient volume of water has entered the well, take a sample for analysis.

10. Samples shall be poured into vials designed for sampling volatile organics. Standard sampling vials are glass, 30-50 milliliters in volume with a Teflon cap. Obtain the sample vials from the lab where the analysis will be performed. Care shall be taken, such that no air bubbles are in the sample vial. Record the sample vial number and the monitoring well number, such that the laboratory analysis may be correlated to a specific well location.

11. Samples shall be securely packed and shipped the same day or in accordance with the protocols for the analysis being conducted. Samples shall be kept cool and not exposed to heat. A record shall be kept of all dates and shipping arrangements. Samples must be analyzed in accordance with the requirements of Appendix S of this Chapter.

12. For monitoring wells, which are installed with the impervious barrier, which contains less than two (2) feet of water, do not attempt to remove three well volumes of water. It may be necessary to sample the well during or after periods of rain whenever possible.

13. For monitoring wells, which do not have enough water to obtain a sample, measure the depth of the well to insure the well is not filled in or has not collapsed. Using a gauge stick or hard plastic tape, apply paste which will turn color upon contact with hydrocarbons. Record the results of both measurements for each well in the logbook.

FIGURE 3

SAMPLE WEEKLY MONITORING WELL LOG SHEET

Monitoring Well No.	1	2	3	4	5	6	7	8
1. Date of Sampling								
2. Time of Sampling								
3. Distance from Casing to Ground Water								
4. Distance from Casing to Bottom of Well								
5. Method for Determining Water Levels								
6. Instrument Cleaned (Washed and Triple Rinsed)								
7. Instrument Used (Bailer, Pump, etc.)								
8. Results of Sight and Smell Test								
9. Initials of Person Performing the Sampling								

10. Comments

Appendix I: Sample Daily Inventory Reporting Log

KEEP THIS COMPLETED FORM FOR 3 YEARS

MONTHLY FUEL REPORT/DAILY INVENTORY

Month/Year

Facility & Location: Registration Number:

Tank Size and Fuel Type: Certified By:

Date	Opening Inventory (Book Inventory of Previous Day)	Gallons Pumped	Gallons Delivered	Book Inventory Balance	Closing Stick Inventory	Cumulative Over or <Short>	Inches Water	Initials
Math Check		-	+	=				

Leak Check: Sum of Gallons Pumped ( ) x .01 =

IF THE ABSOLUTE VALUE OF THE "CUMULATIVE OVER OR SHORT" ON THE LAST DAY OF THE MONTH IS GREATER THAN LEAK CHECK RESULT, IT IS CONSIDERED EVIDENCE OF A POSSIBLE LEAK AND YOU MUST NOTIFY DEP AT (207) 287-7688.

Log Sheet #1

Appendix J: Requirements for Abandonment of Underground Oil Storage Tanks by Removal

1. The top of the tank must be exposed.

2. All piping must be drained and flushed into the tank or other suitable container such that no waste water or product is released to the environment (1 or 2 gallons of water should be sufficient to flush piping).

3. All liquid that can be pumped out must be removed, and any liquids that cannot be used for their originally intended purpose must be disposed of in accordance with the Department's *Waste Oil Management Rules*, 06-096 C.M.R. ch. 860. UL listed explosion proof equipment must be used to remove Class I liquids. Hoses to remove product must be inserted to the low end of the tank, which may still contain product. Flammable vapors from vacuum trucks removing oil from a tank or facility must be vented at least 12 feet above the ground surface.

4. The fill (drop) tube must be removed. Fill, gauge, and product lines must be disconnected. The open ends of all lines must be capped or plugged. All tank openings that will not be used in the inerting procedure also must be plugged. Only the vent line will remain connected and open until the inerting procedure is complete. The vent line must be at least 12 feet above the ground surface.

NOTE: Due to the potential of waste oil tank explosions, the Department strongly recommends treating all waste oil tanks as a Class I liquid tank except where testing shows the internal atmosphere not to be explosive.

5. All tanks that contained Class I liquids must be made safe prior to removing the tank from the ground using one of the following methods:

   A. The tank can be inerted with dry ice in the amount of 1.5 pounds per 100 gallons of tank capacity. Dry ice shall be crushed and distributed evenly over the greatest possible area. During the inerting process, all necessary precautions to prevent ignition in the entire area shall be taken.

   B. The tank can be inerted using nitrogen or another inert gas approved by the Commissioner, introduced at low pressure at the bottom of the tank. Inerting is considered complete when oxygen levels in the tank are measured at less than 6 percent.

   C. The tank can be removed if the tank atmosphere is found to be oxygen deficient as defined by an oxygen reading of less than 6 percent.

   D. The tank can be rendered vapor free by air purging in accordance with API 1604. Air purging is considered complete when an explosimeter indicates an atmosphere inside the tank of less than 10 percent of the LEL while an oxygen meter indicates greater than 14 percent oxygen. Air purging using air-moving equipment found on a vacuum truck is not allowed.

   During any of the above inerting, purging or removal procedures, all necessary precautions to prevent ignition in the area must be taken, including but not limited to: grounding and bonding of equipment; use of explosion proof or intrinsically safe equipment; ambient air monitoring of the surrounding area; and pedestrian and traffic control. All weather and ambient atmospheric conditions must be evaluated prior to inerting or purging, including but not limited to air exchange, wind direction and humidity. All air monitoring instruments must be calibrated according to the manufacturer's specifications. Measurements with air monitoring instruments must be taken at the following points: one foot from the bottom of the tank; at its lowest end; the middle of the tank's diameter; and at the tank opening.

NOTE: All contaminated soil must be removed or otherwise cleaned up to the satisfaction of the Commissioner.

6. All holes, including corrosion holes, must be plugged or capped before the tank is moved from the site, except that one 1/8 inch vent hole must be left to prevent the tank from being subjected to an excessive pressure differential caused by extreme temperature changes.

7. If transported, the tanks must be scraped to remove all loose backfill material adhering to the tank.

8. All tanks removed from the ground, regardless of condition, must be labeled with the following information: Tank Has Contained Leaded Gasoline (or Flammable Liquid) NOT GAS FREE.

NOTE: U. S. Department of Transportation regulations, *Hazardous Materials Regulations*, 49 C.F.R. §172.500-172.560 also require tanks which have not been purged but are being transported to be labeled on the ends and sides with a "Flammable" placard with the appropriate UN Number (1203 or 1993) attached.

9. If transported, the tank must be secured on a truck such that the 1/8 inch vent hole is located on the uppermost point on the tank.

10. All piping must be removed from the ground whenever practicable. Piping that cannot be removed must be blown clear of residual product with an inert gas and securely plugged at all ends. All necessary precautions to prevent spillage or ignition in the entire area must be taken.

11. Some tank disposal facilities require that tanks be cleaned of sludge and residues prior to accepting the tank. Any cleaning and temporary storage operations must be performed at a site acceptable to local public safety officials and not on a sensitive geologic area, as defined in section 3 of this Chapter. Any cleaning operation involving flammable materials or generating flammable vapors must be performed at a remote site where public access can be restricted by fencing or other suitable means 24 hours/day. Tank cleaning may be performed at the site where the tank is removed only with the permission of the local public safety official.

NOTE: If cleaning a tank at the site of its removal, it is recommended that the tank be cleaned while still in its excavation hole, the safest location in the event of an explosion or fire.

12. The only acceptable means of disposal of underground oil storage tanks are:

    A. Sale to a properly approved junk or scrap dealer;

    B. Disposal at a tank processing facility meeting the criteria of Appendix L of these rules and approved by the Department; or

    C. Other techniques for disposal of tanks, provided the expressed written approval of the Department and the State Fire Marshal's office has been obtained.

13. Tanks must be stored with all bung holes open and positioned at a 45 degree angle down from horizontal to prevent rain from entering the tank and to allow vapors to escape.

Appendix K: Requirements for Abandonment of Underground Oil Storage Facilities by Filling in Place

1. Piping must be drained and flushed into the tank.

2. All liquid that can be pumped out, including that liquid requiring a hand pump to remove, must be removed and any liquids that cannot be used for their originally intended purpose must be disposed of in accordance with the Department's *Waste Oil Management Rules*, 06-096 C.M.R. ch. 860. UL approved explosion proof equipment must be used to remove Class I tanks that may still contain product. Flammable vapors from a vacuum truck removing oil from a tank or facility must be vented at least 12 feet above the ground surface, effective September 28, 1991. All sludge will also be removed, handled, stored and disposed of in accordance with 06-096 C.M.R. ch. 851 of the Department's hazardous waste rules. Where it can be demonstrated to Department satisfaction that a sludge is not a hazardous waste, it may be disposed at a solid waste disposal facility licensed for such wastes.

3. The top of the tank must be exposed.

4. The fill (drop) tube must be removed. Fill, gauge, and product lines must be disconnected. Open ends of all lines, except the vent line, must be capped or plugged.

NOTE: Due to the potential of waste oil tank explosions, the Department strongly recommends treating all waste oil tanks as a Class I liquid tank except where testing shows the internal atmosphere not to be explosive.

5. All tanks that contained Class I liquids must be made safe prior to removing the tank from the ground by using one of the following methods:

   A. The tank can be inerted with dry ice in the amount of 1.5 pounds per 100 gallons of tank capacity. Dry ice shall be crushed and distributed evenly over the greatest possible area. During the inerting process, all necessary precautions to prevent ignition in the entire area must be taken.

   B. The tank can be inerted using nitrogen or another inert gas approved by the Commissioner, introduced at low pressure at the bottom of the tank. Inerting is considered complete when oxygen levels in the tank are measured at less than 6 percent.

   C. The tank can be considered inert if the tank atmosphere is found to be oxygen deficient as defined by an oxygen reading of less than 6 percent.

   D. The tank can be rendered vapor free by air purging in accordance with API 1604. Air purging is considered complete when an explosimeter indicates an atmosphere inside the tank of less than 10 percent of the LEL while an oxygen meter indicates greater than 14 percent oxygen. Air purging using air-moving equipment found on a vacuum truck is not allowed.

   During any of the above inerting, purging or removal procedures, all necessary precautions to prevent ignition in the entire area shall be taken, including but not limited to: grounding and bonding of equipment; the use of explosion proof or intrinsically safe equipment; ambient air monitoring of the surrounding area; and pedestrian and traffic control. All weather and ambient atmospheric conditions must be evaluated prior to inerting or purging, including, but not limited to, air exchange, wind direction, and high humidity. All air monitoring instruments must be calibrated according to the manufacturer's specifications. Measurements with air monitoring instruments must be taken at the following points: one foot from the bottom of the tank; at its lowest end; the middle of the tank's diameter; and at the tank opening.

6. Vapors from the tank must be vented at least 12 feet above the ground surface.

7. A suitable, solid, inert material must be introduced through the hole in the top of the tank. The following materials are suitable for this purpose:

   A. Sand. Sand that is free of rocks is suitable for filling. It may be poured dry as long as it flows freely. When the tank is nearly full, sand should be washed into the tank with a nominal amount of water and puddled to cause the sand to flow to the tank ends. The use of large amounts of water must be avoided.

   B. Sand and Earth Fill. The tank can be (1) filled with sand to about 80 percent of the calculated capacity, and (2) filled to overflowing for the remaining capacity using a mixture of soil and water in a free-flowing mud.

   C. Cement or mortar.

Appendix L: Requirements for Underground Oil Storage Tank Processing Facilities

1. Applicability

   A. The requirements of this appendix apply to underground oil storage tank processing facilities where tanks used for the storage of oil and abandoned by removal are cleaned, temporarily stored and processed prior to recycling or re-use of their materials.

   B. For the purpose of this appendix, the cleaning operation of a tank processing facility includes those areas and activities where vapors, liquids, solids, sludge, rust, scale and other residues are removed and cleaned from an abandoned underground oil storage tank, including buffers, structures, roads and equipment.

   C. For the purpose of this appendix, the processing operation of a tank processing facility includes those areas and activities where cleaned tanks are cut, crushed, reduced in volume or otherwise modified prior to sale or re-use of their materials.

2. Siting. Underground oil storage tank processing facilities may not be located:

   A. On a coastal sand dune system, as defined in the *Natural Resources Protection Act,* 38 M.R.S. §480-B(1);

   B. On coastal wetlands as defined in 38 M.R.S. §480-B(2);

   C. On freshwater wetlands, as defined in 38 M.R.S. §480-B(4);

   D. On a one hundred year flood plain, as defined in the Solid Waste Management Rules*: General Provisions,* 06-096 C.M.R. ch. 400 of the Department's rules;

   NOTE: In most areas of Maine, the flood plains have been mapped by the Federal Emergency Management Agency (FEMA). Maps are available at most municipal offices.

   E. Within a public water system's source water protection area as mapped by the Maine Bureau of Health, or a sensitive geological area as defined in section 3(EEE) of this Chapter;

   F. Within 300 feet of bodies of surface water classified as Class GPA waters in the *Water Classification Program*, 38 M.R.S. §465-A or classified as Class AA waters, Class A waters, Class B waters, or Class C waters in 38 M.R.S. §465; or

   G. Within 100 feet of an adjacent property boundary.

   NOTE: If the area of a facility, including all operations, temporary storage areas, structures, roads and buffers, exceeds 3 acres, the owner also must obtain approval under the *Site Location of Development Law*, 38 M.R.S. §§ 481-489-E, and the Maine *Hazardous Waste Septage and Solid Waste Management Act*, 38 M.R.S. §§ 1301 -1319-Y.

3. Design

   A. The entire facility must be surrounded by a fence or otherwise secured to the Commissioner's satisfaction to prevent unauthorized access to the tanks. Signs stating "Caution - Flammable Materials", "No Smoking" and "No Entry of Unauthorized Personnel" must be placed along the fence at intervals no greater than 50 feet.

B. A 25-foot fire protection buffer must be cleared of combustible materials on all sides of the facility. This buffer must be maintained at all times free of all structures, equipment, cleaned tanks and other facility activities. Overhanging branches and vegetation must be cut back to distances safe from fire and explosion. The fire buffer may lie outside the fenced portion of the facility.

NOTE: Graveling the area and removing the vegetation are examples of means that would normally achieve this purpose.

C. The facility must be equipped with fire protection equipment of the size, quantity, type and location directed by local fire officials or by the Commissioner. Equipment must be kept operable at all times.

D. The facility must be equipped with a means of communication (such as a telephone or two-way radio) with fire and medical emergency personnel.

E. A contingency plan meeting the requirements of *Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities,* 40 C.F.R.§264.52 as amended up to July 1, 2017 must be developed to provide for prompt response to fire and explosion hazards, and for containment and removal of any spilled material. A copy of the contingency plan must be sent to the Commissioner and to local public safety officials. A copy must be kept at the facility at all times.

F. Cleaning Operations Design

(1) Any area underlying a cleaning operation must be surrounded by a berm of sufficient height to contain all residues, cleaners and precipitation that may be contaminated by these substances. This area and berm must be underlain by a clay or synthetic liner, which in turn must be completely covered by a firm, continuous working surface (such as concrete) that is compatible with hydrocarbons. The area must be equipped with a collection system which contains for removal of all solid and liquid tank residues, cleaners, and all precipitation that may be contaminated by these substances.

(2) A clay liner must be at least two feet thick and must have a permeability no greater than 10-7 cm/sec. A synthetic liner must be at least 40 mils thick and must be of a material compatible with all residual tank contents and cleaners. It must be installed in accordance with the manufacturer's specifications. An independent professional engineer or authorized liner manufacturer's representative shall observe the entire installation and testing, and shall certify to the Department that the installation, testing and repairs occurred in accordance with the manufacturer's specifications. Either a clay or synthetic liner must extend at least 10 feet in all directions beyond all tanks requiring containment, and must be anchored to the berm in a secure fashion.

(3) The collection sump, tanks, and all equipment must be of adequate size to contain the volumes of tank residues, cleaners, and any contaminated precipitation that will be generated. They must be constructed of materials compatible with the wastes generated.

(4) A tank is deemed clean when:

(a) all loose scale has been removed from the inside of tank walls;

(b) all solid and liquid residues have been removed from tanks walls; and

(c) the tank has been ventilated by air, steam, or some other means so that its atmosphere does not exceed 10 percent of the Lower Explosive Limit (LEL).

G. Processing Operations Design

(1) Processing operations areas must be physically isolated from the cleaning operations area such that no flammable or explosive hazards exist in the processing areas due to cleaning operations.

(2) Processing operations areas need not be lined, but must be maintained in a manner so that processing debris (e.g. cuttings, etc.) can be collected and removed.

H. Temporary Storage Area Design

(1) Tanks at a processing facility may be temporarily stored on site for less than 12 months, provided the following conditions are met:

(a) All tanks must be stored in a "chocked" condition to prevent rolling, and must have the top openings (manufactured openings or bungs) open and located at a 45 degree angle from the ground to prevent rainfall from entering and to facilitate venting. Any corrosion or non-manufactured holes must be plugged.

(b) A 3-foot separation must be maintained between all tanks to allow weekly inspection for leakage and cleanup of spills. Any tanks found to be leaking must be immediately cleaned in accordance with this Chapter.

(c) Any discharge of oil to soil or ground water in any unlined portion of the facility must be immediately reported and removed to Department satisfaction.

(2) Under no circumstances must a tank be stored or remain at a facility for a period exceeding 1 year from the date of the tanks arrival at the facility.

4. Operation

A. All tanks arriving at a processing facility must be brought immediately into a secured area and inspected. The inspector shall note tank condition (severe corrosion, splits, number and size of holes) and evidence of leaks such as product on outside tank surfaces, or adhering contaminated soil. This information must be recorded in a facility log book.

B. Following inspection, all tanks must be marked conspicuously and permanently with a serial number assigned by the facility, date of receipt and product last stored, if known.

C. Any tanks containing liquids must be pumped dry immediately following inspection. Any pumping or removal of liquids must be conducted in a lined portion of the facility. Any liquid-free tanks may then be brought to a temporary storage area provided they are stored in accordance with Appendix L (11)(H).

D. Solid and liquid residues from tank cleaning or processing will be disposed of in compliance with appropriate federal, state and local laws, regulations and ordinances. All residues are presumed to be hazardous waste, requiring disposal under the provisions of the Department's *Hazardous Waste Management Rules*, 06-096 C.M.R. ch. 850-857, unless testing or other information establishes, in accordance with 06-096 C.M.R. ch. 850, that they are not.

NOTE: Sludge and solid wastes found to be non-hazardous are special wastes subject to the requirements of the Department's rules, *Water Quality Monitoring, Leachate Monitoring and Waste Characteristics* 06-096 C.M.R. ch. 405. Liquid petroleum wastes found to be nonhazardous are waste oils subject to the requirements of 06-096 C.M.R. ch. 860 of Department's rules.

E. After tank identification, cleaned tanks must be brought to the processing operation area unless stored in accordance with paragraph 3(H) of this appendix. Tanks not cleaned upon arrival must be taken to a cleaning operations area, unless stored in accordance with paragraph 3(H) of this appendix.

F. The facility must maintain a log book at the facility at all times. It must be kept current and made available to Department inspectors upon request. The log book must contain the following information for each tank:

(1) facility-assigned serial number;

(2) location from which tank was removed;

(3) tank size;

(4) contents when last in use;

(5) tank condition upon arrival (e.g. sound, badly corroded, number of holes);

(6) date cleaned;

(7) date processed; and

(8) final disposition (sold whole, cut up, crushed).

In addition the log book must include information on types and volumes of all residues generated, how they were disposed of, and when. All records must be kept for at least three years.

G. Ground water monitoring must be conducted at the facility. A ground water monitoring plan, developed and certified by a Maine certified geologist, must be submitted to the Commissioner with the facility application. The plan must provide for a minimum of one upgradient and three down-gradient wells, located and screened to detect releases of hydrocarbons as early as practicable.

Appendix M: Cathodic Protection Tester Certification Requirements

1. The requirements of this appendix apply only to individuals not certified by the Maine Board of Underground Tank Installers for underground oil storage facility installation. Maine Certified Underground Oil Storage Tank Installers are considered to meet the definition of a cathodic protection tester as long as their installer certification remains valid.

2. An underground oil storage tank inspector is approved by the Commissioner as a cathodic protection tester when certified by the Maine Board of Underground Storage Tank Installers in accordance with 32 M.R.S. §10010(6)(C).

Appendix N: Corrosion Expert Certification Requirements

1. The Commissioner may certify a person as a corrosion expert on finding that the person has a thorough knowledge of the physical sciences and the principles of engineering and mathematics acquired by professional education and related practical experience and is qualified to engage in the practice of corrosion control on buried or submerged metal piping systems and metal tanks. Only individuals may be certified.

2. Criteria for certification by the Commissioner

   A. Documentation of valid certification by the NACE as a qualified corrosion expert; or

   B. Registration as a professional engineer in Maine, and certification or licensing, by a professional organization or educational institution other than NACE, based on adequate education and experience in corrosion control of buried or submerged metal piping systems and metal tanks.

3. Application procedures

   A. On an application form provided by the Commissioner, applicants must provide the following information and certify its accuracy.

      (1) Applicant's name, business mailing address, and telephone number;

      (2) Documentation of NACE or other professional or educational institution's certification;

      (3) Documentation of Maine registration as a professional engineer, if needed;

      (4) Description of relevant work experience, college courses (including transcript) and other technical training courses; and

      (5) Three written professional references.

   B. Upon the review and approval of an application as meeting all the certification criteria of this Chapter and 38 M.R.S. §567-A(2), the Commissioner shall issue a certificate valid for 12 months.

   C. Requests for recertification must be made to the Commissioner in writing 30 days prior to expiration of the existing certificate. The Commissioner may deny a request for recertification request on any one of the following grounds: a documented improper installation of corrosion protection not in accordance with the requirements of this Chapter; the expiration or loss of NACE or other professional certification; or loss of a valid professional license as a registered Maine professional engineer. An individual who has lost his or her certification may reapply after 12 months for recertification consistent with requirements of paragraph 2 above.

   D. The Commissioner may undertake enforcement actions corrosion experts for violations of this Chapter, in accordance with the provisions of 38 M.R.S. §347-A.

Appendix O: *Repealed*

Appendix P: Requirements for a Site Assessment at Facility Closure or Tank Abandonment

1. The purpose of a site assessment for facility closure or abandonment is to determine if discharges of oil have occurred requiring notification of the Commissioner and corrective action by the owner, operator or another responsible party.

2. General requirements

   A. A site assessment meeting all the requirements of this appendix must be completed prior to the completion of facility closure or the abandonment of any portion of a facility in accordance with section 11. This includes abandonment of only piping.

   B. Site assessor qualifications. If a tank or facility is located within a sensitive geologic area, as defined by this Chapter, the site assessment must be supervised by, and the site assessment report must be certified by, a Maine certified geologist, licensed professional engineer, or other persons meeting the requirements of Maine's professional regulation statutes and regulations for geologists or professional engineers practicing in Maine. As provided under 38 M.R.S. §563-B(1), the closure site assessment for facilities not located in a sensitive geologic area are exempt from the above qualification standards for the person conducting the assessment.

   C. The findings of all site assessments conducted pursuant to this Chapter must be presented in a written report with supporting data, addressing the requirements of this appendix.

   D. One paper copy and one digital PDF version of all site assessment reports conducted pursuant to this Chapter must be submitted to the Commissioner by the facility owner within 45 days of tank and piping removal or abandonment in place. The paper copy must be in an envelope endorsed "UST Site Assessment" and sent to the following address: UST Program Administrator, MDEP-BRWM, 17 SHS, Augusta ME 04333-0017. Electronic submittals must be submitted to UST.Site.Assessment@maine.gov with the tank registration #, address and municipality in the subject line.

   If a site assessment finds evidence of a discharge or contamination above a notification level in Appendix Q, an additional paper copy of the site assessment report must be submitted at the same time, to the chief municipal official of the municipality within which the facility is located or to the county commissioners if located in an unorganized township.

   NOTE: Upon receipt of a site assessment report, the Commissioner will review and determine if further investigation or remediation is needed in addition to any completed at the time of the facility abandonment in accordance with section 12.

   E. Site assessment reports must follow the general format and include the following information:

      (1) A completed summary cover sheet using the, form attached to this appendix;

      (2) A description of the purpose of the site assessment per Appendix P(1), a description of the tanks and piping to be removed or abandoned in place, and a description of the areas to be assessed in the site assessment;

      (3) Identification of the facility name and site location;

      (4) A description of the facility and site history under Appendix P(5) when evidence of a discharge or contamination above notification levels in Appendix Q is found;

(5) Identification of all potential receptors under Appendix P(4) when evidence of a discharge or contamination above notification levels in Appendix Q is found;

(6) Description of the site assessment methods utilized, including field instrument methods, laboratory methods and quality assurance/quality control (QA/QC) procedures followed;

(7) Findings of the site assessment, including field and laboratory analytical results for all soil and water samples collected, a site plan showing the location and sample number of all soil and water samples; and

(8) Recommendations and conclusions.

F. The Commissioner may require sample location and quality data to be submitted in an electronic format compatible with the Maine Environmental and Geographic Analysis Database (EGAD). The format for such data will be provided by the Commissioner.

G. Exception for the removal of flexible primary piping when piping is being replaced. The site assessment requirements in paragraphs 2(B) through 2(E) do not apply to the removal of the flexible primary piping of double-walled piping when conducted in accordance with section 5(B)(6-A) of this Chapter and the following requirements.

(1) Prior notification by the facility owner or operator of the piping abandonment to the Commissioner and the municipality is provided in accordance with section 11(F) of this Chapter.

(2) Upon removal, the entire length of primary piping is visually inspected by a Maine Certified Underground Oil Storage Tank Installer and the physical condition and the integrity of the piping is documented, including any evidence of a discharge or leak.

(3) The Certified Underground Oil Storage Tank Installer submits to the Commissioner and the facility owner or operator the findings of the visual inspection on a reporting form provided by the Commissioner within 30 days of the piping abandonment and removal.

(4) Any oil discharge is reported to the Commissioner within 2 hours of discovery.

3. The following facility and site location information must be included in all site assessments:

A. Mailing and street address of facility;

B. Tax map and lot number;

C. Whether it is located in a sensitive geologic area as defined by this Chapter; and

D. UTM, longitude/latitude decimal coordinates, or Google Earth satellite photograph or comparable map showing the precise location of the facility dispensers, tanks, and piping runs.

4. The following information regarding potential receptors must be provided where contamination or evidence of a discharge of oil has been found:

A. A description of surrounding land uses and the extent of public drinking water service to all abutters and the surrounding area. A facility layout plan showing locations of property boundaries, tanks, product and vent lines, dispensers, subsurface waste water disposal systems, dry wells, floor drains, sewer lines and underground utilities;

B. Type of oil products discharged; and

C. Recommendations regarding the need for further investigation of the extent of contamination and the objectives of the remediation of the oil discharge, including the following:

(1) Free product and oil saturated soils;

(2) Protection and remediation of ground water, private public drinking water supplies, public drinking water supplies and their source water protection areas mapped by the Maine Drinking Water Program, and significant sand and gravel aquifers mapped by the Maine Geological Survey;

(3) Petroleum vapor intrusion or indoor air quality;

(4) Direct human contact to contaminated soils; and

(5) Surface water bodies.

5. If evidence of a discharge of oil is found, the site assessment must also include the following facility and site history information:

A. Product storage and distribution system history, including:

(1) Location of tanks or piping previously abandoned in place;

(2) Type of oil products most recently stored;

B. A list of all known prior oil and hazardous substance discharges and their Commissioner assigned spill number; and

C. Summary of the findings of previous available site assessments and contamination investigations.

6. Site assessment requirements for the removal of heavy oil storage facilities.

A. Tanks, piping and other underground facility components must be inspected visually upon removal for presence of holes, loose fittings and joints, cracks, fractures and evidence of oil stains. If any of the conditions above are found the facility owner or operator shall notify the Commissioner of the occurrence of a discharge within 2 hours of discovery.

B. The tank and piping excavation must be inspected visually for any evidence of a discharge of oil; including oil stained or saturated soil, strong petroleum vapors emitted from soil or free product or an oil sheen on ground water in the excavation. The presence of any of the above conditions is considered an indication of a discharge of oil and must be reported to the Commissioner within 2 hours of discovery by the facility owner or operator and before the excavation hole is filled. The owner shall immediately proceed with an investigation and corrective action measures in accordance with section 12.

C. The entire facility must be inspected visually for surface spills and discharges. Such spills and discharges must be reported to the Commissioner in accordance with section 12(A).

D. Upon visual discovery of evidence of a leak or discharge of oil at a heavy oil facility and reporting such to the Commissioner, the site assessment investigation at the time of closure may be terminated, except where a tank or piping was located on or in bedrock in which case the presence of contaminated ground water must be investigated in accordance with paragraph 9 below.

7. Site assessment requirements for motor fuel and marketing and distribution facilities when tanks or piping are removed and immediately replaced, or when an operating facility will remain.

   A. Applicability. The requirements of this section apply when an underground oil storage facility or a portion thereof, is removed and then replaced with a new underground oil storage facility on the same land parcel, utilizing all or part of the same tank excavation hole. The requirements below also apply to situations when only a portion of a facility is removed and other parts of the facility remain in operation.

   B. Tanks, piping and other underground facility components must be inspected visually upon removal for presence of holes, loose fittings and joints, cracks, fractures and evidence of oil stains. If any of the conditions above are found the facility owner or operator shall notify the Commissioner of the occurrence of a discharge within 2 hours of discovery.

   C. The tank and piping excavation must be inspected visually for any evidence of a discharge of oil; including oil stained or saturated soil, strong petroleum vapors emitted from soil or free product or an oil sheen on ground water in the excavation. The presence of any of the above conditions is considered an indication of a discharge of oil and must be reported to the Commissioner within 2 hours of discovery by the facility owner or operator and before the excavation hole is filled. The owner shall immediately proceed with an investigation and corrective action measures in accordance with section 12.

   NOTE: OSHA regulations governing entering excavations and confined spaces should be strictly followed. Excavations should not be entered if above 20 percent of the Lower Explosive Limit (LEL), or less than 19.2 percent or greater than 25 percent oxygen.

   D. The entire facility must be inspected visually for surface spills and discharges. Such spills and discharges must be reported to the Commissioner in accordance with section 12(A) of this Chapter.

   E. Oil contaminated soil assessment. Soil in the tank and piping excavation holes and under removed dispensers, as well as areas of identifiable surface spills, must be evaluated for oil contamination by one of the methods specified in Appendix Q.

8. Site assessment requirements for waste oil facilities, and motor fuel and marketing and distribution facilities when a facility is removed but not immediately replaced.

   A. Applicability. The following requirements apply to all waste oil facilities. They also apply to motor fuel and marketing and distribution facilities when an underground oil storage facility is fully closed and removed without a replacement facility being immediately installed.

   B. Tanks, piping and other underground facility components must be inspected visually upon removal for presence of holes, loose fittings and joints, cracks, fractures and evidence of oil stains. If any of the conditions above are found the facility owner or operator shall notify the Commissioner of the occurrence of a discharge within 2 hours of discovery.

   C. The tank and piping excavation must be inspected visually for any evidence of a discharge of oil; including oil stained or saturated soil, strong petroleum vapors emitted from soil or free product or an oil sheen on ground water in the excavation. The presence of any of the above conditions is considered an indication of a discharge of oil and must be reported to the Commissioner within 2 hours of discovery by the facility owner or operator and before the excavation hole is filled. The owner shall immediately proceed with an investigation and corrective action measures in accordance with section 12.

D. The entire facility must be inspected visually for surface spills and discharges. Such spills and discharges must be reported to the Commissioner in accordance with section 12(A).

E. The facility and the surrounding area are to be evaluated prior to the facility removal to identify potential receptors and exposure pathways to facilitate remediation decisions in the event a discharge is discovered. At a minimum, these should include public drinking water supplies and their source water protection areas mapped by the Maine Drinking Water Program, private drinking water supplies, significant sand and gravel aquifers mapped by the Maine Geological Survey, surface water bodies, and occupied buildings potentially at risk in the event of vapor intrusion pathways. If known, the next land use of the facility parcel is to be identified and the potential for residents, recreation users, outdoor commercial workers and construction workers to be exposed to oil contaminated soils evaluated.

F. Oil contamination assessment. Soil in the tank and piping excavation holes and under dispensers, as well as areas of identifiable surface spills, are to be evaluated for oil contamination by one of the methods specified in Appendix Q.

9. Requirements for facilities installed on or in bedrock. In addition to other applicable site assessment requirements in this appendix, when a tank or piping run has been installed onto or in bedrock without adequate soil backfill or bedding to test for soil contamination, a minimum of two (2) down gradient ground water monitoring wells must be installed under the supervision of a Maine certified geologist or Maine licens ed professional engineer in addition to above requirements of this appendix. Additional wells may be required by the Commissioner for tanks with more than 20,000 gallons capacity. Monitoring wells must be sampled for visual and olfactory evidence of oil as well as for dissolved phase product using a hydrocarbons laboratory analysis method meeting the requirements of Appendix S and appropriate for the oil products stored at the facility in the past. The detection of oil contamination must be reported to the Commissioner within 2 hours by the facility owner or operator. This paragraph applies to all removed facilities required to do a site assessment, including heavy oil facilities.

10. Site assessment requirements when tanks and piping are abandoned in place.

A. The requirements of this section apply whenever a facility or any portion of a facility are abandoned in place and are not removed. If a tank, piping section or other underground component is not removed, these requirements only apply to that particular portion of the entire facility.

B. Prior approval is required for abandonment in place in accordance with section 11(E).

C. All visible portions of the facility must be inspected for evidence of a leak, spill, overfill or other discharge, including areas around the fill and vent pipes.

D. Evidence of contaminated soils from a tank leak must be determined by either of the methods below:

(1) A minimum of two soil borings must be made per tank, located as close as technically feasible to intersect any oil contamination from the surface to below the estimated depth of the tank bottom or to bedrock or below the ground water table, whichever is shallower. An additional number of borings may be required by the Commissioner for tanks with more than

20,000 gallons capacity. The borings must be logged and screened continuously for visual evidence of oil stained and saturated soils, and oil vapors using a photo or flame ionization field instrument as removed from the ground. A sample must be taken from soil showing the highest reading for field analysis using a method outlined in paragraph 1 of Appendix Q or another Commissioner approved method of comparable accuracy and sensitivity.

(2) Other subsurface investigation methods approved by the Commissioner.

E. If piping cannot be removed such that entire excavation can be inspected, evidence of an oil discharge from the piping is to be evaluated using a methodology appropriate for the site conditions and approved in advance by the Commissioner.

F. When a facility was installed on or into bedrock, when borings encounter bedrock before reaching an elevation below that of the bottom of the tank or piping, or when ground water is encountered prior to reaching the depth below that of the tank or piping; a minimum of two ground water monitoring wells must be installed down gradient, as close as feasible. For tanks greater than 20,000 gallons capacity, the Commissioner may require additional monitoring wells. Monitoring wells samples must be inspected for visual and olfactory evidence of oil as well as analyzed for dissolved phase gasoline, diesel fuel or heating oil, depending on the oil products stored at the facility in the past. Only results from a laboratory method meeting the requirements of Appendix S will be accepted by the Commissioner. The detection of oil contamination must be reported to the Commissioner within 2 hours by the facility owner or operator.

G. When the above site assessment procedures for a facility to be abandoned in place are not technically feasible, another procedure may be used when approved by the Commissioner prior to the initiation of facility closure.

11. After-the-fact site assessments. For circumstances when an underground oil storage facility was previously removed without a site assessment to determine if oil contamination is present, a site specific investigation and sampling plan is required. Such a sampling plan should at a minimum include soil borings, test pits or other similar invasive means to collect soil samples to the depth of a typical tank installation, and describe the field and/or laboratory analytical methods proposed for use. The sampling plan must be submitted in advance of conducting the work for Commissioner approval. The Commissioner may require sampling of ground water, drinking water supplies, or surface water where warranted.

Chapter 691 Summary Cover Sheet Form for Underground Oil Storage Facility Site Assessment

The purpose of a site assessment for facility closure or abandonment is to determine if discharges of oil have occurred requiring notification of the Commissioner and corrective action by the owner, operator or another responsible party.

Facility Registration Number:	
Municipality Where Facility Located:	
Tax Map and Lot Numbers:	

	Facility	Owner	Operator
Name			
Company			
Address			
City, State and Zip			
Phone			

Facility hydrogeological information to be verified by site assessor: Enter No or Yes below.

Facility in Sensitive Geological Area?	Sand & Gravel Aquifer?
≤ 1000’ From Public Water Well/Intake?	≤ 300’ Private Water Well/Intake?

"Evidence" of a Discharge or Contamination Above a Notification Level? Yes ☐ No ☐	
If Yes, Enter Spill #	DEP Responder Name:

For facilities assessed: Enter tank & piping (chamber #) information below. For tank and piping status enter closed (C), not closed (NC), removed (R) or abandoned in place (AIP). ***Provide reference to report narrative for clarifications or inconsistencies with Notice of Intent to Remove.***

Tank #	Status?	Assessed?	Piping? (Chamber #)	Status?	Assessed?	Product Type?
		Yes ☐ No ☐			Yes ☐ No ☐	
		Yes ☐ No ☐			Yes ☐ No ☐	
		Yes ☐ No ☐			Yes ☐ No ☐	
		Yes ☐ No ☐			Yes ☐ No ☐	
		Yes ☐ No ☐			Yes ☐ No ☐	
		Yes ☐ No ☐			Yes ☐ No ☐	
		Yes ☐ No ☐			Yes ☐ No ☐	

Submittal Requirements: Each page of the site assessment report must be consecutively numbered. For email submissions, put DEP registration number, address and municipality name in email subject line and send to UST.Site.Assessment@maine.gov. Please note that the DEP may request additional paper copies.

If **no** "evidence" of a discharge or contamination above a notification level, please send one paper copy to UST Program Administrator, DEP-BRWM, 17 SHS, Augusta ME 04333-0017 and a digital PDF version to the above noted email address.

If **yes** "evidence" of a discharge or contamination above a notification level, please send one paper copy to the above noted postal address and a digital PDF version to the above noted email address and one copy to the chief municipal officer or county Commissioner if unorganized township (List name and address of municipal officer or county Commissioner here:).

Date Site Assessment Field Work Completed:	Date of Site Assessment Report:
Assessor Name and Company:	

Appendix Q: Facility Closure Site Assessment Characterization and Notification Requirements

For the purpose of site assessment soil testing requirements, soil shall mean sand, silt, clay and mixtures thereof to which oil or oil components may adsorb. Soil does not include pea stone, crushed stone, or similar materials used for backfill around tanks, piping and other facility components.

1. One of the following soil sampling methods must be utilized when conducting a closure assessment in accordance with 06-096 C.M.R. ch. 691, §11. Any deviations must be documented and explained in the closure assessment report.

   A. The Department's standard operating soil sampling method.

   NOTE: The Department's standard operating soil sampling method may be found on the website at: http://www.maine.gov/dep/spills/petroleum/documents/sop/ts004.pdf. This method is entitled Compendium of Field Testing of Soil Samples for Gasoline and Fuel Oil, TS004.

   B. The Site Assessment Soil Sampling Method for laboratory analysis and associated notification levels.

      (1) Applicability. This soil sampling procedure is only applicable to facilities that stored gasoline, aviation gasoline, diesel fuel, and #1 and #2 heating oils. Because of the degree of professional judgment required by this procedure, site assessments conducted by this method must be certified by a Maine certified geologist, a Maine licensed professional engineer or geologist or engineer otherwise in compliance with Maine's professional regulation statutes.

      (2) Field screen soil from the walls and bottom of the tank excavation hole and piping run and under dispensers using a photo-ionization device (PID) with a lamp energy of 10.2 to 10.6 eV, calibrated to isobutylene in accordance with the instrument's manufacturer instructions and bump tested to check the calibration at the start of each day and after every 2 hours of use.

      (3) PID field screening to identify suspected oil contaminated soils must be conducted in accordance with the following minimum requirements:

         (a) Collection of 200 gram (6 oz.) soil samples, each placed in a double layered metalized polyester and polyethylene bag, closed, kneaded to break clumps, shaken for 30 seconds, and the headspace concentration immediately measured with the PID while the bag is closed around the instrument probe;

         (b) Collection of at least 5 samples for field analysis from the tank excavation, 1 from each side wall and 1 from the excavation bottom;

         (c) Collection of at least 1 sample from beneath each dispenser or loading rack;

         (d) Collection of samples along each piping run trench beneath the location of joints, elbows, sump penetrations and other likely locations of possible leaks; and

         (e) Recording of headspace readings.

(4) Soil samples must be collected for laboratory analysis from the following locations and where in the professional judgment of the site assessor the highest concentrations of oil contamination will be found:

(a) Gasoline, diesel and fuel oil facilities. A minimum of 2 soil samples must be collected. One sample must be collected and analyzed from the bottom of the tank excavation and 1 sample must be collected and analyzed from beneath the piping.

(b) Gasoline and aviation fuel facilities. At facilities storing gasoline or aviation gasoline, a minimum of 1 sample must be collected and analyzed at each of the following locations:

(i) Tank excavation bottom where PID Bag Headspace ≥ 40 ppm;

(ii) Beneath piping where PID Bag Headspace ≥ 40 ppm; and

(iii) Beneath dispensers where PID Bag Headspace ≥ 40 ppm.

(c) Diesel, kerosene and fuel oil facilities. At facilities storing diesel fuels, or #1 or #2 fuel oils, a minimum of 1 sample must be collected and analyzed at each of the following locations:

(i) Tank excavation bottom where PID Bag Headspace ≥ 10 ppm;

(ii) Beneath piping where PID Bag Headspace ≥ 10 ppm; and

(iii) Beneath dispensers where PID Bag Headspace ≥ 10 ppm.

(5) Laboratory soil and water samples shall be analyzed for volatile (VPH) and extractable petroleum hydrocarbons (EPH) and other parameters including those in Appendix S, as appropriate for the oil products stored at the facility, in accordance with the Massachusetts Department of Environmental Protection Hydrocarbon Fractions Laboratory Method and Appendix S.

C. Other Investigation Methods. Other methods may be proposed for approval by the Commissioner prior to the start of field work. These methods must be able to achieve comparable accuracy and precision and be capable of detecting the corresponding notification levels specified in this appendix. Other investigative methods may include, but are not limited to, soil, ground water, pore water and if applicable surface water contamination investigations using geoprobing, or obtaining samples for analysis from soil test pits, or other similar intrusive methods to assess the presence and areal extent of oil contaminated soils, and the presence of ground water and surface water contamination.

2. Notification levels

A. Any exceedance of the VPH, EPH, 1,2 dichloroethane, ethylene dibromide, or lead laboratory notification levels for soil in Table 1 below, or any exceedance of a PID baghead space for gasoline or aviation fuel of 40 ppm or for diesel, kerosene and fuel oil 10 ppm, is considered evidence of a reportable oil discharge, and shall be reported by the facility owner or operator within two (2) hours of discovery. The owner and operator must plan for additional investigation or removal of impacted soils if laboratory results show evidence of contamination above site-specific cleanup goals.

B. Any VPH, EPH, 1,2 dichloroethane, ethylene dibromide, or lead analytical result from ground water indicative of contamination as defined in this Chapter is considered evidence of a reportable discharge and shall be reported by the facility owner or operator within two (2) hours of discovery. Table 2 presents ground water notification levels based on maximum exposure guidelines published by the Maine Center for Disease Control and Prevention (December 31, 2016).

C. Any of the conditions in Appendix P(7)(B) through (D) must be reported to the Department in accordance with Appendix P.

Table 1
Laboratory Soil Notification Levels

Chemical/Fraction	**Concentration** (mg/kg)
1,2 Dichloroethane	0.036
2-Methylnaphthalene	3.6
Acenaphthene	170
Acenaphthylene	68
Anthracene	760
Benzene	0.51
Benzo(a)anthracene	2.3
Benzo(a)pyrene	2.3
Benzo(b)fluoranthene	3.5
Benzo(g,h,i)perylene	750
Benzo(k)fluoranthene	2.6
Chrysene	26
Dibenz(a,h)anthracene	0.48
Ethylbenzene	0.81
Ethylene dibromide	7.1
Fluoranthene	1,000
Fluorene	120
Indeno(1,2,3-cd) pyrene	1.6
Lead	100
Methyl tertiary butyl ether	0.19
Naphthalene	1.7
Phenanthrene	97
Pyrene	750
Toluene	8.1
Xylene	26
C5-C8 Aliphatics	1,400
C9-C12 Aliphatics	2,700
C9-C18 Aliphatics	2,700
C19-C36 Aliphatics	10,000
C9-C10 Aromatics	75
C11-C22 Aromatics	460

Table 2

Laboratory Notification Levels in Ground Water

Chemical/Fraction	**Concentration (µg/l)**
1,2 Dichloroethane	4
2-Methylnaphthalene	30
Acenaphthene	400
Acenaphthylene	400
Anthracene	2,000
Benzene	4.0
Benzo(a)anthracene	0.5
Benzo(a)pyrene	0.05
Benzo(b)fluoranthene	0.5
Benzo(g,h,i)perylene	200
Benzo(k)fluoranthene	5.0
Chrysene	50
Dibenz(a,h)anthracene	0.05
Ethylbenzene	30
Ethylene dibromide	0.2
Fluoranthene	300
Fluorene	300
Indeno(1,2,3-cd) pyrene	0.5
Lead	10
Methyl tertiary butyl ether	35
Naphthalene	10
Phenanthrene	200
Pyrene	200
Toluene	600
Xylene	1,000
C5-C8 Aliphatics	300
C9-C12 Aliphatics	700
C9-C18 Aliphatics	700
C19-C36 Aliphatics	10,000
C9-C10 Aromatics	200
C11-C22 Aromatics	200

Appendix R: List of National Standards and Codes Cited

1. American National Standards Institute (ANSI/ASME), 1430 Broadway, NY 10018.
    - Process Piping, ANSI/ASME B31.3, 2014.
2. American Petroleum Institute (API), 1220 L Street, Northwest, Washington, DC 20005-40.
    - Welded Tanks for Oil Storage, API Standard 650, 12th Edition, 2013.
    - Closure of Underground Petroleum Storage Tanks, API Recommended Practice 1604, 3rd Edition, 2010.
    - Installation of Underground Petroleum Storage Systems, API Publication 1615, 6th Edition, 2011.
    - Bulk Liquid Stock Control at Retail Outlets, API Recommended Practices 1621, 5th Edition, May 1993.
    - Interior Lining and Periodic Inspection of Underground Storage Tanks, API Recommended Practice 1631, 5th Edition, June, 2001.
    - Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems, API Recommended Practice 1632, 3rd Edition, 2002.
    - Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids, or Carbon Dioxide, Recommended Practice 1110, 6th Edition, 2013.
    - Design, Construction, Operation, Maintenance, and Inspection of Terminal & Tank Facilities, API Standard 2610, 2nd Edition, July 2005.
3. National Association of Corrosion Engineers (NACE) International, 1440 South Creek Drive, Houston, Texas 77084-4906.
    - Standard Practice, External Corrosion Control of Underground Storage Tank Systems by Cathodic Protection, NACE SP0285-2011 Edition.
    - Standard Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems, NACE SP 0169-2013.
    - Standard Test Method, Measurement Techniques Related to Criteria for Cathodic Protection of Underground Storage Tank Systems, NACE Standard TM0101-2012.
    - Standard Test Method, Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems, NACE Standard TM 0497-2012.
4. National Fire Protection Association (NFPA), 11 Tracy Drive, Avon, MA 02322.
    - Flammable and Combustible Liquids Code, NFPA 30-2015.

- Code for Motor Fuel Dispensing Facilities and Repair Garages, NFPA 30A-2018.
- Standard of the Installation of Oil Burning Equipment, NFPA 31, 2016.

5. Petroleum Equipment Institute (PEI), P. O. Box 2380, Tulsa, Oklahoma 74101.

   - Recommended Practices for Installation of Underground Liquid Storage Systems, PEI Publication RP 100-2017.
   - Recommended Practices for Inspection and Maintenance of Motor Fuel Dispensing Equipment, PEI RP500, 2011.
   - Recommended Practices for Inspection and Maintenance of UST Systems, PEI RP900, 2017.
   - Recommended Practices for the Installation of Marina Fueling Systems, PEI RP1000, 2014.
   - Recommended Practices for the Testing and Verification of Spill, Overfill, Leak Detection and Secondary Containment Equipment at UST Facilities, PEI RP 1200-2017.

6. Steel Tank Institute (STI), 5700 Oakwood Rd, Lake Zurich, IL 60047.

   - Recommended Practice for Corrosion Protection of Underground Piping Networks Associated with Liquid Storage and Dispensing Systems, R892- January 2006.
   - STI-P3 Specification and Manual for External Corrosion Protection of Underground Steel Storage Tanks, November 2015.
   - Standard for Dual Wall Underground Steel Storage Tanks, STI F841, January 2006.
   - STI Specification for Permatank, STI – F922, October 2014.
   - ACT-100 ® Specification of External Corrosion Protection of FRP Composite, Steel USTS, F894-November 2015.
   - Recommended Practice for the Addition of Supplemental Anodes to STI-P3® USTs, R972, Revised January 2006.

7. Underwriters Laboratories Inc. (UL), 333 Pfingsten Road, Northbrook, Illinois 60062-2096.

   - Standard for Steel Underground Tanks for Flammable and Combustible Liquids UL Standard 58, December 13, 1996.
   - Nonmetallic Underground Piping for Flammable Liquids, UL Standard 971, October 30, 1995, revised 2006.
   - Glass-Fiber Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols, and Alcohol-Gasoline Mixtures. UL Standard 1316. January 7, 1994.
   - External Corrosion Protection Systems for Steel Underground Storage Tanks, UL Standard 1746, January 1, 2007.

- Standard for Emergency Breakaway Fittings, Swivel Connectors and Pipe Connectors for Petroleum Products and LP-Gas, UL Standard 567, May 7, 2014.

- Outline of Investigation for Underground Fuel Tank Internal Retrofit Systems, UL Standard 1856, June 14, 2013.

8. Underwriters Laboratories of Canada, 7 Underwriters' Road, Toronto, ON, M1R3B4.

   - Standard for External Corrosion Protection for Steel Underground Tanks for Flammable and Combustible Liquids, 4th Edition, CAN/ULC-S603-14- 2014.

   - Standard for Isolating Bushings for Steel Underground Tanks Protected with External Corrosion Protection Systems, ULC – S 631-05.

   - Standard for Fibre Reinforced Plastic Underground Tanks for Flammable and Combustible Liquids, ULC – S615-14, 3rd Edition, October 2014.

   - Standard for Non-metallic Underground Piping for Flammable and Combustible Liquids, ULC – S660-08, 1st Edition, May 1, 2008.

   - Flexible Underground Hose Connectors for Flammable and Combustible Liquids, UL Canada Standard CAN/ULC-S633, August 1, 1999.

   - Outline of Investigation for Underground Fuel Tank Internal Retrofit Systems, UL1856, 1st Edition, June 14, 2013.

9. Unified Facilities Criteria, Department of Defense, National Institute of Building Sciences, 1090 Vermont Avenue NW, Suite 700, Washington, DC 20005

   - Unified Facilities Criteria (UFC) 3-460-01, Design: Petroleum Fuel Facilities, Change 2, June 17, 2015.

Appendix S: Department Approved Laboratory Analytical Methods and Performance Standards for Analyses of Oil and Oil Constituents in Water, Soil, Soil Gas and Indoor Air

1. All chemical laboratory analyses of soil, water and indoor air or soil gas samples required by these rules must meet the requirements of this appendix. Sampling and analyses will be conducted in accordance with quality assurance procedures approved by the Commissioner. The Commissioner may require test methods and parameters other than those listed in this appendix to address site specific circumstances.

2. Soil and water analyses. Acceptable laboratory methods for the analysis of soil and water for oil contamination include those listed below.

   A. For soil and water samples of weathered diesel, weathered #1 and #2 fuel oils, weathered jet fuel, and heavy oils – Extractable Petroleum Hydrocarbons (EPH) Analysis by Massachusetts Department of Environmental Protection, Division of Environmental Analysis; Method for Determination of Extractable Petroleum Hydrocarbons (EPH), Version 1.1, 2004.

   B. For soil and water samples of fresh diesel fuel, #2 heating oil, jet fuels, kerosene/#1 heating oil – Volatile Petroleum Hydrocarbons (VPH) Analysis by Massachusetts Department of Environmental Protection , Division of Environmental Analysis Method for the Determination of Volatile Petroleum Hydrocarbons (VPH), Version 1.1, 2004 or after April 30, 2019 the Massachusetts Department of Environmental Protection, Method for the Determination of Volatile Petroleum Hydrocarbons (VPH) by Gas Chromatography/Photoionization Detector/Flame Ionization Detector, Revision 2.1, February 2018, in conjunction with EPH analysis.

   C. Waste oil in soil or water that is not suspected of being a hazardous waste is to be analyzed using the Massachusetts Department of Environmental Protection EPH and VPH laboratory methods above, and the waste oil parameters in *Waste Oil Management Rules*, 06-096 C.M.R. ch. 860, §4.

   D. Water samples of unleaded gasoline and gasoline constituents - Volatile Petroleum Hydrocarbons (VPH) Analysis by Massachusetts Department of Environmental Protection, Division of Environmental Analysis Method for the Determination of Volatile Petroleum Hydrocarbons (VPH), Version 1.1, 2004 or after April 30, 2019 the Massachusetts Department of Environmental Protection, Method for the Determination of Volatile Petroleum Hydrocarbons (VPH) by Gas Chromatography/Photoionization Detector/Flame Ionization Detector, Revision 2.1, February 2018.

   E. Water and soil samples of leaded gasoline. Leaded gasoline must be sampled for VPH, 1,2 dichloroethane (1,2 DCA), Ethylene dibromide (EDB), and lead. Racing fuels must be sampled for VPH, lead and EPH. Aviation fuels must be sampled for VPH, 1,2 DCA, EDB, lead and EPH. The following laboratory methods must be used:

      (1) In water:
      (a) VPH method in Appendix S(2)(B);

      (b) 1,2 DCA in ground water or drinking water – EPA Method 524.2 (1995) or 8260C (2006);

      (c) EDB in ground water or drinking water - EPA Method 504.1 (1995) or 8011 (1992);

(d) Lead in ground water or drinking water - EPA Methods 200.7 (1994), 200.8 (1994), 200.9 (1994), 6020B (2014), or 7010 (2007); and

(e) EPH method in Appendix S(2)(A).

(2) In soils:
(a) VPH method in Appendix S(2)(B);

(b) 1, 2 DCA and EDB – EPA Method 8260;

(c) Lead – EPA Method 6010C:

(d) Lead – EPA Method1311/6010C; and

(e) EPH method in Appendix S(2)(A),

F. Soil samples of gasoline and gasoline constituents - Volatile Petroleum Hydrocarbon (VPH) Analysis by the Massachusetts Department of Environmental Protection, Division of Environmental Analysis, Method for the Determination of Volatile Petroleum Hydrocarbons (VPH), Version 1.1, 2004 or after April 30, 2019 the Massachusetts Department of Environmental Protection, Method for the Determination of Volatile Petroleum Hydrocarbons (VPH) by Gas Chromatography/Photoionization Detector/Flame Ionization Detector, Revision 2.1, February 2018.

G. Other laboratory methods for testing for the presence and concentrations of oil and its constituents in soil or water, approved by or required by the Commissioner, such as indicator parameters for specific site conditions or circumstances.

3. Indoor air and soil gas analyses.

A. Massachusetts Department of Environmental Protection Method for the Determination of Air Phase Petroleum Hydrocarbons (APH), 2008 in conjunction with U.S. EPA Method TO-15 SIM, Determination of Volatile Organic Compounds (VOCs) In Air Collected In Specially-Prepared Canisters And Analyzed By Gas Chromatography Mass Spectrometry (GC/MS), 1999.

B. Other laboratory methods for testing for the presence and concentrations of petroleum hydrocarbons in the air phase approved by or required by the Commissioner for a specific site or circumstance.

4. Other analytes. When testing for analytes other than those listed in Appendix S(2) and (3) above, the laboratory methods must be approved by the Commissioner prior to the collection of samples.

5. Performance standards.

A. For water analyses by the Massachusetts Department of Environmental Protection Methods for EPH or VPH, laboratories must be certified to perform the method by the Maine Department of Health and Human Services at the time an analysis is performed and meet quality control standards set forth in section 10 of the analytical method.

B. For soil analyses by the Massachusetts Department of Environmental Protection Methods for EPH or VPH, laboratories must be certified to perform the method by the Maine Department of

Health and Human Services at the time an analysis is performed and meet quality control standards set forth in section 10 of the analytical method.

C. For water analyses, other than EPH and VPH methods, the Estimated Quantitation Limit (EQL), as determined by EPA guidelines, SW-846, is to be equal to or lower than the Maximum Contaminant Level (MCL) or primary drinking water standard, and in the absence of a MCL, is to be less than the Maine Department of Health and Human Services published Maximum Exposure Guideline (MEG) or site remediation target approved by the Commissioner for that test parameter.

D. For soil analyses by methods other than EPH and VPH methods, the Estimated Quantitation Limit (EQL), as determined by EPA guidelines SW-846, is to be equal to or less than EPA MCL and applicable remediation target.

E. All laboratory analytical data submitted to the Commissioner pursuant to this Chapter must come from a laboratory certified under the applicable requirements of the Maine Department of Health and Human Services rules.

Appendix T: Containment Sumps and Spill Bucket Integrity Testing Protocol and Management of Waste Fluids

These requirements apply to all sumps and spill buckets at underground storage tank facilities. Waste fluids are encountered during routine inspections of sumps and spill buckets, after spills, and during integrity testing. Containment sumps must be tested for integrity in accordance with the provisions of section 5(D)(18) and the *Recommended Practices for the Testing and Verification of Spill, Overfill, Leak Detection and Secondary Containment Equipment at UST Facilities*, PEI RP 1200, or the manufacturer's instructions, or an alternate procedure approved by the Department. The following steps must be followed to minimize the quantity and hazard of the wastes generated:

1. Routinely and before any integrity testing, wipe out the sumps and spill buckets. Remove petroleum residue so that any water that enters the sump or spill bucket will remain uncontaminated. Dispose of wipes and absorbent material as oily debris or hazardous waste depending on test results or generator knowledge;

2. Remove and properly manage in accordance with all applicable local, state and federal requirements liquids that have accumulated in the sumps and spill buckets. Determine by visual and olfactory means if the liquids are petroleum contaminated. Clean liquids and clean test fluids with no petroleum odors or sheen may be transported to a wastewater treatment facility with the facility's permission, or the liquid can be collected and sent to a facility authorized to accept the liquids. When new sumps are tested with clean water, the test waters may be discharged onsite with the owner's permission. If the liquid exhibits petroleum odors or a sheen, then the liquid must be containerized, and using appropriate representative sample collection procedures and sealable sample containers, sample the surface layer for laboratory analysis. The analysis must be conducted by a laboratory certified by the Maine Department of Health and Human Services, Laboratory Certification Program using certified laboratory procedures. The analysis must include flash point, TCLP, EPH, and VPH analytical method to determine proper treatment and/or disposal. Alternately, the owner of the facility or generator of the waste may elect to manage the waste as a hazardous waste using generator knowledge of the waste. Waste that is determined to be a hazardous waste must be managed in accordance with the *Hazardous Waste Management Rules*, 06-096 C.M.R. ch. 850-857;

3. Examine the sumps and spill buckets for signs of damage, cracks or holes. If cracks or holes exist, repair or replace the damaged item in accordance with this Chapter. Do not conduct integrity testing on a sump or spill bucket with a crack or hole;

4. When conducting integrity testing of sumps and spill buckets, the testing company must either:

    A. Utilize uncontaminated water for each test to minimize the amount of petroleum contaminated liquids that will require disposal and prevent introduction of potentially contaminated liquids to the containment, or

    B. If water is to be reused for additional tests, the water remains a product of the testing company and may be reused until it no longer is acceptable for reuse, usually due to contamination. Contamination will be determined through physical evidence such as sheen and olfactory means. Once evidence of contamination is present, the water must be managed as a waste by the testing company. The waste must be managed for disposal in accordance with the provisions of section 2 of this appendix. The testing company may not place the waste in an oil water separator or remove evidence of contamination through the use of sorbent pads or other means.

C. In either case for A or B above, the testing company will be responsible for the proper management and disposal of any test waters;

5. Petroleum and petroleum contaminated water found in sumps and spill buckets and water used for integrity testing may not be disposed on the ground, in storm drains, septic systems or in surface waters.

STATUTORY AUTHORITY: 38 M.R.S., sections 341-H and 561-570-M.

EFFECTIVE DATE:
April 5, 1986 – filing 86-99

AMENDED:
July 21, 1987
March 28, 1990

REPEALED AND REPLACED:
September 16, 1991

EFFECTIVE DATE (ELECTRONIC CONVERSION):
May 4, 1996

AMENDED:
December 24, 1996
June 13, 2002 – section 3-A, Appendix T -- also, graphics inserted into file
March 14, 2004 – filing 2004-88
April 3, 2007 – filing 2007-115
September 12, 2010 – filing 2010-392
March 13, 2012 – filing 2012-71
January 7, 2014 – filing 2014-003
April 3, 2016 – changed “Maine Ground Water Oil Clean-up Fund” to “Maine Ground and Surface Waters Clean-up and Response Fund”; changed M.R.S.A. to M.R.S. - filing 2016-056
September 26, 2018 – filing 2018-205

Appendix H

Appendix H Crosswalk for ME DEP LUST Program QAP

CIO 2105-S-02.1 ELEMENTS	MEDEP QAP ELEMENTS
A1 Title and Approval Sheet	Title Page with Provision for Signatures
A2 Approval Page	Title Page with Provision for Signatures
A3 Table of Contents	Table of Contents
A4 Project Purpose/Definition/Background	1.0 Introduction
A5 Project Task Description	6.0 Procedural Requirements for Meeting QAP
A6 Quality Objectives and Performance/Acceptance Criteria	5.0 Data Quality Objectives
A7 Distribution List	14.0 Distribution List
A8 Project/Task Organization	3.0 MEDEP/LUST Program Organization
A9 Project QAM Independence	3.0 MEDEP/LUST Program Organization
A10 Project Organizational Chart and Communications	3.0 MEDEP/LUST Program Organization; Appendix A
A11 Personnel Training/Certification	6.0 Procedural Requirements for Meeting QAP
A12 Documentats and Records	11.0 Document Control; Appendix B - MEDEP/LUST SOP Manual
B1 Identification of Project Environmental Information Operations	6.0 Procedural Requirements for Meeting QAP; Appendix G, Chapter 691 Rules for Underground Oil Storage Facilities
B2 Methods for Environmental Information Acquisition	6.0 Procedural Requirements for Meeting QAP; Appendix B - MEDEP/LUST Program SOP Manual; Appendix G, Chapter 691 Rules for Underground Oil Storage Facilities
B3 Integrity of Environmental Information	5.0 Data Quality Objectives; Appendix B - MEDEP/LUST Program SOP Manual
B4 Quality Control	10.0 Data Quality Assessment; Appendix B - MEDEP/LUST Program SOP Manual; Appendix F - Laboratory Certifications; Appendix I BRWM Basic Data Review Checklist
B5 Instrument/Equipment Calibration, Testing, Inspection, and Maintenance	7.1 Equipment
B6 Inspection/Acceptance Requirements for Supplies and Consumables	7.2 Supplies
B7 Environmental Information Management	10.0 Data Quality Assessment
C1 Assessments and Response Actions	4.0 Assessment
C2 Oversight and Reports to Management	4.4 Yearly Review
D1 Environmental Information Review	10.0 Data Quality Assessment; Appendix I BRWM Basic Data Review Checklist
D2 Usability Determination	10.0 Data Quality Assessment

Appendix I

Site	
Project	
Date(s) Sampled or Sampling Event	
Reviewed by	
Date Reviewed	

A. Data Completeness

Item for Review	**Reviewer Comments**	**Yes**	**No**	
Did report include original lab reports?			*	
Was report paginated?			*	
Were all report pages received?			*	
Did report contain results for all samples and analyses requested on the chain of custody form?			*	
Were required QA/QC results included with lab report?			*	
Was EGAD EDD received?			*	
Were required QA/QC results included on EGAD EDD?			*	
Did reported analyte lists meet project specifications?			*	
Did reporting limits meet project specifications?			*	
Was the laboratory Maine certified for all methods/analytes/matrices performed at the time of sample analysis(if required)?			*	

*For all items checked N- contact chemist, lab or consultant for resolution

B. Preservation and Technical Holding Times

Item for Review	**Reviewer Comments**	**Yes**	**If No, put X in box then click button**		
Sample cooler within required temperature range at time of receipt at laboratory(if No, enter receipt date and cooler temp in reviewer comments)?			1		No
Samples properly preserved at time of receipt at laboratory?			1		No
Was sample extraction/digestion performed within holding time?			2		No
Was sample analysis performed within analytical holding time?			2		No

(1) Review SAP/QAPP requirements, if unavailable use professional judgment to flag data as estimated “J” or as unusable “R”

(2) Review SAP/QAPP requirements, if unavailable,
If method HT<sample extraction/digestion/analysis time≤2X method HT, then estimate data and flag with “J”
If sample extraction/digestion/analysis time>2X method HT, flag detections with a “J”, flag non-detects as “UJ” or reject data and flag with “R”

C. Blanks

Item for Review	**Reviewer Comments**	**Yes**	**No**

		If Yes, put X in box then click button			
Were blanks run at the frequency specified by the method or SAP/QAPP?				*	
Were target analytes detected in laboratory method blanks?		Yes			
Were target analytes detected in trip blanks(if applicable)?		Yes			
Were target analytes detected in equipment blanks (if applicable)?		Yes			
Were target analytes detected in any other types of blanks included in the laboratory data report?		Yes			
Was data appropriately qualified for blank contamination?				3	

*Contact chemist, lab or consultant for resolution

(3)Review SAP/QAPP requirements- if unavailable see Attachment A

D. Surrogates

Item for Review	Reviewer Comments	Yes	No If No, put X in box then click button		
Did the laboratory report results for surrogates (if required by the analytical method)?			*		No
If surrogates required were recoveries within acceptance ranges?					No
If surrogate recoveries were outside acceptance ranges, did the lab re-analyze to confirm matrix interference?			*		
Was data appropriately qualified for unacceptable surrogate recovery(if required)?			4		No

*Contact chemist, lab or consultant for resolution

(4)Review SAP/QAPP requirements, if unavailable:

If recovery > higher acceptance range, flag associated detects with “J”

If lower acceptance range > recovery $\geq$ 10% (20% for volatiles), flag associated detects with “J” and associated non-detects with “UJ”

If recovery <10% (20% for volatiles), reject associated data and flag with “R”

E. Laboratory Control Samples (LCS/LCSD)

Item for Review	Reviewer Comments	

		Yes		**If No, put X in box then click button**		
Did the LCS include all spiked compounds as required by SAP/QAPP or method?				*		No
Were recoveries within acceptance ranges?				**5**		No
Was data appropriately qualified for unacceptable LCS recovery?				**5**		No
Were RPD between LCS and LCSD within acceptance ranges?				**6**		No

*Contact chemist, lab or consultant for resolution
(5)Review SAP/QAPP requirements, if unavailable:
Organics and wet chem: If recovery > higher acceptance range, flag associated detects with “J”
If recovery <lower acceptance range, reject data and flag with “R”

Metals: 40%<Aqueous/Water and Soil/Sediment %R <lower acceptance limit	Qualify results that are ≥ MDL as estimated low “J”, Qualify non-detects as estimated “UJ”
Upper acceptance limit<Aqueous/Water and Soil/Sediment %R < 150%	Qualify results that are ≥ MDL as estimated high “J”
%Recovery < 40%	Qualify all results as unusable “R”
%Recovery > 150%	Qualify all results as unusable “R”

(6) Review SAP/QAPP requirements, if unavailable use professional judgment to flag data as estimated “J” or as unusable “R”

F. Matrix Spike Samples (MS/MSD)

Item for Review	**Reviewer Comments**	**Yes**		**If No, put X in box then click button**		
Did the MS (if performed) include all spiked compounds as required by SAP/QAPP or method?				*		
Were recoveries within acceptance ranges (if MS performed)?				**7**		No
Was data appropriately qualified for unacceptable MS recovery (if MS performed)?				**7**		No
Were RPD between MS and MSD (if performed) within acceptance ranges?				**7**		No

*Contact chemist, lab or consultant for resolution
(7) Review SAP/QAPP requirements, if unavailable use professional judgment to flag data as estimated “J” or as unusable “R”

G. Duplicates (Note this also applies for analytes reported by more than one method)

Item for Review	Reviewer Comments	Yes		If No, put X in box then click button		
Were lab duplicate or field duplicate analyses performed (if yes list type in reviewer comments)?						
Were RPDs (if applicable) within acceptance ranges?				8		No

(8) Review SAP/QAPP requirements, if unavailable:

Qualification of Organic Analytes in Lab or Field Duplicates

Situation 1: Positive Detects in Both Lab or Field Duplicates

RPD	Aqueous ≤ 30% Non-aqueous ≤ 50%	Aqueous > 30% Non-aqueous > 50%		
Sample Results	**Both Duplicates ≥ 2xSQL**	**Both Duplicates Both Duplicates ≥ 2 x SQL**	**SQL ≤ Both Duplicate samples concs. < 2 x SQL**	**One sample conc. > 2 x SQL SQL ≤ Other sample conc. < 2 x. SQL**
Detects	No Flag	J	Professional Judgment	Professional Judgment
Non-detects	No Flag	NA	NA	NA

Situation 2: Positive Detect in Only One Lab or Field Duplicate Sample[9]

Non-Aqueous Lab or Field Duplicate Sample Results		
Sample Results	**One Sample conc. = ND (or value reported as less than the SQL) SQL < Other Sample Conc. < 2 x SQL**	**One Sample conc. = ND (or value reported as less than the SQL) Other Sample Conc. >2x SQL**
Detects	Professional Judgment	J
Non-detects	Professional Judgment	UJ

(9) RPDs should not be determined for duplicate pairs in this situation.

Qualification of Inorganic Analytes Based on Lab or Field Duplicates – Aqueous Matrices

Sample Results	Aqueous Lab or Field Duplicate Sample Results			
	Both Duplicates ≥ 5 x SQL		**One or Both Duplicates < 5 x SQL[10]**	
	RPD ≤ 30%	**RPD > 30%**	**Abs. Diff. ≤ 2 x SQL**	**Abs. Diff. > 2 x SQL**
Detects	No Flag	J	No Flag	J
Non-detects	No Flag	UJ	No Flag	UJ

(10) No action is taken when both field duplicate results are positive detects < SQL or are non-detects.

Qualification of Inorganic Analytes Based on Lab or Field Duplicates - Non-Aqueous Matrices

Sample Results	**Non-Aqueous Lab or Field Duplicate Sample Results**			
	Both Duplicates ≥ 5 x SQL		**One or Both Duplicates < 5 x SQL**(11)	
	RPD ≤ 50%	**RPD > 50%**	**Abs. Diff. ≤ 4 x SQL**	**Abs. Diff. > 4 x SQL**
Detects	No flag	J	No Flag	J
Non-detects	No flag	UJ	No Flag	UJ

(11) No action is taken when both field duplicate results are positive detects < SQL or are non-detects.

H. Data Usability						
Item for Review	**Reviewer Comments**	**If Yes, put X in box then click button**		**If No, put X in box then click button**		
Is there any reason to suspect carryover?		* Yes				
Is there any reason to suspect matrix interference?		* Yes				
Do chromatograms (if provided) look reasonable?				*		No
Is there a compound detected below quantitation limits that should be noted?		Yes				
Is there any other reason that the data should be qualified?		Yes				
Was all (or most) data qualified for a particular method or analyte?		*				
Was any data rejected during the above review?		*				
Is data quality sufficient for the intended use of the data?				*		

*Contact chemist, lab or consultant for resolution

Site:	0	EGAD Site ID #	
Date Data Validated:	0	Data Validated by:	0

EGAD Sample Point ID	DEP Sample ID	Lab Sample ID

Item Reviewed	Validation Qualifer Adjustments needed
Preservation and Holding Times	
Blanks	
Surrogates	
Lab Control Samples	
Matrix Spike Samples	
Duplicates	
Data Usability	

Press to Create Sorted Table

*

Item Reviewed	Method	Analyte	Flag to be entered into Validation Qualifier field	Reason (enter into Validation Comment field)	Lab Sample IDs affected

*

*

EGAD Sample Point ID	DEP Sample ID	Lab Sample ID	Method	Analyte	Flag to be entered into Validation Qualifier field	Reason (enter into Validation Comment field)

Attachment 2
(from EPA New England Guidance and National Functional Guidelines-NFG and Modified for MEDEP EGAD Flagging Conventions)

Organic – Blank Contamination Data Review Guidance

All blank sample results should be evaluated manually for contamination in accordance with the most recent NFG blank criteria. **Note:** This represents a change from previous EPA NE data validation guidance which included the application of a “5x or 10x” rule in accepting, qualifying or rejecting sample results based on blank contamination.

Apply the NFG criteria and actions based on the highest blank contamination associated with the samples. PES (Performance Evaluation Sample) contamination is not used to qualify data.
− In determining the highest blank contamination, evaluate all blanks including method, clean-up, instrument, storage, bottle, trip and equipment rinsate blanks.

− If the blank action for an analyte is determined using the concentration from an equipment, trip or bottle blank, then the positive values in the equipment, trip or bottle blank should be reported unqualified on the Data Summary Tables. However, if the blank action is determined from a laboratory blank (e.g., method, clean-up, storage, or instrument blank), then the positive values in the equipment, trip or bottle blanks should be qualified.

− For aqueous equipment, trip and bottle blanks, if an analyte is present in the non-aqueous sample and is also present in the associated aqueous equipment blank, trip blank or bottle blank, then flag that sample result (in the EGAD sample comments field) as B, to indicate to the end user that an indeterminate amount of sampling error has potentially impacted the sample results.

NFG criteria:

Table 1. Blank Actions for Low/Medium Volatiles Analyses

Blank Type	Blank Result	Sample Result	Action for Samples
Method, Storage, Field, Trip, Instrument **	Detects	Not detected	No qualification
	< RL*	< RL*	Report RL value with a U
		≥ RL*	Use professional judgment- Flag affected sample data with “B”
		< RL*	Report RL value with a U

	> RL*	> RL* and < blank	Report the blank concentration for the sample with a U or qualify the data as unusable R
		≥ RL* and ≥ blank concentration	Use professional judgment- Flag affected sample data with "B" qualifier
	= RL*	< RL*	Report RL value with a U
		≥ RL*	Use professional judgment- Flag affected sample data with "B"
	Gross	Detects	Qualify results as unusable R

* 2x the RL for methylene chloride, 2-butanone, and acetone.

** Qualifications based on instrument blank results affect only the sample analyzed immediately after the sample that has target compounds that exceed the calibration range or non-target compounds that exceed 100 µg/L.

Table 2. Blank Actions for Semivolatiles Analyses

Blank Type	Blank Result	Sample Result	Action for Samples
Method, Field	Detects	Not detected	No qualification
	< RL*	< RL*	Report RL value with a U
		≥ RL*	Use professional judgment- Flag affected sample data with "B" qualifier
	> RL*	< RL*	Report RL value with a U
		≥ RL* and <blank concentration	Report the blank concentration for the sample with a U or qualify the data as unusable R
		≥ RL* and ≥ blank	Use professional judgment- Flag affected sample data with

	= RL*	< RL*	Report RL with a U
		≥ RL*	Use professional judgment- Flag affected sample data with “B” qualifier
	Gross contamination	Detects	Qualify results as unusable R
	TIC > 10 µg/L (for aqueous blanks) TIC > 330 µg/kg (for non- aqueous blanks)	Detects	Use professional judgment- Flag affected sample data with “B” qualifier

* 5x the RL for bis(2-ethylhexyl)phthalate for low-level non-aqueous and aqueous samples.

Table 3. Blank Actions for Pesticide Analyses

Blank Type	Blank Result	Sample Result	Action for Samples
Method, Sulfur Cleanup, Instrument, Field	Detects	Not detected	No qualification
	< RL	< RL	Report RL value with a U
		≥ RL	Use professional judgment- Flag affected sample data with “B” qualifier
	> RL	< RL	Report RL value with a U
		≥ RL and < blank concentration	Report the blank concentration for the sample with a U, or qualify the data as unusable R
		≥ RL and ≥ blank concentration	Use professional judgment- Flag affected sample data with “B” qualifier

	= RL	< RL	Report RL values with a U
		≥ RL	Use professional judgment- Flag affected sample data with “B” qualifier
	Gross	Detects	Qualify results as unusable R

Table 4. Blank Actions for Aroclor Analyses

Blank Type	Blank Result	Sample Result	Action for Samples
Method, Sulfur Cleanup, Instrument, Field	Detects	Not detected	No qualification
	< RL	< RL	Report RL value with a U
		≥ RL	Use professional judgment- Flag affected sample data with “B” qualifier
	> RL	< RL	Report RL value with a U
		≥ RL and < blank concentration	Report the blank concentration for the sample with a U, or qualify the data as unusable R
		≥ RL and ≥ blank concentration	Use professional judgment- Flag affected sample data with “B” qualifier
	= RL	< RL	Report RL values with a U
		≥ RL	Use professional judgment- Flag affected sample data with “B” qualifier
	Gross	Detects	Qualify results as unusable R

Attachment A
(from EPA New England Guidance and National Functional Guidelines-NFG and Modified for MEDEP EGAD Flagging Conventions)

Inorganic – Blank Contamination Data Review Guidance

All blank sample results should be evaluated manually for contamination in accordance with the most recent NFG blank criteria. **Note:** This represents a change from previous EPA NE data validation guidance which recommended the application of a 5x rule in accepting, qualifying or rejecting sample results based on blank contamination.

Apply the NFG criteria and actions based on the highest blank contamination associated with each sample. PES (Performance Evaluation Sample) contamination is not used to qualify data.
− In determining the highest blank contamination, evaluate all blanks including preparation/method, calibration/instrument, bottle, and equipment rinsate blanks.

− Initial and continuing calibration blank contamination within an analytical sequence applies to all samples analyzed in that sequence. Use professional judgment- Flag affected sample data with "B" qualifier to apply contamination only to a specific subset of samples.

− If the blank action for an analyte is determined using the concentration from an equipment or bottle blank, then the positive values in the equipment or bottle blank should be reported unqualified on the Data Summary Tables. However, if the blank action is determined from a laboratory blank (e.g., preparation or calibration blank), then the positive values in the equipment and bottle blanks should be qualified.

− For aqueous equipment and bottle blanks, if an analyte is present in the non-aqueous sample and is also present in the associated aqueous equipment blank or bottle blank, then flag that sample result as EB or BB, respectively, to indicate to the end user that an indeterminate amount of sampling error has potentially impacted the sample results.

NFG criteria:

Table 5. Blank Actions for ICP-AES Analysis

Blank Type	Blank Result	Sample Result	Action for Samples
ICB/CCB	≥ MDL but ≤ RL	Non-detect	No action
		≥ MDL but ≤ RL	Report RL value with a "U"
		> RL	Use professional judgment- Flag affected sample data with "B" qualifier

ICB/CCB	> RL	≥ MDL but ≤ RL	Report RL value with a "U"
		> RL but < Blank Result	Report at level of Blank Result with a "U" or qualify data as unusable (R)
		> Blank Result	Use professional judgment- Flag affected sample data with "B" qualifier
ICB/CCB	≤ (-MDL) but ≥ (-RL)	≥ MDL, or non-detect	Use professional judgment- Flag affected sample data with "B" qualifier
ICB/CCB	< (-RL)	< 10x the RL	Qualify results that are ≥ RL as estimated low (J) Qualify non-detects as estimated (UJ)
Preparation Blank	> RL	≥ MDL but ≤ RL	Report RL value with a "U"
		> RL but < 10x the Blank Result	Use professional judgment- Flag affected sample data with "B" qualifier to qualify results as unusable (R) or estimated high (J)
		≥ 10x the Blank Result	No action
Preparation Blank	≥ MDL but □≤ RL	Non-detect	No action
		≥ MDL but □≤ RL	Report RL value with a "U"
		> RL	Use professional judgment- Flag affected sample data with "B" qualifier
Preparation Blank	< (-RL)	< 10x the RL	Qualify results that are ≥ RL as estimated low (J) Qualify non-detects as estimated (UJ)

Table 6. Blank Actions for ICP-MS Analysis

Blank Type	Blank Result	Sample Result	Action for Samples
ICB/CCB	≥ MDL but ≤ RL	Non-detect	No action
		≥ MDL but ≤ RL	Report RL value with a "U"
		> RL	Use professional judgment- Flag affected sample data with "B" qualifier

ICB/CCB	> RL	≥MDL but ≤RL	Report RL value with a “U”
		> RL but < Blank Result	Report at level of Blank Result with a “U” or qualify data as unusable (R)
		> Blank Result	Use professional judgment- Flag affected sample data with “B” qualifier
ICB/CCB	≤(-MDL),but ≥(-RL)	≥MDL, or non-detect	Use professional judgment- Flag affected sample data with “B” qualifier
ICB/CCB	< (-RL)	< 10x RL	Qualify results that are ≥RL as estimated low (J-) Qualify non-detects as estimated (UJ)
Preparation Blank	> RL	≥MDL but ≤RL	Report RL value with a “U”
		> RL but < 10x the Blank Result	Qualify results as unusable (R) or estimated high (J)
		≥10x the Blank Result	No action
Preparation Blank	≥MDL but ≤ RL	Non-detect	No action
		≥MDL but ≤RL	Report RL value with a “U”
		> RL	Use professional judgment- Flag affected sample data with “B” qualifier
Preparation Blank	< (-RL)	< 10x RL	Qualify results that are ≥RL as estimated low (J) Qualify non-detects as estimated (UJ)

Table 7. Blank Actions for Mercury Analysis

Blank Type	Blank Result	Sample Result	Action for Samples
ICB/CCB	Absolute value is ≥ MDL but ≤ RL	Non-detect	No action
		≥ MDL but □≤ RL	Report RL value with a “U”
		> RL	Use professional judgment- Flag affected sample data with “B” qualifier
ICB/CCB	Absolute value is	≥ MDL but □≤ RL	Report RL value with a “U”

	> RL	> RL but < Blank Result	Report at level of Blank Result with a “U” or qualify data as unusable (R)
		> Blank Result	Use professional judgment- Flag affected sample data with “B” qualifier
ICB/CCB	≤ (-MDL), but ≥ (-RL)	≥ MDL, or non-detect	Use professional judgment- Flag affected sample data with “B” qualifier
ICB/CCB	< (-RL)	< 10x the RL	Qualify results that are ≥ RL as estimated low (J) Qualify non-detects as estimated (UJ)
Preparation Blank	> RL	≥ MDL but ≤ RL	Report RL value with a “U”
		> RL but < 10x the Blank Result	Qualify results as unusable (R) or estimated high (J)
		≥ 10x the Blank Result	No action
Preparation Blank	≥ MDL but ≤ RL	Non-detect	No action
		≥ MDL but □≤ RL	Report RL with a “U”
		> RL	Use professional judgment- Flag affected sample data with “B” qualifier
Preparation Blank	< (-RL)	< 10x the RL	Qualify results that are ≥ RL as estimated low (J) Qualify non-detects as estimated (UJ)

Table 8. Blank Actions for Cyanide and Wet Chemistry Analyses

Blank Type	Blank Result	Sample Result	Action for Samples
ICB/CCB	Absolute value is ≥ MDL but ≤ RL	Non-detect	No action
		≥ MDL but ≤ RL	Report RL value with a ”U”
		> RL	Use professional judgment- Flag affected sample data with “B” qualifier

Attachment A
(from EPA New England Guidance and National Functional Guidelines-NFG and Modified for MEDEP EGAD Flagging Conventions)

ICB/CCB	Absolute value is > RL	≥ MDL but ≤ RL	Report RL value with a "U"
		> RL but < Blank	Report at level of Blank Result with a "U" or qualify data as unusable (R)
		> Blank Result	Use professional judgment- Flag affected sample data with "B" qualifier
ICB/CCB	≤ (-□MDL), but ≥ (-RL)	≥ MDL, or non-detects	Use professional judgment- Flag affected sample data with "B" qualifier
ICB/CCB	< (-RL)	< 10x the RL	Qualify results that are ≥ RL as estimated low (J) Qualify non-detects as estimated (UJ)
Preparation Blank	> RL	≥ MDL but ≤ RL	Report RL value with a "U"
		> RL but < 10x the Blank Result	Qualify results as unusable (R) or estimated high (J)
		≥ 10x the Blank Result	No action
Preparation Blank	≥ MDL but ≤ RL	Non-detect	No action
		≥ MDL but ≤ RL	Report RL value with a "U"
		> RL	Use professional judgment- Flag affected sample data with "B" qualifier
Preparation Blank	< (-RL)	< 10x the RL	Qualify results that are ≥ RL as estimated low (J) Qualify non-detects as estimated (UJ)

Appendix J

DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE OF MAINE

PROCESS FOR THE COLLECTION OF EPA LUST TRUST DATA FOR MOTOR FUEL DISCHARGES

1.0 PURPOSE. The purpose of this document is to outline the general process for the collection of public record data to comply with statutory requirements for Subtitle I funding from the United States Environmental Protection Agency (U.S. EPA).

2.0 BACKGROUND AND DOCUMENT ORGANIZATION.

In 1986, the Leaking Underground Storage Tank (LUST) Trust Fund was established to address petroleum releases from federally regulated underground storage tanks (USTs) by amending Subtitle I of the Solid Waste Disposal Act. In 2005, the Energy Policy Act expanded eligible uses of the LUST Trust Fund to include certain leak prevention activities. The LUST Trust Fund provides money, in part, to oversee cleanups of petroleum releases by responsible parties; pay for cleanups at sites where the owner or operator is unknown, unwilling, or unable to respond, or which require emergency action; and conduct inspections and other release prevention activities.

As part of Maine’s LUST Trust funding, the Department must collect and convey data to EPA regarding UST performance measures including the number of active and closed tanks, releases confirmed, cleanups initiated and completed, facilities in compliance with UST requirements, and inspections.

This document outlines the purpose, background, definitions, and procedure for the collection of EPA LUST Trust data for motor fuel discharges.

3.0 DEFINITIONS.

3.1 Confirmed Release. A Confirmed Release is the number of incidents where the owner/operator or Responsible party has identified a release from a Subtitle I regulated petroleum UST system, reported the release to the state/local or other designated implementing agency and the state/local implementing agency has verified the release according to state procedures such as a site visit (including state contractors), phone call, follow-up letter, or other reasonable mechanism that confirmed the release. A site visit does not have to be made to be considered a Confirmed Release. A release which requires no further action should be counted as a Confirmed Release.

3.2 Farm Tank. Farm Tank is a tank located on a tract of land devoted to the production of crops or raising animals, including fish, and associated residences and improvements. A farm tank must be located on the farm property. “Farm” includes fish hatcheries, rangeland and nurseries with growing operations. Farm tanks do not include those located on land to grow timber.

3.3 Flow-through Process Tank. Flow-through Process Tank is a tank that forms an integral part of a production process through which there is a steady, variable, recurring, or intermittent flow of materials during the operation of the process.

Flow-through process tanks do not include tanks used for the storage of materials prior to their introduction into the production process or for the storage of finished products or by-products from the production process. Flow-through process tanks do not include oil-water separators.

3.4 Liquid Trap. Liquid Trap means sumps, well cellars, and other traps used in association with oil and gas production, gathering, and extraction operations (including gas production plants), for the purpose of collecting oil, water, and other liquids. These liquid traps may temporarily collect liquids for subsequent disposition or reinjection into a production or pipeline stream, or may collect and separate liquids from a gas stream.

3.5 Motor fuel. Motor Fuel means petroleum or a petroleum-based substance that is motor gasoline, aviation gasoline, No. 1 or No. 2 diesel fuel, or any grade of gasohol, and is typically used in the operation of a motor engine.

3.6 Public Record. Public Record[1] is a record of underground storage tanks regulated under Subtitle I of the Solid Waste Disposal Act. Section 1526 of the Energy Policy Act of 2005 requires states receiving federal funds under Subtitle I to maintain, update at least annually, and make available the public. The public record must include the number, sources, and causes of underground storage tank releases, the record of compliance by underground storage tanks in the state with Subtitle I or approved state program, and data on equipment failures.

4.0 EXCLUDED TANKS. According to U.S. EPA Subtitle I Regulations, nine types of tanks are excluded from the definition of an UST based on size, contents, or place of use. These tanks should not be included on the data collection form. Additionally, bare steel tanks, which are considered noncompliant should not be included. Excluded tanks are:

4.1 Farm or residential tanks of 1,100 gallon or less capacity;

4.2 Tanks storing heating oil for consumptive use on the premises where stored;

4.3 Septic tanks;

4.4 Pipeline facilities regulated under the Natural Gas Pipeline Safety Act, the Hazardous Liquid Pipeline Safety Act, or their state counterpart statutes;

4.5 Surface impoundments, pits, ponds, or lagoons;

4.6 Stormwater or wastewater collection systems;

4.7 Flow through process tanks;

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[1] U.S. Environmental Protection Agency, Office of Underground Storage Tanks, Grant Guidelines To States For Implementing The Public Record Provision Of The Energy Policy Act of 2005, EPA 510-R-07-001, January 2007.

4.8 Liquid traps or associated gathering lines directly related to oil or gas production and gathering operations; and

4.9 Storage tanks situated above the floor in an underground area, such as a basement, cellar, or mine.

The exclusion does not apply to oil-water separators, which are used following a production process.

5.0 PROCEDURE.

5.1 Public Record. The Public Record is compiled by the Director of the Division of Technical Services with assistance from the Divisions of Response Services and Petroleum Management. The Public Record is posted on the Department's website by December 31 of each year at http://maine.gov/dep/waste/ust/pubs.html. At a minimum, the Public Record must contain Public Record Posted Date, Total UST Facilities, Total USTs, Number of UST Facilities Inspected, Inspection Period Dates, Percent Compliance, Compliance Measurement Statement, Release Reporting Period Dates, Number Of Confirmed Releases, Number And Percent Of Releases By Source, and Number And Percent Of Causes By Source.

6.0 FORMS. The BRWM Six (6) Month EPA LUST Trust Report Data Collection Form and LUST Site Release Report must be used to collect semiannual data. The Public Record template must be used to collect annual LUST Trust data.

6.1 BRWM Six (6) Month EPA LUST Trust Report Data Collection Form (Data Collection Form). The Data Collection Form includes the spill number, facility name, whether the discharge was an emergency, whether a clean-up was initiated and completed, and whether a site was referred to the Division of Technical Services.

6.1.1 Was This An Emergency? Emergency Sites are sites where the state or responsible party takes immediate action to mitigate imminent threats to human health and the environment posed by an UST system release (e.g., venting of explosive vapors, immediately providing point-of-entry treatment or providing bottled water).

6.1.2 Clean-up Initiated. Clean-up Initiated means a confirmed release at which the state or responsible party has evaluated the site and initiated:

6.1.2.1 The management of petroleum-contaminated soil;

6.1.2.2 The removal of free product (from the surface or subsurface environment);

6.1.2.3 The management or treatment of dissolved petroleum contamination;

6.1.2.4 The monitoring of the groundwater or soil being remediated by natural attenuation; or

6.1.2.5 The state has determined that no further actions are currently necessary to protect human health and the environment.

For a site undergoing closure activities, a confirmed release is counted only if petroleum contamination is discovered and verified. Sites being remediated by natural attenuation can be counted in this category when site characterizations, monitoring plans, and site-specific cleanup goals are established for these sites.

6.1.3 Clean-up Fully Complete. Clean-up Fully Complete means a confirmed release where cleanup has been initiated and where the state has determined that no further actions are currently necessary to protect human health and the environment. A determination of “Clean-up Fully Complete” will allow a confirmed release that does not require further action to meet the definition of both an initiated and completed cleanup. A Clean-up is not considered fully complete if emergency response actions have been completed but the site is referred to Technical Services.

6.1.4 Site Referred To Technical Services. Sites Referred To Technical Services include any long-term remediation site where emergency response actions have been completed but long-term remediation is needed to reach clean-up goals. The number of sites counted under this category come from closures under the Priority List maintained by the Division of Technical Services.

6.2 LUST Site Release Report. The LUST Site Release Report includes site, system, and release information.

6.2.1 Release Information. Release Information includes the source and cause of the discharge. The source and cause are the two most important parameters to record when completing the forms.

6.2.1.1 Specific sources include:

6.2.1.1.1 Tank. This term means the tank that stores the product and is part of the UST system.

6.2.1.1.2 Piping. This term means the piping and connectors running from the tank or submersible turbine pump to the dispenser or other end-use equipment. It does not include vent, vapor recovery, or fill lines.

6.2.1.1.3 Dispenser. This term includes the dispenser and equipment used to connect the dispenser to the piping. For example, a release from a suction pump or components located above the shear valve would be considered a release from the dispenser.

6.2.1.1.4 Spill/Overfill. This term identifies releases that occurred during product delivery to the tank including customer spills and overfills.

6.2.1.1.5 Unknown/Other. This option should be used when the release source does not fit into one of the above categories. For example, releases from vent lines, vapor recovery lines, and fill lines would be included in this category.

6.2.1.2 Specific discharge causes include:

6.2.1.2.1 Physical Damage. Some examples of physical damage include: a puncture of the tank or piping and broken components.

6.2.1.2.2 Corrosion. Use this cause when a metal tank, piping, or other component has a release due to corrosion (for steel, corrosion takes the form of rust).

6.2.1.2.3 Mechanical Damage. Use this cause for all types of mechanical damage except corrosion. Some examples of mechanical damage include: loose fittings and components that have changed dimension (for example, elongation or swelling).

6.2.1.2.4 Spill/Overfill. Use this cause when a spill or overfill occurs. For example, spills may occur when the delivery hose is disconnected from the fill pipe of the tank or when the nozzle is removed from the vehicle at the dispenser. An overfill may occur from the fill pipe at the tank or when the nozzle fails to shut off at the dispenser.

6.2.1.2.5 Faulty Installation. Use this cause when the problem is determined to have occurred specifically because the UST system was not installed properly. Note that these problems may be difficult to determine.

6.2.1.2.6 Unknown. Use this option only when the cause is not known.

6.2.1.2.7 Other. Use this option when the cause is known but does not fit into one of the above categories. For example, accidentally or intentionally putting regulated substances into a monitoring well would be included in this category. Use the comment section to provide additional information if known.

7.0 REFERENCES.

7.1 US. EPA, UST And LUST Performance Measures Definitions, January 18, 2018.

7.2 U.S. EPA, Grant Guidelines To States For Implementing The Public Record Provision Of The Energy Policy Act Of 2005, Office Of Underground Storage Tanks, EPA 510-R-07-001, January 2007.

7.3 U.S. EPA, RCRA Subtitle I: The Federal Underground Storage Tank Program.

Public Record Template - Summary Information On Motor Fuel Underground Storage Tanks (USTs)

General Information

Total Number of Active UST Facilities:
Total Number of Active USTs:

Summary Information for On-Site Inspections[1]

Number of UST Facilities Inspected:
Inspection Period Dates: To
Percent Compliance (Combined Measure):

Note: Tank, facility, and on-site inspection information is based on inspections of UST motor fuel facilities only; heating oil USTs are not included. On-site inspections measure compliance with State of Maine and U.S. EPA laws and regulations governing the prevention and detection of petroleum releases or discharges.

Summary Information for Releases[2]

Number of Confirmed UST Releases:
Release Reporting Period Dates: To

Summary Information for Release Sources and Causes[3]

(Information does not include bare steel tanks and piping)

Source			**Cause**											
			Spill/ Overfill		Physical/ Mechanical Damage		Corrosion		Installation Problem		Other		Unknown	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Tank														
Piping														
Dispenser														
Delivery Problem														
Unknown														
Totals														

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[1] Percent compliance is based only on the number of inspections conducted by MDEP staff (#). An additional ### inspections were conducted by Maine certified UST installers and inspectors for a total of X,XXX inspections.

[2] Release, source and cause information is based on reported releases at motor fuel UST facilities constructed of approved corrosion resistant materials (no bare steel). Source and cause data were compiled from data collected in the course of investigating UST system releases and using EPA's LUST Site Release Reports. Some reported releases had multiple sources. Therefore, the number of sources exceeds the number of release incidents. For information about specific petroleum spills and releases in your town go to the Department's Hazardous and Oil Spill System (HOSS) online report service (http://www.maine.gov/dep/rwm/hoss/). For questions about the information on this page, please contact Victoria Eleftheriou at (207) 287-2651 or Victoria.H.Eleftheriou@maine.gov.

[3] # = number, Source % = percent of total number of sources, Cause % = percent of total number of causes.

BRWM Six (6) Month EPA LUST Trust Report Data Collection Form

Motor Fuel LUST Facility Discharges/Releases
GSWCRF Funded or RP Lead Clean-ups Only

For Reporting Period: __________ to _________

Spill No. (Confirmed discharges based on site visit)	**Facility Name**	**Was this an emergency? (Y/N)**	**Clean-up initiated (Y/N)**	**Clean-up fully complete (Y/N)**	**Site referred to Technical Services** (for further invest/remed) **(Y/N)**

Spill No. (Confirmed discharges based on site visit)	**Facility Name**	**Was this an emergency? (Y/N)**	**Clean-up initiated (Y/N)**	**Clean-up fully complete (Y/N)**	**Site referred to Technical Services** (for further invest/remed) **(Y/N)**

LUST Site Release Report

***Agency Information* – Maine Department of Environmental Protection**

___________________________________ ___________________________
(Responder) (Date)

Site Information:

__________________ ____
(Facility ID #) (Site Name/Street Address)

____ Facility type: ☐ Retail Gasoline Outlet
(City / State) ☐ Other _______________

System Information:

TANK

Material: ☐ Galv. Steel ☐ Fiberglass ☐ Composite ☐ Unprotected bare steel ☐ Other ____________________

C.P./lining (✓ all that apply): ☐ Lined ☐ Sacrificial anode ☐ Retrofit C.P/Impressed Current.

Walls: ☐ Single wall ☐ Double wall (same material) ☐ Double wall (jacketed) ☐ Unknown

Product: ☐ Gasoline ☐ Diesel ☐ Used oil ☐ Hazardous Substance ☐ Heating oil ☐ Other

Age: ☐ 0-5yr ☐ 6-10yr ☐ 11-15yr ☐ >15yr ☐ Unknown
Upgrade: ☐ Spill bucket ☐ Overfill protection ☐ None ☐ Unknown

PIPING

Material: ☐ Galv. steel ☐ C.P. ☐ Rigid fiberglass ☐ Flexible plastic ☐ Other____________

Walls: ☐ Single wall ☐ Double wall (rigid) ☐ Double wall (trench liner)

Age: ☐ 0-5yr ☐ 6-10yr ☐ 11-15yr ☐ >15yr ☐ Unknown

Containment: ☐ Dispenser sump ☐ Turbine sump ☐ None ☐ Unknown

---

Release Information: Date release discovered: ___________________ Estimated date of initial release: ____________________

Source of release: ☐ Tank ☐ Piping ☐ Dispenser ☐ Spill/Overfill ☐ Unknown

Cause: ☐ Physical damage ☐ Corrosion ☐ Mechanical failure ☐ Spill/Overfill
☐ Faulty installation ☐ Unknown ☐ Other____________________________

How identified? ☐ LD method(s) Specify _____________________ ☐ Closure/Removal ☐ Property transfer
☐ Visual/olfactory ☐ Water in tank ☐ Unknown ☐ Other_______________

Estimated age of spill/release: ☐ Recent (< 1yr) ☐ Old (>1yr) ☐ Unknown

Estimated extent: ☐ Localized tank ☐ Localized piping ☐ Localized Dispenser
☐ Large (beyond excavated area) ☐ Off-site

Estimated quantity: ☐ < 20 gallons ☐ 20 to 100 gallons ☐ > 100 gallons
Medium affected: ☐ Soil ☐ Groundwater ☐ Surface water

Additional Information:

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Key to abbreviations:

C.P.	Cathodic Protection
LD	Leak Detection
Galv.	Galvanized