State of Vermont
Agency of Natural Resources

INVESTIGATION AND REMEDIATION OF CONTAMINATED PROPERTIES PROCEDURE

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Investigation and Remediation of Contaminated Properties Procedures
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CHAPTER 1. INTRODUCTION

This procedure has been developed by the Sites Management Section (SMS) of the Waste Management and Prevention Division (WMPD), Vermont Department of Environmental Conservation (VTDEC), Agency of Natural Resources (ANR) to provide guidance for the investigation and remediation of releases of hazardous materials. This procedure provides a process that can be utilized for all properties on the State's Hazardous Sites List in a manner that is protective of public health and the environment. This procedure provides information to be used by responsible parties and their consultants to determine what actions are needed to clean up hazardous material releases and describes considerations for the different media which can be affected by a hazardous material release. Understanding this procedure will enable a responsible party (RP) to know what is required to obtain either a Site Management Activity Completed (SMAC) designation or, for sites enrolled in the Brownfields Re-use and Environmental Liability Limitation Act (BRELLA), a Certificate of Completion (COC). Typically a SMAC designation is issued following the investigation and remediation of a particular site condition requiring state notification and remediation. A COC follows a more comprehensive site wide investigation and if necessary, remediation, of all recognized environmental conditions on a site.

The "Site" as defined in this document includes the extent of contaminated media attributable to a release of hazardous materials and/or petroleum products. Sites are each provided a unique VT SMS Site number, however one property may have multiple releases, and depending on the size of the property, may have multiple site numbers. A glossary of terms and list of acronyms are provided at the end of this document in Appendix J.

1.1 Authority and Release Notification

The Sites Management Section (SMS) is responsible for the review and approval of site investigations and response actions required when a release of hazardous materials has occurred. According to 10 V.S.A. Chapter 159 Section 6617, **"Any person who has knowledge of a release or a suspected release and who may be subject to liability for a release, as detailed in section 6615 (e.g. owners or operators of a facility), shall immediately notify the Agency**." Releases of hazardous materials into the surface or groundwater or onto the land of the State are prohibited, according to 10 V.S.A. Chapter 159 Section 6616. **The responsible party is required to take necessary response actions to address the release according to 10 V.S.A., Chapter 159, Section 6615b Corrective Action Procedures**, which include determining the degree and extent of contamination present, assessing the need for corrective action and implementing the site remediation and monitoring to its completion. This may include sampling of various environmental media, monitoring over time, and/or more complex cleanup methods involving implementing remedial systems. The purpose of corrective action is to reduce or remove contaminants to the extent required by State and Federal regulations and to protect against adverse environmental and human health effects. Consideration for the current and expected future use of the property should be included in the evaluation, as required by the statutory definition below.

This document has also been developed in response to Act 164 of the 2004 Vermont legislative session which included a definition of **Remediation Standards** at 10 V.S.A. Section §6642(6) as follows:

> Standards developed by the secretary for the remediation of contaminated properties. The secretary shall determine appropriate remediation standards on a site-specific basis and shall consider all the following:
>
> (A) Future land use and the appropriate use of institutional controls.
>
> (B) Environmental media, including soil, groundwater, surface water, and air.
>
> (C) Requirements for source removal, treatment, or containment.

(D) Appropriate use of monitored natural attenuation.

(E) Any other issue related to the protection of public health and the environment. (Added 2007, No. 147 (Adj. Sess.), § 7.)

Notification of hazardous material releases into the surface or groundwater, or onto the land of the state must be provided to the Waste Management and Prevention Division as specified in 10 V.S.A. Section 6617, the Vermont Underground Storage Tank Rules and the Vermont Hazardous Waste Management Regulations. This notification can be made by calling the Waste Management Division during business hours at 802-241-3888, or by using the 24-hour hazardous materials hotline at 800-641-5005.

Any person who is determined to be liable for the release or threatened release of a hazardous material as established in Section 6615 must conduct site investigation and corrective action within the timeframes established in Section 6615b Corrective Action Procedures. The person or entity determined liable for cleanup of the release is also responsible for hiring a qualified environmental consultant, and ensuring that work is conducted in a time frame specified in 10 V.S.A. Section 6615b.

Once a release has been reported to the Agency, oversight by the SMS will be provided to insure that the responsible party initiates the appropriate actions in order to protect human health and the environment.

1.2 Document Submission

All reports submitted to the SMS must have a title page with the following information**:** SMS site name, site address, mailing address, SMS site number, names, addresses, and phone numbers of contacts (responsible parties and consultants).

All reports and correspondence regarding contaminated sites must be submitted in digital format. Paper copies of correspondence and reports must be submitted only upon request of the SMS. Reports and correspondence (including all figures, tables, images and attachments, including laboratory reports) shall be provided as Adobe Acrobat (.pdf) text-searchable (not image) files and must allow copying and extraction. SMS project managers may on a case-by-case basis require site data, including data from field instrumentation, field analytical results, and lab analytical results as Microsoft Excel spreadsheets (.xls) or Microsoft Access database (.mda) files. Microsoft Office files must be compatible with Microsoft Office 97 or later versions.

Electronic report copies must be submitted to the project manager by email, up-loaded to the DEC file transfer protocol (ftp) web site at *ftp.anr.state.vt.*us, or on a CD or DVD. Contact the SMS directly for instructions on using the ftp site. Please note that Corrective Action Plans require submittal of one paper copy which will be sent to the Town Clerk's office for public comment.

1.3 State or Federal Funding

In certain circumstances, there may be state or federal funds available for site investigation and remediation. Below are brief descriptions of two programs that provide funds for site investigation and/or remediation; the Vermont Petroleum Cleanup Fund (PCF) and the Vermont Brownfields Program. Other state and/or federal programs may be available as well as private insurance. The status of a responsible party's funding eligibility does not in any way defer or eliminate the owner's legal and financial responsibility for performing the required site work in a timely manner, pursuant to 10 V.S.A. §6615b (Corrective Action Procedures).

1.3.1. Petroleum Cleanup Fund (PCF)

The PCF, established under the authority of 10 V.S.A. Chapter 59, §1941, was created to provide reimbursement, subject to available funding, for certain uninsured costs for the cleanup and restoration of contaminated soil and groundwater caused by releases of petroleum from aboveground storage tanks (ASTs) and underground storage tanks (USTs) and for compensation of third party claims for injury and damage caused by such a release. Please refer to our guidance document Procedures for Reimbursement from the Petroleum Cleanup Fund, http://www.anr.state.vt.us/dec/wastediv/sms/pubs/PCFReimb.pdf for more specific details about this program.

1.3.2. Brownfields Redevelopment

Brownfields redevelopment involves the investigation and cleanup of properties where there has been a historic land use where hazardous materials may have been released. Brownfield reuse projects are a means of accomplishing positive environmental and human health impacts while advancing sound land-use practices. Reutilization of historically productive properties supports sustainable development trends and promotes community and economic growth.

The Brownfields Reuse Initiative comprises several programs designed to provide brownfield developers with tools to help deliver projects in a safe, timely and cost effective manner. The program focuses on three areas: limitation of environmental liability; technical assistance; and financial assistance. The program is administered either directly by the SMS or, in some instances, in collaboration with the SMS's partners, the Vermont Agency of Commerce and Community Development, and Vermont's eleven Regional Planning Commissions. The Program includes the following elements:

- **Technical Assistance Program** (Grant of Services)
- **Brownfields Revitalization Fund** (Grants and Loans)
- **Regional Assessment Program** (Grant of Services)
- **Vermont Community Development Program** (Grants/Loans)
- **Vermont Economic Development Authority** (Loans)
- **Federal Assistance Programs** (Grants)

These programs are described more fully at http://www.anr.state.vt.us/dec/wastediv/sms/brownfields-home.htm

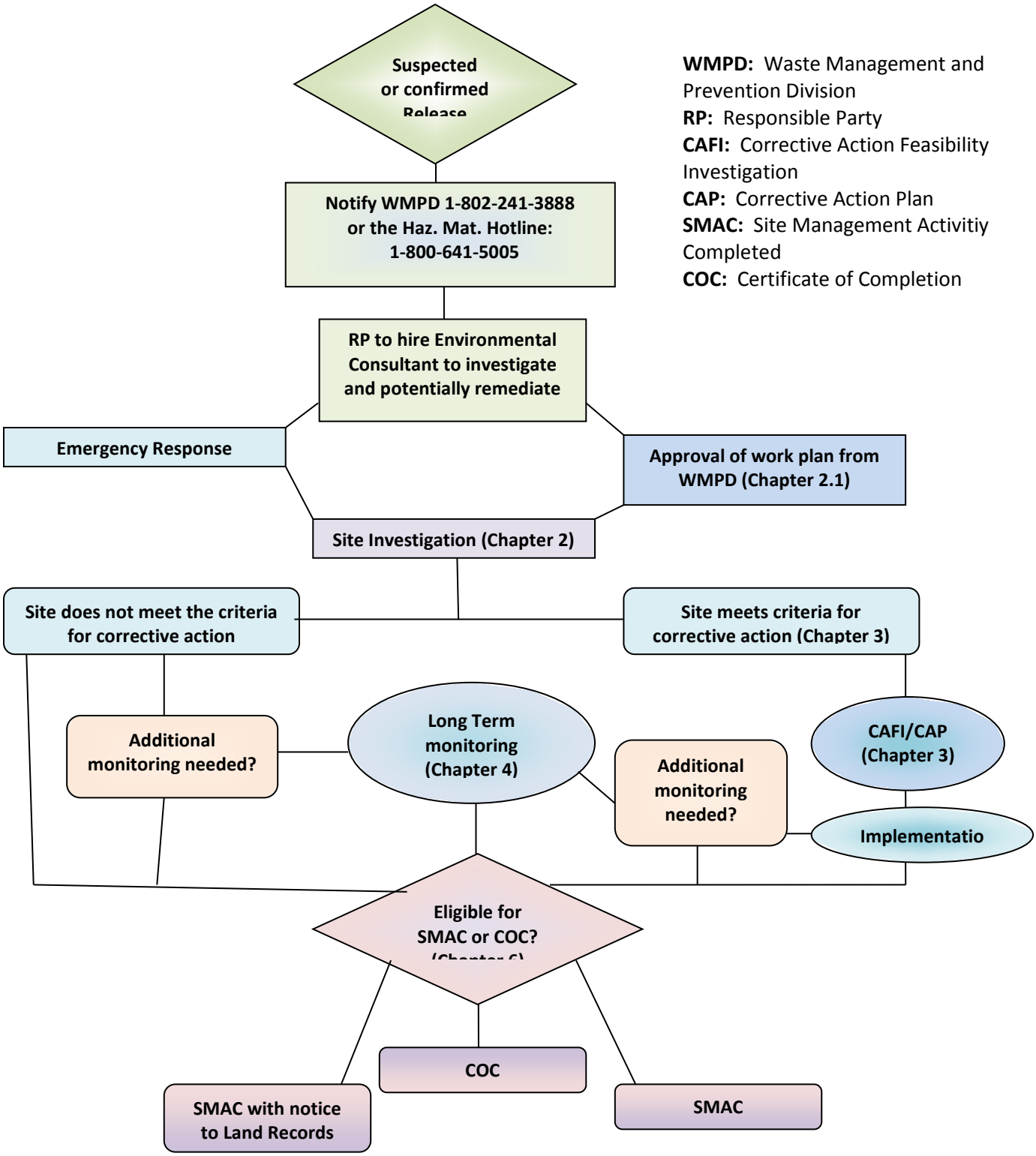
1.4 Green and Sustainable Investigation and Remediation

The SMS encourages all stakeholders involved in the investigation and remediation of any hazardous site in Vermont to become familiar with the concepts of green and sustainable remediation. The benefits of considering green remediation alternatives during early stages of an investigation can substantially decrease the overall carbon footprint of a project. Incorporating simple concepts of green and sustainable remediation into existing remedial systems has also proven in some cases to provide measurable improvements to system performance while simultaneously decreasing a systems carbon footprint. The broad categories that have been identified by the United States Environmental Protection Agency (USEPA) as the core elements of a green cleanup are: 1) Reducing total energy use and increasing renewable energy use, 2) Reducing air pollutants and greenhouse gas (GHG) emissions, 3) Reducing water use and negative impacts on water resources, 4) Improving materials management and waste reduction efforts, and 5) Enhancing land management and ecosystems protection. USEPA defines Green Remediation as, *the practice of considering all environmental effects of remedy implementation and incorporating options to maximize net environmental benefit of cleanup actions.* There are many tools available to aid in determining the environmental footprint of a specific remedy as well as comparing

remedies at a site. The USEPA Technology Innovation Program maintains a list of recommended best management practice (BMP) fact sheets for green remediation on their website, http://www.clu-in.org/greenremediation. The following links also provide additional information and tools needed to understand green and sustainable remediation:

- United States Environmental Protection Agency; Principles for Greener Cleanups; August 2009; http://www.epa.gov/oswer/greencleanups/principles.html
- United States Environmental Protection Agency; Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites; EPA 542-R-08-002, April 2008; http://www.clu-in.org/download/remed/Green-Remediation-Primer.pdf
- Interstate Technology & Regulatory Council (ITRC) - Green & Sustainable Remediations; http://www.itrcweb.org/teampublic_GSR.asp

1.5 Figure 1. Remediation Process Flowchart



WMPD: Waste Management and Prevention Division
RP: Responsible Party
CAFI: Corrective Action Feasibility Investigation
CAP: Corrective Action Plan
SMAC: Site Management Activitiy Completed
COC: Certificate of Completion

If at any time during the investigation, sensitive receptors are impacted or site conditions change, notify the SMS immediately!

CHAPTER 2. SITE INVESTIGATION

Any person who may be liable for the release or threatened release of a hazardous material as established in Section 6615 must conduct site investigation work within the time frames established in Section 6615b Corrective Action Procedures. The person determined liable for cleanup of the release is responsible for hiring a qualified environmental consultant, and ensuring that work is conducted in a timely manner.

The site investigation is a comprehensive study of a hazardous materials release and relevant site conditions. Multiple site investigation phases are often required. The purpose of the investigation is to develop sufficient site characterization information to provide recommendations for future activities at the site.

2.1 Site Investigation Work Plan

Once an environmental consultant has been hired, a work plan must be developed which addresses the contamination. This work plan must be approved by the SMS prior to the initiation of on-site work. When multiple site investigation and corrective action phases are necessary to adequately characterize and remediate the site, there will need to be an approved work plan for each phase, unless otherwise directed by the SMS. The SMS will provide verbal approval in some instances to conduct an expedited site investigation without a written work plan.

Traditional or dynamic work plans (http://www.epa.gov/swertio1/download/char/dynwkpln.pdf) are acceptable to the SMS. Either type of work plan developed must include all proposed site investigation tasks; however, a dynamic work plan allows the investigation to respond to real time site specific data. As these data are collected, the work plan is revised to best reflect actual site conditions and to best investigate the contamination. This helps the investigation to be more efficient with less field mobilization phases and often at lower costs than are associated with traditional work plans. However, the SMS must be kept informed as to changing site conditions, and must approve significant changes to the work scope when a dynamic work plan is being used at a site.

The work plan must address all appropriate items required for a complete site investigation, which are detailed in sections 2.2 – 2.6.

2.2 Elements of the Site Investigation:

As stated in Section 1.1, the Sites Management Section (SMS) is responsible for the review and approval of site investigations and response actions required when a release of hazardous materials has occurred. Therefore, information collected during the Site Investigation must be presented to the responsible party and the SMS in one or more written reports as outlined below. Reports not meeting the minimum requirements will be returned to the RP and/or the consultant for completion and resubmittal. Where multiple investigation phases are required, each phase of the investigation must be clearly and completely described in one or more written reports.

Site Investigation Reports must include:

- **Executive Summary** - brief summary of findings, conclusions and recommendations.
- **Site Information** - table of names, addresses and phone numbers of site land owners (past and present), site operators, potentially responsible parties, and landowners adjacent to the site.
- **Conceptual Site Model** - See section 2.3 on Conceptual Site Model for a complete description as well as Appendix I.

- **Site History** - past and present owners, past and present land use, waste storage or disposal areas, potential sources of contamination, hazardous materials disposal practices, previous hazardous materials releases with location of release or releases, if known, and estimated volume(s) or mass released. Presentation may include copies of historic maps (Insurance maps, Town maps) and copies of Town Directories.

- **Receptor Study/ Risk Evaluation** - Identify all at risk or potentially threatened sensitive receptors. These include, but are not limited to: water supply Source Protection Areas, residential water wells, surface waters and surface water water supply intakes, buildings with basements, wetlands, sensitive ecological areas, areas of direct soil contact threat, utility corridors, and others as identified. A list of the names and addresses of impacted or threatened third parties must be included. Compare all measured concentrations with applicable Vermont Groundwater Enforcement Standards (VTGWES), Vermont Water Quality Standards (VWQS), Maximum Contaminant Levels, health advisories of the Vermont Department of Health (VHD), or other risk-based screening levels, as appropriate. See section 2.4 on Risk Evaluation for a discussion of site-specific risk assessments.

- **Sources/Contaminants**- Identify all pertinent contaminants, and contaminant sources and potential contaminant source areas; and contaminant physical properties such as viscosity, density, K_{oc}, etc. as appropriate. Provide applicable VTGWES, VWQS, Maximum Contaminant Levels (MCLs), health advisories of the Vermont Department of Health (VDH), or other risk-based screening levels, (including those provided in Appendices A, C and D) as appropriate.

- **Maps and Photographs**-

    - **Vicinity Map (or Property Map)**- including property boundary lines, surrounding land use, buildings, street names, sensitive receptors, engineered structures (ie. asphalt parking surfaces, concrete sidewalks, drainage ways, diversion ditches, drain tiles, manholes, lined areas, leachate collection systems, septic systems, sewer lines); chemical storage or process areas, waste storage and disposal areas, hazardous materials, drums, tanks and any other pertinent property features.

    - **Area Map**- a copy of the most recent USGS 7.5 minute topographic quadrangle that includes the site. Map should include contour interval and name and date of USGS quadrangle. An alternate area map will be acceptable providing it accurately depicts the location and elevation of the site as it compares to surrounding land uses.

    - **Site (Investigation) Map**- showing locations of all sampling locations (soil borings, ground water monitoring wells, drinking water wells, test pits, sediment and surface water sampling, background sampling locations, etc.), as well as contaminant source areas (former or current tank locations, contaminant release areas, waste disposal locations, etc.). Multiple maps may be used for large or complex sites.

    - **Latitude/longitude of the site** – referenced to the WGS1984 coordinate system, (Mercator) in decimal degrees. Minimum acceptable accuracy is plus-or-minus 30 feet.

    - **Photographs** – color images showing the site and pertinent features.

    - **Orthophoto or NAIP color aerial photos**- a copy of the most recent coverage that includes the site. Photo should include sheet name and date, if applicable. One source is: *www.state.vt.us/tax/vermontmapping.htm*

- **Subsurface Contaminant Source Areas** – identify the portion or portions of the subsurface where immiscible liquids (free-phase or residual NAPL) are present.

- **Free Product** – map with estimated areal extent and thicknesses. Include product removal logs or graphs.

- **Geology** - regional and site specific soils and bedrock information, boring logs, well logs and groundwater confining layers. As appropriate, values for soil bulk density, porosity, fraction organic content, pH, reduction-oxidation potential, etc. should be included. This can also include geologic maps, fracture trace maps, geophysical data, cross sections, etc.

- **Hydrogeology** - regional and site specific hydrogeologic information, horizontal and vertical groundwater flow gradients and direction, and an assessment of the potential for preferential pathways and multiple aquifers. Hydraulic conductivity, transmissivity, and other parameters should also be included, as appropriate.

- **Plume Definition** – compound specific isoconcentration maps and contaminant migration pathways for all potentially affected media.

- **Contaminant Fate and Transport** – describe/model contaminant distribution in the subsurface, migration pathways, the amount of migration occurring, the predicted movement of the contamination over time, and as appropriate, the adsorption, desorption, and retardation of the contaminant and naturally occurring degradation processes.

- **Work plan protocol deviations** – any deviations from the approved work plan must be discussed.

- **Discussion** – a descriptive analysis of how the data gathered supports the Conceptual Site Model, and whether the validity of the data are sufficient to establish credible recommendations. The discussion must also establish that the data collected are suitable to determine the risk posed by the contaminant(s), and the potential remedial actions. Only data which passes Quality Assurance/Quality Control QA/QC criteria will be acceptable (see Section 2.5.6 for QA/QC requirements).

- **Data Interpretation** - all data should be organized in narrative and tabular and graphical form, including maps and cross sections as appropriate. At sites in which multiple contaminants are present and samples of various media are collected at different depths, the SMS encourages the data be reported in a manner such as what is shown in the following table:

SAMPLE:

Boring	Depth (ft)	PID (ppm)	Observation	Sample label	Analysis	Comments
B-2	4-6	30-112	Diesel odor	B-2A	TPH-DRO by EPA Method 8015; VOCs by EPA Method 8260B	
B-3	0-2	ND		B-3A	PAHs by EPA Method 8270C; Arsenic and Lead by EPA Method 6010; PCBs by EPA Method 8082	
B-4	6-8	200-2000	Petroleum odor	B-4C	TPH-DRO by EPA Method 8015; VOCs by EPA Method 8260	

- **Conclusions and Recommendations** - a discussion of the findings of the investigation and, specifically, the risk contaminants pose to identified receptors, the identification of data gaps and potentially appropriate remedial methods, proposed monitoring frequency, and need for further investigation and/or corrective action, etc.

- **Appendices -**

    - **Monitoring Well and Soil Boring Logs**- A description and discussion of monitoring well, soil boring and test pit installation(s). Logs must include well/boring/test pit location, elevation, total depth, depth to groundwater, soil descriptions, well construction and/or hole backfill/sealing information and field screening results. This should include an explanation of any problems encountered or anomalies discovered. Monitoring wells, soil boring and test pits must also be shown graphically on appropriate site maps.

    - **Field notes** – If requested, copies of the original field notes. Field notes shall include documentation of weather conditions, sampling timeline with locations, low flow sampling logs, and calibration information for each field analytical equipment.

    - **Laboratory Results** - a copy of the actual laboratory results, chains of custody and all QA/QC data, as specified in the approved work plan must be included. Any deviations from QA/QC procedures or acceptable limits must be identified and discussed.

    - **Calculations** – All calculations, such as travel and migration time, natural attenuation, and groundwater gradients. If computer modeling is conducted, a reference to the model used, the data inputs, and data output package must be included (this may be submitted solely in electronic format).

2.3 Conceptual Site Model

The SMS requires a Conceptual Site Model (CSM) to be developed as an initial part of preparing a site investigation (SI) work plan. The CSM is used to help guide the development of the SI work plan. It helps to ensure that the SI will be conducted in an efficient manner and develop the information necessary to provide the SMS with a comprehensive understanding of site conditions and contaminant fate and transport that allows the SMS to make informed decisions.

A CSM is a description of the site. It is initially based on available data and typically begins as a broad and somewhat general hypothesis of physical conditions of a site incorporating available information on site geology, anthropogenic conditions, potential contaminant types and sources, and other data as appropriate.

The CSM and SI are intertwined. As the SI generates site specific data, these are used to continually refine the CSM allowing it to reflect the growing knowledge and understanding of the site. The revised CSM in turn is used to iteratively refine the SI work plan to focus SI resources in the directions that will best characterize contaminant fate and transport and possible risk to human health and the environment. As the SI is completed and the CSM finalized, the CSM provides context for and helps guide long term site decision processes. The CSM should continue to be updated as additional work and monitoring is conducted at the site, and must be reported on in routine sampling reports.

Appendix H provides an outline of data used to develop and refine the CSM. In addition, the EPA document, *Streamlined Investigations and Cleanups Using the Triad Approach (SP-28 – SP-43)* contains a detailed section on the development of a site conceptual model.

2.4 Risk Evaluation

The SMS uses the term "sensitive receptor" throughout this document to refer to areas which may be affected by a release of a hazardous material such as public or private water supplies; surface waters; wetlands; sensitive ecological areas, outdoor and indoor air; and enclosed spaces such as basements, sewers, and utility corridors. The SMS understands that the term "sensitive receptor" is also used in formal quantitative human health risk assessment, and means, "a hypothetical person defined to come into contact with site related environmental media and site related contamination in specific ways defined by exposure scenarios." The meaning of "sensitive receptor" in this document DOES NOT refer to the specific quantitative human health risk assessment meaning.

In general, an iterative approach is used to evaluate risk to sensitive receptors of a hazardous materials release. Initially, site specific information such as sampling results from groundwater, soil, sediments, surface water, soil gas and indoor air is collected and compared to existing standards or guidance such as the VTGWES, VWQS, or risk based concentrations such as the Soil Screening Values (SSVs) (Appendix A Table 2), the Vapor Intrusion (VI) Screening Values in Appendix C, and the fresh water sediment quality guidelines in Appendix D.

Additional site specific information such as geology, hydrogeology, analytical results, and soil types may be collected either during the initial investigation or in subsequent field efforts. This site specific information will be used to predict movement of contamination over time, as well as the adsorption, desorption, bioavailability and retardation of the contaminant and the naturally occurring degradation processes. This additional information is used to refine the CSM in order to predict the potential risks and effects of the contaminants of concern on sensitive receptors.

If necessary, a formal baseline quantitative human health risk assessment that includes use of chemical and endpoint specific toxicity values and site specific exposure assumptions may be performed for both current and potential future site uses. The need for such an assessment is determined on a case by case basis. If this type of risk assessment is found to be necessary at a site, it must follow standard USEPA risk assessment methodology and human health risk assessments must be approved by the Vermont Department of Health (VDH). The methodology used will involve a tiered approach that integrates site assessment and corrective action with human health and environmental risk. Work plans for site specific risk evaluations must be approved by the SMS.

EPA's Risk Assessment Guidance for Superfund (RAGS) (*http://www.epa.gov/superfund/programs/risk/ragsd/tara.htm*) is a technical guide for performance of site-specific risk assessments. The RAGS approach assumes a 30 year residential exposure duration whereas the Vermont Department of Health employs a 70 year residential exposure duration. There are also other differences between EPA RAGS and practices acceptable to the VDH. Chemical specific toxicity information is available in USEPA's Integrated Risk Information System (IRIS), *www.epa.gov/iris*, as well as other peer reviewed sources as noted in the USEPA 2003 document, www.epa.gov/oswer/riskassessment/pdf/hhmemo.pdf.

2.5 Data Evaluation / Sampling

Sampling of soil, groundwater, sediment and surface water is necessary when determining the degree and extent of contamination at a site. The potential for vapor intrusion must also be evaluated at sites. The purpose of this section is to provide general guidelines on what the SMS requires for evaluating data from different media, as well as appropriate standards and guideline levels to compare results. Non-detect analytical results must be reported as below the test practical quantitation limits (PQLs) and the PQLs must be reported. Analytical methods should be selected that have a method detection limit (MDL) below applicable screening values, or the best available technology if the screening levels cannot be met. Tables containing sample results should also contain the applicable regulatory standard or guideline level for comparison (e.g. VTGWES, VWQS, etc.).

Analysis requirements: The contaminants of concern at a site will dictate which analytical method is most appropriate for different media. However, the SMS follows some general guidelines at sites, which include the following:

- For volatile organic compounds (VOCs), the first round of groundwater and/or soil samples must be analyzed via USEPA Method 8260. Drinking water well samples must be analyzed via USEPA Method 524.2.

- Depending on site use history, other analyses may be necessary, including semi-volatiles via USEPA 8270, PCBs via USEPA 8082, priority pollutant metals, dioxins via USEPA 8280 or 8290, polycyclic aromatic hydrocarbons (PAHs) via USEPA 8100, and total petroleum hydrocarbons (TPH) via USEPA 8015 diesel range organics/gasoline range organics (DRO/GRO). In addition, analysis for ethylene dibromide (EDB) is required at petroleum releases which are believed to have occurred prior to 1985 and where a water supply is in close proximity to the release. Alternate laboratory methods may be acceptable on a case by case basis.

- **Guidelines for appropriate use of TPH analysis(eg – Method 8015 DRO or GR):** TPH analysis should be used as a screening tool, as specific petroleum compounds are not identified in this test method. In general, TPH analysis is used to determine if petroleum compounds are present in surface soils which could pose a direct contact risk. TPH analysis should not be used to evaluate risk to subsurface soils. In this case, samples must be analyzed using a compound specific laboratory method and the results should be evaluated to determine if there is a risk to groundwater or potential vapor intrusion. TPH is only appropriate to use for soils when direct contact is a concern, such as prior to thinspreading a soil pile contaminated with petroleum compounds. TPH analysis for groundwater is not required unless requested by the SMS project manager.

- If analytical results indicate only benzene, toluene, ethylbenzene, xylenes (BTEX), trimethylbenzenes, naphthalene and/or methyl-tert-butyl ether (MTBE) compounds are of concern at the property (such as petroleum releases from a known source), later analyses may use the VTDEC Petroleum Target Compound list (Method 8021B), which includes:
    - Benzene
    - Toluene
    - Ethylbenzene
    - Xylene
    - 1,2,4-trimethylbenzene
    - 1,3,5-trimethylbenzene
    - Methyl tertiary butyl ether (MTBE)
    - Naphthalene

- Other analyses not identified above may be required depending on site specific contaminants.

- Biodegradation of gasoline containing high levels of ethanol can result in the generation of explosive levels of methane gas. The use of a landfill gas meter may be an appropriate site investigation instrument for structures that are above gasoline plumes. Methane cannot be detected using a 10.6 eV photoionization detector, typically used for the investigation of petroleum releases.

2.5.1 Soil

The extent of the contaminated soil characterization effort varies on a case by case basis and may involve multiple horizontal and vertical discrete sampling locations including both saturated and unsaturated zones which are analyzed for a wide array of potential contaminants. The SMS generally supports discrete soil sample collection for laboratory analysis; however, in some situations composite samples are acceptable. Examples of when soil sampling and analysis will be required include, but are not limited to the following (see Chapter 3: Investigation/Remediation of Contaminated Soils for additional information):

- At sites in which groundwater is not encountered during the site investigation; in order to determine the degree and extent of contamination in the subsurface;
- To define the extent of soil contamination as part of a corrective action feasibility investigation (CAFI);
- Confirmatory samples following soil remediation (including when excavation is used for remediation);
- To investigate the potential for vapor intrusion;
- When determining disposal options;
- To investigate the potential for direct contact risk for contaminated surface soils;
- When determined necessary by the SMS.

Soil sampling results should be compared to the Soil Screening Values (SSVs) located in Appendix A. The SSVs are guideline levels to be used for site screening, and if applicable, as initial cleanup goals. For example, SSVs can be used as long-term targets in the assessment of remedial alternatives, a technique that may streamline the decision-making process and aid in the selection of an appropriate remedial alternative.

The SSVs are intended to be used for initial screening of data collected during a site investigation. They are not intended to be considered cleanup standards, though they may be used to establish cleanup goals if the default exposure scenarios are consistent with or more conservative than the actual exposure pathways and durations at the site. In certain instances conducting a site specific risk assessment may be the appropriate method to determine site specific soil cleanup standards (see Section 2.4 for risk assessment requirements). Background concentrations in the area of the site may be considered during the initial screening and during the development of cleanup goals. Refer to Appendix E for additional guidance concerning the establishment of background concentrations.

Contaminant concentrations in excess of the SSV indicate the need to further identify and define the vertical and horizontal extent of impacted soils. Generally, at properly characterized sites where contaminant concentrations are below the residential SSV, no further action or study of soil is warranted. Where contaminant concentrations are equal to or exceed the SSV and are above background levels; corrective action, site specific risk assessments, or further study or investigation of the nature and/or extent of contamination will be required.

Comparison to the SSVs should consider the end use of the site; specifically if that use is intended to be residential or commercial/industrial. Sites that remediate only to a commercial/industrial SSV will be required to restrict use at that site as commercial/industrial only until residential cleanup values have been met. In this event, a notice to land record/deed restriction (see Section 6 on land use restrictions) will be required in order to obtain a SMAC or COC.

Documentation of the sample location, sampling method, sample depth, water level, preservation methods, field parameters and other applicable information shall be recorded, and the field notes included in the report field notes appendix required by Section 2.2.

2.5.2 Groundwater

Proper characterization of contamination in groundwater may be accomplished by installation of groundwater monitoring wells, groundwater profiling, or other SMS accepted groundwater characterization techniques.

The SMS is required to manage groundwater quality as specified in the Groundwater Protection Rule and Strategy. The SMS will require properties on the hazardous sites list to be managed so that no constituents in groundwater will exceed the Vermont Groundwater Enforcement Standards (VTGWES) at applicable compliance points. These compliance points may include, but are not limited to, onsite monitoring wells, the site property boundary or locations where groundwater is used as a potable water supply. If contamination has migrated past the applicable compliance points, the groundwater will be managed so that the concentrations of contaminants in groundwater will be returned to below VTGWES at applicable compliance points and will no longer migrate past compliance points in concentrations above VTGWES.

During initial site investigations, and/or during site assessment conducted during underground storage tank (UST) or aboveground storage tank (AST) removals, if a drinking water supply is located on the property or on adjacent at risk properties, the SMS requires a drinking water sample be collected for laboratory analysis.

The VTGWES are defined in Appendices 1 and 2 of the Vermont Groundwater Protection Rule and Strategy *www.anr.state.vt.us/dec/watersup/wsrules.htm*. The SMS also requires management of groundwater to prevent the degradation of surface water quality, sediments, soils, and air above applicable standards, and to prevent any unacceptable risk to human health and the environment.

Proper groundwater sampling collection procedures may be found in the USEPA Groundwater Sampling Operating Procedure: *http://www.epa.gov/region04/sesd/fbqstp/Groundwater-Sampling.pdf*. Alternative sampling procedures may be acceptable if approved by the SMS. Documentation of the sample location, method and intake depth, water level, purge rates and volume, field parameters and other applicable information shall be recorded, and the field notes included in the report field notes appendix required by Section 2.2.

2.5.3 Surface Water

If a surface water body has been identified as a threatened receptor, further characterization may be appropriate. Vermont Water Quality Standard (VWQS) provide maximum safe concentrations for individual constituents based upon the potential receptors. The average allowable concentration (AAC) is based upon environmental impacts from chronic exposure. The maximum allowable concentration (MAC) is based upon environmental impacts from acute exposure. Concentrations for the protection of human health are based upon 1) consumption of fish, and 2) consumption of water and fish. Corrective action must be evaluated or a site-specific risk assessment performed whenever it is determined that the contaminants of concern from the site release(s) cause a violation of the applicable VWQS MAC, or either of the human health based concentrations as they are applicable to the Site (*http://www.nrb.state.vt.us/wrp/publications/wqs.pdf*). An evaluation of the applicability of the human health based VWGS should take into account the presence or absence of fish normally eaten by humans, and the presence or absence of drinking water supply in-take in the contaminated area. Exceedances of the AAC require evaluation in regard to the extent and duration of the exceedances in order to determine if corrective action is needed. Surface waters include all rivers, streams, brooks, reservoirs, ponds, lakes, springs, wetlands and all bodies of surface waters, artificial or natural, which are contained within, flow through or border the State.

Documentation of the sample location, sampling method, sample depth, water level, preservation methods, field parameters and other applicable information shall be recorded and the field notes included in the report field notes appendix required by Section 2.2.

2.5.4 Sediment:

If surface water may have been impacted (including groundwater discharge, overland discharge, or direct discharge), characterization of the sediment may be appropriate. Contamination may also be present in sediments when surface water is not impacted, as is often the case for metals or PAHs. To evaluate the risk to aquatic biota, refer to the Water Quality Division's, "Recommended Guidelines for Evaluating Contaminant Concentrations in Freshwater Sediments and the Potential for Those Contaminants to Adversely Affect Aquatic Biota" (provided in Appendix D). These Sediment Quality Guidelines (SQGs) include a Threshold Effect Concentration (TEC) and a Probable Effects Concentration (PEC). The TEC is a concentration below which adverse effects are unlikely to occur. The PEC is a concentration above which adverse effects are likely to be observed.

SQGs are derived primarily from co-occurrence data collected from field studies with additional laboratory confirmatory toxicity testing data. There is a considerable degree of imprecision when extrapolating sediment contaminant concentrations to actual environmental effects, e.g. adverse impacts on ambient organisms and communities. Therefore, SQG comparisons should be the first step in the context of a hierarchal evaluation of sediment impacts. If one or more contaminants exceed probable effects concentrations (PECs), the need for additional site assessment or corrective action is very likely. In some cases where exceedances are extreme, biological impairment may be assumed with high confidence.

If sediment contamination is found at levels above the Sediment Quality Guidelines PEC (not related to background levels including any off-site upstream sources) (located in Appendix D), then additional investigation, evaluation, site specific risk assessments, or corrective action measures are needed.

Documentation of the sample location, sampling method, sample depth, water level, preservation methods, field parameters and other applicable information shall be recorded and the field notes included in the report field notes appendix required by Section 2.2.

2.5.5 Vapor intrusion (VI):

Vapor Intrusion (VI) occurs when VOCs migrate from contaminated soil or groundwater through the subsurface to the indoor air of a building or other enclosed structure. The potential for VI exists at any site where there has been a release of VOCs near a building, and may also present a risk for any future buildings constructed above or near a contaminated area. Generally, VI sites are grouped into two categories: sites contaminated with petroleum hydrocarbons, and sites contaminated with chlorinated solvents. Chlorinated solvents have a higher potential to produce indoor air impacts than petroleum hydrocarbons, due to the fact that they are more readily mobile, have low odor thresholds, create toxic byproducts upon degradation, and exhibit a limited potential to undergo bioremediation.

The SMS requires a phased approach using multiple lines of evidence to evaluate the potential for VI at a site. For most VI investigations, initial data is gathered during the Site Investigation, in which past and present property uses, contaminant use history, etc. are established. The evaluation can then proceed to site-specific sampling data, including groundwater, soil, soil gas, and sometimes indoor air. Appendix C contains detailed information regarding VI investigations, as well as the VI Screening Levels Table (Table C.7). Please note that the VI Screening Values presented in Table C.7 are intended for use as remedial goals at sites with a known vapor intrusion issue. However, there may be instances in which a site-specific risk assessment can be conducted in order to establish site-specific VI remedial goals.

2.5.5.a VI Evaluation at Petroleum Sites:

The SMS requires additional VI evaluation at sites contaminated with petroleum hydrocarbons (and other readily degradable contaminants) if the following conditions exist:

- For situations where contamination is contact with a structure or is within 5 feet, the risk based health standard developed in Appendix C will be used to determine if more VI work is necessary. In these situations the following criteria must be used: Soils located within 5 ft of a structure which contain TPH >100 mg/kg **or** VOC concentrations (as measured by PID) of >10 ppm, and/or groundwater concentrations above the VI Screening Values, or;

- For situations where contamination is farther away from a structure (>5 ft), the SMS has chosen to rely on empirical data developed by studies done in CA and UT (CA LUFT Manual p.213-224) to determine if additional VI evaluation is necessary. In these situations the following criteria must be used: Soils located between 5 ft and 10 ft of a structure contain TPH >100 mg/kg **and** VOC concentrations (as measured by PID) >10 ppm, and/or groundwater concentrations which exceed 1,000 µg/L benzene or 10,000 µg/L TPH, or;

- There is NAPL present on the water table anywhere within 30 ft of the building, or;

- There is visible NAPL in soils directly adjacent to the structure's foundation.

2.5.5.b VI Evaluation at Chlorinated Solvent Sites:

- Additional VI evaluation is necessary at sites contaminated with chlorinated solvents if contamination is present in soil, groundwater or soil gas within 100 ft of a structure at concentrations which are in excess of the VI Screening Values

If additional evaluation is determined to be necessary based on the above, a work plan must be submitted to the SMS and RP for review. (See Appendix C for more information regarding VI investigation requirements.) The work plan must be approved by the SMS prior to its implementation, and documentation of all sampling methods and data must be included. The work plan should be included as part of the site's Corrective Action Plan (CAP), unless it is appropriate to submit the work plan independently of the CAP, and should detail the long-term monitoring and maintenance plan for the proposed remedial system. Alternately, the RP may consider the option of implementing a remedial alternative as a proactive approach, in cases where VI is suspected may be an issue in the future, but data has not yet shown this to be occurring.

2.5.5.c Soil Gas/Indoor Air Sampling Guidelines:

If soil gas and/or indoor air samples are deemed to be necessary at a site, samples must be collected, at a minimum, from the following locations:

- Soil gas – At least two distinct points, as close as possible to the exterior building foundation, 2 to 5 ft below the structure. One of the points should be as close as possible to the contaminant source while remaining adjacent to the foundation exterior.

- Sub slab soil gas – Directly below the basement floor. The total number of samples should be determined on the construction type and overall size of the basement. In circumstances where

the collection of sub slab soil gas is not practical (i.e. due to the presence of a high groundwater table), additional data collection tools (flux chambers, gore sorbers, etc.) may be necessary.

- Ambient outdoor air - Upwind of building.

- Indoor air – Basement and living space. Indoor air samples should be collected **only** when deemed necessary based on previous soil gas sampling results, and **only** in conjunction with the collection of soil gas samples. A detailed inventory of household products, chemicals, and other potential air contaminant sources must be included.

Note that sampling locations may need to be modified based on basement configuration details and/or the configuration of the contaminant plume.

If the sampling data demonstrate that there is an exceedance of and VI Screening Value as a result of a release at a hazardous site, and that vapor intrusion is occurring, an appropriate remedial action must be selected and implemented. Depending on the degree of the contamination and other site-specific factors, currently (and potentially future) inhabited buildings and applicable environmental media may be monitored to assess any vapor intrusion risks.

If indoor air exceedances that pose an immediate risk to human health are measured at any time during a site investigation, **the SMS must be notified immediately and mitigation of the impacts must be initiated.** In some situations, it may be appropriate to proceed directly to obtaining soil vapor and indoor air data to determine if vapor intrusion is occurring and if mitigation is warranted.

2.5.6 Quality Control/Quality Assurance (QA/QC) Requirements

As defined by the EPA below, quality assurance and quality control (QA/QC) are two separate activities designed to ensure that environmental data that is collected is of a known quality, is good enough for its intended purpose, and can be used to support project management decisions. Often project QA/QC is performed by one person and not as separate activities. It is the subject of numerous papers, books, and study; this section is not meant to describe all QA/QC activities that might be required for environmental sampling, lab analysis, sample program design, or data analysis.

Quality Control - technical activities that measure the performance of environmental sampling to verify that the performance meets the stated requirements. QC is typically applied by technical personnel. Example QC activities include the use of control samples during sample collection, handling, and analysis, and activities such as data review.

Quality Assurance - management activities involving planning, implementation, assessment, reporting, and improvement to ensure that the environmental sampling is of the type and quality needed. QA is typically applied by managers or technical personnel assigned to a specific oversight role. Example QA activities include technical and management assessments of field and analytical operations.

For environmental sampling, whether ongoing monitoring or for site investigations, the WMPD will typically require a trip blank or field blank, a duplicate sample, chain of custody documentation, and documentation of the laboratory's QA/QC samples analyzed along with the project samples, as the minimum QA/QC for a sample delivery group. The trip blank typically is prepared by the laboratory and carried by the technician throughout the sample event. The field blank will be prepared by the technician in the field during the sample event. The duplicate sample is a second sample collected under identical conditions and field location. These QA/QC samples are analyzed along with the field samples. They are used to demonstrate measurement repeatability, accuracy, sample collection and handling

procedure cleanliness. Additional QA/QC samples can be collected at various stages in the sample collection, delivery, and analysis process in order to document that QC has been maintained and if necessary identify particular steps that may have problems.

The purpose of environmental sampling is to determine if any health or environmental hazards are present, when site remediation is complete, and ultimately when the site can be closed as a hazardous site. Adequate QA/QC is required so that the data can be relied upon to make project management decisions that are protective of human health and the environment, as well as cost efficient. The WMPD expects that all reports will contain a section with the results of the QA/QC evaluation. If problems are found, the WMPD expects the environmental consultant to determine the cause of the problem and more importantly make the changes required to correct this problem.

Projects may have more stringent QA/QC requirements than those outlined above. For example EPA funded brownfields investigations require a formal Quality Assurance Project Plan (QAPP); please see the appropriate guidance document and consult with the WMPD project manager on preparing this plan. Depending on project requirements (especially if litigation is involved or contemplated) project QA/QC plans and data validation may be required. Again the WMPD project manager should be consulted in developing these project specific procedures.

2.5.7 Investigation Derived Waste

Contaminated waste generated during site investigations must be disposed of properly. Contaminated drill cuttings must be dealt with according to Chapter 3. Investigation/Remediation of Contaminated Soils. Purge water from groundwater monitoring wells and equipment decontamination water contaminated with petroleum compounds may be returned to the ground within the area of contamination, providing these actions do not increase the risk potential at the site. Disposal of non-petroleum contaminated purge water and decontamination water will be determined on a case by case basis.

2.6 Heating Oil site investigation/remediation requirements

In many cases, contamination from heating oil underground storage tanks (USTs) and above-ground storage tanks (ASTs) is limited to soil in the immediate tank vicinity and therefore can be addressed in a more expedited manner than the traditional site investigation process described above.

This section is intended to be used as guidance for investigation and remediation during the removal of residential and commercial heating oil (kerosene and #2 fuel oil) USTs and ASTs smaller than 1,100 gallons. The work is intended to be performed as part of the heating oil UST or AST removal when it is clear that an observed release is minor in nature and may be remediated during the UST or AST removal.

This section **is not applicable** if the property has a history of having been used for a purpose where it might reasonably be expected that other site contaminants are present (machine shop, industrial facility, auto repair, fuel sales, fuel storage, etc.) or if the UST is (or was) used to store anything other than #2 fuel oil or kerosene.

If no evidence is found of overfills or leaks (no soil staining, no petroleum odors, and no PID readings >10 ppmV by the headspace method in Section 3.1a) this must be documented in the UST removal report and submitted to the VTDEC UST Program. If the UST Program and SMS agree no further investigation is necessary, the property will not be placed on the State's Hazardous Sites List and no further investigation will be required in response to the UST removal.

If some evidence of leaks, staining, odors or PID reading >10 ppmV are found, a limited investigation and remediation resulting in site closure may be accomplished during the UST removal. The responsible party's environmental consultant must follow the procedures below during UST removal:

If **all** of the following conditions bulleted below are met, the property will be placed on the State's Hazardous Sites List; however, a Sites Management Activity Completed (SMAC) designation will subsequently be issued based on the UST removal report and no further investigation will be required.

- No free product is present in the tank grave,
- No bedrock is present in the tank grave,
- No risk of vapor intrusion is present (based upon the VI screening methods detailed in Section 2.5.5),
- The site is served by an off-property public water system or, if there is a water supply well on the property, a sample of the well water is collected and analyzed, and results must show non-detect for petroleum constituents by USEPA Method 524.2,
- During tank removal all contaminated soil has been excavated and disposed of off-site at an appropriate facility (see Chapter 3 for off-site soil disposal),
- A minimum of two confirmatory soil samples from the tank pit must be collected for lab analysis for EPA 8015 TPH DRO and EPA 8021B. Subsurface TPH concentrations must meet the industrial SSV.
- For sites where there may be residual petroleum left in the ground, an adequate amount of clean fill must be placed to prevent direct contact exposure.

If the above conditions are not met or the SMS feels that site conditions warrant additional investigation, then an initial site investigation of the tank removal following the procedures laid out in this document must be performed.

CHAPTER 3. INVESTIGATION/REMEDIATION OF CONTAMINATED SOILS

These requirements were developed as a common sense approach for responding to both large and small scale hazardous material releases to soil that is protective of public health and the environment. The information in this Chapter is intended for use by responsible parties and their consultants, to determine what actions are necessary to address soil contamination. It is the responsibility of the responsible party and their consultant to understand the Vermont Hazardous Waste Management Regulations (VHWMR) and how to determine whether the contaminated soil is subject to regulation as hazardous waste. For petroleum-contaminated soils, it is important to understand that, when certain criteria are met, the contaminated soil may be exempt from regulation as hazardous waste.

3.1 Petroleum Contaminated Soil / VTHWMR Petroleum Contaminated Soil Exemption; VTHWMR Section 7-203(p)

Petroleum-contaminated soil is considered hazardous waste if it exhibits a hazardous waste characteristic (i.e., ignitability, corrosivity, reactivity or toxicity), contains a listed hazardous waste (e.g., it is also considered contaminated with a spent solvent like tetrachloroethylene), and/or it contains greater than 5% by weight petroleum distillates. With that said, soils that are just contaminated with petroleum products usually are considered hazardous waste because: 1) they exhibit the characteristic of ignitability; 2) they exhibit the toxicity characteristic due to the presence of benzene – a prominent constituent of gasoline; or 3) they contain petroleum greater than 5%, by weight.

Some petroleum-contaminated soils that qualify as hazardous waste may be considered exempt from regulation under the VHWMR when the criteria of the Petroleum Contaminated Soil exemption are met (see VHWMR Section 7-203(p)).

In general, the following categories of petroleum-contaminated soil can be managed under the Petroleum Contaminated Soil exemption (and not as hazardous waste):

- Petroleum-contaminated soil generated as a result of a release from a Category One underground storage tank (and that is subject to corrective action under 40 CFR Part 280) provided the soil does not exhibit the characteristic of ignitability (see VHWMR Section 7-205), and the soil is managed according to this chapter.

- Other gasoline-contaminated soils (i.e., resulting from a release of gasoline from sources other than a Category One underground storage tank) that do not exhibit the characteristics of ignitability (see VHWMR Section 7-205) or toxicity for benzene (see VHWMR Section 7-208), provided the soil is managed according to this chapter.

Soil contaminated with other petroleum products are subject to regulation as hazardous waste (and therefore eligible for management under the Petroleum Contaminated Soil exemption) if petroleum concentrations exceed the "greater than 5% by weight of petroleum distillates" criteria for the VT02 hazardous waste code.

In general, petroleum-contaminated soils may be managed under the Petroleum Contaminated Soil exemption if volatile organic compounds (VOCs) measured with a photoionization detector (PID) are at <1,000 parts per million by volume (ppmV) for gasoline, or <400 ppmV for fuel oil or diesel oil (by the headspace method in Section 3.1a).

A condition of the VHWMR 7-203(p) exemption is that the soil be managed according to this chapter.
All petroleum-contaminated soils being considered for management under the exemption must be evaluated by field screening and, if necessary, laboratory analysis and/or testing to establish the concentration of the contaminant(s). Failure to meet any of the conditions in the VHWMR Section 7-203(p) will result in the soil being subject to full regulation as hazardous waste under the VHWMR. Please refer to VHWMR Section 7-203(p) for the specific conditions the must be met in order to manage petroleum-contaminated soil as an exempt waste.

3.1.1 Field Measurements / Sampling Requirements for Petroleum Contaminated Soil

In determining the initial degree and extent of petroleum contamination to soil, field measurements must be taken using a screening tool, such as a photoionization detector (PID). The PID offers the ability to collect numerous samples for immediate analysis. Proper maintenance and consistent operation of this instrument provides a relatively inexpensive and adequate measure of the degree and extent of the contamination. This information, along with relevant site information such as soil types, adjacent receptors, contaminant migration routes, presence of free product and groundwater contamination, must be used to determine the need for future site work.

The PID does not measure specific compounds (e.g. benzene); it is calibrated using a compound which produces a meter response equivalent to the contaminant of concern, and this response factor determines relative concentrations of contaminants. The PID response is affected by temperature, wind, and humidity. Sensitivity may also vary with different models and manufacturers.

A PID may be used for the direct screening of soil contaminated with gasoline, diesel, kerosene and #2 fuel oils. The SMS recognizes that many other instruments and techniques can be used to measure the degree and extent of petroleum contamination. The use of other methods requires review and approval by the SMS.

A PID is not sufficient for low volatility petroleum contamination such as #4 fuel oil, #6 fuel oil, or used oil. While the PID may still be useful for field screening purposes, the following laboratory analysis of samples collected will be required. For #4 and #6 fuel oils, laboratory analysis for volatile organic compounds (VOCs) by gas chromatograph / photoionization detector methodology (the VTDEC Petroleum Target Compound List; 8021B)and an approved Total Petroleum Hydrocarbon (TPH) method must be used. In this instance, the results

of TPH analysis can be compared to the SSVs, in conjunction with additional site information to determine if additional investigation or remediation is needed. For used oil, laboratory analysis for RCRA 8 total metals, PCBs, cyanides, VOCs and semi-volatile organic compounds (SVOCs) by gas chromatograph / mass spectrometry methodology (EPA Method 8260 and 8270) , and an approved TPH method must be used. In most cases, a minimum of two samples per excavation will be required.

For spills or overfills, the minimum number of samples will be determined by the SMS or the UST Program on a case-by-case basis. The exact sample locations should be based on site specific information but should be obtained from locations in the excavation which provide representative results of the most contaminated soil.

The SMS has developed the following minimum standards for use of a PID. These standards do not replace any standard operating procedures (SOPs) employed by the user or operating instructions recommended by the manufacturer, but are meant to provide a minimum standard which is required by the SMS.

- PID assays are to be done on-site, using a minimum 10.2 electron volt (eV) unit calibrated to a benzene equivalent (e.g. isobutylene).

- Calibrations must be performed each day the instrument is in use. The instrument must be calibrated on-site and whenever significant climatic changes occur during screening activities.

- An instrument log book must be maintained by the operator and shall be provided to the SMS for review upon request. The log book must contain the PID make and model, the date and time of calibration, and the type of calibration gas used. Other information included in the field notes must include relative humidity, wind, temperature, sample locations, background air and empty container values and any other relevant information.

- Headspace vapor readings on samples must be taken by placing a sample of soil or debris into a closed plastic bag or sample jar. The sample must occupy approximately 50% of the volume of the sample container. The sample container must be agitated, then allowed to sit undisturbed for at least 5 minutes to allow for sample equilibration, and agitated again right before drawing the headspace sample.

- In cold weather conditions, the sealed sample container must be warmed to room temperature (~ 68° F) prior to screening.

- In humid conditions, the samples must be taken into a dry environment prior to screening to prevent outside moisture interference.

- In windy conditions, the samples must be shielded from the wind during collection.

- SOPs for sample collection must be maintained by the sampler and made available to the SMS upon request. USEPA's Standard Operating Procedures for Soil Sampling must be followed.

3.1.2 Soil Contamination Threshold Levels

The following threshold levels must be used in the decision-making process concerning petroleum contaminated soils.

The PID headspace screening levels which generally trigger the need for further evaluation are 20 ppmV for gasoline contaminated soils or 10 ppmV for fuel oil or diesel fuel contaminated soils. Depending on site conditions, this evaluation may result in excavation, leaving the soil in place, or backfilling. The PID

concentrations measured in the field must be used in conjunction with other site information when determining what additional actions are necessary. For example, it may not be appropriate to backfill soils with less than 20 ppmV by PID for gasoline contaminated soil if a drinking water supply is nearby, and it may not be practical to remove soils above 20 ppmV PID if the degree of contamination is extensive and free product contamination is observed.

Soils with PID readings > 1,000 ppmV gasoline or > 400 ppmV fuel oils, or soil saturated with free product may need to be handled as a hazardous waste in accordance with the VHWMR, and may not be eligible for the petroleum exemption (VTHWMR Section 7-203(p)) if levels are above the ignitability threshold for the waste. Further testing to determine if the soil exhibits characteristics of hazardous waste using the toxicity characteristic leaching procedure (TCLP) and/or other accepted methods will be required.

3.1.3 Residential Waste:

Petroleum contaminated soil generated from residential sources is exempt from being handled as a hazardous waste according to VHWMR Section 7-203 (a) and 40 CFR 261.4 (b)(1). Therefore, no testing is necessary to demonstrate whether the soil is considered a listed hazardous waste. However, the soil or debris must be handled in accordance with this document.

3.1.4 Excavation of Petroleum Contaminated Soil

Soil excavation will be approved by the SMS providing the following:

(1) the full extent of contamination has been delineated,
(2) the majority of the contamination will be removed,
(3) a soil disposal plan is in place,
(4) excavation is a cost effective alternative, and
(5) approval has been granted for the soil removal by the SMS.

Whenever soils are removed for stockpiling and/or treatment, samples of the native material remaining in the ground must be collected and screened using a PID in order to demonstrate that the full extent of contamination was removed. At sites where there is no groundwater contamination, confirmatory samples must be laboratory analyzed via USEPA Method 8021B. Sample results must be compared to the SSVs located in Appendix A. If concentrations do not exceed the residential SSVs, no further action will be necessary. In cases where replacement USTs are installed, and/or the full extent of contamination cannot be removed, screening the remaining native soil with a PID provides useful information on the degree and extent of contamination left in the subsurface.

In some instances the SMS discourages large scale removal of petroleum contaminated soil when groundwater is known to be impacted, and/or when extensive contaminated soil is present which is impractical to remove. In these situations, the SMS recommends backfilling all contaminated soil and will require a full site investigation to determine the nature, degree and extent of the contamination (see Chapter 2. Site Investigation). However, the SMS recognizes in some instances removal of a limited amount of contaminated soil can be an effective cleanup strategy and may lessen the risks to sensitive receptors.

3.1.5 Polyencapsulation/ Soil stockpiling

On-Site Polyencapsulation- This treatment option relies on the processes of biodegradation and photochemical reactions to reduce concentrations of petroleum in soils. Polyencapsulation is only acceptable for petroleum contaminated soils. The treatment method requires the complete containment or encapsulation of the contaminated soil within a polyethylene, plastic liner. The plastic should be a minimum thickness of 6 mils. Clear

plastic should be used to enhance petroleum degradation through photochemical reactions. The integrity of the plastic must be maintained to prevent leaching of contaminants out of the pile, and to minimize the rate of volatilization. The soils must remain polyencapsulated on-site until vapor levels are non-detectable (< 1 ppmV headspace) using a PID, and there is no olfactory or visual evidence of contamination. Aerating the soil pile to accelerate cleanup is not allowable. Soils must be screened periodically to track the rate of biodegradation.

Excavated petroleum contaminated soils can be treated on-site via polyencapsulation if no potential sensitive receptors are adjacent to the site (e.g. - water supplies, surface waters, wetlands, etc.) and adequate room is available so that the contaminated soils can be secured from public access. If contaminated soil is removed during a tank removal and the criteria for polyencapsulation are met, pre-approval from the SMS is not required. However, on-site soil treatment of soils not related to tank removals must be pre-approved by the SMS. A corrective action plan to excavate and polyencapsulate the soil may be necessary prior to soil removal in some circumstances and will require pre-approval by the SMS.

Two additional options to enhance polyencapsulation which are acceptable to the SMS are vapor extraction and bioremediation.

- Vapor extraction involves designing and implementing a system which draws air and contaminants out of the polyencapsulated soil pile. The emissions from the soil vapor extraction system must be treated to meet the Hazardous Most Stringent Emission Rate as defined in the Vermont Air Pollution Control Regulations (*http://www.anr.state.vt.us/air/htm/AirRegulations.htm*).

- Bioremediation involves designing a system for stimulating naturally occurring bacteria to enhance the degradation of petroleum products within the polyencapsulated soil pile. This is typically done by adding manure, nutrients, water, and/or oxygen to the soil pile. The addition of bacteria to the soil piles will be allowed on a case-by-case basis only.

Once vapor levels are non-detect when measured with a PID, soils may be thin-spread at the site where they were generated if the soils contain no olfactory or visual evidence of contamination, and approval to thin-spread has been obtained from the SMS. For soil contaminated with used oil, #4 or #6 fuel oil, confirmatory lab samples will be required for compound specific and TPH analysis prior to thin-spreading soil onsite If the soil is to be thin-spread off-site, then the minimum criteria for **off-site** thin-spreading must be met (see below).

Off-Site Polyencapsulation – Off-site polyencapsulation will only be allowed with prior written SMS approval. Form B.5 in Appendix B must be filled out and sent to the SMS for their review prior to the transport of contaminated soil off-site. The following criteria must be met in order to polyencapsulate soil at an off-site location (a checklist is included in Form B.5):

- There are no bedrock drinking water supplies within a 200 foot radius.

- There are no shallow water supplies (e.g. dug wells, driven wells, etc.) within a 300 foot radius. This limit may need to be extended if shallow water supplies are shown to be hydraulically downgradient.

- There are no sensitive environments such as a stream, river, lake, pond, wildlife refuge, wetland, floodplain, Class I or Class II groundwater zone or other similar areas, within 100 feet of the treatment location.

- The treatment location is not within a wellhead protection area.

- There is adequate room to allow for treatment to occur over the necessary time frame.

- Public access to the treatment area must be restricted (e.g. fencing, posted).
- The treatment location is not in a residential area.
- Written approval from the landowner, if different from soil generator, for the soil treatment is obtained before treatment begins.
- Written approval from the landowner is obtained before treatment begins granting SMS investigators property access for the purpose of inspecting soil treatment at any reasonable time.
- The local municipality must be notified in writing of the off-site location prior to initiating any soil treatment. If applicable, local permits should be obtained. The responsible party must provide evidence to the SMS that this notification has been made.
- An area map and street address of the soil location are submitted to the SMS.

Once the following conditions have been met, soils may be thinspread at the off-site location where they were treated. Approval must be granted by the SMS prior to thin-spreading soils at an off-site location. The soil must contain no olfactory or visual evidence of contamination, vapor levels are non-detect (<1 ppmV headspace) via a PID, and confirmatory soil samples must be collected for laboratory analysis. For soil contaminated with gasoline and fuel oil (except #6 fuel oil-see below), samples must be analyzed for the VT Petroleum Target Compound list (Method 8021B) and for TPH (fuel oil). For used oil and #6 fuel oil contaminated soil, samples must be analyzed using USEPA Method 8270. For used oil, laboratory analysis for RCRA 8 total metals, PCBs, total cyanide, VOCs by USEPA Method 8260, semi volatile organic compounds (SVOCs) by USEPA Method 8270, and an approved TPH method. For soil stockpiles not exceeding 50 cubic yards, a minimum of two discrete soil samples for analysis must be collected from soil core samples. For soil stockpiles not exceeding 100 cubic yards, a minimum of three discrete samples must be collected in the same manner. For soil stockpiles not exceeding 200 cubic yards, a minimum of four discrete samples must be collected, and an additional sample is required for each additional 100 cubic yards.

Following laboratory analysis, soils may not be thin-spread until all petroleum compounds meet the SSVs as well as EPA's "Protection of Groundwater" soil screening levels located on their Regional Screening Levels (RSL) Summary Table (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm). In circumstances where there is both a VDH SSV value and a RSL value, the VDH value must be used.

If polyencapsulated contaminated soil piles are not properly maintained and monitored according to a SMS approved work plan, the SMS will require additional laboratory testing in order to insure contamination has sufficiently degraded prior to approving thin-spreading. If the polyencapsulated soil pile has been neglected and soil contamination may have impacted the off-site property, the off-site property may be placed on the State's Hazardous Sites List, and the property owner will be required to conduct a site investigation to determine the degree and extent of contamination.

3.1.6 Offsite Soil Disposal

Soils may be disposed at the following locations after site specific approval is granted by the SMS; additional testing may be required before disposal at these locations.

In state disposal is limited to Certified Lined Landfills. Following approval from the owner/operator of the landfill, the WMD's Solid Waste Program, and the SMS, petroleum contaminated soils may be disposed as waste

material or as alternative daily cover (ADC) material at Vermont certified lined landfills. To determine if soils can be disposed in a landfill and to determine if the material can be used as ADC contaminant testing needs to be conducted. In general, one soil sample per 200 cubic yards is required up to a maximum of five samples. However, depending on site conditions, field data collected during soil removal may be sufficient, in lieu of additional lab analysis, to determine if the soil will be disposed of as waste or as ADC. Laboratory analysis must include RCRA 8 metals and, VOCs. Sample results will need to be compared to the SSV industrial standards. Petroleum contaminated soils with results below the industrial SSVs can be used as ADC, while soils with concentrations above the SSVs may need to be disposed of as waste material. In some cases where there are high vapor levels in soils as measured by a PID, yet the laboratory results of the soils do not exceed SSV levels, the DEC may require that these soils are handled as waste material to protect the onsite landfill workers. This will be determined on a case by case basis. If the soils exhibit either the characteristic of ignitability (refer to the VHWMR Section 7-204) or toxicity (refer to the VHWMR Section 7-207, specifically TCLP for benzene) then the soil will not be suitable for landfill disposal.

The SMS allows out-of-state disposal of petroleum contaminated soils at approved locations, such as hazardous waste facilities, landfills, asphalt batching plants, thermal treatment plants, and other treatment facilities. Approval to dispose of soils out-of-state must be granted by the SMS. The SMS must receive written proof that the soils were disposed of at such facilities.

3.2 Non-Petroleum Contaminated Soil

This section is applicable to contaminated soil classified as a hazardous waste. Soil classified as a hazardous waste is regulated by the Vermont Hazardous Waste Management Regulations (VHWMR). It is the responsibility of the generator of the soil to understand the relevant parts of these regulations, and any exemptions that may apply. Failure to handle the waste in accordance with the VTHWMR is considered a violation of statute or regulation, and such violation could result in the imposition of penalties or fines.

Non-petroleum contaminated soil must be analyzed using the laboratory analysis most appropriate for the contaminants of concern.

If soil has been, or is proposed to be, excavated at a site, non-petroleum contaminated soil must be either disposed of as hazardous waste at a hazardous waste disposal facility, or may be disposed of at a certified lined landfill, providing approval has been granted by both the Solid Waste Program and the landfill owners. In order to gain approval for disposal of soil at a landfill, the following must occur:

- Soil samples must be obtained according to these sampling requirements: For soil stockpiles not exceeding 50 cubic yards, a minimum of two discrete soil samples for analysis must be collected from soil core samples; for soil stockpiles not exceeding 100 cubic yards, a minimum of three samples must be collected in the same manner. For soil stockpiles not exceeding 200 cubic yards, a minimum of four samples must be collected. Soil stockpiles exceeding 200 cubic yards may require additional analysis to be determined by the SMS and/or the disposal facility.

- Sampling results must be compiled in a brief letter report to the Solid Waste Program, and must be copied to the SMS site manager for their review and approval to be sent to a landfill. The Solid Waste Program will compare laboratory results to the SSVs using the Industrial standard to determine if the soil may be disposed of as ADC or as waste material.

- A written request must be made to the owner of the landfill for permission to dispose of the contaminated soil. This request must also be copied to the SMS.

- If disposal is approved by the landfill owner, the Solid Waste Program, and the SMS, written confirmation that the soil has been disposed of must be received by the SMS from the generator of the soil or their consultant.

CHAPTER 4. CORRECTIVE ACTION/SITE REMEDIATION

The SMS will require corrective action as authorized under 10 V.S.A. § 6615b as well as the Underground Storage Tank (UST) Regulations, the Hazardous Waste Management Regulations, the Groundwater Protection Rule and Strategy, the Vermont Water Quality Standards, and the Vermont Air Pollution Control Regulations.

Responsible party elected corrective action that involves remediating petroleum releases from leaking underground storage tank(s) will not be considered eligible for reimbursement from the Vermont Petroleum Cleanup Fund (PCF) unless the work is conducted under an SMS approved corrective action plan (CAP) or part of an emergency corrective action directed by the State in order to protect human health and the environment.

Corrective action **must** be initiated if one or more of the following conditions exist:

- When a sensitive receptor is either directly affected or likely to be affected by contamination in soil, water or air at concentrations that pose an unacceptable human health or environmental risk.

- When the SSVs or risk-based maximum soil concentrations are exceeded **and** there is a threat to human health or the environment from these soils.

- When target indoor air concentrations have been exceeded and/or soil gas concentrations indicate that vapor intrusion is likely occurring AND the source of the impact is from a release of a hazardous material from a hazardous site.

- When mobile/continuous phase light non-aqueous phase liquid (LNAPL) exists on the water table and poses a threat to sensitive receptors including soil vapor and groundwater quality.

- When residual phase volatile NAPL exists in the unsaturated zone in amounts that are practicable to recover.

- When dense non-aqueous phase liquid (DNAPL) is present either as residual phase DNAPL or as a pool of free product and poses a threat to sensitive receptors including soil vapor and groundwater quality.

- When groundwater standards are exceeded or will be exceeded at a groundwater compliance point or points as defined in the Groundwater Protection Rule and Strategy. If this criteria is met, in many cases monitored natural attenuation will be considered the corrective action.

- When required as part of a federally mandated cleanup at sites regulated under the CERCLA or RCRA corrective action program and being managed in cooperation with the State of Vermont.

All corrective actions must be approved by the SMS before being implemented with the exception of sites managed under a Federal program where the USEPA has the primary regulatory authority, in which case both agencies need to approve. In cases of human health or environmental emergencies, verbal approval for actions may be granted by the SMS, but must be followed by a written CAP and formal SMS approval.

A responsible party may elect to remediate a site that does not meet the conditions stated above for various reasons including liability concerns, to improve property value, property redevelopment, or other reasons not considered to

warrant a state mandated remediation. Approval of a RP-elected corrective action by the SMS does not constitute an approval of funding by the SMS either through the Petroleum Cleanup Fund or other SMS controlled funds.

4.1 Corrective Action Feasibility Investigation (CAFI)

The CAFI is completed to evaluate corrective action technology(ies) in relation to site specific conditions and determine what corrective action technology(ies) might be best suited to the conditions at a particular site. The CAFI justifies the selection of an appropriate corrective action strategy. Pilot tests may be necessary to confirm appropriate remediation technologies and provide data for the final remediation system design. Data gaps in the site investigation may be identified and filled during development of the CAFI. The results of a CAFI are incorporated into the Corrective Action Plan (CAP). A CAFI work plan must be approved by the SMS prior to its initiation.

The SMS expects the CAFI to include a general review of all appropriate remedial alternatives capable of achieving comparable corrective action objectives. In addition, a detailed evaluation is required on one or more of the most appropriate remedial alternatives. The number of remediation alternatives evaluated will depend upon factors such as: the complexity of the site, number of contaminant releases, extent of the contamination, number of complete exposure pathways, persistence of the contaminant(s), existence of single or multiple phases of contaminant, etc. The SMS may require evaluation of a specific technology or further evaluation of other remedial alternatives.

If the CAFI demonstrates that remediation is not feasible, or that it will not remediate a site any faster than natural attenuation, the SMS may allow long term monitoring of natural attenuation instead of active remediation, provided that human health and the environment are protected. Even if monitored natural attenuation is the chosen remedy, the SMS may require source reduction, engineering or institutional controls, groundwater reclassification, or a combination of these actions. Long term monitoring alone will not be allowed if there is an unacceptable risk to human health and the environment. Corrective action may be required to prevent migration of the contamination. Monitored natural attenuation may be considered as an alternative to continuing active remediation, once the remedial goals of a project have been met, such as source area reduction or contaminant migration stabilization.

Table 1 presents examples of common corrective action technologies. These are examples and do not include all corrective action technologies that may be approved by the SMS.

4.1.1 Corrective Action Feasibility Investigation (CAFI) Elements

The first element of a CAFI is clarification of the remedial action objectives or goals of the corrective action. The appropriate State and Federal regulations and cleanup standards or SMS guidelines must be identified for each affected or at risk media. These remediation action objectives identify the goals for each affected media.

The screening elements of a CAFI address the factors that may make a proposed corrective action viable or unacceptable. These screening elements should include, but are not necessarily limited to:

- Technical feasibility
  - identification and elimination of data gaps,
  - pilot testing and collection of design data,
  - summary of technologies evaluated. Monitored natural attenuation (MNA) must be evaluated in accordance with the USEPA guidance document, *"Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites" (OSWER Directive 9200.4-17, November 1997)* or appropriate alternative guidance,
- Associated waste stream treatment and/or disposal requirements,
- Conceptual design of chosen remediation method
- Schedule

  - As appropriate, time constraints, such as construction or redevelopment schedules, installation and performance milestones.
- Cultural Feasibility
  - Community acceptability and involvement, historic preservation
- Legal Feasibility
- Institutional controls, deed restrictions, notice to land record,
- Environmental Impact of each alternative (green remediation)
- Economic feasibility
  - Cost analysis spanning installation through operation and monitoring (if using State funds),
  - Funding source, such as: responsible party, insurance, grant funding, administrative order, or state funding

4.1.2 Pilot Testing:

Pilot tests are used to determine if a remediation technology is technically feasible for the site and to collect site specific data for a full scale remediation system. Some examples of common pilot tests which are used to determine the potential effectiveness of remedial systems include, but are not limited to, radius of influence tests, pump tests/slug tests, bench scale tests, and laboratory treatability studies.

The pilot test report should document how the outcome of the pilot study supports or does not support the remedial action objective. Data gathered should be subsequently incorporated into the CAP as appropriate for the design of the remediation system.

The CAFI report must include a complete discussion of the results of the investigation, pilot test(s), work conducted, findings, analytical results, costs (if using State funds), conclusions and recommendations and must be submitted to the SMS for review. The CAFI must include a summary table reporting the relative benefits of alternatives and their implementation costs. It must also summarize the principles leading to the chosen set of corrective action measures. The CAFI will conclude with a recommended conceptual corrective action measure, expected cost, and description of necessary design parameters.

Following review of the CAFI, the SMS will either:

- Approve the CAFI recommendations and require a Corrective Action Plan.
- Request additional study and evaluation of remediation alternatives.
- Determine that remediation is technically or economically infeasible and look toward other alternatives for site management.

TABLE 1. CORRECTIVE ACTION TECHNOLOGIES[1,2]

NAPL	Soils		Groundwater	Plume Containment	Indoor Air
	EX-SITU:	IN-SITU:			
direct NAPL recovery	land fill disposal	SVE	air sparging with SVE	slurry walls	SVE
Soil Vapor Extraction (SVE)	asphalt batching	bioventing	oxygen injection	interceptor trenches	sub-slab venting
absorbents	land farming	thermal	enhanced bioremediation	containment caps	building ventilation
surfactant flood	bioremediation	Bioremediation	chemical oxidation	sheet piling	vapor barrier
chemical oxidation	composting		monitored natural attenuation	pump and treat	Groundwater remediation
Electrical heating	polyencapsulation		permeable reactive barrier	Permeable reactive barriers	Unsaturated zone soil remediation
	High temperature thermal desorption (incineration)		Bio-remediation		
	low temp thermal/SVE				

[1]Air Emissions from remedial systems: All discharges will need to meet the Hazardous Most Stringent Emission Rate (HMSER) as defined in the Vermont Air Pollution Control Regulations (APCR). For the treatment of gasoline contamination, the following discharge levels represent the HMSER:

- **The effluent concentration from an air treatment system shall not exceed 5 ppmV as measured by a PID that is calibrated to benzene, or a benzene equivalent; and**
- **In cases where the influent concentrations are high enough to prevent achieving the 5 ppmV discharge level using best available air treatment technologies, then the effluent concentrations shall not exceed 5% of the influent concentration (i.e. 95% removal efficiency) as measured by PID, and in no case shall discharge levels represent unsafe or unhealthy conditions to surrounding receptors.**
- **These maximum discharge levels have been established using a standard flow rate of 100 standard cubic feet per minute (scfm), and will need to be adjusted for any increased flow rate. The APCR limit is 0.011 pounds/8 hours (0.0014 pounds per hour). In addition, for the treatment of vapors contaminated with other non-gasoline related, hazardous materials, specific discharge levels and methods of monitoring will need to be established on a case-by-case basis, and must be designed to achieve HMSER as defined in the APCR.**

[2] Water emissions from the remedial system: Discharges of contaminated water from remedial systems must be pre-treated prior to discharge to the subsurface, storm sewer, surface waters or publicly owned water treatment plants. A Water Quality Division discharge permit, section 1272 order, will be required *http://www.anr.state.vt.us/dec/waterq/permits/htm/pm_1272order.htm*. A General Permit is available for petroleum contaminated water discharges. If another contaminant is present an individual permit will be required.

4.2 Corrective Action Plan (CAP)

The goals of corrective action defined in this document are to prevent and eliminate unacceptable risk to human health and the environment caused by the release of hazardous materials into the environment A Corrective Action Plan (CAP) is prepared after the CAFI has identified an acceptable remedial action, when site conditions warrant corrective action, and the SMS has approved the CAFI. A CAP must be prepared by a professional consultant experienced in the investigation and remediation of releases of hazardous materials. Any remedial system design must be reviewed and sealed by a Vermont licensed Professional Engineer qualified to conduct the work that is being proposed. Any violation of the Board of Engineers code of conduct by a Professional Engineer may result in a complaint by the SMS filed to the Board of Engineers, which ultimately may result in the revocation of the individual's P.E. license.

The objectives of a CAP are to clearly communicate the basis and details of a proposed cleanup strategy to the SMS such that Site Managers can ensure technical feasibility of the plan, effective engineering design, reasonable cost, public participation, compliance with applicable standards, and protection of human health and the environment.

4.2.1 Elements of the CAP:

A complete CAP must include the following:

- An Executive Summary that includes a description of the contamination, a review of the results of the investigation(s), a description of the chosen corrective action technology, a statement of site operations and monitoring activities, and an estimate of the duration of the cleanup;
- A one-page News Brief (under separate cover);
- Appropriately scaled maps including a detailed site plan, area plan (including sensitive receptors and neighboring properties), and a USGS 7.5 minute topographical map. An alternate area map will be acceptable providing it accurately depicts the location of the site as it compares to surrounding land uses and elevation.
- Tabular, time series summaries of contaminant concentrations by media;
- Groundwater table elevations where applicable;
- A recent groundwater elevation contour map;
- Recent contaminant concentration isocontour maps of all contaminated media;
- A list of all sensitive receptors at risk or affected;
- A list of all interested, threatened, or impacted third parties including contact names, locations and addresses, and phone numbers;
- A list of all landowners of properties adjacent to the Site, including contact names, locations and addresses, and phone numbers. A map should be included showing adjacent landowner's property relative to the site.
- A clear description of all remedial goals including a list of any regulatory standards and screening values that must be addressed as part of the corrective action.

- A discussion of the reasons for and the goals of the corrective action; e.g., to remediate gross contamination, to reduce impacts on a receptor, to reduce risk to a receptor, etc.

- A summary of the CAFI;

- Cross-sections of the contaminated zone depicting well or boring depths, soil stratigraphy, recent soil contaminant concentrations, and recent water levels.

- An in-depth, quantitative review of the recommended remedial alternative(s) chosen with a discussion of any limitations.

- A schedule for CAP implementation.

- An estimate of the contaminant mass or volume, expected removal rates, and the estimated duration of the cleanup.

- Detailed plans and specifications of the corrective action remedial design and related calculations including discussion of any institutional controls and how they will be developed.

- A list of all proposed contractors, sub-contractors, and town officials including contacts, addresses and phone numbers.

- A list of all permits required for the project, and the contacts necessary to obtain these permits.

- A discussion of all hazardous and solid waste disposal issues.

- If State funding will be utilized, a separate itemized cost estimate for CAP implementation and system operations and maintenance (O&M). This cost estimate should be broken down by task and by labor costs, sub-contractor costs, and equipment costs. Estimates for sub-contractors must also be itemized into labor and equipment costs. Lump sum estimates will not be accepted. If bills are to be submitted to the state for reimbursement, they must be submitted by task according to the approved work plan.

- A long-term monitoring and O&M plan for the corrective action.

- Standard Operating Procedures (SOP's) appropriate to the technologies being proposed for the corrective action (proprietary SOPs including information that is confidential for the remediation firm may be kept confidential to protect the remediation firm).

- An updated Health & Safety Plan.

- A Vermont Licensed Professional Engineer's signature of review for remedial systems. The engineer must be practicing within their area of competency and have a specialization in Environmental Engineering or a closely related field.

- A cost estimate for implementing the corrective action (capital costs plus 2 years of O&M and required sampling) for corrective actions performed using funds requiring SMS approval.

4.2.2 CAP Approval:

Once a CAP has been submitted to the SMS, it will be reviewed for completeness and content. If a CAP is not complete, the SMS will inform the RP and their consultant that additional information is needed.
Following SMS review of the CAP, the SMS will send the news brief and CAP to the appropriate town/city clerk (with copies to the responsible party and their consultant) to solicit public comments, as required by 10 V.S.A. Chapter 159 Section 6608(d). The SMS will request that the town/city clerk make their copy of the CAP available to any interested party. Upon request, the SMS will also send a copy (either hard copy or electronic) of the cover letter, News Brief and CAP to all interested/threatened third parties, owners of land adjacent to the Site, and other appropriate town officials.

In most cases, the SMS will allow two weeks for public comment. However, if public comment is extensive, this public comment period can be extended to a duration which is reasonable for the level of public interest. Notice of any extension will be provided in writing to the parties listed above. If there is public interest, the SMS may hold an informational meeting to discuss the details of the corrective action plan, and to answer any questions the public may have about the project. Once the public notice period is closed and all questions raised during this period have been answered, the SMS may request modifications to the CAP.

After final approval, implementation of the CAP may begin. Any significant modifications to the CAP must be made to the SMS in writing, and must be pre-approved by the SMS. An exception will only be made in cases of emergency corrective actions. In these cases, part or all of this procedure may be modified in order to expedite implementation of the CAP to protect human health and/or the environment. Such emergency work may only be performed at the direction of an SMS Site Manager.

Once the CAP has been implemented, an As-Built/Start up report must be prepared and submitted to the RP and the SMS, which documents the installation and start-up of the remediation system. As-built reports must be submitted within 45 days following the completion of one week of successful unattended remediation system operation. They must include the following elements appropriate to the installed remediation system:

- Description of work performed
- Description of remedial system installed
- Deviations from approved CAP
- Site plan with treatment locations and piping runs
- Mechanical system layout and list of major components w/serial numbers
- Piping, control, and instrumentation diagrams
- Photo documentation
- Initial remedial system operation
  - Flow rate
  - Pressure/vacuum influence
  - Contaminant removal rates
  - Treatment system effluent sample results
- Site restoration
- Recovery/injection well boring logs
- Permits
- Waste disposal manifests
- Inspection results– building, zoning, electrical, etc.

4.2.3 Monitoring the Operation and Maintenance (O&M) of Corrective Action Systems

Following CAP implementation, O&M of any installed remedial system is necessary to ensure the system efficacy and to achieve the goals of the corrective action. O&M of a system must occur as identified in the O&M plan that is included in the approved CAP, and must be summarized in the form of O&M reports submitted to the SMS. If a remedial system is shutdown or is not functioning as intended, the SMS must be notified immediately of the problem and the steps being taken to remedy the problem. O&M reports should be submitted as outlined in the CAP and must include the following information:

- A brief overview of remedial system operation and general site status.

- Remedial system operation data as specified in the approved O&M schedule of the CAP. This data should be in tabular form, and may include: pre- and post-blower pressures; fluid flow rates; influent, mid and effluent vapor concentration readings from vapor phase carbon units; influent, mid and effluent sample analysis data from aqueous phase carbon units; temperature differentials across incinerator processes; vapor extraction well vacuum differentials; air sparging pressure differentials; groundwater treatment system samples; soil vent balancing data; etc. Graphs of the remedial system data versus time should be provided in cases where the presentation is useful in understanding site conditions or in supporting any conclusions which are drawn from the data.

- Groundwater elevation data both in tabular form and presented on a groundwater contour map. Estimated thickness of free phase NAPL, where applicable, should be presented on the groundwater contour map or on a separate map or maps. Graphs of elevation (and/or thickness) versus time should be included if appropriate.

- Analytical data from groundwater sampling and other environmental monitoring in tables, graphs, and their original laboratory forms. Monitoring of groundwater and other media should be conducted in accordance with the approved CAP. Data must be compared to applicable standards or guidelines as specified in this document and/or the CAP. Analytical information should be presented on a site plan, with contaminant isoconcentration lines.

- Contaminant removal estimates for the remedial system. Free product, dissolved phase, and/or vapor phase recovery should be tabulated. When incinerators are used, removal estimates based on temperature differentials, PID readings, and other applicable data should be included. Product recovery estimates should be presented in graphs of product recovered per day and cumulative product removed versus time. Multi-system operations (i.e. soil vapor extraction and free product recovery) should include graphs of recovery rates for each system.

- Discussion of system down times and the reasons for such down times. Any system balancing activities should be noted, justified, and follow the consultant SOPs, manufacturer literature and/or guidelines. All repairs of the system must be documented.

- Remedial system emissions must be measured and shown to be below applicable State and Federal standards.

- Recommendations for system design and/or operational changes in the system should be made to increase efficiency. These may include sampling frequency, site visitation frequency, system modifications or additions, etc.

- Any other pertinent information detailing activities conducted during the last reporting period.

- Paper and electronic O&M Reports should be submitted to the SMS Site Manager within six weeks of the sampling date and prior to any operational changes requiring SMS review or approval.

CHAPTER 5. LONG TERM MONITORING

Long term monitoring is a site management activity intended to track contaminant levels at a site and is used to manage risk to sensitive receptors. In many instances long term monitoring is a sufficient method of managing a site until it is established that the natural processes of dilution, dispersion, degradation, or other mechanism(s) will reduce contaminant concentrations to levels that no longer exceed applicable standards and no longer are an unacceptable risk to sensitive receptors.

By contrast, monitored natural attenuation is an in-situ approach to cleanup that uses natural processes to contain the spread of contamination from chemical spills/releases of hazardous materials and reduce the concentrations and amounts of pollutants in contaminated media, including but not limited to soil and groundwater. Natural subsurface processes, such as dilution, volatilization, biodegradation, adsorption, degradation and chemical reactions with subsurface materials, are allowed to reduce concentrations of contaminants to acceptable levels. Monitored natural attenuation (MNA) is a specific remedial strategy which collects additional data such as pH, dissolved oxygen (DO), and oxygen reduction potential (ORP) to quantify the rates and mechanisms that are limiting the extent and/or concentration of contamination. Long term monitoring is not necessarily monitored natural attenuation as defined by the USEPA**.**

Long term monitoring should be conducted as part of an approved site monitoring plan, or as identified in an approved CAP, or an approved site investigation recommendation. Long term monitoring is conducted for a variety of reasons including the following:

- To identify time variant trends in environmental conditions and/or in the operation of remedial systems.
- To understand environmental conditions and tracking the fate and transport and/or attenuation of contamination.
- To determine if and when action must be taken to further control the release, reduce risks to receptors, improve remedial system performance, conduct further site investigation, or discontinue corrective actions.
- To determine when site management activity completed status is appropriate.

The frequency of monitoring at a site is determined once the site investigation is complete. The frequency will depend on the degree of contamination, potential for the contaminants to adversely affect sensitive receptors, and the potential for site conditions to change. The frequency of sampling may be reduced once long term trends have been established for a site.

Site monitoring reports must be submitted no later than 90 days from the completion of any on-site sampling or activity. When corrective action activities are occurring at a site concurrent with a site monitoring event, the O&M report may be combined with the site monitoring report. A monitoring report should consist of the following information:

- A brief overview of the site status.

- A site plan drawn to scale with North arrows, monitoring well locations suspected and identified source areas, sensitive receptors, surface water, and other pertinent physical features, including on and offsite buildings, roadways and utility locations.

- Groundwater elevation data should be summarized in tabular form and presented on a groundwater contour map. Estimated mobile NAPL thickness data, where applicable, and presented in the groundwater contour map. Graphs of elevation (and/or thickness) versus time if appropriate.

- Analytical data from all sampled media in tables and in their original forms (lab reports), with QA/QC sample results included. Tables must also include applicable media standard and/or guideline levels. Graphs of concentration versus time, if appropriate.

- Contaminant isoconcentration maps for all contaminated media.

- Field screening results from contaminated stockpiled soils in tabular format, with a map showing the locations of the screened samples and the stockpile location in reference to other pertinent physical features including buildings, roadways, surface water bodies, etc.

- Discussion of the current site conditions and effectiveness of remediation should be included. This should be based on the analytical results, groundwater elevations, etc. Recommendations concerning site management or the frequency or scope of monitoring should be provided based on the data gathered during the site visit.

- Observable changes in site and neighboring property conditions, which might affect site management must be discussed in the monitoring report. Such changes would include but are not limited to: damage to the monitoring network, change in property use, change in property occupancy, water supply changes, construction, etc. Significant changes must be reported immediately to the SMS. For example: a contaminated water supply, evidence of a new release, site access denial, discontinuance of required site work, appearance of free product, or destruction of the monitoring network (site paving, site demolition, etc.).

CHAPTER 6. LAND USE RESTRICTIONS

When a chosen remedy results in residual contamination left in place, land use restrictions (LURs) may be needed to ensure that terminating SMS site management is protective of human health and the environment. LURs are administrative or legal mechanisms as well as physical installations used to protect onsite or future workers/residents and the general public from exposure to contaminants that exist or remain on the property.

Residual contamination may be in the form of contaminated soils that require a cap or may be a contaminated ground water plume that requires restrictions on use or reclassification. Current property use or intended use will influence land use restrictions. LURs will be more stringent for residential, school, childcare facilities, etc. use, than for an industrial/commercial property which is expected remain as such for the foreseeable future. If the future use of a property is not known, then LURs will default to ones protective for residential use.

6.1 Notice to Land Record

A notice to the land record will be required prior to a Site Management Activity Completed (SMAC) designation or issuing a Certificate of Completion (COC) in cases where residual ground water or soil contamination within the compliance boundary exceeds Groundwater Enforcement Standards, or other applicable standards (or guidance values if no site specific risk assessment was performed). A notice to the land record cannot be removed by the property

owner. The notice does not legally bind the owner or other entities to perform maintenance, monitoring or ensure that restrictions are upheld. These notices are not binding on the landowner and are not enforceable. A Notice to Land Records template is located in Appendix H.

A notice may be used in the following scenarios:

- If no site-specific risk assessment was performed, and residual soil contamination remains at levels above the SSVs but does not pose a current risk to public health or the environment, (e.g. no direct contact risk). The notice is meant to inform future owners of the residual contamination so appropriate steps can be taken if property conditions change;

- If groundwater is not impacted above VTGWES beyond the site property boundary, and there are no impacted drinking water supplies; and

- If vapor intrusion is a concern for current or future property use, but not a current unacceptable risk to human health.

6.2 Deed Restriction or Easement

A deed restriction or easement is a legal restriction on the property that grants an easement to the state which is recorded in the book of deeds. This grants the right to the state to enforce requirements of maintenance, monitoring or restrictions that are placed on the contaminated portion of the property. The restriction also does not allow for removal of the easement without concurrent state and property owner approval. These restrictions are enforceable by the Agency of Natural Resources.

If a deed restriction is required, a long term maintenance program may be required by the SMS and the property owner will be responsible for carrying this out. The property owner will then be required to submit periodic reports to the SMS. Failure to conduct the maintenance work will result in re-opening the site as a Hazardous Site until the deficiencies are proven to be corrected. A Deed Restriction template is listed in Appendix H.

If a deed restriction is required at a site, it must be prepared by a licensed Vermont attorney, and must include:

- a surveyed map showing the restricted area in recordable form (e.g. a mylar map stamped by a surveyor);
- a legal description of the property
- an attorney's certificate of title to the benefit of the State of Vermont, Agency of Natural Resources; and
- in some cases, a title insurance policy in an agreed upon amount.

Once the restriction has been approved by the SMS, it must be approved by the following entities:

- Program Attorney
- Attorney General's Office
- Municipal Legislative Body (e.g. Town Selectboard)
- DEC Commissioner
- ANR Secretary
- Governor of Vermont

The official copies will be filed with the Vermont lands division in Forest, Parks, and Recreation.

All conditions of the deed restriction must be stated in the SMAC letter or COC and referenced within the restriction. The SMAC or COC shall also be attached as an exhibit to the restriction.

6.3 Institutional Controls in a Certificate of Completion (COC)

A certificate of completion is a site closure that has been performed while in the state brownfield program and affords certain liability protections to the party that has completed the site remediation. The COC is recorded in the land records for the property and may contain property use restrictions or requirements for the maintenance of engineering controls used to achieve closure. See Sections 6.1 and 6.2 for additional details on notices and deed restrictions that may be required by the the COC.

6.4 Reclassification of Groundwater

Reclassification of Groundwater to a Class IV (non-potable groundwater) is an institutional control which documents the location of non-potable groundwater and intends to prevent contaminated groundwater from being used for human consumption. The Secretary of the Agency of Natural Resources (ANR) developed groundwater protection rules under the authority of 10 V.S.A. 1390-1394, Groundwater Protection, which includes criteria for groundwater classification.

By default, all groundwater in the state of Vermont is considered a Class III groundwater, which means that the groundwater is a suitable water supply for individual domestic use, irrigation, agricultural use, and industrial and commercial uses. Class IV groundwater is groundwater that has been classified by the Secretary, or its designee, and is not suitable as a source of potable water for at least five years but may be suitable for some agricultural, industrial, and commercial use.

Groundwater reclassification may be appropriate if:

- The contaminant plume poses a current or future risk to human health;
- The contaminant plume will be present at least five years;
- The contaminants of concern are persistent over time, such as chlorinated solvents, metals, PAHs, and PCBs. There may be site specific circumstances where petroleum compounds may also be considered persistent over time.

In most cases, groundwater reclassification is not appropriate at sites, since contaminants are expected to degrade over time. However, if it is determined that groundwater reclassification is appropriate, the Vermont Groundwater Coordinating Committee will be consulted. The Groundwater Coordinating Committee is a committee established by the Secretary under 10 V.S.A., Section 1392, to advise the Secretary on matters concerning groundwater. For more information on the requirements and procedures for reclassifying groundwater, refer to the *Procedure for Class IV Groundwater Reclassification November 12, 2000,* State of Vermont, Chapter 12-Groundwater Protection Rule and Strategy.

CHAPTER 7. SITE CLOSURE

7.1 Site Management Activity Completed (SMAC)

The purpose of this section is to provide the necessary guidance on when and how to end SMS management of a hazardous site investigation and remediation. Sites which have met the requirements presented in this section will be given a Site Management Activity Completed (SMAC) designation and will be removed from the State's Active Hazardous Sites List.

7.1.1 Conditions

A hazardous site shall be eligible for a SMAC designation under the following conditions:

- The source[s] (e.g spill, tanks, drums, floor drains, drywells), nature, degree, and extent of the contamination has been adequately defined.

- The site has been evaluated to verify that the source(s) of contamination has (have) been removed, remediated, or adequately contained. All remedial action objectives have been achieved, and any active remedial actions or activities have been discontinued.

- Levels of contaminants are stable, falling, or non-detectable as monitored over a reasonable period of time. All post-remedial phase monitoring shall be completed.

- Groundwater enforcement standards as listed in the Groundwater Protection Rule and Strategy (or, in the absence of a standard, other appropriate concentrations of contaminants in groundwater) have been met at compliance points established for the site in accordance with the Groundwater Protection Rule and Strategy.

- Appropriate risk-based soil guideline concentrations have been met at compliance/exposure points established for any site where exposure to contaminated soils has been determined to pose a threat to human health or the environment. Since Vermont has not adopted specific soil standards, other approved guidelines may be used such as the Soil Screening Values (SSVs) located in Appendix A. Site specific risk-based standards may also be developed by the potentially responsible party only after having received prior approval of the SMS.

- The site has been evaluated to verify that migration of contaminants from soil to groundwater is not occurring at concentrations which will result in an exceedance of the Groundwater Enforcement Standards beyond the established compliance boundary.

- No contaminants are present in off-site drinking water wells.

- Risk based contaminant concentrations from onsite source areas (e.g. not background concentrations) must be met for indoor air, if applicable. Since Vermont has not adopted specific indoor air quality standards, other approved guidelines may be used such as the VI Screening Values located in Appendix C7. Site specific risk-based standards may also be developed by the potentially responsible party only after having received prior approval of the SMS.

- Vermont Water Quality standards and Air Pollution Control Emission standards have been met, if applicable.

- All groundwater monitoring wells used during the site investigation have been properly closed in accordance with Section 12.3.5 in Appendix A of the Vermont Water Supply Rule-Chapter 21, unless a plan has been developed and approved by the SMS for maintaining the monitoring wells. See Appendix G for the Well Closure Guidance.

- All soil gas sampling and site remediation points must be properly closed.

- No unacceptable threat to human health or the environment exists at the site from exposure to hazardous materials.

- Sites subject to the Corrective Action provisions contained in the Vermont Hazardous Waste Management Regulations will have met the requirements of those provisions.

- Sites subject to regulation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) will have met the requirements of 40 CFR 300 - 399.

- Any outstanding or overdue balances owed to the state (e.g PCF deductible, Environmental Contingency Fund (ECF) cost recovery) have been paid to the satisfaction of the WMD .

Land use restrictions may be required prior to a SMAC designation. See Chapter 6 for additional information.

7.1.2 Procedure

The steps for designating a hazardous site as SMAC are as follows:

- The State, through the site manager, may advise the potentially responsible party that the site is considered to be eligible for a SMAC designation, or the potentially responsible party may petition for a SMAC designation. If there are no identifiable potentially responsible parties for the site, the current site owner may petition for a SMAC designation. The State may also initiate a SMAC designation.

- The site manager will review the final site report and the status of any required site activities. If these are satisfactory, the site manager will send a letter to the RP and their consultant stating the site is eligible for a SMAC designation and the monitoring wells must be closed or a maintenance plan drafted and submitted for approval to the SMS.

- The site manager will prepare the state's SMAC designation letter addressed to the site owner and to any identified potentially responsible parties. These documents shall be submitted to the Chief of the SMS for approval and signature.

- If the SMAC letter is approved, it will be sent to the responsible party and to any other interested parties. A copy of the SMAC letter shall also be sent to the local municipal authority, and recorded in the land record for the site if the site listing was originally noticed under the provisions of 10 V.S.A. 6608(d). Copies may also be sent to other parties as requested.

- The site will be designated as "Site Management Activity Completed" (SMAC). The list of SMAC sites will be maintained by the SMS and will record the presence of known residual contamination, if any, at the time of this designation. The list will also record the existence of deed restrictions or land record notices.

The WMD reserves the right to return the site to active status if additional activities are required:

- to supplement previous remedial activities that were found to be inadequate in extent, depth, or effectiveness; or
- based on new information on the times, extent, amounts, types, and nature of materials released; or
- based on new information on the spread of contaminants, health effects, or site conditions; or
- due to new or revised regulations; or
- due to errors or omissions; or
- as a result of additional releases; or
- for the site to meet all terms and conditions included in the final SMAC letter from the WMD.

7.2 Certificate of Completion (COC)

A Certificate Of Completion is issued following the identification, characterization, and if necessary, remediation of all recognized environmental conditions under the state brownfield program (Brownfields Reuse and Environmental

Liability Limitation Act codified at 10 V.S.A §6641, or BRELLA. The COC is recorded in the land records of the property and may include land use restrictions.

A COC will be issued following the completion of the following tasks as required:

- Enrollment and acceptance into the BRELLA Program.
- Completion of a Phase I ESA in accordance with ASTM International's E1527-05 "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process" or ASTM E2247-08 "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process for Forestland and Rural Property" as compliant with the All Appropriate Inquiries Regulation. Either of these ASTM International Phase I standards may be used to satisfy the statutory requirements for conducting all appropriate inquiries under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).
- Completion of Phase II investigation work in accordance with ASTM E1903 - 11 Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process ASTM E1903-97(2002) “Standard Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process” and this document.
- Completion of a CAFI.
- Completion of a CAP.
- Implementation of a CAP.

Remediation requirements, if necessary, are identical to those laid out in this document for the procurement of a SMAC designation.

APPENDIX A: Soil Screening Values (SSVs)

The SSV table provided below is a compilation of screening values derived by the Vermont Department of Health (VDH) and the United States Environmental Protection Agency (USEPA). The USEPA values are the Regional Screening Levels (RSL). USEPA updates the RSLs periodically. The USEPA values listed below are reflective of the Regional Screening Levels Summary Table June 2011. Prior to using the RSL values for site decisions, USEPA's website http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm must be verified to insure the latest values are being used. The USEPA table also includes screening levels for soil contaminants partitioning into groundwater.

The VDH risk-based residential soil concentrations for carcinogens are based on a de minimus incremental lifetime carcinogenic risk of one in one million (10^{-6}) and assume a 70 year residential exposure duration. Residential scenario RSLs are derived based on the same levels of de minimus risk but assume a 30 year residential exposure duration. Both VDH and the RSLs employ a total hazard index of 1 and the appropriate young child based exposure duration in the development of residential soil screening values for noncarcinogenic health effects.

The SSVs are intended to be used for initial screening of data collected during a site investigation. They are not intended to be considered cleanup standards, though they may be used to establish cleanup goals if the default exposure scenarios are consistent with or more conservative than the actual exposure pathways and durations at the site. In certain instances conducting a site specific risk assessment may be the appropriate method to determine site specific soil cleanup standards. Background concentrations in the area of the site may also be part of this consideration. Refer to Appendix E for additional guidance concerning background investigations.

Contaminant concentrations in excess of the SSV indicate the need to further identify and define areas of impacted soils, contaminants, and conditions. Generally, at properly characterized sites where contaminant concentrations are below the SSV, no further action or study of soil is warranted. Where contaminant concentrations are equal or exceed the SSV, further study or investigation is warranted.

Comparison to the SSVs should be used based on the end use of the site, residential or commercial/industrial. Sites that remediate to a commercial/industrial value will be required to restrict use at that site as commercial/industrial only until residential cleanup values have been met. A notice to land record/deed restriction (see Section 6 on land use restrictions) will be required. In cases where there is both a VDH value and a RSL value, the VDH value must be used.

Soil Screening Values (SSV) Table
(EPA values are RSL Summary Table November 2013; VDH Values December 2013)

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
ALAR	1596-84-5		2.7E+01	9.6E+01
Acephate	30560-19-1		5.6E+01	2.0E+02
Acetaldehyde	75-07-0		1.0E+01	5.2E+01
Acetochlor	34256-82-1		1.2E+03	1.2E+04
Acetone	67-64-1		6.1E+04	6.3E+05
Acetone Cyanohydrin	75-86-5		5.3E+01	2.2E+02
Acetonitrile	75-05-8		8.7E+02	3.7E+03
Acetophenone	98-86-2		7.8E+03	1.0E+05
Acetylaminofluorene, 2-	53-96-3		1.3E-01	4.5E-01

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Acrolein	107-02-8		1.5E-01	6.5E-01
Acrylamide	79-06-1		2.3E-01	3.4E+00
Acrylic Acid	79-10-7		3.0E+04	2.9E+05
Acrylonitrile	107-13-1		2.4E-01	1.2E+00
Adiponitrile	111-69-3		8.5E+06	3.6E+07
Alachlor	15972-60-8	3.37E+00	8.7E+00	3.1E+01
Aldicarb	116-06-3		6.1E+01	6.2E+02
Aldicarb Sulfone	1646-88-4		6.1E+01	6.2E+02
Aldrin	309-00-2	1.58E-02	2.9E-02	1.0E-01
Ally	74223-64-6		1.5E+04	1.5E+05
Allyl Alcohol	107-18-6		3.0E+02	3.1E+03
Allyl Chloride	107-05-1		6.8E-01	3.4E+00
Aluminum	7429-90-5		7.7E+04	9.9E+05
Aluminum Phosphide	20859-73-8		3.1E+01	4.1E+02
Amdro	67485-29-4		1.8E+01	1.8E+02
Ametryn	834-12-8		5.5E+02	5.5E+03
Aminobiphenyl, 4-	92-67-1		2.3E-02	8.2E-02
Aminophenol, m-	591-27-5		4.9E+03	4.9E+04
Aminophenol, p-	123-30-8		1.2E+03	1.2E+04
Amitraz	33089-61-1		1.5E+02	1.5E+03
Ammonium Sulfamate	7773-06-0		1.6E+04	2.0E+05
Amyl Alcohol, tert-	75-85-4		8.8E+01	3.7E+02
Aniline	62-53-3		8.5E+01	3.0E+02
Anthraquinone, 9,10-	84-65-1		1.2E+01	4.3E+01
Antimony (metallic)	7440-36-0		3.1E+01	4.1E+02
Antimony Pentoxide	1314-60-9		3.9E+01	5.1E+02
Antimony Potassium Tartrate	11071-15-1		7.0E+01	9.2E+02
Antimony Tetroxide	1332-81-6		3.1E+01	4.1E+02
Antimony Trioxide	1309-64-4		2.8E+05	1.2E+06
Apollo	74115-24-5		7.9E+02	8.0E+03
Aramite	140-57-8		1.9E+01	6.9E+01
Arsenic, Inorganic	7440-38-2		6.1E-01	2.4E+00
Arsine	7784-42-1		2.7E-01	3.6E+00
Assure	76578-14-8		5.5E+02	5.5E+03
Asulam	3337-71-1		3.1E+03	3.1E+04
Atrazine	1912-24-9		2.1E+00	7.5E+00
Auramine	492-80-8		5.5E-01	2.0E+00
Avermectin B1	65195-55-3		2.4E+01	2.5E+02
Azobenzene	103-33-3		5.1E+00	2.3E+01
Barium	7440-39-3		1.5E+04	1.9E+05
Baygon (Propoxur)	114-26-1	7.30E+01	2.4E+02	2.5E+03

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Bayleton	43121-43-3		1.8E+03	1.8E+04
Baythroid	68359-37-5		1.5E+03	1.5E+04
Benefin	1861-40-1		1.8E+04	1.8E+05
Benomyl	17804-35-2	1.08E+00	3.1E+03	3.1E+04
Bentazon	25057-89-0		1.8E+03	1.8E+04
Benzaldehyde	100-52-7		7.8E+03	1.0E+05
Benzene	71-43-2	4.71E-01	1.1E+00	5.4E+00
Benzenediamine-2-methyl sulfate, 1,4-	6369-59-1		4.9E+00	1.7E+01
Benzenethiol	108-98-5		7.8E+01	1.0E+03
Benzidine	92-87-5		5.0E-04	7.5E-03
Benzoic Acid	65-85-0		2.4E+05	2.5E+06
Benzotrichloride	98-07-7		4.9E-02	2.2E-01
Benzyl Alcohol	100-51-6		6.1E+03	6.2E+04
Benzyl Chloride	100-44-7		1.0E+00	4.9E+00
Beryllium and compounds	7440-41-7		1.6E+02	2.0E+03
Bidrin	141-66-2		6.1E+00	6.2E+01
Bifenox	42576-02-3		5.5E+02	5.5E+03
Biphenthrin	82657-04-3		9.2E+02	9.2E+03
Biphenyl, 1,1'-	92-52-4		5.1E+01	2.1E+02
Bis(2-chloro-1-methylethyl) ether	108-60-1		4.6E+00	2.2E+01
Bis(2-chloroethoxy)methane	111-91-1		1.8E+02	1.8E+03
Bis(2-chloroethyl)ether	111-44-4		2.1E-01	1.0E+00
Bis(chloromethyl)ether	542-88-1		7.7E-05	3.9E-04
Bisphenol A	80-05-7		3.1E+03	3.1E+04
Boron And Borates Only	7440-42-8		1.6E+04	2.0E+05
Boron Trichloride	10294-34-5		1.6E+05	2.0E+06
Boron Trifluoride	7637-07-2		3.1E+03	4.1E+04
Bromate	15541-45-4		9.1E-01	4.1E+00
Bromo-2-chloroethane, 1-	107-04-0		2.4E-02	1.2E-01
Bromobenzene	108-86-1		3.0E+02	1.8E+03
Bromochloromethane	74-97-5		1.6E+02	6.8E+02
Bromodichloromethane	75-27-4		2.7E-01	1.4E+00
Bromoform	75-25-2		6.2E+01	2.2E+02
Bromomethane	74-83-9		7.3E+00	3.2E+01
Bromophos	2104-96-3		3.1E+02	3.1E+03
Bromoxynil	1689-84-5	2.61E+00	1.2E+03	1.2E+04
Bromoxynil Octanoate	1689-99-2		1.2E+03	1.2E+04
Butadiene, 1,3-	106-99-0		5.4E-02	2.6E-01
Butanol, N-	71-36-3		6.1E+03	6.2E+04
Butyl Benzyl Phthlate	85-68-7		2.6E+02	9.1E+02
Butyl alcohol, sec-	78-92-2		1.2E+05	1.2E+06

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Butylate	2008-41-5		3.1E+03	3.1E+04
Butylated hydroxyanisole	25013-16-5		2.4E+03	8.6E+03
Butylated hydroxytoluene	128-37-0		1.4E+02	4.8E+02
Butylbenzene, n-	104-51-8		3.9E+03	5.1E+04
Butylbenzene, sec-	135-98-8		7.8E+03	1.0E+05
Butylbenzene, tert-	98-06-6		7.8E+03	1.0E+05
Cacodylic Acid	75-60-5		1.2E+03	1.2E+04
Cadmium (Diet)	7440-43-9	6.56E+01	7.0E+01	8.0E+02
Caprolactam	105-60-2		3.0E+04	3.0E+05
Captafol	2425-06-1		3.2E+00	1.1E+01
Captan	133-06-2		2.1E+02	7.5E+02
Carbaryl	63-25-2	3.08E+02	6.1E+03	6.2E+04
Carbofuran	1563-66-2		3.1E+02	3.1E+03
Carbon Disulfide	75-15-0		8.2E+02	3.7E+03
Carbon Tetrachloride	56-23-5	2.65E-01	6.1E-01	3.0E+00
Carbosulfan	55285-14-8		6.1E+02	6.2E+03
Carboxin	5234-68-4		6.1E+03	6.2E+04
Ceric oxide	1306-38-3		1.3E+06	5.4E+06
Chloral Hydrate	302-17-0		6.1E+03	6.2E+04
Chloramben	133-90-4		9.2E+02	9.2E+03
Chloranil	118-75-2		1.2E+00	4.3E+00
Chlordane	12789-03-6		1.6E+00	6.5E+00
Chlordecone (Kepone)	143-50-0		4.9E-02	1.7E-01
Chlorfenvinphos	470-90-6		4.3E+01	4.3E+02
Chlorimuron, Ethyl-	90982-32-4		1.2E+03	1.2E+04
Chlorine	7782-50-5		7.5E+03	9.1E+04
Chlorine Dioxide	10049-04-4		2.3E+03	3.0E+04
Chlorite (Sodium Salt)	7758-19-2		2.3E+03	3.1E+04
Chloro-1,1-difluoroethane, 1-	75-68-3		5.8E+04	2.4E+05
Chloro-1,3-butadiene, 2-	126-99-8		9.4E-03	4.7E-02
Chloro-2-methylaniline HCl, 4-	3165-93-3		1.1E+00	3.7E+00
Chloro-2-methylaniline, 4-	95-69-2		4.9E+00	1.7E+01
Chloroacetaldehyde, 2-	107-20-0		1.8E+00	6.4E+00
Chloroacetic Acid	79-11-8		1.2E+02	1.2E+03
Chloroacetophenone, 2-	532-27-4		4.3E+04	1.8E+05
Chloroaniline, p-	106-47-8		2.4E+00	8.6E+00
Chlorobenzene	108-90-7		2.9E+02	1.4E+03
Chlorobenzilate	510-15-6		4.4E+00	1.6E+01
Chlorobenzoic Acid, p-	74-11-3		1.8E+03	1.8E+04
Chlorobenzotrifluoride, 4-	98-56-6		2.1E+02	2.3E+03
Chlorobutane, 1-	109-69-3		3.1E+03	4.1E+04

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Chlorodifluoromethane	75-45-6		5.3E+04	2.2E+05
Chloroethanol, 2-	107-07-3		1.2E+03	1.2E+04
Chloroform	67-66-3		2.9E-01	1.5E+00
Chloromethane	74-87-3		1.2E+02	5.0E+02
Chloromethyl Methyl Ether	107-30-2		1.9E-02	9.4E-02
Chloronitrobenzene, o-	88-73-3		1.6E+00	5.7E+00
Chloronitrobenzene, p-	100-00-5		6.1E+01	2.7E+02
Chlorophenol, 2-	95-57-8		3.9E+02	5.1E+03
Chloropicrin	76-06-2		2.1E+00	8.8E+00
Chlorothalonil	1897-45-6		1.6E+02	5.6E+02
Chlorotoluene, o-	95-49-8		1.6E+03	2.0E+04
Chlorotoluene, p-	106-43-4		1.6E+03	2.0E+04
Chlorozotocin	54749-90-5		2.0E-03	7.2E-03
Chlorpropham	101-21-3		1.2E+04	1.2E+05
Chlorpyrifos	2921-88-2		6.1E+01	6.2E+02
Chlorpyrifos Methyl	5598-13-0		6.1E+02	6.2E+03
Chlorsulfuron	64902-72-3		3.1E+03	3.1E+04
Chlorthiophos	60238-56-4		4.9E+01	4.9E+02
Chromium(III), Insoluble Salts	16065-83-1	3.45E+04	1.2E+05	1.5E+06
Chromium(VI)	18540-29-9	8.61E-02	2.9E-01	5.6E+00
Cobalt	7440-48-4		2.3E+01	3.0E+02
Copper	7440-50-8		3.1E+03	4.1E+04
Cresol, m-	108-39-4		3.1E+03	3.1E+04
Cresol, o-	95-48-7		3.1E+03	3.1E+04
Cresol, p-	106-44-5		6.1E+03	6.2E+04
Cresol, p-chloro-m-	59-50-7		6.1E+03	6.2E+04
Cresols	1319-77-3		6.1E+03	6.2E+04
Crotonaldehyde, trans-	123-73-9		3.4E-01	1.5E+00
Cumene	98-82-8		2.1E+03	1.1E+04
Cupferron	135-20-6		2.2E+00	7.8E+00
Cyanazine	21725-46-2		5.8E-01	2.1E+00
Cyanides				
~Calcium Cyanide	592-01-8		7.8E+01	1.0E+03
~Copper Cyanide	544-92-3		3.9E+02	5.1E+03
~Cyanide (CN-)	57-12-5		2.2E+01	1.4E+02
~Cyanogen	460-19-5		7.8E+01	1.0E+03
~Cyanogen Bromide	506-68-3		7.0E+03	9.2E+04
~Cyanogen Chloride	506-77-4		3.9E+03	5.1E+04
~Hydrogen Cyanide	74-90-8		2.3E+01	1.5E+02
~Potassium Cyanide	151-50-8		1.6E+02	2.0E+03
~Potassium Silver Cyanide	506-61-6		3.9E+02	5.1E+03

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
~Silver Cyanide	506-64-9		7.8E+03	1.0E+05
~Sodium Cyanide	143-33-9		7.8E+01	1.0E+03
~Zinc Cyanide	557-21-1		3.9E+03	5.1E+04
Cyclohexane	110-82-7		7.0E+03	2.9E+04
Cyclohexane, 1,2,3,4,5-pentabromo-6-chloro-	87-84-3		2.1E+01	7.5E+01
Cyclohexanone	108-94-1		3.1E+05	3.1E+06
Cyclohexene	110-83-8		3.1E+02	2.8E+03
Cyclohexylamine	108-91-8		1.2E+04	1.2E+05
Cyhalothrin/karate	68085-85-8		3.1E+02	3.1E+03
Cypermethrin	52315-07-8		6.1E+02	6.2E+03
Cyromazine	66215-27-8		4.6E+02	4.6E+03
DDD	72-54-8		2.0E+00	7.2E+00
DDE, p,p'-	72-55-9		1.4E+00	5.1E+00
DDT	50-29-3		1.7E+00	7.0E+00
Dacthal	1861-32-1		6.1E+02	6.2E+03
Dalapon	75-99-0		1.8E+03	1.8E+04
Decabromodiphenyl ether, 2,2',3,3',4,4',5,5',6,6'- (BDE-209)	1163-19-5		4.3E+02	2.5E+03
Demeton	8065-48-3		2.4E+00	2.5E+01
Di(2-ethylhexyl)adipate	103-23-1		4.1E+02	1.4E+03
Diallate	2303-16-4		8.0E+00	2.8E+01
Diazinon	333-41-5		4.3E+01	4.3E+02
Dibenzothiophene	132-65-0		7.8E+02	1.0E+04
Dibromo-3-chloropropane, 1,2-	96-12-8		5.4E-03	6.9E-02
Dibromobenzene, 1,4-	106-37-6		6.1E+02	6.2E+03
Dibromochloromethane	124-48-1		6.8E-01	3.3E+00
Dibromoethane, 1,2-	106-93-4		3.4E-02	1.7E-01
Dibromomethane (Methylene Bromide)	74-95-3		2.5E+01	1.1E+02
Dibutyltin Compounds	NA		1.8E+01	1.8E+02
Dicamba	1918-00-9		1.8E+03	1.8E+04
Dichloro-2-butene, 1,4-	764-41-0		6.9E-03	3.5E-02
Dichloro-2-butene, cis-1,4-	1476-11-5		6.9E-03	3.5E-02
Dichloro-2-butene, trans-1,4-	110-57-6		6.9E-03	3.5E-02
Dichloroacetic Acid	79-43-6		9.7E+00	3.4E+01
Dichlorobenzene, 1,2-	95-50-1		1.9E+03	9.8E+03
Dichlorobenzene, 1,4-	106-46-7		2.4E+00	1.2E+01
Dichlorobenzidine, 3,3'-	91-94-1		1.1E+00	3.8E+00
Dichlorobenzophenone, 4,4'-	90-98-2		5.5E+02	5.5E+03
Dichlorodifluoromethane	75-71-8		9.4E+01	4.0E+02
Dichloroethane, 1,1-	75-34-3		3.3E+00	1.7E+01
Dichloroethane, 1,2-	107-06-2		4.3E-01	2.2E+00

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Dichloroethylene, 1,1-	75-35-4		2.4E+02	1.1E+03
Dichloroethylene, 1,2- (Mixed Isomers)	540-59-0		7.0E+02	9.2E+03
Dichloroethylene, 1,2-cis-	156-59-2	1.35E+02	1.6E+02	2.0E+03
Dichloroethylene, 1,2-trans-	156-60-5	1.50E+02	1.5E+02	6.9E+02
Dichlorophenol, 2,4-	120-83-2		1.8E+02	1.8E+03
Dichlorophenoxy Acetic Acid, 2,4-	94-75-7		6.9E+02	7.7E+03
Dichlorophenoxy)butyric Acid, 4-(2,4-	94-82-6		4.9E+02	4.9E+03
Dichloropropane, 1,2-	78-87-5		9.4E-01	4.7E+00
Dichloropropane, 1,3-	142-28-9		1.6E+03	2.0E+04
Dichloropropanol, 2,3-	616-23-9		1.8E+02	1.8E+03
Dichloropropene, 1,3-	542-75-6		1.7E+00	8.3E+00
Dichlorvos	62-73-7		1.7E+00	5.9E+00
Dicyclopentadiene	77-73-6		3.1E+01	1.3E+02
Dieldrin	60-57-1		3.0E-02	1.1E-01
Diethanolamine	111-42-2		1.2E+02	1.2E+03
Diethylene Glycol Monobutyl Ether	112-34-5		1.8E+03	1.8E+04
Diethylene Glycol Monoethyl Ether	111-90-0		3.6E+03	3.6E+04
Diethylformamide	617-84-5		6.1E+01	6.2E+02
Diethylstilbestrol	56-53-1		1.4E-03	4.9E-03
Difenzoquat	43222-48-6		4.9E+03	4.9E+04
Diflubenzuron	35367-38-5		1.2E+03	1.2E+04
Difluoroethane, 1,1-	75-37-6		5.2E+04	2.2E+05
Dihydrosafrole	94-58-6		2.4E-01	1.2E+00
Diisopropyl Ether	108-20-3		2.4E+03	1.0E+04
Diisopropyl Methylphosphonate	1445-75-6		6.3E+03	8.2E+04
Dimethipin	55290-64-7		1.2E+03	1.2E+04
Dimethoate	60-51-5		1.2E+01	1.2E+02
Dimethoxybenzidine, 3,3'-	119-90-4		3.0E-01	1.1E+00
Dimethyl methylphosphonate	756-79-6		2.9E+02	1.0E+03
Dimethylamino azobenzene [p-]	60-11-7		1.1E-01	3.7E-01
Dimethylaniline HCl, 2,4-	21436-96-4		8.4E-01	3.0E+00
Dimethylaniline, 2,4-	95-68-1		2.4E+00	8.6E+00
Dimethylaniline, N,N-	121-69-7		1.6E+02	2.0E+03
Dimethylbenzidine, 3,3'-	119-93-7		4.4E-02	1.6E-01
Dimethylformamide	68-12-2		6.1E+03	6.2E+04
Dimethylhydrazine, 1,1-	57-14-7		6.1E+00	6.1E+01
Dimethylhydrazine, 1,2-	540-73-8		8.8E-04	3.1E-03
Dimethylphenol, 2,4-	105-67-9		1.2E+03	1.2E+04
Dimethylphenol, 2,6-	576-26-1		3.7E+01	3.7E+02
Dimethylphenol, 3,4-	95-65-8		6.1E+01	6.2E+02
Dimethylvinylchloride	513-37-1		2.0E-01	1.0E+00

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Dinitro-o-cresol, 4,6-	534-52-1		4.9E+00	4.9E+01
Dinitro-o-cyclohexyl Phenol, 4,6-	131-89-5		1.2E+02	1.2E+03
Dinitrobenzene, 1,2-	528-29-0		6.1E+00	6.2E+01
Dinitrobenzene, 1,3-	99-65-0		6.1E+00	6.2E+01
Dinitrobenzene, 1,4-	100-25-4		6.1E+00	6.2E+01
Dinitrophenol, 2,4-	51-28-5		1.2E+02	1.2E+03
Dinitrotoluene Mixture, 2,4/2,6-	NA		7.2E-01	2.5E+00
Dinitrotoluene, 2,4-	121-14-2		1.6E+00	5.5E+00
Dinitrotoluene, 2,6-	606-20-2		3.3E-01	1.2E+00
Dinitrotoluene, 2-Amino-4,6-	35572-78-2		1.5E+02	2.0E+03
Dinitrotoluene, 4-Amino-2,6-	19406-51-0		1.5E+02	1.9E+03
Dinitrotoluene, Technical grade	25321-14-6		1.1E+00	3.8E+00
Dinoseb	88-85-7		6.1E+01	6.2E+02
Dioxane, 1,4-	123-91-1	2.69E+00	4.9E+00	1.7E+01
Dioxins				
~Hexachlorodibenzo-p-dioxin, Mixture	NA		9.4E-05	3.9E-04
~TCDD, 2,3,7,8-	1746-01-6	2.29E-06	4.5E-06	1.8E-05
Diphenamid	957-51-7		1.8E+03	1.8E+04
Diphenyl Sulfone	127-63-9		4.9E+01	4.9E+02
Diphenylamine	122-39-4		1.5E+03	1.5E+04
Diphenylhydrazine, 1,2-	122-66-7		6.1E-01	2.2E+00
Diquat	85-00-7		1.3E+02	1.4E+03
Direct Black 38	1937-37-7		6.6E-02	2.3E-01
Direct Blue 6	2602-46-2		6.6E-02	2.3E-01
Direct Brown 95	16071-86-6		7.3E-02	2.6E-01
Disulfoton	298-04-4		2.4E+00	2.5E+01
Dithiane, 1,4-	505-29-3		6.1E+02	6.2E+03
Diuron	330-54-1		1.2E+02	1.2E+03
Dodine	2439-10-3		2.4E+02	2.5E+03
EPTC	759-94-4		2.0E+03	2.6E+04
Endosulfan	115-29-7		3.7E+02	3.7E+03
Endothall	145-73-3		1.2E+03	1.2E+04
Endrin	72-20-8		1.8E+01	1.8E+02
Epichlorohydrin	106-89-8		2.0E+01	8.8E+01
Epoxybutane, 1,2-	106-88-7		1.7E+02	7.2E+02
Ethephon	16672-87-0		3.1E+02	3.1E+03
Ethion	563-12-2		3.1E+01	3.1E+02
Ethoxyethanol Acetate, 2-	111-15-9		6.1E+03	6.2E+04
Ethoxyethanol, 2-	110-80-5		5.5E+03	5.5E+04
Ethyl Acetate	141-78-6		6.7E+02	2.8E+03
Ethyl Acrylate	140-88-5		1.3E+01	6.0E+01

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Ethyl Chloride (Chloroethane)	75-00-3		1.5E+04	6.1E+04
Ethyl Ether	60-29-7		1.6E+04	2.0E+05
Ethyl Methacrylate	97-63-2		1.5E+03	7.5E+03
Ethyl-p-nitrophenyl Phosphonate	2104-64-5		6.1E-01	6.2E+00
Ethylbenzene	100-41-4		5.4E+00	2.7E+01
Ethylene Cyanohydrin	109-78-4		4.3E+03	4.3E+04
Ethylene Diamine	107-15-3		5.5E+03	5.5E+04
Ethylene Glycol	107-21-1		1.2E+05	1.2E+06
Ethylene Glycol Monobutyl Ether	111-76-2		6.1E+03	6.2E+04
Ethylene Oxide	75-21-8		1.7E-01	8.3E-01
Ethylene Thiourea	96-45-7		4.9E+00	3.8E+01
Ethyleneimine	151-56-4		2.3E-03	1.0E-02
Ethylphthalyl Ethyl Glycolate	84-72-0		1.8E+05	1.8E+06
Express	101200-48-0		4.9E+02	4.9E+03
Fenamiphos	22224-92-6		1.5E+01	1.5E+02
Fenpropathrin	39515-41-8		1.5E+03	1.5E+04
Fluometuron	2164-17-2		7.9E+02	8.0E+03
Fluoride	16984-48-8		3.1E+03	4.1E+04
Fluorine (Soluble Fluoride)	7782-41-4		4.7E+03	6.1E+04
Fluridone	59756-60-4		4.9E+03	4.9E+04
Flurprimidol	56425-91-3		1.2E+03	1.2E+04
Flutolanil	66332-96-5		3.7E+03	3.7E+04
Fluvalinate	69409-94-5		6.1E+02	6.2E+03
Folpet	133-07-3		1.4E+02	4.9E+02
Fomesafen	72178-02-0		2.6E+00	9.1E+00
Fonofos	944-22-9		1.2E+02	1.2E+03
Formaldehyde	50-00-0		1.2E+04	1.2E+05
Formic Acid	64-18-6		4.9E+04	4.2E+05
Fosetyl-AL	39148-24-8		1.8E+05	1.8E+06
Furans				
~Dibenzofuran	132-64-9		7.8E+01	1.0E+03
~Furan	110-00-9		7.8E+01	1.0E+03
~Tetrahydrofuran	109-99-9		1.8E+04	9.5E+04
Furazolidone	67-45-8		1.3E-01	4.5E-01
Furfural	98-01-1		1.8E+02	1.8E+03
Furium	531-82-8		3.2E-01	1.1E+00
Furmecyclox	60568-05-0		1.6E+01	5.7E+01
Glufosinate, Ammonium	77182-82-2		2.4E+01	2.5E+02

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Glutaraldehyde	111-30-8		1.1E+05	4.8E+05
Glycidyl	765-34-4		2.4E+01	2.5E+02
Glyphosate	1071-83-6		6.1E+03	6.2E+04
Goal	42874-03-3		1.8E+02	1.8E+03
Guthion	86-50-0		1.8E+02	1.8E+03
Haloxyfop, Methyl	69806-40-2		3.1E+00	3.1E+01
Harmony	79277-27-3		7.9E+02	8.0E+03
Heptachlor	76-44-8		1.1E-01	3.8E-01
Heptachlor Epoxide	1024-57-3		5.3E-02	1.9E-01
Hexabromobenzene	87-82-1		1.2E+02	1.2E+03
Hexabromodiphenyl ether, 2,2',4,4',5,5'- (BDE-153)	68631-49-2		1.2E+01	1.2E+02
Hexachlorobenzene	118-74-1	1.68E-01	3.0E-01	1.1E+00
Hexachlorobutadiene	87-68-3		6.2E+00	2.2E+01
Hexachlorocyclohexane, Alpha-	319-84-6		7.7E-02	2.7E-01
Hexachlorocyclohexane, Beta-	319-85-7		2.7E-01	9.6E-01
Hexachlorocyclohexane, Gamma- (Lindane)	58-89-9		5.2E-01	2.1E+00
Hexachlorocyclohexane, Technical	608-73-1		2.7E-01	9.6E-01
Hexachlorocyclopentadiene	77-47-4		3.7E+02	3.7E+03
Hexachloroethane	67-72-1		1.2E+01	4.3E+01
Hexachlorophene	70-30-4		1.8E+01	1.8E+02
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	3.31E+00	5.6E+00	2.4E+01
Hexamethylene Diisocyanate, 1,6-	822-06-0		3.4E+00	1.4E+01
Hexamethylphosphoramide	680-31-9		2.4E+01	2.5E+02
Hexane, N-	110-54-3		5.7E+02	2.6E+03
Hexanedioic Acid	124-04-9		1.2E+05	1.2E+06
Hexanone, 2-	591-78-6		2.1E+02	1.4E+03
Hexazinone	51235-04-2		2.0E+03	2.0E+04
Hydrazine	302-01-2		2.1E-01	9.5E-01
Hydrazine Sulfate	10034-93-2		2.1E-01	9.5E-01
Hydrogen Chloride	7647-01-0		2.8E+07	1.2E+08
Hydrogen Fluoride	7664-39-3		3.1E+03	4.1E+04
Hydrogen Sulfide	7783-06-4		2.8E+06	1.2E+07
Hydroquinone	123-31-9		8.1E+00	2.9E+01
Imazalil	35554-44-0		7.9E+02	8.0E+03
Imazaquin	81335-37-7		1.5E+04	1.5E+05
Iodine	7553-56-2		7.8E+02	1.0E+04
Iprodione	36734-19-7		2.4E+03	2.5E+04
Iron	7439-89-6		5.5E+04	7.2E+05
Isobutyl Alcohol	78-83-1		1.8E+04	1.8E+05
Isophorone	78-59-1		5.1E+02	1.8E+03
Isopropalin	33820-53-0		9.2E+02	9.2E+03

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Isopropanol	67-63-0		9.9E+09	4.2E+10
Isopropyl Methyl Phosphonic Acid	1832-54-8		6.1E+03	6.2E+04
Isoxaben	82558-50-7		3.1E+03	3.1E+04
JP-7	NA		4.3E+08	1.8E+09
Kerb	23950-58-5		4.6E+03	4.6E+04
Lactofen	77501-63-4		1.2E+02	1.2E+03
Lead Compounds				
~Lead acetate	301-04-2		1.7E+00	6.2E+00
~Lead and Compounds	7439-92-1		4.0E+02	8.0E+02
~Lead subacetate	1335-32-6		1.3E+01	4.5E+01
~Tetraethyl Lead	78-00-2		6.1E-03	6.2E-02
Linuron	330-55-2		1.2E+02	1.2E+03
Lithium	7439-93-2		1.6E+02	2.0E+03
Londax	83055-99-6		1.2E+04	1.2E+05
MCPA	94-74-6		3.1E+01	3.1E+02
MCPB	94-81-5		6.1E+02	6.2E+03
MCPP	93-65-2		6.1E+01	6.2E+02
Malathion	121-75-5		1.2E+03	1.2E+04
Maleic Anhydride	108-31-6		6.1E+03	6.1E+04
Maleic Hydrazide	123-33-1		3.1E+04	3.1E+05
Malononitrile	109-77-3		6.1E+00	6.2E+01
Mancozeb	8018-01-7		1.8E+03	1.8E+04
Maneb	12427-38-2		3.1E+02	3.1E+03
Manganese (Non-diet)	7439-96-5		1.8E+03	2.3E+04
Mephosfolan	950-10-7		5.5E+00	5.5E+01
Mepiquat Chloride	24307-26-4		1.8E+03	1.8E+04
Mercury Compounds				
~Mercuric Chloride (and other Mercury salts)	7487-94-7		2.3E+01	3.1E+02
~Mercury (elemental)	7439-97-6		1.0E+01	4.3E+01
~Methyl Mercury	22967-92-6		7.8E+00	1.0E+02
~Phenylmercuric Acetate	62-38-4		4.9E+00	4.9E+01
Merphos	150-50-5		1.8E+00	1.8E+01
Merphos Oxide	78-48-8		1.8E+00	1.8E+01
Metalaxyl	57837-19-1		3.7E+03	3.7E+04
Methacrylonitrile	126-98-7		7.6E+00	9.2E+01
Methamidophos	10265-92-6		3.1E+00	3.1E+01
Methanol	67-56-1		1.2E+05	1.2E+06
Methidathion	950-37-8		6.1E+01	6.2E+02
Methomyl	16752-77-5		1.5E+03	1.5E+04
Methoxy-5-nitroaniline, 2-	99-59-2		9.9E+00	3.5E+01
Methoxychlor	72-43-5		3.1E+02	3.1E+03

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Methoxyethanol Acetate, 2-	110-49-6		4.9E+02	4.9E+03
Methoxyethanol, 2-	109-86-4		3.1E+02	3.1E+03
Methyl Acetate	79-20-9		7.8E+04	1.0E+06
Methyl Acrylate	96-33-3		1.5E+02	6.4E+02
Methyl Ethyl Ketone (2-Butanone)	78-93-3	2.54E+04	2.8E+04	2.0E+05
Methyl Hydrazine	60-34-4		6.1E+01	6.1E+02
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	108-10-1		5.3E+03	5.3E+04
Methyl Isocyanate	624-83-9		5.0E+00	2.1E+01
Methyl Methacrylate	80-62-6		4.8E+03	2.1E+04
Methyl Parathion	298-00-0		1.5E+01	1.5E+02
Methyl Phosphonic Acid	993-13-5		3.7E+03	3.7E+04
Methyl Styrene (Mixed Isomers)	25013-15-4		2.4E+02	1.5E+03
Methyl methanesulfonate	66-27-3		4.9E+00	1.7E+01
Methyl tert-Butyl Ether (MTBE)	1634-04-4	6.47E+02	4.3E+01	2.2E+02
Methyl-1,4-benzenediamine dihydrochloride, 2-	615-45-2		1.8E+01	1.8E+02
Methyl-5-Nitroaniline, 2-	99-55-8		5.4E+01	1.9E+02
Methyl-N-nitro-N-nitrosoguanidine, N-	70-25-7		5.9E-02	2.1E-01
Methylaniline Hydrochloride, 2-	636-21-5		3.7E+00	1.3E+01
Methylarsonic acid	124-58-3		6.1E+02	6.2E+03
Methylbenzene,1-4-diamine monohydrochloride, 2-	74612-12-7		1.2E+01	1.2E+02
Methylbenzene-1,4-diamine sulfate, 2-	615-50-9		4.9E+00	1.7E+01
Methylcholanthrene, 3-	56-49-5		5.2E-03	7.8E-02
Methylene Chloride	75-09-2		5.6E+01	9.6E+02
Methylene-bis(2-chloroaniline), 4,4'-	101-14-4		1.2E+00	1.7E+01
Methylene-bis(N,N-dimethyl) Aniline, 4,4'-	101-61-1		1.1E+01	3.7E+01
Methylenebisbenzenamine, 4,4'-	101-77-9		3.0E-01	1.1E+00
Methylenediphenyl Diisocyanate	101-68-8		8.5E+05	3.6E+06
Methylstyrene, Alpha-	98-83-9		5.5E+03	7.2E+04
Metolachlor	51218-45-2		9.2E+03	9.2E+04
Metribuzin	21087-64-9		1.5E+03	1.5E+04
Mineral oils	8012-95-1		1.8E+05	1.8E+06
Mirex	2385-85-5		2.7E-02	9.6E-02
Molinate	2212-67-1		1.2E+02	1.2E+03
Molybdenum	7439-98-7		3.9E+02	5.1E+03
Monochloramine	10599-90-3		7.8E+03	1.0E+05
Monomethylaniline	100-61-8		1.2E+02	1.2E+03
N,N'-Diphenyl-1,4-benzenediamine	74-31-7		1.8E+01	1.8E+02
Naled	300-76-5		1.2E+02	1.2E+03
Naphtha, High Flash Aromatic (HFAN)	64724-95-6		2.3E+03	3.1E+04
Naphthylamine, 2-	91-59-8		2.7E-01	9.6E-01

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Napropamide	15299-99-7		6.1E+03	6.2E+04
Nickel Carbonyl	13463-39-3		8.2E+02	9.9E+03
Nickel Oxide	1313-99-1		8.4E+02	1.0E+04
Nickel Refinery Dust	NA		8.2E+02	9.9E+03
Nickel Soluble Salts	7440-02-0		1.5E+03	2.0E+04
Nickel Subsulfide	12035-72-2		3.8E-01	1.7E+00
Nitrate	14797-55-8		1.3E+05	1.6E+06
Nitrite	14797-65-0		7.8E+03	1.0E+05
Nitroaniline, 2-	88-74-4		6.1E+02	6.0E+03
Nitroaniline, 4-	100-01-6		2.4E+01	8.6E+01
Nitrobenzene	98-95-3		4.8E+00	2.4E+01
Nitrocellulose	9004-70-0		1.8E+08	1.8E+09
Nitrofurantoin	67-20-9		4.3E+03	4.3E+04
Nitrofurazone	59-87-0		3.7E-01	1.3E+00
Nitroglycerin	55-63-0		6.1E+00	6.2E+01
Nitroguanidine	556-88-7		6.1E+03	6.2E+04
Nitromethane	75-52-5		5.0E+00	2.5E+01
Nitropropane, 2-	79-46-9		1.3E-02	6.4E-02
Nitroso-N-ethylurea, N-	759-73-9		4.3E-03	6.4E-02
Nitroso-N-methylurea, N-	684-93-5		9.6E-04	1.4E-02
Nitroso-di-N-butylamine, N-	924-16-3		8.7E-02	4.0E-01
Nitroso-di-N-propylamine, N-	621-64-7		6.9E-02	2.5E-01
Nitrosodiethanolamine, N-	1116-54-7		1.7E-01	6.2E-01
Nitrosodiethylamine, N-	55-18-5		7.7E-04	1.1E-02
Nitrosodimethylamine, N-	62-75-9		2.3E-03	3.4E-02
Nitrosodiphenylamine, N-	86-30-6		9.9E+01	3.5E+02
Nitrosomethylethylamine, N-	10595-95-6		2.2E-02	7.8E-02
Nitrosomorpholine [N-]	59-89-2		7.3E-02	2.6E-01
Nitrosopiperidine [N-]	100-75-4		5.2E-02	1.8E-01
Nitrosopyrrolidine, N-	930-55-2		2.3E-01	8.2E-01
Nitrotoluene, m-	99-08-1		6.1E+00	6.2E+01
Nitrotoluene, o-	88-72-2		2.9E+00	1.3E+01
Nitrotoluene, p-	99-99-0		3.0E+01	1.1E+02
Nonane, n-	111-84-2		1.2E+01	7.4E+01
Norflurazon	27314-13-2		2.4E+03	2.5E+04
Nustar	85509-19-9		4.3E+01	4.3E+02
Octabromodiphenyl Ether	32536-52-0		1.8E+02	1.8E+03
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	3.59E+03	3.8E+03	4.9E+04
Octamethylpyrophosphoramide	152-16-9		1.2E+02	1.2E+03
Oryzalin	19044-88-3		3.1E+03	3.1E+04

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Oxadiazon	19666-30-9		3.1E+02	3.1E+03
Oxamyl	23135-22-0		1.5E+03	1.5E+04
Paclobutrazol	76738-62-0		7.9E+02	8.0E+03
Paraquat Dichloride	1910-42-5		2.7E+02	2.8E+03
Parathion	56-38-2		3.7E+02	3.7E+03
Pebulate	1114-71-2		3.1E+03	3.1E+04
Pendimethalin	40487-42-1		2.4E+03	2.5E+04
Pentabromodiphenyl Ether	32534-81-9		1.2E+02	1.2E+03
Pentabromodiphenyl ether, 2,2',4,4',5- (BDE-99)	60348-60-9		6.1E+00	6.2E+01
Pentachlorobenzene	608-93-5		4.9E+01	4.9E+02
Pentachloroethane	76-01-7		5.4E+00	1.9E+01
Pentachloronitrobenzene	82-68-8		1.9E+00	6.6E+00
Pentachlorophenol	87-86-5	4.61E-01	8.9E-01	2.7E+00
Pentaerythritol tetranitrate (PETN)	78-11-5	1.14E+02	1.2E+02	4.3E+02
Pentane, n-	109-66-0		8.7E+02	3.7E+03
Perchlorates				
~Ammonium Perchlorate	7790-98-9		5.5E+01	7.2E+02
~Lithium Perchlorate	7791-03-9		5.5E+01	7.2E+02
~Perchlorate and Perchlorate Salts	14797-73-0	4.97E+01	5.5E+01	7.2E+02
~Potassium Perchlorate	7778-74-7		5.5E+01	7.2E+02
~Sodium Perchlorate	7601-89-0		5.5E+01	7.2E+02
Permethrin	52645-53-1		3.1E+03	3.1E+04
Phenacetin	62-44-2		2.2E+02	7.8E+02
Phenmedipham	13684-63-4		1.5E+04	1.5E+05
Phenol	108-95-2		1.8E+04	1.8E+05
Phenothiazine	92-84-2		3.1E+01	3.1E+02
Phenylenediamine, m-	108-45-2		3.7E+02	3.7E+03
Phenylenediamine, o-	95-54-5		1.0E+01	3.7E+01
Phenylenediamine, p-	106-50-3		1.2E+04	1.2E+05
Phenylphenol, 2-	90-43-7		2.5E+02	8.9E+02
Phorate	298-02-2		1.2E+01	1.2E+02
Phosgene	75-44-5		3.3E-01	1.4E+00
Phosmet	732-11-6		1.2E+03	1.2E+04
Phosphates, Inorganic				
~Aluminum metaphosphate	13776-88-0		3.8E+06	5.0E+07
~Ammonium polyphosphate	68333-79-9		3.8E+06	5.0E+07
~Calcium pyrophosphate	7790-76-3		3.8E+06	5.0E+07
~Diammonium phosphate	7783-28-0		3.8E+06	5.0E+07
~Dicalcium phosphate	7757-93-9		3.8E+06	5.0E+07
~Dimagnesium phosphate	7782-75-4		3.8E+06	5.0E+07
~Dipotassium phosphate	7758-11-4		3.8E+06	5.0E+07

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
~Disodium phosphate	7558-79-4		3.8E+06	5.0E+07
~Monoaluminum phosphate	13530-50-2		3.8E+06	5.0E+07
~Monoammonium phosphate	7722-76-1		3.8E+06	5.0E+07
~Monocalcium phosphate	7758-23-8		3.8E+06	5.0E+07
~Monomagnesium phosphate	7757-86-0		3.8E+06	5.0E+07
~Monopotassium phosphate	7778-77-0		3.8E+06	5.0E+07
~Monosodium phosphate	7558-80-7		3.8E+06	5.0E+07
~Polyphosphoric acid	8017-16-1		3.8E+06	5.0E+07
~Potassium tripolyphosphate	13845-36-8		3.8E+06	5.0E+07
~Sodium acid pyrophosphate	7758-16-9		3.8E+06	5.0E+07
~Sodium aluminum phosphate (acidic)	7785-88-8		3.8E+06	5.0E+07
~Sodium aluminum phosphate (anhydrous)	10279-59-1		3.8E+06	5.0E+07
~Sodium aluminum phosphate (tetrahydrate)	10305-76-7		3.8E+06	5.0E+07
~Sodium hexametaphosphate	10124-56-8		3.8E+06	5.0E+07
~Sodium polyphosphate	68915-31-1		3.8E+06	5.0E+07
~Sodium trimetaphosphate	7785-84-4		3.8E+06	5.0E+07
~Sodium tripolyphosphate	7758-29-4		3.8E+06	5.0E+07
~Tetrapotassium phosphate	7320-34-5		3.8E+06	5.0E+07
~Tetrasodium pyrophosphate	7722-88-5		3.8E+06	5.0E+07
~Trialuminum sodium tetra decahydrogenoctaorthophosphate (dihydrate)	15136-87-5		3.8E+06	5.0E+07
~Tricalcium phosphate	7758-87-4		3.8E+06	5.0E+07
~Trimagnesium phosphate	7757-87-1		3.8E+06	5.0E+07
~Tripotassium phosphate	7778-53-2		3.8E+06	5.0E+07
~Trisodium phosphate	7601-54-9		3.8E+06	5.0E+07
Phosphine	7803-51-2		2.3E+01	3.1E+02
Phosphoric Acid	7664-38-2		3.0E+06	2.7E+07
Phosphorus, White	7723-14-0		1.6E+00	2.0E+01
Phthalates				
~Bis(2-ethylhexyl)phthalate	117-81-7	1.92E+01	3.5E+01	1.2E+02
~Butylphthalyl Butylglycolate	85-70-1		6.1E+04	6.2E+05
~Dibutyl Phthalate	84-74-2		6.1E+03	6.2E+04
~Diethyl Phthalate	84-66-2		4.9E+04	4.9E+05
~Dimethylterephthalate	120-61-6		7.8E+03	1.0E+05
~Octyl Phthalate, di-N-	117-84-0		6.1E+02	6.2E+03
~Phthalic Acid, P-	100-21-0		6.1E+04	6.2E+05
~Phthalic Anhydride	85-44-9		1.2E+05	1.2E+06
Picloram	1918-02-1		4.3E+03	4.3E+04
Picramic Acid (2-Amino-4,6-dinitrophenol)	96-91-3		6.1E+00	6.2E+01
Pirimiphos, Methyl	29232-93-7		6.1E+02	6.2E+03
Polybrominated Biphenyls	59536-65-1		1.6E-02	5.7E-02

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Polychlorinated Biphenyls (PCBs)				
~Aroclor 1016	12674-11-2		3.9E+00	2.1E+01
~Aroclor 1221	11104-28-2		1.4E-01	5.4E-01
~Aroclor 1232	11141-16-5		1.4E-01	5.4E-01
~Aroclor 1242	53469-21-9		2.2E-01	7.4E-01
~Aroclor 1248	12672-29-6		2.2E-01	7.4E-01
~Aroclor 1254	11097-69-1	1.20E-01	2.2E-01	7.4E-01
~Aroclor 1260	11096-82-5		2.2E-01	7.4E-01
~Heptachlorobiphenyl, 2,3,3',4,4',5,5'- (PCB 189)	39635-31-9		1.1E-01	3.8E-01
~Hexachlorobiphenyl, 2,3',4,4',5,5'- (PCB 167)	52663-72-6		1.1E-01	3.8E-01
~Hexachlorobiphenyl, 2,3,3',4,4',5'- (PCB 157)	69782-90-7		1.1E-01	3.8E-01
~Hexachlorobiphenyl, 2,3,3',4,4',5- (PCB 156)	38380-08-4		1.1E-01	3.8E-01
~Hexachlorobiphenyl, 3,3',4,4',5,5'- (PCB 169)	32774-16-6		1.1E-04	3.8E-04
~Pentachlorobiphenyl, 2',3,4,4',5- (PCB 123)	65510-44-3		1.1E-01	3.8E-01
~Pentachlorobiphenyl, 2,3',4,4',5- (PCB 118)	31508-00-6		1.1E-01	3.8E-01
~Pentachlorobiphenyl, 2,3,3',4,4'- (PCB 105)	32598-14-4		1.1E-01	3.8E-01
~Pentachlorobiphenyl, 2,3,4,4',5- (PCB 114)	74472-37-0		1.1E-01	3.8E-01
~Pentachlorobiphenyl, 3,3',4,4',5- (PCB 126)	57465-28-8		3.4E-05	1.1E-04
~Polychlorinated Biphenyls (high risk)	1336-36-3	1.20E-01	2.2E-01	7.4E-01
~Tetrachlorobiphenyl, 3,3',4,4'- (PCB 77)	32598-13-3		3.4E-02	1.1E-01
~Tetrachlorobiphenyl, 3,4,4',5- (PCB 81)	70362-50-4		1.1E-02	3.8E-02
Polymeric Methylene Diphenyl Diisocyanate (PMDI)	9016-87-9		8.5E+05	3.6E+06
Polynuclear Aromatic Hydrocarbons (PAHs)				
~Acenaphthene	83-32-9		3.4E+03	3.3E+04
~Anthracene	120-12-7		1.7E+04	1.7E+05
~Benz[a]anthracene	56-55-3		1.5E-01	2.1E+00
~Benzo(j)fluoranthene	205-82-3		3.8E-01	1.3E+00
~Benzo[a]pyrene	50-32-8	1.00E-02	1.5E-02	2.1E-01
~Benzo[b]fluoranthene	205-99-2		1.5E-01	2.1E+00
~Benzo[k]fluoranthene	207-08-9		1.5E+00	2.1E+01
~Chloronaphthalene, Beta-	91-58-7		6.3E+03	8.2E+04
~Chrysene	218-01-9		1.5E+01	2.1E+02
~Dibenz[a,h]anthracene	53-70-3		1.5E-02	2.1E-01
~Dibenzo(a,e)pyrene	192-65-4		3.8E-02	1.3E-01
~Dimethylbenz(a)anthracene, 7,12-	57-97-6		4.3E-04	6.2E-03
~Fluoranthene	206-44-0		2.3E+03	2.2E+04
~Fluorene	86-73-7		2.3E+03	2.2E+04
~Indeno[1,2,3-cd]pyrene	193-39-5		1.5E-01	2.1E+00
~Methylnaphthalene, 1-	90-12-0		1.6E+01	5.3E+01
~Methylnaphthalene, 2-	91-57-6		2.3E+02	2.2E+03

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
~Naphthalene	91-20-3	1.53E+00	3.6E+00	1.8E+01
~Nitropyrene, 4-	57835-92-4		3.8E-01	1.3E+00
~Pyrene	129-00-0		1.7E+03	1.7E+04
Prochloraz	67747-09-5		3.2E+00	1.1E+01
Profluralin	26399-36-0		3.7E+02	3.7E+03
Prometon	1610-18-0		9.2E+02	9.2E+03
Prometryn	7287-19-6		2.4E+02	2.5E+03
Propachlor	1918-16-7		7.9E+02	8.0E+03
Propanil	709-98-8		3.1E+02	3.1E+03
Propargite	2312-35-8		1.2E+03	1.2E+04
Propargyl Alcohol	107-19-7		1.2E+02	1.2E+03
Propazine	139-40-2		1.2E+03	1.2E+04
Propham	122-42-9		1.2E+03	1.2E+04
Propiconazole	60207-90-1		7.9E+02	8.0E+03
Propionaldehyde	123-38-6		8.0E+01	3.4E+02
Propyl benzene	103-65-1		3.4E+03	2.1E+04
Propylene	115-07-1		2.4E+03	1.0E+04
Propylene Glycol	57-55-6		1.2E+06	1.2E+07
Propylene Glycol Dinitrate	6423-43-4		3.9E+05	1.6E+06
Propylene Glycol Monoethyl Ether	1569-02-4		4.3E+04	4.3E+05
Propylene Glycol Monomethyl Ether	107-98-2		4.3E+04	4.3E+05
Propylene Oxide	75-56-9		2.0E+00	9.0E+00
Pursuit	81335-77-5		1.5E+04	1.5E+05
Pydrin	51630-58-1		1.5E+03	1.5E+04
Pyridine	110-86-1		7.8E+01	1.0E+03
Quinalphos	13593-03-8		3.1E+01	3.1E+02
Quinoline	91-22-5		1.6E-01	5.7E-01
Refractory Ceramic Fibers	NA		4.3E+07	1.8E+08
Resmethrin	10453-86-8		1.8E+03	1.8E+04
Ronnel	299-84-3		3.1E+03	3.1E+04
Rotenone	83-79-4		2.4E+02	2.5E+03
Safrole	94-59-7		5.2E-01	7.8E+00
Savey	78587-05-0		1.5E+03	1.5E+04
Selenious Acid	7783-00-8		3.9E+02	5.1E+03
Selenium	7782-49-2		3.9E+02	5.1E+03
Selenium Sulfide	7446-34-6		3.9E+02	5.1E+03
Sethoxydim	74051-80-2		5.5E+03	5.5E+04
Silica (crystalline, respirable)	7631-86-9		4.3E+06	1.8E+07
Silver	7440-22-4		3.9E+02	5.1E+03
Simazine	122-34-9		4.1E+00	1.4E+01
Sodium Acifluorfen	62476-59-9		7.9E+02	8.0E+03

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Sodium Azide	26628-22-8		3.1E+02	4.1E+03
Sodium Diethyldithiocarbamate	148-18-5		1.8E+00	6.4E+00
Sodium Fluoride	7681-49-4		3.9E+03	5.1E+04
Sodium Fluoroacetate	62-74-8		1.2E+00	1.2E+01
Sodium Metavanadate	13718-26-8		7.8E+01	1.0E+03
Stirofos (Tetrachlorovinphos)	961-11-5		2.0E+01	7.2E+01
Strontium, Stable	7440-24-6		4.7E+04	6.1E+05
Strychnine	57-24-9		1.8E+01	1.8E+02
Styrene	100-42-5		6.3E+03	3.6E+04
Sulfolane	126-33-0		6.1E+01	6.2E+02
Sulfonylbis(4-chlorobenzene), 1,1'-	80-07-9		4.9E+01	4.9E+02
Sulfuric Acid	7664-93-9		1.4E+06	6.0E+06
Systhane	88671-89-0		1.5E+03	1.5E+04
TCMTB	21564-17-0		1.8E+03	1.8E+04
Tebuthiuron	34014-18-1		4.3E+03	4.3E+04
Temephos	3383-96-8		1.2E+03	1.2E+04
Terbacil	5902-51-2		7.9E+02	8.0E+03
Terbufos	13071-79-9		1.5E+00	1.5E+01
Terbutryn	886-50-0		6.1E+01	6.2E+02
Tetrabromodiphenyl ether, 2,2',4,4'- (BDE-47)	5436-43-1		6.1E+00	6.2E+01
Tetrachlorobenzene, 1,2,4,5-	95-94-3		1.8E+01	1.8E+02
Tetrachloroethane, 1,1,1,2-	630-20-6		1.9E+00	9.3E+00
Tetrachloroethane, 1,1,2,2-	79-34-5		5.6E-01	2.8E+00
Tetrachloroethylene	127-18-4	1.57E+00	2.2E+01	1.1E+02
Tetrachlorophenol, 2,3,4,6-	58-90-2		1.8E+03	1.8E+04
Tetrachlorotoluene, p- alpha, alpha, alpha-	5216-25-1		2.4E-02	8.6E-02
Tetraethyl Dithiopyrophosphate	3689-24-5		3.1E+01	3.1E+02
Tetrafluoroethane, 1,1,1,2-	811-97-2		1.1E+05	4.6E+05
Tetryl (Trinitrophenylmethylnitramine)	479-45-8		1.2E+02	1.2E+03
Thallium (I) Nitrate	10102-45-1		5.5E-01	7.2E+00
Thallium (Soluble Salts)	7440-28-0		7.8E-01	1.0E+01
Thallium Acetate	563-68-8		4.7E-01	6.1E+00
Thallium Carbonate	6533-73-9		1.6E+00	2.0E+01
Thallium Chloride	7791-12-0		4.7E-01	6.1E+00
Thallium Sulfate	7446-18-6		1.6E+00	2.0E+01
Thiobencarb	28249-77-6		6.1E+02	6.2E+03
Thiodiglycol	111-48-8		5.4E+03	6.8E+04
Thiofanox	39196-18-4		1.8E+01	1.8E+02
Thiophanate, Methyl	23564-05-8		4.9E+03	4.9E+04
Thiram	137-26-8		3.1E+02	3.1E+03
Tin	7440-31-5		4.7E+04	6.1E+05

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Titanium Tetrachloride	7550-45-0		1.4E+05	6.0E+05
Toluene	108-88-3		5.0E+03	4.5E+04
Toluene-2,5-diamine	95-70-5		2.7E+00	9.6E+00
Toluidine, p-	106-49-0		1.6E+01	5.7E+01
Total Petroleum Hydrocarbons (Aliphatic High)	NA		1.8E+05	1.8E+06
Total Petroleum Hydrocarbons (Aliphatic Low)	NA		1.1E+01	5.8E+01
Total Petroleum Hydrocarbons (Aliphatic Medium)	NA		6.1E-01	3.1E+00
Total Petroleum Hydrocarbons (Aromatic High)	NA		6.7E-02	2.4E-01
Total Petroleum Hydrocarbons (Aromatic Low)	NA		1.1E+00	5.4E+00
Total Petroleum Hydrocarbons (Aromatic Medium)	NA		1.1E+02	6.3E+02
Toxaphene	8001-35-2		4.4E-01	1.6E+00
Tralomethrin	66841-25-6		4.6E+02	4.6E+03
Tri-n-butyltin	688-73-3		1.8E+01	1.8E+02
Triacetin	102-76-1		4.9E+06	4.9E+07
Triallate	2303-17-5		7.9E+02	8.0E+03
Triasulfuron	82097-50-5		6.1E+02	6.2E+03
Tribromobenzene, 1,2,4-	615-54-3		3.1E+02	3.1E+03
Tributyl Phosphate	126-73-8		5.4E+01	1.9E+02
Tributyltin Compounds	NA		1.8E+01	1.8E+02
Tributyltin Oxide	56-35-9		1.8E+01	1.8E+02
Trichloro-1,2,2-trifluoroethane, 1,1,2-	76-13-1		4.3E+04	1.8E+05
Trichloroacetic Acid	76-03-9		6.9E+00	2.5E+01
Trichloroaniline HCl, 2,4,6-	33663-50-2		1.7E+01	5.9E+01
Trichloroaniline, 2,4,6-	634-93-5		1.8E+00	1.8E+01
Trichlorobenzene, 1,2,3-	87-61-6		4.9E+01	4.9E+02
Trichlorobenzene, 1,2,4-	120-82-1		2.2E+01	9.9E+01
Trichloroethane, 1,1,1-	71-55-6		8.7E+03	3.8E+04
Trichloroethane, 1,1,2-	79-00-5		1.1E+00	5.3E+00
Trichloroethylene	79-01-6	4.71E-01	9.1E-01	6.4E+00
Trichlorofluoromethane	75-69-4		7.9E+02	3.4E+03
Trichlorophenol, 2,4,5-	95-95-4		6.1E+03	6.2E+04
Trichlorophenol, 2,4,6-	88-06-2		4.4E+01	1.6E+02
Trichlorophenoxyacetic Acid, 2,4,5-	93-76-5		6.1E+02	6.2E+03
Trichlorophenoxypropionic acid, -2,4,5	93-72-1		4.9E+02	4.9E+03
Trichloropropane, 1,1,2-	598-77-6		3.9E+02	5.1E+03
Trichloropropane, 1,2,3-	96-18-4	3.13E-03	5.0E-03	9.5E-02
Trichloropropene, 1,2,3-	96-19-5		7.8E-01	3.3E+00
Tricresyl Phosphate (TCP)	1330-78-5		5.6E+03	3.1E+04
Tridiphane	58138-08-2		1.8E+02	1.8E+03
Triethylamine	121-44-8		1.2E+02	5.2E+02
Trifluralin	1582-09-8		6.3E+01	2.2E+02

Analyte	CAS No.	VDH Values (mg/kg)	Resident Soil (mg/kg)	Industrial Soil (mg/kg)
Trimethyl Phosphate	512-56-1		2.4E+01	8.6E+01
Trimethylbenzene, 1,2,3-	526-73-8	4.93E+01	5.3E+01	2.2E+02
Trimethylbenzene, 1,2,4-	95-63-6	4.16E+01	6.2E+01	2.6E+02
Trimethylbenzene, 1,3,5-	108-67-8	3.51E+01	7.8E+02	1.0E+04
Trinitrobenzene, 1,3,5-	99-35-4		2.2E+03	2.7E+04
Trinitrotoluene, 2,4,6-	118-96-7	1.13E+01	1.9E+01	7.9E+01
Triphenylphosphine Oxide	791-28-6		1.2E+03	1.2E+04
Tris(1,3-Dichloro-2-propyl) Phosphate	13674-87-8		1.2E+03	1.2E+04
Tris(1-chloro-2-propyl)phosphate	13674-84-5		6.1E+02	6.2E+03
Tris(2-chloroethyl)phosphate	115-96-8		2.4E+01	8.6E+01
Tris(2-ethylhexyl)phosphate	78-42-2		1.5E+02	5.4E+02
Uranium (Soluble Salts)	NA		2.3E+02	3.0E+03
Urethane	51-79-6		1.2E-01	1.7E+00
Vanadium Pentoxide	1314-62-1		4.0E+02	2.0E+03
Vanadium and Compounds	7440-62-2		3.9E+02	5.1E+03
Vernolate	1929-77-7		6.1E+01	6.2E+02
Vinclozolin	50471-44-8		1.5E+03	1.5E+04
Vinyl Acetate	108-05-4		9.7E+02	4.1E+03
Vinyl Bromide	593-60-2		1.1E-01	5.6E-01
Vinyl Chloride	75-01-4		6.0E-02	1.7E+00
Warfarin	81-81-2		1.8E+01	1.8E+02
Xylene, P-	106-42-3		6.0E+02	2.6E+03
Xylene, m-	108-38-3		5.9E+02	2.5E+03
Xylene, o-	95-47-6		6.9E+02	3.0E+03
Xylenes	1330-20-7		6.3E+02	2.7E+03
Zinc Phosphide	1314-84-7		2.3E+01	3.1E+02
Zinc and Compounds	7440-66-6		2.3E+04	3.1E+05
Zineb	12122-67-7		3.1E+03	3.1E+04
Zirconium	7440-67-7		6.3E+00	8.2E+01

APPENDIX B. DEPARTMENT OF ENVIRONMENTAL CONSERVATION / WASTE MANAGEMENT DIVISION OFF-SITE PETROLEUM CONTAMINATED SOIL TREATMENT REQUEST FORM

Off-Site Location

Soil Volume/Peak PID/Avg. PID:_____
Off-Site Street Address:
_____
_____Name
of Land Owner:_____

Generator/Owner of Soil

Phone # of Land Owner:_____
Name:_____
Facility ID#, Name, and Street Address:_____
_____
Contact:_____
Phone #:

Off-Site Soil Treatment Siting Criteria Checklist

- ☐ There are no bedrock drinking water supplies within 200 feet of the treatment location.
- ☐ There are no shallow water supplies (e.g. dug wells, driven wells, etc.) within 300 feet of the treatment location. This limit may need to be extended if shallow water supplies are shown to be hydraulically downgradient.
- ☐ There are no sensitive environments such as a stream, river, lake, pond, wildlife refuge, wetland, floodplain or other similar areas, within 100 feet of the treatment location.
- ☐ There is adequate room to allow for treatment to occur over the necessary time frame.
- ☐ Public access to the treatment area has been restricted (e.g. fencing, posted).
- ☐ The treatment location is not in a residential area.
- ☐ Written approval from the landowner, if different from the soil generator, has been obtained before treatment begins. This must include written approval from the landowner granting Department of Environmental Conservation (DEC) investigators property access for the purpose of inspecting soil treatment at any reasonable time.
- ☐ The local municipality has been notified in writing of the off-site location prior to initiating any soil treatment. The soil generator has provided evidence to the Waste Management Division (WMD) that this notification has been made. If applicable, local permits should be obtained.
- ☐ An area map of the soil location has been submitted to the WMD.
- ☐ The WMD has given approval to move soils to the off-site location specified above, as indicated by the WMD representative's signature below.

As the party responsible for compliance with the "Agency Guidelines for Petroleum Contaminated Soil and Debris," subchapter 6 of the "Vermont Underground Storage Tank Regulations," and applicable statutes, I hereby certify that the representations made on this form are to the best of my knowledge true and correct.

_____ _____
Name of Owner/Operator Representative (printed) Company Title

_____ _____
Signature Date

As land owner of the soil treatment location, I hereby give approval to the soil generator to treat the soil volume cited above at the above referenced location. In addition, I hereby grant property access to DEC investigators for the purpose of inspecting soil treatment at any reasonable time.

_____ _____
Signature of Land Owner Date

_____ _____
Signature of WMD Representative Date of Approval

APPENDIX C: VAPOR INTRUSION

C.1 HOW VAPOR INTRUSION OCCURS

Many factors relating to air movement, environmental conditions, and building types influence how vapors will affect a particular area. This section describes several air movement patterns and site conditions that may reduce or increase the risk of vapor intrusion.

Diffusion

Diffusion occurs as a result of a concentration gradient between the source and the surrounding area; in the example provided below, the source is NAPL. This can result in the migration of vapors through the vadose (unsaturated) zone above the groundwater table (see Figure 2). Soil vapors can also be produced by dissolved contamination in groundwater, and by contamination in dry soils. Depending on the soil permeability and heterogeneity, the time since chemicals were released, and natural attenuation processes, the distribution of volatile chemicals in soil vapor may extend considerable distances.

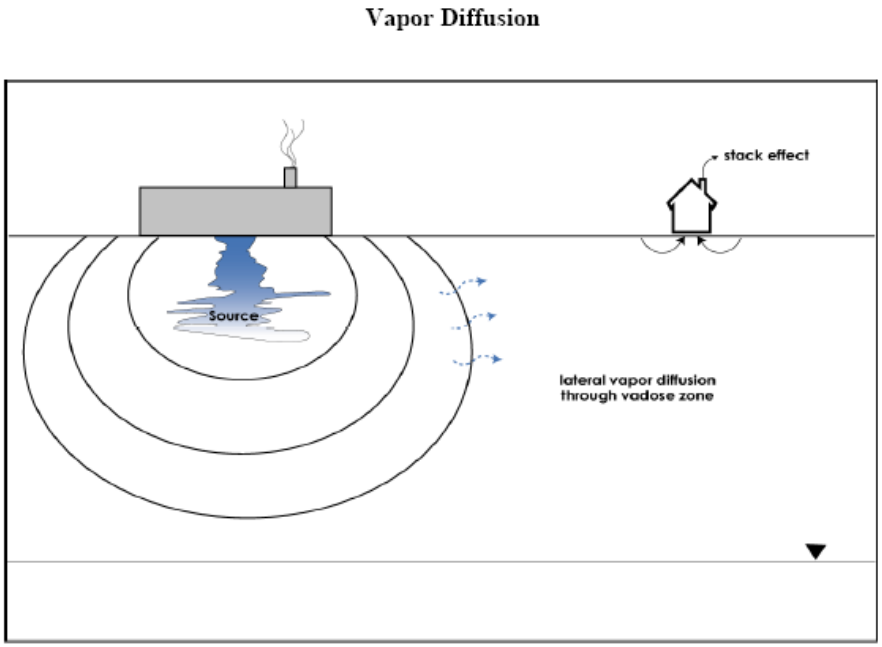


Figure 2: Diffusion of vapors in the vadose zone

Advection/Convection

The horizontal and vertical movement of vapors located near a building foundation is often affected within an area referred to as the “zone of influence” (see Figure 3).

Advective/Convective Transport of Vapors

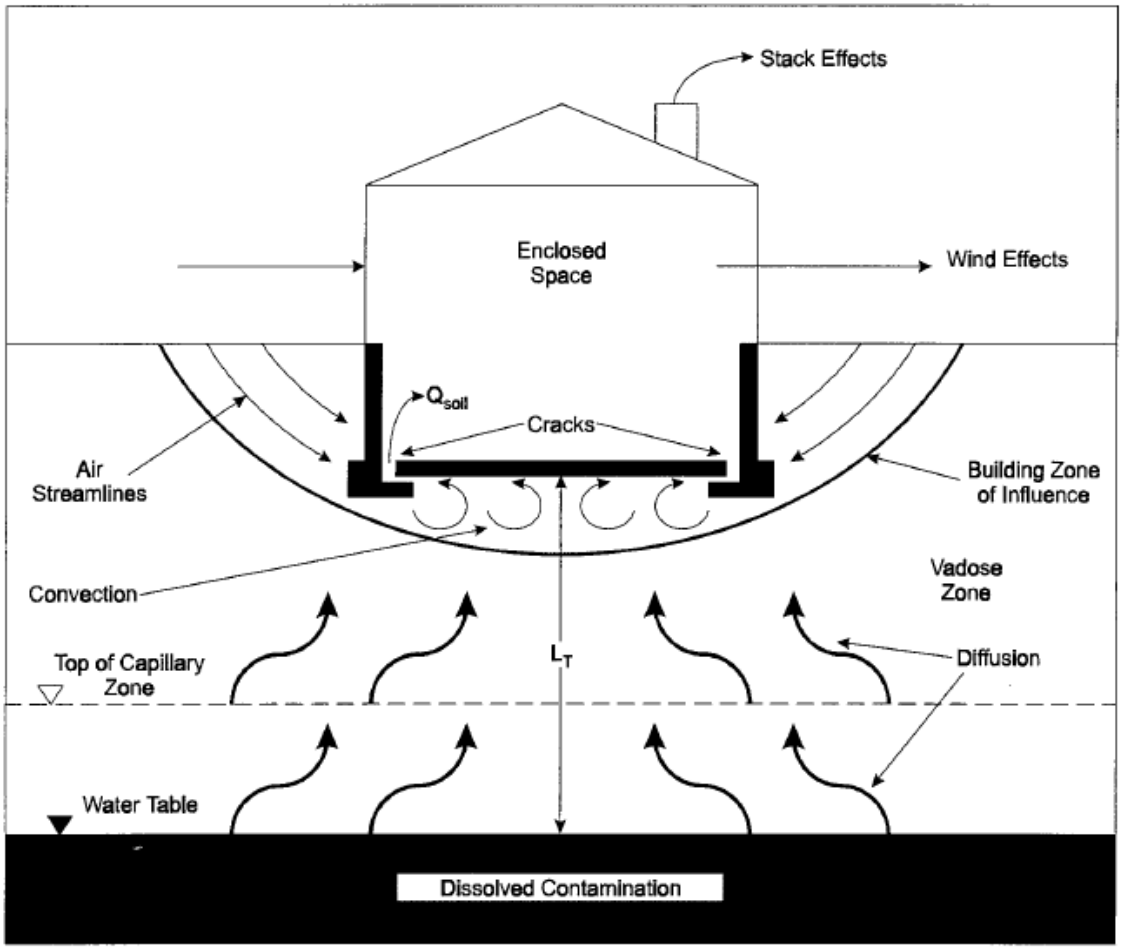


Figure 3: This illustrates advective and convective transport surrounding a building.

Chemicals entering this zone of influence are drawn into the building via advection and convection, in air and soil gas being drawn into the building through the foundation. This migration results from building interiors that exhibit a negative pressure relative to the outdoors and the surrounding soil. This pressure differential may be caused by a number of factors, including differences in temperature, wind currents, and operation of heating/cooling systems that draw air into the building.

Factors that Affect Vapor Intrusion

The following list describes factors which should be taken into account when assessing the potential for vapor intrusion:

- **Construction style** – Vapor intrusion occurs in structures with or without basements. Investigation of sites in other states has found that even slab-on-grade construction can be affected by vapor intrusion. The condition and construction of the foundation and presence/absence of an adequate vapor barrier are important factors to consider. A simple polyethylene vapor barrier installed during construction below the concrete is often effective at reducing or eliminating vapor migration into

the house. Positive pressure heating, ventilation and air conditioning systems can prevent vapor intrusion. Low wattage sub-slab vacuum systems (similar to radon remediation systems) have also proven effective at remediating vapor intrusion.

- **Structure age** – Older structures are less likely to have adequate vapor barriers incorporated into the foundation construction, and the foundation itself is more likely to have developed cracks. However, newer structures generally are more airtight and have less air exchange, and therefore may have higher differential pressures between the building and the soil vapor.

- **Dirt floors and stone foundations** - Earthen floors or field stone foundations are more porous and provide increased opportunity for vapor intrusion.

- **Drain tile/sumps** - If the building has a foundation drain tile or sump, VOC concentrations in the water can contribute to indoor air problems.

- **Wet basement** - If the building has groundwater infiltrating into the basement, dissolved VOCs can volatilize into indoor air. Wet basements can indicate a shallow water table (which could increase vapor intrusion in the event of contaminated groundwater), or be related to surface water drainage problems (which are less likely to cause indoor air quality issues).

- **Utility lines** - Gaps or cracks around piping or other utility lines that enter a building can be important preferential migration paths for vapors. Permeable soil in a utility trench can also provide a conduit for contaminants to migrate to a building.

- **Proximity of contamination to buildings** - Vapor intrusion should be a concern when buildings are close to the source of VOC contamination.

- **Shallow groundwater** - The potential for vapor intrusion typically decreases with increasing groundwater depth for many chemicals, particularly those that are known to biodegrade such as petroleum hydrocarbons.

- **Soil type** - Soil type greatly influences the transport of contaminants in soil vapor and groundwater. Coarse-grained soil types can promote contaminant migration over long distances, but also provide easier venting to the atmosphere if paving is not present. Fine grained or tight soils will tend to inhibit vapor transport. The soil stratigraphy is also important in developing a conceptual model of soil gas migration.

- **Fractured bedrock** - Shallow fractured bedrock connected to a subsurface source of VOC vapors can increase vapor intrusion potential by allowing soil gas migration. This becomes a greater concern when the bedrock is at or near the base of a building foundation.

- **Degradation** - Petroleum hydrocarbons can biodegrade in unsaturated soils which can reduce or eliminating some vapor intrusion of VOCs. Nevertheless the degradation of gasoline containing ethanol can result in the production of explosive levels of methane. In contrast, chlorinated solvents will likely undergo limited aerobic biodegradation and, therefore, may have the ability to cause a vapor intrusion impact a longer distance away from the VOC source than petroleum compounds.

C.2. VI INVESTIGATIVE TECHNIQUES

Soil Gas Sampling Overview

Soil gas sampling is one of the most common ways of assessing the vapor intrusion pathway. The distinction between soil gas sampling and sub slab soil gas sampling is critical for the investigation of the vapor intrusion pathway. While both procedures involve the collection of soil vapor, soil gas sampling specifically refers to the collection of soil gas samples outside a structure, as close as possible to the building's foundation, at a depth of approximately five feet below the bottom of the structure. Sub-slab soil gas sampling specifically refers to the collection of soil gas samples inside of a building directly under the slab of the structure.If groundwater does not allow for the collection of such a sample, then the investigation should proceed to sub-slab soil gas sampling, and then if necessary, to indoor air sampling. Indoor air data should be used in conjunction with soil gas and sub-slab data to assess if vapor intrusion is occurring.

Soil gas data is acceptable to the SMS as a standalone assessment of the vapor intrusion pathway if the following conditions are met:

- The soil gas samples are collected at a range from 2-5 feet beneath the slab.
- The samples are collected from the vadose zone, at least one foot above the groundwater table.
- Samples are collected from at least two distinct points near the building being investigated, with at least one of these samples being taken from as close to the contaminant source as possible. Samples should be taken as close to the structure being investigated as practical, and the report describing the results of this work should include a discussion of any variation from this practice.

In order to insure samples are representative of soil gas and not indoor or outside air being drawn into the sample, supplemental tools may need to be used such as flux chambers and tracer gas.

Sub-Slab Gas Sampling

Two different basic procedures for sub-slab soil gas sampling are provided below.

The first method employs a permanent sample point with stainless steel tubing and fittings. This method is recommended for long term monitoring of sub-slab soil gas as part of a remedial action. The approved Corrective Action work plan shall include a vapor monitoring plan to assess the changing concentration of contaminants of concern over time. Any decision to terminate a remedial action involving VI will most likely be made in part based on the sub-slab soil gas results.

The second procedure utilizes Teflon or metal (or similar) tubing for a temporary sample point. This method is more appropriate during the initial phases of investigation when the VI pathway is being evaluated. However, the investigator may want to use permanent sample points as part of the remedial investigation. Any sampling method will incorporate measures to prevent leakage or short-circuiting. If leak detection is not employed during sampling, then oxygen content should also be measured and evaluated.

Groundwater Sampling

Just as with a typical site investigation, groundwater samples should be collected and analyzed to determine if contaminants in groundwater have any influence on vapor intrusion. To ensure that the vapor intrusion pathway is adequately addressed in the process, at least one groundwater sample should be collected

between the building of concern and any known source of contamination, if possible.

Indoor Air Sampling

Indoor air sampling is the most challenging method for assessment of the vapor intrusion pathway since there are often items in residential and commercial structures which contain contaminants and can lead to an elevated indoor air background concentration of the contaminant of concern. For this reason, indoor air sampling should be conducted after groundwater and soil gas data indicate the potential for vapor intrusion. However, in certain situations indoor air sampling may occur before a groundwater or vapor investigation occurs. Indoor air sampling may also be conducted under other circumstances including contaminated groundwater intrusion into buildings, before, during or after corrective actions have been taken at a site, at residential fuel oil spill sites, or where there are odors complaints.

Recommended Sampling Methods

The following air sampling methods are acceptable to the SMS; however, the SMS recognizes other laboratory methods may be appropriate for use, and will approve other methods on a case by case basis.

Method No.	Collection Device Methodology	Type of Compounds	Detection Limit Range
TO-3	Cryotrap GC/FID	VOC	0.2-400 ug/m^3 (0.1 – 200 ppbv)
TO-13A	Polyruethane foam GC/MS	PAH	0.5-500 ug/m^3 (0.6 – 600 ppbv)
TO-15	Canister GC/MS	VOC (polar/nonpolar)	0.4-20 ug/m^3 (0.2-2.5 ppbv)
TO-17	Single/multi-bed adsorbent GC/MS FID	VOC	0.4-20 ug/m^3 (0.2-2.5 ppbv)
8021B	Tedlar Bag Canister GC/PID	VOC (VTDEC Petroleum Compound target list)	4.0-60 ug/m^3 (0.3 ppbv – 30 ppbv)
8260B	Tedlar Bag Canister GC/MS	VOC	10.0-50.0 ug/m^3 (0.6 ppbv – 25 ppbv)
8270C	Tedlar Bag Canister GC/MS	SVOC	1000 ug/m^3 ((20,000 ppbv – 100,000 ppbv)

The following items should be taken into consideration before conducting analysis of indoor air:

- Contaminants of concern;
- Sampling location and number of samples;
- Duration of the sampling event;
- Sampling method;
- QA/QC requirements, including detection limits and remedial goals.

A work plan must be submitted to the SMS prior to the initiation of any indoor air sampling procedure.

Sampling Protocol

Prior to and while collecting indoor air samples, a site inspection must be conducted and a building inventory of potential VOC sources should be completed. Field screening of potential preferential pathways into the structure should be conducted. The field screening survey should evaluate any foundation penetrations such as water, sewer, gas, electric and telecommunication lines, as well as sumps. Samples will need to be collected from these foundation penetrations, if present.

In addition field screening of potential VOC sources in the building should also be conducted to determine if any products may be leaking VOC vapors. Field screening should be conducted using either an FID or PID appropriate for detecting the chemicals of concern. If potential sources of VOC to the indoor air from common household products exist, these products should be documented and consideration should be given to removing these sources from the structure at least 48 hours before sampling begins to minimize their effects on the results on the indoor air samples.

During the sampling, detailed notes should be collected regarding the indoor and outdoor air temperature, barometric pressure and relative humidity. An interview should be conducted with occupants about recent and current activities that may affect air quality (painting, new carpets, and smoking for instance). The condition (open/shut on/off) of windows, heaters, vents, etc. should be documented before and during the sampling event.

To minimize the impact of elevated indoor air background concentrations for residential sampling, indoor activities such as smoking, use of sprays and solvents, paints, etc. should be suspended before and during sampling. Outdoor activities that could influence indoor air levels such as mowing, painting, asphalting, etc. should also be suspended.

When collecting indoor air samples it is advisable to sample under conditions that are the most likely to show an exceedance, and as such should represent worst case conditions (seasonal high groundwater conditions and/or after the start of the heating season in the fall, with windows closed and heat on).

At a minimum at least one sample should be collected from the lowest level of the structure where vapors are expected to enter (typically the basement or crawl space, often near a pipe entrance, sump or other potential preferential pathway), one from a common area living space/work space on the first floor and one from an outdoor location representative of background ambient air. It is generally appropriate to collect soil gas and adjacent groundwater samples concurrent with indoor air samples.

VI often changes over time due to seasonality. Changes in barometric pressure and soil gas temperature can significantly affect vapor intrusion. These potential variations must be incorporated into the vapor intrusion evaluation.

C.3. BACKGROUND CONCENTRATIONS OF CONTAMINANTS IN AIR

There are two types of background contamination associated with indoor air sampling; indoor air background and ambient outdoor background. Either can often exceed indoor air screening levels, particularly for certain petroleum related VOCs such as benzene. Although there is a simple way to measure ambient outdoor background, it is difficult to reliably measure indoor air background. For these reasons, collection of indoor air data without additional lines of evidence to indicate the potential for vapor intrusion

from subsurface sources is not advised. Indoor air data should be accompanied by the simultaneous collection of soil gas data or groundwater data as noted above in the evaluation of the vapor intrusion pathway.

There have been several extensive indoor air background studies that have measured indoor air and ambient outdoor air background levels. The Vermont Department of Health conducted a study of 60 homes in rural Vermont in the early 1990s to determine the background concentrations of chemicals in "non-impacted" homes or "background". The Vermont Department of Environmental Conservation conducted a small-scale survey of indoor ambient air concentrations for benzene in the early 1990's. Both of these studies were used to help determine some of the indoor air screening values in the VI Screening Values Table. The New York State Department of Health collected samples from 104 single family homes heated with fuel oil between 1997 and 2003. More than 600 samples were collected in New York including basement, living space and outdoor ambient air samples. The USEPA Building Assessment and Survey Evaluation (BASE) study was conducted on 100 public and commercial office buildings between 1994 and 1998.

At least one ambient outdoor air sample should be collected concurrently with the indoor air sampling event. Ambient outdoor air results and indoor air results should be compared to evaluate if ambient outdoor air is impacting indoor air values and to also determine a baseline for outdoorambient contaminants of concern. Indoor air values that do not exceed ambient outdoor air values or predetermined background concentrations from indoor air background studies will not be considered "impacted" and therefore mitigation would not be required by the VTDEC.

C.4. DATA EVALUATION

Determining if there is an exceedance of the indoor air screening level attributable to vapor intrusion can be difficult. If sampling is conducted under worst case conditions and there is no exceedance of the screening level then one can be reasonably sure that there is not an indoor air vapor intrusion problem, and further evaluation of the pathway is not necessary.

However, exceedance of an indoor air screening level does not in and of itself indicate a vapor intrusion problem caused by a hazardous site. When reviewing indoor air data, it is important to distinguish between background VOCs in indoor air from VOCs determined to be the result of vapor intrusion. Comparison of the outdoor air, groundwater, sub-slab and soil gas data to the indoor air data could be used to rule out contributions from background related VOC sources either in the structure or from ambient outdoor air. Any indoor air screening level exceedance must be interpreted in view of the indoor air background levels and one must also verify that similar composition vapors exist immediately adjacent to and/or below the structure. Vapor below a structure is an indicator that vapor intrusion may be occurring. Its absence suggests an indoor air contaminant source other than soil gas. Preferential pathways into indoor air should be considered and evaluated as well.

If the levels in indoor air exceed the screening level, and vapor intrusion is occurring, remediation of the site, vapor abatement measures and/or continued monitoring or further assessment are required.

C.5 OSHA REGULATIONS

The Occupational Safety and Health Act of 1970 (OSHA) uses Permissible Exposure Limits (PELs) to regulate work place exposure to chemicals. OSHA PELs are not based solely on risk, but are adjusted to account for

factors including economic feasibility. Therefore, PEL's are different than the VI Screening Values which have been compiled for chemicals that are released to the environment and are based on risk exposure criteria. For most hazardous chemicals the VI Screening Values are well below the established OSHA PEL's.

The following examples illustrate where OSHA standards would apply or where the vapor intrusion should be managed in accordance with this SMS policy.

- If a worker is exposed to vapors from a subsurface source of contamination regulated by the SMS (regardless of whether that contamination is derived from that facility or another) and are simultaneously exposed to the same hazardous vapors in the work place (e.g., a vapor degreaser) and is knowledgeable of their exposures, then the exposure is regulated under OSHA.

- If a worker is exposed to vapors from subsurface contamination and exposed to different hazardous chemicals in the work place that they protect themselves against, but not those associated with the subsurface contamination, then the exposure associated with the release would be managed in accordance with this policy. However, the employer has the option of incorporating the additional environmental exposure into their employee protection program (inform staff of their exposure and provide appropriate monitoring and/or protection), in which case OSHA requirements would apply.

- If a worker is exposed to subsurface contamination and works in a non-industrial work area at a site where exposure to a hazardous vapor is part of the normal operating conditions at a different location within the work place (i.e., office staff associated with manufacturing operations), that employee's exposure shall be managed in accordance with this document

- If a worker is exposed to vapors from subsurface contamination that is not associated with the normal operating conditions of that work place (e.g., a retail operation or daycare center), then the employee's exposure shall be managed in accordance with this document.

The SMS will generally manage sites using this guidance in workplaces in the vicinity of the sub-surface contaminant plume, or where employees within buildings have not voluntarily accepted a risk associated with environmental contamination in connection with their employment.

C.6. VAPOR INTRUSION MITIGATION STRATEGIES

When evaluation of the vapor intrusion pathway shows that vapor intrusion is a concern, abatement strategies can eliminate or mitigate the potential exposure pathway. Strategies for mitigating vapor intrusion involve both passive and active techniques. A combination of strategies may be most effective. Techniques may include the following:

- Sealing cracks, utility conduits, sumps, etc. in the basement or crawl space;
- Providing indoor air treatment;
- Increasing natural ventilation;
- Installing a heating recovery ventilation system;
- Making adjustments to an existing heating, ventilation and air conditioning system;
- Providing positive pressure in the structure;
- Installing a sub-slab depressurization (SSD) system;
- Providing soil pressurization; and

- Temporarily relocating the occupants of the building to eliminate exposure to the vapors.

If passive sealing techniques are insufficient to limit risk, a more active technique may be necessary to prevent the entry of contaminant vapors into a building. The most common technique for eliminating the vapor intrusion pathway for a residential scenario is the installation of a SSD system (aka Radon system). This technique has been used for many years to eliminate radon vapor issues. The system works by depressurizing the soil beneath the building envelope thus creating a negative pressure zone that becomes a "sink" for the contaminated vapors.

The contaminated vapors are collected and discharged to ambient air, typically above the building's roof line. SSD systems can be used in buildings with a basement, crawl space or slab-on-grade foundation. If the floor of the basement or crawl space is dirt, a membrane/vapor barrier must be placed and sealed to the foundation wall prior to installing the system. SSD systems have been successful in reducing the health risks associated with vapor intrusion for building occupants.

The components of a typical residential SSD system include: an extraction pit beneath the slab (or membrane), PVC piping and a blower. A couple of important considerations prior to installation of the SSD system are that groundwater should be more than six inches below the foundation and that all entry points such as cracks in the foundation floor and walls and sumps must be sealed. It is also recommended that the change in pressure created by the system below the slab be 2 Pascals or greater. This should be confirmed by conducting diagnostic testing on the system over the entire slab.

Calculations of VI Screening Values

The VI Screening Values for soil gas and groundwater were calculated from indoor air values. The indoor air values were derived from either the 1991 Indoor Air Study conducted by the VDH or from the Hazardous Ambient Air Standards calculated by the VDH. Of the two VDH values, the higher of the two values was used as the indoor air value. Attenuation factors (alpha α) factors of 0.1 and 0.01 for shallow soil gas and deep soil gas, respectively, were used to calculate the soil gas screening values with exception of petroleum related compounds. The Henry's law constant was used to calculate a groundwater screening value. For petroleum compounds, an alpha factor of 0.001 and 0.0001 shallow soil gas and deep soil gas, respectively, for BTEX compounds, were used to calculate the soil gas screening values.

Table C.7. VI Screening Values Table

Compound	Target Indoor Air (ug/m3)	GW conc. (ug/L)	Shallow Soil Gas ug/m^3 ≤5ft alpha 0.1	Deep Soil Gas ug/m^3 >5ft alpha 0.01
Acetaldehyde	15.69	4862.46	156.9	1569
Acetone	315	315000	3150	31500
Acrylamide	0.00076	nsv	0.0076	0.076
Acrylonitrile	0.015	3.56	0.15	1.5
Allyl chloride	0.1	nsv	1	10
Aniline	0.61	nsv	6.1	61
Antimony trioxide	0.02	nsv	0.2	2
Arsine	0.005	nsv	0.05	0.5

Compound	Target Indoor Air (ug/m3)	GW conc. (ug/L)	Shallow Soil Gas ug/m^3 ≤5ft alpha 0.1	Deep Soil Gas ug/m^3 >5ft alpha 0.01
Benzene *	1.18	5.2	1180	11800
Benzidine	0.000015	nsv	0.00015	0.0015
Benzo-a-pyrene	0.00048	nsv	0.0048	0.048
Biphenyl	0.0018	0.15	0.018	0.18
Bromodichloromethane	0.056	0.86	0.56	5.6
Bromoform	0.9	37.34	9	90
Bromomethane (methyl bromide)	5	141.99	50	500
1,3-Butadiene	0.033	0.011	0.33	3.3
2-Butanone (methyl ethyl ketone)	5000	2187096.1	50000	500000
2-Butoxyethanol	1,300	nsv	13000	130000
Butoxyethyl acetate	1,300	nsv	13000	130000
Carbon disulfide	657	530.2	6570	65700
Carbon tetrachloride	0.41	0.33	4.1	41
Chlorobenzene	2	13.22	20	200
Chloroform	0.38	2.53	3.8	38
Chloromethane (methyl chloride)	90	1004.87	900	9000
Chloroprene	0.7	nsv	7	70
Cyclohexane	82	10	820	8200
Dibromochloromethane	0.042	1.31	0.42	4.2
1,2-Dibromoethane (ethylene dibromide)	0.0045	0.15	0.045	0.45
1,2-Dichlorobenzene (o)	200	2573.87	2000	20000
Dichlorodifluoromethane (Freon 12)	200	14.26	2000	20000
1,1-Dichloroethane	50	217.54	500	5000
Dichloroethyl ether	0.0029	nsv	0.029	0.29
Dimethyl sulfate	0.01	nsv	0.1	1
2,4-Dinitrotoluene	0.0051	nsv	0.051	0.51
Dioxane	0.32	nsv	3.2	32
Doxorubicin	0.01	nsv	0.1	1
Epichlorohydrin	0.83	nsv	8.3	83
1,2-Epoxybutane	2	nsv	20	200
Ethyl benzene *	100	310.3	1.00E+05	1.00E+06
Ethyl bromide	0.01	nsv	0.1	1
Ethylene dibromide	0.0045	nsv	0.045	0.45
Ethylene dichloride (1,2-dichloroethane)	0.038	0.95	0.38	3.8
Ethylene oxide	0.01	0.44	0.1	1
Formaldehyde	12.88	nsv	128.8	1288
Furfural	0.01	nsv	0.1	1
Hexachlorobenzene	0.0022	0.04	0.022	0.22
Hexachlorobutadiene	0.045	0.14	0.45	4.5
Hexachloroethane	0.25	1.57	2.5	25
n-Hexane	7000	102.7	70000	700000

Compound	Target Indoor Air (ug/m3)	GW conc. (ug/L)	Shallow Soil Gas ug/m^3 ≤5ft alpha 0.1	Deep Soil Gas ug/m^3 >5ft alpha 0.01
Hydroquinone	0.01	nsv	0.1	1
Isophorone	70.7	nsv	707	7070
Methylene chloride	2.1	5.82	21	210
Naphthalene	0.3	15.19	3	30
Nitrobenzene	0.15	152.82	1.5	15
Nitromethane	0.01	nsv	0.1	1
2-Nitropropane	0.00037	0.07	0.0037	0.037
Pentachlorophenol	0.029	nsv	0.29	2.9
Propylene dichloride	0.051	nsv	0.51	5.1
Propylene imine	0.01	nsv	0.1	1
Propylene oxide	0.27	nsv	2.7	27
Pyridine	0.01	nsv	0.1	1
Styrene monomer	100	889.15	1000	10000
1,1,2,2-Tetrachloroethane	0.018	1.28	0.18	1.8
Tetrachloroethylene	0.57	0.76	5.7	57
Toluene *	300	1104.75	3.00E+05	3.00E+06
Toluene-2,4-diisocyanate/toluene-2,6-diisocyanate	0.007	nsv	0.07	0.7
o-Toluidine	0.015	nsv	0.15	1.5
1,1,1-Trichloroethane	1000	1421.61	10000	100000
1,1,2-Trichloroethane	0.063	1.69	0.63	6.3
Trichloroethylene	0.5	1.19	5	50
Trichlorofluoromethane (Freon 11)	562	141.67	5620	56200
1,1,2-Trichloro-1,2,2-trifluoroethane	30000	1525.37	300000	3000000
2,4,6-Trichlorophenol	0.32	nsv	3.2	32
1,2,3-Trichloropropane	0.0005	0.03	0.005	0.05
Vanadium pentoxide	0.01	nsv	0.1	1
Vinyl acetate	20	957.02	200	2000
Vinyl chloride	0.11	0.1	1.1	11
Vinylidene chloride (1,1-Dichloroethylene)	20	18.74	200	2000
Xylenes (total)*	100	363.64	1.00E+05	1.00E+06

Notes:

nsv = no screening value

* Alpha for petroleum related compounds 0.001 for shallow soil gas and 0.0001 for deep soil gas
Alpha factor of 0.001 for water, 0.01 for deep soil gas (>5 feet) and 0.1 for shallow soil gas (≤5 feet).
Indoor Air values taken from the VDH Background Indoor Air Study or the VT Hazardous Ambient Air Standards.

APPENDIX D: Vermont Water Quality Division's Recommended Guidelines for Evaluating Contaminant Concentrations in Freshwater Sediments and the Potential for those Contaminants to Adversely Affect Aquatic Biota

Sediments in aquatic ecosystems serve as habitat for a wide variety of aquatic organisms which are dependent on the quality of that sediment for their well-being. Higher trophic level organisms can be affected through bioaccumulation and biomagnification of sediment pollutants. The purpose of this document is to provide guidance for assessing the results of chemical testing of sediments in the context of the potential for contaminants in sediments to adversely affect aquatic organisms either through direct toxicity or bioaccumulative exposure.

Evaluation of sediment chemistry serves as an initial screening assessment for the purpose of identifying contaminants of potential concern and ranking the relative risk those contaminants pose to aquatic organisms. This initial screening is accomplished by comparing sediment chemistry results to levels of contaminants that have a high probability of causing adverse effects to aquatic biota. These values are generally referred to as Sediment Quality Guidelines (SQGs), and are located on Table C.1.

Vermont Department of Environmental Conservation recommended SQGs for use in assessing sediment contaminant concentrations are provided in Table D.1. These SQGs are predominantly from MacDonald et al. (2000). These SQGs include a Threshold Effect Concentration (TEC) and a Probable Effects Concentration (PEC). The TEC is a concentration below which adverse effects are unlikely to occur. The PEC is a concentration above which adverse effects are likely to be observed.

SQGs are derived primarily from co-occurrence data collected from field studies with additional laboratory confirmatory toxicity testing data. MacDonald et al. (2000) demonstrate the relative precision of the ability of the SQGs to predict the absence or presence of toxic effects. However, there is a considerable degree of imprecision when extrapolating sediment contaminant concentrations to actual environmental effects, e.g. adverse impacts on ambient organisms and communities. Therefore, SQG comparisons should be the first step in the context of an hierarchal evaluation of sediment impacts.

Exceedence of SQGs may indicate the need for further site assessment, usually based on assessments which increase the precision with which biological impacts are predicted or observed. Such hierarchal assessments may include direct assessment of ambient biological communities or sediment toxicity testing. In the case of bioaccumulative compounds, additional assessment may include biomagnification modeling, laboratory testing of biomagnifications or direct measurement of contaminant concentrations in appropriate organisms. Rarely are SQGs used independently to draw conclusions about environmental impacts or to direct site management decisions.

The SQGs in Table D.1 should be used to 1) identify contaminants of concern, 2) rank the relative site risk based on the extent (number of contaminants and spatial extent) and magnitude of SQG exceedances, and ultimately 3) assess the need for more intensive site evaluations of biological impacts related to the site and the contaminants. For contaminants not included in Table D.1, reliable effects-based sediment quality guidelines published in the scientific literature may be used to find appropriate SQGs. Other potential resources include, but are not limited to:

1. Buchman M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. Office of Response and Restoration Division, National Oceanic and Atmospheric Administration, Seattle, WA. 34 pp. http://response.restoration.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf

2. Long E.R., Morgan L.G. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Tech. Memo. NOS OMA 52. National Oceanic and Atmospheric Administration, Seattle, WA. 175 pp.

3. Persaud D., Jaagumagi R., Hayton A. 1993. Guidelines for the Protection and Management of Sediment Quality in Ontario. Water Resources Branch, Ontario Ministry of the Environment, Toronto, ON, CAN. 27 pp.

4. http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/screenbench.htm

5. http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/R3_BTAG_FW_Sediment_Benchmarks_8-06.pdf

The SQGs cited in Table D.1 and in the above references are primarily for the protection of benthic organisms. Other approaches such as food chain modeling and fish tissue back calculations may be more appropriate for calculating sediment concentrations protective of fish and wildlife (including humans) at higher trophic levels. The following are some general considerations that may be useful when using SQGs for screening potential adverse effects to aquatic biota:

1. Compare sediment contaminant concentrations with SQGs.
    a. evaluate the quantity, quality and analytical characteristics of the data;
    b. evaluate the spatial and horizontal (depth) distribution of the data;
    c. determine biological receptors likely to be exposed;
    d. describe the number of contaminants and the magnitude of SQG exceedances;

2. For naturally-occurring substances such as metals, determine reference condition (minimally affected by human activity) concentrations for the assessment site and compare to sediment concentrations. Normalize data (e.g. percent fines, total organic carbon (TOC)) if appropriate for inter-site comparisons or comparisons to reference conditions.

3. If data are being used to evaluate impacts from a discrete source (e.g. discharge, site) it may be necessary to evaluate local background conditions (conditions upstream of or outside the influence of the source being evaluated).

4. Information from 1-3 above may be used to prioritize future actions based on general weight-of-evidence (WOE) findings. For example:

1) If all contaminants are below threshold effect concentrations (TECs) and no other site information indicates the presence of adverse effects, low priority for further action may be appropriate (all available chemical, physical and biological information should be reviewed prior to dismissing need for further evaluation of biological effects);

2) If threshold effects concentrations (TECs) are exceeded but probable effects concentrations (PECs) are not, it is likely that further site assessment in the form of biological community assessments, toxicity testing or both will be required. The degree of response would be dictated by the WOE from 1-3 above;

3) If one or more contaminants exceed probable effects concentrations (PECs), additional site assessment is very likely. In some cases where exceedances are extreme, biological impairment may be assumed with high confidence.

Sampling and Analysis Considerations: Sediment samples should be collected using standard sampling protocols appropriate to the target analyte. Ancillary data required to utilize SQG comparisons (e.g. total organic carbon for organics) should be generated using standard analytical protocols. Chemical analyses should be conducted using standard operating procedures appropriate to the target analyte. Practical quantitation limits should be less than the SQG to which analytical results will be compared or based upon the best available technology. The precision and accuracy of all data should be documented using standard quality control and assurance procedures appropriate to the analysis. There are many guidance documents for sampling SOPs, an example of which is referenced below.

Field Sampling Guidance Document #1215 - Sediment Sampling. U.S.EPA Region 9 Laboratory, Richmond, CA. 10 pp.
http://www.epa.gov/region6/qa/qadevtools/mod5_sops/sediment_sampling/r9-sedimentsample_gui.pdf

General Comments Regarding SQGs:
1. The potential effects of multiple contaminants in sediments on aquatic biota are relatively unpredictable and unknown at this time; assumptions about independent action, additivity or synergism are not supportable. Hazard quotients (HQ), calculated by dividing the sediment concentration by the SQG (Sed. Conc./SQG) can be used to calculate a mean HQ (Σ HQs/no. of contaminants) and total HQ (ΣHQs) for consideration under WOE, remembering that while common sense would suggest that multiple contaminants at or in exceedance of SQGs present a greater risk than a single contaminant at or above an SQG, there is little scientific data to either support or refute that suggestion.

2. The amount of data necessary to make an appropriate evaluation of a site will vary depending on site-specific attributes. In general, data should be sufficient to estimate the spatial distribution (heterogeneous/homogeneous) of the contamination, have some estimate of temporal reproducibility (i.e., multiple sampling events) of findings, and address any seasonal or temporal considerations that may affect results.

3. The Minnesota Pollution Control Agency maintains a web site with useful resources for assessing and evaluating sediment contaminants.
http://www.pca.state.mn.us/water/sediments/links-assessment.html

D.1: Recommended Sediment Quality Guidelines for the Protection of Aquatic Biota in Freshwater Ecosystems

Substance	TEC	PEC	Notes
Metals (in mg/kg - ppm DW)			
Arsenic	9.79	33.0	1,2
Cadmium	0.99	4.98	1,2
Chromium	43.4	111	1,2
Copper	31.6	149	1,2
Lead	35.8	128	1,2
Mercury	0.18	1.06	1,2,4
Nickel	22.7	48.6	1,2
Zinc	121	459	1,2
Polycyclic Aromatic Hydrocarbons (in µg/kg - ppb DW)			
Anthracene	57.2	845	1,3
Fluorene	77.4	536	1,3
Naphthalene	176	561	1,3
Phenanthrene	204	1,170	1,3
Benz(a)anthracene	108	1,050	1,3
Benzo(a)pyrene	150	1,450	1,3,4
Chrysene	166	1,290	1,3
Dibenz(a,h)anthracene	33	1,3	
Fluoranthene	423	2,230	1,3
Pyrene	195	1,520	1,3
Total PAHs	1,610	22,800	1,3
Polychlorinated Biphenyls (in µg/kg – ppb DW)			
Total PCBs	59.8	676	1,3,4
Organochlorine Pesticides (in µg/kg – ppb DW)			
Chlordane	3.24	17.6	1,3,4
Dieldrin	1.90	61.8	1,3,4
Sum DDD	4.88	28.0	1,3,4
Sum DDE	3.16	31.3	1,3,4
Sum DDT	4.16	62.9	1,3,4
Total DDTs	5.28	572	1,3,4
Endrin	2.22	207	1,3
Heptachlor Epoxide	2.47	16.0	1,3
Lindane (gamma-BHC)	2.37	4.99	1,3

Notes for Table D.1:

1. Consensus-Based Sediment Quality Guidelines (SQGs) from: MacDonald D.D., Ingersoll C.G. and Berger T.A. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology 39(1). 20-31.

2. SQGs for metals are based on bulk (unsorted) sediment concentrations. Concentrations of metals in sediments can be normalized on percent fines for the purpose of inter-site comparisons but not for comparisons to these SQGs.

3. The SQGs for organics are derived from samples normalized to 1 percent total organic carbon (TOC) in the sediment. The SQGs presented here are based on an assumed TOC of 1 percent. If site specific data show organic carbon content to be significantly different from 1 percent, concentrations should be normalized to 1 percent TOC (divide the site concentration by the percent TOC) prior to comparison with the SQGs in this table. If non site-specific TOC data are available, assume 1 percent TOC.

4. Included on USEPA's list of important persistent, bioaccumulative, toxic compounds (PBTs). http://www.epa.gov/pbt/pubs/cheminfo.htm.

TEC = Threshold Effect Concentration
PEC = Probable Effects Concentration
DW = dry weight

APPENDIX E: Establishment of Background Concentrations

Not all detections of hazardous materials are associated with on-site activities. For example, arsenic may be present at levels in excess of standards or guidelines due to natural sources. However, arsenic may also be related to site activities. Another example are polynuclear aromatic hydrocarbons (PAHs), that may be present at a site due to human activities occurring over an extended period of time or atmospheric deposition, and not associated with any particular release or site. The purpose of this section is to describe the process to determine if concentrations of hazardous materials are representative of background conditions or are the result of an onsite or off-site release requiring corrective action.

If a contaminant is found in any area of concern in excess of the applicable remediation standard/screening value which may not be attributed to onsite releases, the following data must be evaluated to demonstrate that the contaminant concentration is due to natural background:

An adequate number of background samples should be collected from onsite or in the region of the site; the WMD recognizes that the number of samples needed to establish background concentrations will vary based on specific site conditions, however a minimum of three is required, and five to eight is preferred. The SMS may require a statistical analysis of the background sampling data set, and/or a statistical comparison with area of concern concentrations, to determine the validity of the comparison.

Soil, groundwater, sediment, and surface water:

- Background samples should be collected at locations unaffected by current and historic site operations as documented in the Initial Site Investigation. Wherever possible, background samples should be collected from locations which are topographically upgradient and upwind of site-related contaminant sources.

- Background samples should be collected and analyzed using the same methods as were used for area of concern samples.

- Background soil and sediment samples should be collected from soil/sediment types and depths similar to the area of concern samples.

- Background groundwater samples should be collected from the same water bearing zone that is believed to represent background groundwater quality that may be contributing naturally elevated levels of constituents. A sufficient number of additional monitoring wells should be installed to evaluate all offsite locations potentially affecting onsite groundwater quality. All monitoring wells shall be installed and constructed in a manner similar to the onsite/source area wells.

- Background surface water samples should be co-located spatially and temporally with background sediment samples. Background surface water samples must be collected the same day as area-of-concern surface water samples. Surface water shall be collected before the collection of sediment samples, and from down-steam to up-stream. These precautions are taken to minimize disturbance and migration of potentially contaminated sediments downstream or into surface water before those samples are collected. Additional determinations, such as benthic community structure, may be required on a case-by-case basis.

Air:

- Background indoor air samples must be collected in the basement and first floor levels, and must be accompanied by the collection of soil gas data. To minimize the potential for false positives in residential samples, indoor activities such as smoking, use of sprays and solvents, paints, etc. should be suspended prior to and during sampling. Outdoor activities that could influence indoor air levels such as mowing, painting, asphalting, etc. should also be suspended.

- During the collection of ambient outdoor background samples, activities which could influence results such as mowing, painting, asphalting, fuel deliveries, etc. should be suspended.

General considerations of background sampling:

The SMS will not require mitigation of contaminant concentrations which have been determined to be representative of background conditions, but which are above screening levels. The SMS may require that a notice to the land record is prepared to alert current and potential/future land owners and users of the risk from elevated background concentrations. Additionally, if the property is proposed for redevelopment the SMS may choose to require risk mitigation as part of the development.

In no case will historic/urban fill areas be considered a background condition for soils or representative of background soils. While it is not the policy of the state to require removal of historic fill areas, these wastes may require proper disposal if they are relocated off site from their historic location.

APPENDIX F: Dioxins, PAHs and PCBs

Dioxins:

Dioxins (are by-products of a wide range of manufacturing processes including smelting, chlorine bleaching of paper pulp, the manufacturing of some herbicides and pesticides, and waste incinerators. The term 'dioxins' is often used for the family of structurally and chemically related *polychlorinated dibenzo para dioxins (PCDDs)* and *polychlorinated dibenzofurans (PCDFs)*. Certain dioxin-like *polychlorinated biphenyls (PCBs)* with similar toxic properties are also included under the term "dioxins". Some 419 types of dioxin-related compounds have been identified but only about 30 of these are considered to have significant toxicity, with 2,3,7,8- tetrachlorodibenzo para dioxin (TCDD) being the most toxic.

Dioxin samples must be reported as a Toxic Equivalency Quotient (TEQ) to Tetrachlorodibenzo-p-Dioxin(2,3,7,8). The Toxic Equivalency Factors (TEF) to be used by the laboratory during analysis must be the 2005 World Health Organization (WHO) values (or most current values), which may be found on the EPA website: *http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm*. Laboratory results must include the 2,3,7,8-TCDD values and concentrations reported for each individual dioxin compound.

Polycyclic Aromatic Hydrocarbons (PAHs):

PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances. There are more than 100 different PAHs. PAHs generally occur as complex mixtures (for example, as part of combustion products such as soot), not as single compounds. PAHs usually occur naturally, but they can be manufactured as individual compounds for research purposes; however, not as the mixtures found in combustion products. A few PAHs are used in medicines and to make dyes, plastics, and pesticides. Others are contained in asphalt used in road construction. They can also be found in substances such as crude oil, coal, coal tar, pitch, creosote, and roofing tar. They are found throughout the environment in the air, water, and soil. They can occur in the air, either attached to dust particles or as solids in soil or sediment.

All environmental media (soil, groundwater, sediment, surface water)for PAHs should be reported as a TEQ to Benzo(a)Pyrene. Groundwater, sediment and surface water should be compared to the individual PAH. The Toxic Equivalency Factors (TEF) to be used by the laboratory during analysis should be those presented in *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (EPA/600/R-93/089, July 1993) which may be found on the EPA website *http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm*. The Toxic Equivalency Factors (TEF) to be used by the laboratory during analysis must be the 2005 World Health Organization (WHO) values (or most current values), which may also be found on this EPA website. Laboratory results must include the B(a)P-TE values and concentrations reported for each individual PAH.

Polychlorinated Biphenyls (PCBs):

Polychlorinated biphenyls are mixtures of up to 209 individual chlorinated compounds. There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. Many commercial PCB mixtures are known in the US by the trade name Aroclor. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical

devices containing PCB capacitors, and old microscope and hydraulic oils, dyes, industrial paint, window caulk and cutting oil.

PCBs may also be reported as homologs. The sum of all homologs is also referred to as Total PCBs and should be compared to the soil SSVs located in Appendix A or appropriate groundwater and/or air comparison values. If PCBs are reported as individual congeners, dioxin-like congeners should be segregated; weighted using the 2005 WHO TEQs found on the website: *www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/userguide.htm*; and assessed in conjunction with TCDD-TEQ. The remaining congeners would be summed and assessed as Total PCBs.

Based on the concentration and location of a release, PCBs may be managed by the VTDEC only or by VTDEC and the Environmental Protection Agency's Toxic Substance Control Act (TSCA). TSCA regulations can be found at this link: *http://www.access.gpo.gov/nara/cfr/waisidx_04/40cfr761_04.html*. TSCA only accepts the Sohxlet extraction analytical method for PCBs. In addition, EPA strongly encourages analyzing caulking in buildings which were constructed in the late 1950's into the late 1970's due to the potential for the caulking to cause PCBs to be present in indoor air.

APPENDIX G: Monitor Well Closure Guidance

When a site is eligible to receive a Site Management Section (SMS) Site Management Activity Completed (SMAC) designation, there may be monitor wells present on the site. As per state regulation, (Water Supply Rule, Chapter 21, Section 12.3.5) if wells are not used, they must be properly abandoned. Generally, once a site is suitable for a SMAC or COC designation, monitor wells will no longer be needed and must be properly abandoned. However, some property owners or responsible parties (RP) may have further use for wells once a site receives a SMAC designation. If this is the case, it is the responsibility of the site owner/RP to properly maintain the wells and properly abandon them once they are no longer needed.

This issue needs to be considered before a site receives a SMAC designation. The SMS needs to insure that any wells are either correctly abandoned or if the property owner/RP has further use for the monitoring wells, that there is a plan in place to correctly maintain and use the monitor wells, including plans to properly abandon the wells when they are no longer of any use. In order to accomplish this, the following review process shall be followed:

- Monitor wells not proposed for further use:

  If an owner or RP chooses to abandon existing monitor wells, the owner/RP will request SMS authorization to abandon these wells along with the request to SMAC the site (or at the request of the SMS if the SMS proposes the SMAC designation). They shall submit a work plan that shall detail the proposed procedures for abandoning the wells as per State regulation.

  The SMS site manager shall review the request and the site file with the proposal to SMAC the site. If the SMS agrees with the proposal to SMAC the site, it shall direct the property owner/RP to abandon the wells and shall hold the SMAC decision until it receives proof that the wells have been abandoned in accordance with applicable laws and guidance. Once proof that the wells have been adequately abandoned is received, the SMS may issue the SMAC decision.

  If a well is destroyed, but not adequately abandoned, and poses a threat to groundwater quality, the SMS may require overdrilling and grouting, or the use of other methods to insure a vertical preferential pathway that may cause groundwater contamination is not created by the destroyed well.

- The owner/RP proposes maintaining and using monitor wells:

  If the site owner/RP decides to use some or all of the monitoring wells, as discussed above, it becomes the site owner/RP's responsibility to properly maintain wells and abandon the wells once they are no longer used. Once a site receives a SMAC designation, and monitoring wells are retained for some purpose other than their original intended use, the PCF will not cover any future costs for abandoning the monitor wells.

  In order for the SMS to accept a proposal to continue using monitor wells after the site receives a SMAC designation, the owner/RP must first demonstrate to the SMS that he/she has a valid use for the wells and must submit to the SMS a plan for review and approval. This plan will commit the owner/RP to maintaining the well/s and must include the following:

- the proposed use of the monitor well/s;

- a plan to inspect and maintain the well/s including but not limited to the details of how to maintain integrity of any well, including maintaining the locking cap, cement surface seal, road box or stick up if one is present (including replacing if damaged by plow or other means);

- written approval granting the State access as needed to inspect the monitor well/s; and

- a written commitment that he/she will properly abandon wells once they are no longer needed for the proposed use and agree that prior to selling property, he/she will either abandon the wells or insure next property owner will abide by these procedures (including allowing site access to State personnel and agreeing to abandon the wells once they are no longer used).

- If the monitor wells are located on a property not owned by the responsible party, the party wishing to utilize the wells shall obtain written permission from the property owner allowing the wells to remain on her/his property, and written approval granting site access to the RP and State to inspect, monitor and maintain the wells.

APPENDIX H: Notice to Land Records

H.1. Frequently Asked Questions

What is a Notice to Land Records?

A notice to the land records is a notice which is placed in the land records for a parcel of land. It cannot be removed unilaterally by the property owner. The notice describes environmental conditions that exist on the property and helps to fully disclose these conditions to future potential purchasers, lenders, or owners. The notice serves at a local level to notify an interested party, that a property has environmental contamination that required investigation, monitoring, or remediation, that low-level residual contamination still exists on site, and that additional information is available from the State. A notice to the land records does not legally bind the owner or other entities to perform maintenance, monitoring, or ensure that restrictions are upheld. The notice is not a deed restriction or easement held by a 3rd party and does not restrict land or property use, though it does suggest notification of the VT DEC if future activities so warrant.

When is a Notice to Land Records used?

A notice to the land records is used in the following scenarios:

- Site contamination has been shown by testing to exist and be stable or slowly declining, nevertheless it remains at a level that might present a low risk if disturbed by groundwater extraction or soil excavation; or
- If groundwater is affected, the contaminant plume is not migrating off the property boundary above VTGES, and municipal services are available or the point of groundwater use has been shown not to be at risk of contamination; or
- If vapor intrusion may be a concern for future use; or
- If a sub-slab depressurization system (similar to a radon removal system) is required to be operated at a residence or commercial building.

Why should a Notice to Land Records be used to close a site and not just leave the site open as an active hazardous site?

In some cases complete site remediation to reach all environmental standards or guidelines within the property boundary of the site is not technically or economically feasible within a reasonable time. Continued site management as an active hazardous site serves no additional protective purpose. Site closure with a notice to the land records recognizes this fact.

Site closure signifies that no further site management is required and removes the property from the state active hazardous sites list (*http://www.anr.state.vt.us/dec/wastediv/SMS/hazsites.htm*). As part of site closure, monitor wells may be closed and remediation system dismantled. Depending on the bank involved, site closure may make a property sale or refinancing easier than for an active hazardous site.

Will a Notice to Land Records affect my property value?

In the opinion of the VT DEC, the Notice itself does not affect property value. The notice to the land records describes property conditions caused by environmental pollution. If property value has been diminished, it is due to the pollution; not the disclosure of the pollution.

H.2. Notice to Land Records Template

Please fill in the applicable sections and edit as appropriate by deleting the bolded and any inapplicable sections. Prior to recording at the town office, please send the draft notice back to the SMS project manager for approval. Please consult with the site project manager for guidance.

Notice to the Town of.....Land Records

This is to serve notice to the Town of ....., Vermont, that at the .....property located at ....., **(street address)** soil/groundwater in the subsurface is impacted by petroleum released from ..... **(source – leaking underground storage tank, spill, etc.)** This property is further described in town records as lot #..... tax parcel #..... The property is filed in the Waste Management and Prevention Division records as the.....property, SMS Site #.....

On site contamination resulted from..... **(source – leaking underground storage tank, spill, etc.)** and consists of..... **(type of contamination – diesel, gasoline, used motor oil, or fuel oil)** This contamination is located at..... **(location on property)** and present in soil approximately .....feet below grade. This contamination is present in groundwater at..... **(location on property)** and approximately .....feet below grade. Laboratory analysis performed on soil/groundwater samples collected from the vicinity, indicate contamination concentrations in the range of ..... **(give concentration in appropriate units: mg/kg or mg/kg [soil]; mg/L or μg/L [water])**

Details are outlined in the report titled ..... **(reference appropriate report – Underground Storage Tank Closure Report, etc.)** prepared by ..... **(environmental consultant name)**, dated ....., and in the report titled ..... **(reference appropriate report – Initial Site Investigation Report**, **etc.**) Copies of these reports are in the site file and are available for review at the Vermont Department of Environmental Conservation (VTDEC) offices in Waterbury, Vermont.

The conditions described in the above reports and VTDEC site file do not require further remedial action or VTDEC management. These conditions do not represent a significant risk to human health or the environment. Nevertheless residual contamination remains in the subsurface soil and/or groundwater. Contact with these materials may present a low level of risk.

Prior to conducting any subsurface work, excavation, or groundwater extraction in the vicinity of the above described contamination on the property, the Agency of Natural Resources, Department of Environmental Conservation, Waste Management Division (VTANR/DEC/WMD), should be notified. The status of this site may only be updated or altered by the Vermont ANR/DEC/WMD. For further information contact:

Vermont ANR Department of Environmental Conservation
Waste Management and Prevention Division
103 South Main Street / West Building
Waterbury, VT 05671-0404
Tel: (802) 241-3888

Current Property Owner

H.3. Deed Restriction Template

Note: There is a significant amount of variation that takes place in the easement depending on site specific issues. Unlike a notice to the land records, you should consult with the division attorney prior to initiating a deed restriction.

GRANT OF ENVIRONMENTAL RESTRICTIONS, RIGHT OF ACCESS, AND EASEMENT

THIS GRANT OF ENVIRONMENTAL RESTRICTIONS, RIGHT OF ACCESS, AND EASEMENT ("Grant") is made this _____ day of _____, 2007, by _____, a Vermont limited liability company with its principal place of business located in _____, Vermont, its successors and assigns ("Grantor"), for the benefit of the State of Vermont, Agency of Natural Resources, and any successor agencies, Grantee ("Agency of Natural Resources").

WITNESSETH:

WHEREAS, the property, is situated on lands and premises owned by Grantor consisting of _____ acres, more or less, located at _____ in the Town of _____, in _____ County, Vermont (the "Parcel"), as more particularly described in Exhibit A; and

WHEREAS, the Parcel is currently used for a mixture of commercial and industrial purposes; and

WHEREAS, the Grantor proposes to re-develop portions of the Parcel for residential use; and

WHEREAS, the Grantor and its predecessor in title have cooperated with the Agency of Natural Resources in studying and evaluating conditions on the Parcel associated with prior industrial uses; and

WHEREAS, certain easements, rights, obligations, covenants and restrictions, as more particularly set forth below, are necessary at certain portions of the Parcel for construction, operation, and maintenance of response actions at the site and to ensure that future activities at the Parcel, including the areas owned by Grantor, do not interfere with response activities, or in any way increase the ecological, human, or environmental risks at the Parcel; and

WHEREAS, it is the purpose of this instrument to convey real property rights from the Grantor to the Grantee, the State of Vermont, Agency of Natural Resources, including, but not limited to, easements, rights of access, other rights, obligations, covenants and use restrictions, all in perpetuity, to the Agency of Natural Resources, which will run with the Parcel, in perpetuity; and

WHEREAS, these environmental restrictions, right of access and easement are required under the terms of the Certificate of Completion entered into between Grantor and Grantee dated [Date], a true and correct copy of which is attached hereto as Exhibit B, and

WHEREAS, the Grantor agrees that these environmental restrictions, right of access and easement will run with the Parcel in perpetuity.

NOW, THEREFORE, in consideration of the mutual covenants and agreements contained herein and in the Certificate of Completion, and for other good and valuable consideration, the sufficiency and receipt of which is hereby acknowledged by the Grantor and Grantee, the Grantor, on behalf of itself, by these presents does hereby GIVE, GRANT, BARGAIN, SELL, CONVEY AND CONFIRM unto the Grantee,

and its authorized representatives, successors and assigns, and with WARRANTY, COVENANTS forever, these environmental restrictions, right of access and easement, and shall apply to the Parcel, as set forth below:

1. Easement Rights of Access. Grantor grants to Grantee the perpetual right and easement and right of access in, on, upon, to, through, over and under the Parcel for the following purposes:

    a. monitoring and oversight of all aspects of the response actions;
    b. capping and closure of the response areas;
    c. verifying any data or information submitted to the Agency of Natural Resources;
    d. assessing the need for, planning, or implementing additional response actions at or near the Parcel;
    e. determining whether the Parcel is being used in a manner that is prohibited or restricted;
    f. enforcing the rights of Grantees to the Parcel and the covenants of the Grantor set forth herein;
    g. surveying;
    h. all other activities necessary to implement, construct, operate or maintain the response actions.

2. Restricted Uses and Activities. Grantor makes the following covenants and agrees to permanent use restrictions and obligations on behalf of Grantor, its successors and assigns, for the benefit of Grantee, its authorized representatives, successors and assigns, which covenants, restrictions and obligations shall run with and bind the Parcel in perpetuity:
    a. Grantor shall comply with all federal, state, and local laws and regulations regarding the handling and disposal of hazardous substances, pollutants or contaminants on or from the Parcel;
    b. Grantor shall not use the Parcel or conduct any activities on the Parcel, or allow uses or activities to be conducted on the Parcel that would:
        i. unreasonably interfere with any investigations of the environmental conditions at the Parcel;
        ii. cause or exacerbate contamination of the Parcel or contamination of off-site properties; or
        iii. pose or present any risk to the implementation, construction, operation, or maintenance of the remedy.
    c. Grantor shall not take or authorize any of the following activities or actions on the Parcel without the prior express written consent from the Grantee:
        i. Construction, substantial improvement, or stabilization of buildings or any work on the foundations of buildings;
        ii. Plowing, tilling, ditching, draining, diking, filling, excavating, dredging, mining or drilling, removal of topsoil, sand, gravel, rock, minerals or other materials;
        iii. Construction activities which will materially change hydrogeologic conditions or will likely cause migration of contaminated groundwater;
        iv. Any other use that may impact or adversely affect the implementation, construction, operation, and maintenance of the remedy.

3. Enforcement.
    a. The Grantee shall be entitled to enforce the terms of these Environmental Restrictions by resort to specific performance or other legal process, including enforcement in the courts of the State of Vermont.
    b. The Grantor agrees that a violation of the Environmental Restrictions will constitute irreparable harm and entitle Grantee to injunctive relief.
    c. All reasonable costs and expenses of Grantee, including, but not limited to, attorneys' fees, incurred in any enforcement action shall be borne by the Grantor or its successors in interest or assigns if Grantee prevails in any such action.
    d. All remedies available hereunder shall be in addition to any and all remedies at law or in equity, including but not limited to federal and state hazardous waste management statutes. Nothing in these Environmental Restrictions shall be construed to limit or otherwise affect the Agency of Natural Resources' rights of entry and access provided by law or regulation.
    e. Enforcement of the terms of these Environmental Restrictions shall be at the discretion of the Grantee, and any forbearance, delay or omission to exercise their rights under these Environmental Restrictions shall not be deemed to be a waiver by the Grantee of such term or of any subsequent breach of the same or any other term, or of any of the rights of the Grantee under these Environmental Restrictions. .
    f. Grantee shall be entitled to recover monetary damages for violations of the terms of these Environmental Restrictions, or for any injury to the response actions.
    g. Grantee shall be entitled to recover damages for injury to the public health and welfare or to the environment protected by these Environmental Restrictions.

4. Severability. The provisions of these Environmental Restrictions are severable. If any provision of these Environmental Restrictions is invalid, or if any application of these Environmental Restrictions to any circumstance is invalid, the invalidity shall not affect other provisions or applications that can be given effect without the invalid provision or application.

5. Provisions to Run With the Land in Perpetuity. The environmental restrictions, rights of access, easements, obligations and covenants, granted in this instrument shall run with the land, and any portion thereof, in perpetuity, and shall be binding on the Grantor, the Grantor's agents, successors and assigns, and shall inure to the benefit of the Grantee and its authorized representatives, successors and assigns.

6. Incorporation into Leases. Grantor hereby agrees to incorporate these Environmental Restrictions, in full or by reference, into all leases, licenses, occupancy agreements, or any other instrument of transfer by which a right to use the Parcel, or any portion thereof, is conveyed.

7. Termination.
    a. This Grant of environmental restrictions, right of access and easement may be modified, or terminated in whole or in part only upon written agreement between of the Grantor, its successors or assigns, and the Grantee, signed by the Grantee and recorded in the land records in the Town of _____.
    b. The Grantee may terminate, in whole or in part, the environmental restrictions, right of access and easement at such time or times, if ever, when the Grantee, in its sole reasonable

discretion, determines that termination is necessary or that the purposes for which these environmental restrictions, right of access and easement were created have been achieved.

8. Miscellaneous Rights and Obligations.
   a. Nothing contained herein shall give or grant to the public a right to enter upon or to use the Parcel or any portion thereof where no such right existed in the public immediately prior to the execution of these Environmental Restrictions.

   b. If Grantor or its successors and assigns become delinquent in payment of said taxes or assessments such that a lien against the Parcel is created, the Grantee shall have the right to take actions as may be necessary to protect the Grantee's interest in the Parcel and to assure the continued enforceability of the rights granted herein.
   c. Grantor does further covenant and represent that the Grantor is seized of the Parcel in fee simple and warrants that it has good right and title to grant and convey the interests granted herein, and that the Parcel is free and clear of any and all encumbrances, that Grantor shall warrant, defend, and indemnify against all lawful claims whatever, and that Grantee and its successors and assigns shall have the use of and enjoyment all of the benefits derived from and arising out of these Environmental Restrictions.
   d. Grantee shall be entitled to record these Environmental Restrictions, or to record a notice making reference to the existence of these Environmental Restrictions, in the Land Records for the Town of _____ as may be necessary to satisfy the requirements of the Record Marketable Title Act, 27 V.S.A. Chapter 5, Subchapter 7, including 27 V.S.A. §§ 603 and 605.
   e. The parties hereto recognize and agree that the benefits of the environmental restrictions, easement, and right of access granted and imposed herein are in gross and are assignable by Grantee, subject to notice to Grantor and recording of the assignment in the Land Records for the Town of _____.

TO HAVE AND TO HOLD this Grant of Environmental Restrictions, Rights of Access and Easements unto the said Grantee Agency of Natural Resources of Vermont, its authorized representatives, successors and assigns forever.

IN WITNESS WHEREOF, the Grantor _____ has caused these presents to be executed and sealed below the day and year first above written.

_____ by: _____
Witness Printed name: _____.

STATE OF VERMONT
COUNTY OF _____, ss.

At _____ this ___ day of _____, 200_, _____
_____of _____, personally appeared and acknowledged this instrument by him sealed and subscribed to be his own free act and deed.

Before me: _____
Notary Public
Commission expires _____

Appendix I: Conceptual Site Model Outline

Major elements of a Conceptual Site Model can include:

- General site description
- Land use:
  - Current land use
  - Past land use
  - Proposed land use (if known)
- Regional physical setting
  - Geomorphology
  - Geology
  - Hydrogeology
  - Hydrology
- Regional environmental setting
  - Habitat description
  - Endangered species
- Contaminants of concern and site investigations
  - Results of previous site investigations if available
  - Contaminants of concern
  - Contaminant sources (known or estimated)
  - Contaminant nature and extent (including all applicable media)
  - Contaminant fate and transport (known or estimated)
    - Contaminant variability in time and space (at larger and smaller scales)
    - Contaminant susceptibility to various treatment or destruction options
- Potential risks and potential receptors
  - Human Health
    - Exposure pathways
    - Activities and risks
  - Ecological
    - Exposure pathways
    - Risks
- Data quality evaluation
- Identification of data gaps and data needs to serve various exposure or remedial decisions
- Narrative of how the site conditions affect the potential exposure pathways, and transport mechanisms
- Description of how current data modifies the initial Conceptual Site Model

APPENDIX J: Glossary of Terms

Above Ground Storage Tank (AST): any tank, other than an underground storage tank, used to store any regulated substances or any of the following petroleum products: gasoline, diesel, kerosene, used oil or heating oil.

Background: Refers to constituents or locations that are not influenced by the releases from a site, and may be described as naturally occurring or from off-site sources.

Brownfields: real property, the expansion redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant. *http://www.epa.gov/Compliance/cleanup/brownfields/index.html*.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): Commonly known as Superfund, was enacted by Congress on December 11, 1980. This law created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. Over five years, $1.6 billion was collected and the tax went to a trust fund for cleaning up abandoned or uncontrolled hazardous sites. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous sites; provided for liability of persons responsible for releases of hazardous waste at these sites; and established a trust fund to provide for cleanup when no responsible party could be identified.

Conceptual Site Model (CSM): A model of how chemicals were released at a site, their transport mechanism, and exposure routes for both ecological and human receptors. See Section 2.3 and Appendix H.

Contaminant: Any physical, chemical, biological, or radiological material that can potentially have adverse impacts on environmental media, or that can adversely impact public health and the environment. It represents any undesirable substance/material that normally is not present in the environmental media of concern.

Corrective Action: Remedial actions taken when a release of a hazardous material has occurred and has impacted the environment. A typical example involves the remediation of chemical contamination in soil and groundwater.

Dense Nonaqueous Phase Liquid (DNAPL): liquids (generally organic) that have low aqueous solubilities (they are immiscible) and have a greater density than water (they will sink in water). They are characterized by their component composition, density, viscosity, and interfacial tension with water. Common DNAPLs include compounds that have been and are still widely used in industrial and commercial processes. Possibly the most common DNAPLs are halogenated solvents such as trichloroethylene (TCE) and tetrachloroethylene (PCE). These DNAPLs have been used as degreasers in many industrial processes and have frequently been released to the subsurface. Other DNAPLs include, but are not limited to, coal tar, creosote, some pesticides, and polychlorinated biphenyls (PCBs).

Dynamic Work Plan: a workplan that allows the project teams to make decisions in the field about how subsequent site activities will progress. Workplans provide the strategy for how dynamic field activities will take place. As such, they document a flexible, adaptive sampling and analytical strategy. *http://www.epa.gov/superfund/programs/dfa/dynwork.htm*

Environmental Site Assessment (ESA): An assessment of a piece of property by an environmental professional for the presence of recognized environmental conditions as per ASTM standards. A Phase 1 ESA is a non-invasive site inspection and use history review. A Phase 2 ESA will conduct a more detailed investigation of the recognized environmental conditions identified during Phase 1; this will usually include sampling of air, soil, or water. Please see ASTM International's E1527-05 "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process" or ASTM E2247-08 "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process for Forestland and Rural Property" and/or ASTM E1903 - 11 Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process ASTM E1903-97(2002) "Standard Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process" for additional information.

Free Product: refers to an immiscible fluid such as gasoline or a chlorinated solvent. In the subsurface free product may be continuous and able to flow independently of groundwater.

Hazardous Material: Defined in 10 V.S.A. Section 6602(16)(A) and (B) as: all petroleum and toxic, corrosive or other chemicals and related sludge included in any of the following:
(i) any substance defined in section 101(14) of the federal Comprehensive Environmental Response, Compensation and Liability Act of 1980;
(ii) petroleum, including crude oil or any fraction thereof; or
(iii) hazardous wastes, as determined under 10 V.S.A. Section 6602 (4). Does not include herbicides and pesticides when applied consistent with good practice conducted in conformity with federal, state and local laws and regulations and according to manufacturer's instructions.

Hazardous Waste: As defined in 10 V.S.A. Section 6602(4): any waste or combination of wastes of a solid, liquid, contained gaseous, or semi-solid form, including but not limited to those which are toxic, corrosive, ignitable, reactive, strong sensitizers, or which generate pressure through decomposition, heat or other means, which in the judgment of the secretary may cause, or contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness, taking into account the toxicity of such waste, its persistence and degradability in nature, and its potential for assimilation, or concentration in tissue, and other factors that may otherwise cause or contribute to adverse acute or chronic effects on the health of persons or other living organisms, or any matter which may have an unusually destructive effect on water quality if discharged to ground or surface waters of the state. All special nuclear, source or by-product material, as defined by the Atomic Energy Act of 1954 and amendments thereto, codified in 42 U.S.C Section 2014, is specifically excluded from this definition.

Light Nonaqueous Phase Liquid (LNAPL): liquids (generally organic) that have low aqueous solubilities (they are immiscible) and have less density than water (they will float on water). They are characterized by their component composition, density, viscosity, and interfacial tension with water. Common LNAPLs include petroleum products such as gasoline, diesel fuel, and home heating oil.

Monitored Natural Attenuation: an in-situ approach to cleanup that uses natural processes to contain the spread of contamination from releases of hazardous materials and reduce the concentrations and amounts of pollutants in contaminated media, including but not limited to soil and groundwater. Natural processes, such as dilution, volatilization, biodegradation, adsorption, degradation and chemical reactions, are allowed to reduce concentrations of contaminants to acceptable levels.

Non-aqueous phase liquid (NAPL): Non-aqueous phase liquids are liquids that are sparingly soluble in water. Because they do not mix with water, they form a separate phase. For example, oil is an NAPL because it does not mix with water, and oil and water in a glass will separate into two separate phases. NAPLs can be lighter than water (LNAPL) or denser than water (DNAPL). Hydrocarbons, such as oil and gasoline, and chlorinated solvents, such as trichloroethylene, are examples of NAPLs (as defined by the United States Geological Study).

Petroleum Cleanup Fund (PCF): established under the authority of 10 V.S.A. Chapter 59 Section 1941, was created to pay, subject to available funding, for certain uninsured costs for the cleanup and restoration of contaminated soil and groundwater caused by releases of petroleum from aboveground storage tanks (ASTs) and underground storage tanks (USTs) and for compensation of third party claims for injury and damage caused by such a release.

Product sheen: A layer of light non-aqueous phase liquid (LNAPL) that is too thin to measure but is visible on top of water.

Receptor: Areas which may be affected by a release of a hazardous material. These may include public or private water supplies, surface waters, wetlands, sensitive ecological areas, outdoor and indoor air, and enclosed spaces such as basements, sewers, and utility corridors.

Regulated substances: means all petroleum and toxic, corrosive or other chemicals and related sludge including: (1) Any substance defined in **§101(14)** of CERCLA, but does not include any substance regulated as a hazardous waste under Chapter 159 of Title 10; (2) Petroleum, including crude oil or any fraction thereof which is liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute); (3) Any other motor fuel which is liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute); and (4) Any other substance as designated by the Secretary in rule.

Release: As defined in 10 V.S.A. Section 6602(17): any intentional or unintentional action or omission resulting in the spilling, leaking, pumping, pouring, emitting, emptying, dumping, or disposing of hazardous materials into the surface or groundwaters, or onto the lands in the state, or into waters outside the jurisdiction of the state when damage may result to the public health, lands, waters or natural resources within the jurisdiction of the state.

Release Notification: Releases of hazardous materials into the surface or groundwater or onto the land of the State are prohibited. Releases or suspected releases must be reported to the State according to Section 8-602 of the State of Vermont Underground Storage Tank Regulations (*http://www.anr.state.vt.us/dec/wastediv/ust/ust_regs.htm)*, section 7-105 of the Vermont Hazardous Waste Management Regulations, (*http://www.anr.state.vt.us/dec/wastediv/rcra/regs.htm)*, 10 V.S.A. Sections 6615 and 6615b, *(http://www.leg.state.vt.us/statutes/fullsection.cfm?Title=10&Chapter=159&Section=06615)*, and 10 V.S.A. Section 6616, (*http://www.leg.state.vt.us/statutes/fullsection.cfm?Title=10&Chapter=159&Section=06616)*.

Resource Conservation and Recovery Act (RCRA): A Federal law enacted in 1976 that established a regulatory system to track hazardous substances from their generation to their disposal. The law requires the use of safe and secure procedures in treating, transporting, storing, and disposing of hazardous substances. RCRA is designed to prevent the creation of new, uncontrolled hazardous sites.

Responsible Party (RP): Any person, potentially liable under 6615, which may include, but is not necessarily limited to, an individual or organization, including owners, operators, transporters, or generators, who is potentially responsible for or contributed to contamination at a site**.**

Sensitive Receptors: Areas which may be affected by a release of a hazardous material. These may include public or private water supplies; surface waters; wetlands; sensitive ecological areas, outdoor and indoor air; and enclosed spaces such as basements, sewers, and utility corridors.

Site: The "Site" as defined in this document includes the extent of contaminated media attributable to a release of hazardous materials and/or petroleum products. Sites are each provided a unique VT SMS Site number.

Site Management Activity Completed (SMAC) designation: Sites which the Waste Management Division (WMD) have determined require no further management are given a SMAC designation. The designation does not release the responsible party from any past or future liability which may arise from the contamination which originated at the site. The SMAC designation does mean that the Sites Management Section (SMS) is not requiring any additional work be performed at the site in response to the release specified in the SMAC letter.

Sites Management Section (SMS): The Sites Management Section (SMS) is a section of the State of Vermont Agency of Natural Resources, Department of Environmental Conservation, Waste Management Division which provides state oversight for the investigation and cleanup of properties where a release of a hazardous material has contaminated the environment including soils, groundwater, surface water and indoor air. The primary authority for this oversight can be found in 10 V.S.A. Section 6615. The SMS manages a state Brownfields program (Redevelopment of Contaminated Properties) and provides support to the federal USEPA Brownfields program. The SMS also participates with USEPA on the management of sites listed on the national priorities list (Superfund).
http://www.anr.state.vt.us/dec/wastediv/SMS/sites_management_section.htm

Standard Operating Procedures (SOPs): A detailed set of instructions for performance of a specific, discrete task. It should identify the necessary equipment and provide step-by-step instructions for performance of a task. It needs to be written clearly and unambiguously so that the task described will be performed the same way regardless of who is performing the task. SOPs are commonly developed for many site investigation activities, including sample collection, decontamination, and field screening techniques. The SMS does not publish or distribute SOPs for activities associated with hazardous site investigations and cleanups, but may from time to time review contractor SOPs and recommend or require modifications or revisions.

Surface water: All rivers, streams, brooks, reservoirs, ponds, lakes, springs, wetlands and all bodies of surface waters, artificial or natural, which are contained within, flow through or border the State.

Toxic Equivalent (TEQ): weighs the toxicity of the less toxic compounds as fractions of the toxicity of the most toxic compound.

Toxic Equivalency Factor (TEF): the degree of toxicity compared with the most toxic compound.

Underground Storage Tank (UST): UST means any one or combination of tanks including underground pipes connected to it or them, which is or has been used to contain an accumulation of regulated substances, and the volume of which, including the volume of the underground pipes connected to it or them, is 10 percent or more beneath the surface of the ground.
http://www.anr.state.vt.us/dec/wastediv/ust/ust_regs.htm

Vadose Zone: (or unsaturated zone): the zone between land surface and the capillary fringe within which the moisture content is less than saturation and pressure is less than atmospheric. Soil pore spaces typically contain water, air or other gases. The capillary fringe is not included in the unsaturated zone.