QUEST Home

Over the years, ITRC products have helped to provide a common understanding and acceptance of environmental challenges and solutions. Many beneficial ITRC products go underutilized because newer staff are unaware of how to locate them. The ITRC Quickening Environmental Solutions and Training (QUEST) Knowledge Map incorporate existing ITRC products to help new environmental program staff gain rapid exposure to years of lessons learned and proven best practices and help them to better understand the nuances of the environmental profession.

The ITRC Quickening Environmental Solutions and Training (QUEST) Knowledge Map is an interactive tool for navigating ITRC's environmental guidance documents and resources, allowing users to filter through ITRC's vast library based on concise subjects. The Knowledge Map presents a "roadmap" of where to find key environmental topic and concept information within the ITRC document library and resources and is organized by the Assessment and Remediation phases of environmental cleanups. By clicking on these phases on the top toolbar of this tool, users can navigate topics and subtopics, and access links to published ITRC documents
and resources that provide an overview for these topics.

Assessment Phase

The portion of the project life cycle from the discovery of a release to the environment to the investigation the site and effect to human health and the environment. this includes investigations depending on the facility type, using the Triad method, and site characterization.

- Triad Approach
- Data Management
- Type of Site
    - Brownfields
    - Dry Cleaners
    - Landfills
    - Mining Sites
    - Munitions
    - USTs
- Site Characterization
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        - Emerging Contaminants
            - 1,4 Dioxane
            - Ethylene Oxide Emissions
            - Per- and Polyfluoroalkyl Substances (PFAS)
            - Microplastics
        - Metals
        - Microorganisms
        - Non-Aqueous Phase Liquid (NAPL)
            - Dense Non-Aqueous Phase Liquid (DNAPL)
            - Light Non-Aqueous Phase Liquid (LNAPL)
        - Pesticides
        - Polycyclic Aromatic Hydrocarbons (PAHs)
        - PCBs
        - Radionuclides
        - SVOCs

    - Unexploded Ordnance
    - VOCs
- Media
    - Air
    - Fractured Rock
    - Geology/Hydrogeology
    - Groundwater
    - Plants
    - Sediment
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    - Stormwater
    - Surface Water
    - Tissue
    - Waste
- Investigation Methods
    - Traditional Investigative Techniques
    - Incremental Sampling Methodology (ISM)
    - Direct Push Wells
    - Diffusion/Passive Samplers
- Conceptual Site Model (CSM)
- Advanced Techniques
    - Accelerated Site Characterization
    - Environmental Molecular Diagnostics
    - Geophysical Technologies
    - Groundwater Statistics and Monitoring Compliance
- Risk Assessment
    - Risk Communications
    - Migration Pathways
        - Groundwater Fate and Transport
        - Soil Fate and Transport
        - Vapor Intrusion

Triad Approach

Triad approach focuses on systematic project planning, dynamic work strategies, and real-time measurement technologies. The central principle of the Triad approach is the management of decision uncertainty.

Triad Approach: A New Paradigm for Environmental Project Management (SCM-1)
Section 2 (The Triad Approach)
Introduces the Triad approach to conducting environmental work, which increases effectiveness and quality and reduces project costs.

Dense, Nonaqueous-Phase Liquids (DNAPLs-5)
Section 3.3.5 **(Benefits of Utilizing Triad Approach for DNAPL Performance Assessment)**
List of specific benefits of using the triad approach. Includes a case example to demonstrate the benefits to a project.

Green and Sustainable Remediation (GSR-2)
Section 1.4.1 (The Triad Approach), page 5
Pulls direct quotes from Technical and Regulatory Guidance for the Triad Approach: A New Paradigm for Environmental Project Management (ITRC 2003) and discusses further.

Green and Sustainable Remediation (GSR-2)
Section 3.1.2 (Investigation Phase GSR Options), page 31, paragraph 3
Discusses how systematic planning brings the stakeholders together and helps to consume fewer resources.

Green and Sustainable Remediation (GSR-2)
Table 3-2, page 32
Table contains general examples of best management practices to use for environmental, social and economic benefits.

[Phytotechnologies (PHYTO-3)]

Section 2 (Phytotechnologies Project Management Requirements), pages 32-36

Describes project management requirements including project structure, team organization, objectives and checklists for deliverables by project phase.

[Radionuclides (RAD-4)]

Section 3.1 (Data Collection), pages 16-18

Describes how data quality indicators and real time data benefit the project as a whole.

[Radionuclides (RAD-4)]

Appendix C, pages C1-C7

Describes the components of the Triad approach including conceptual site models, decision statements, how to identify data gaps, and dynamic work strategies.

[Remediation Process Optimization (RPO-7)]

Section 2.2.1 (The Triad Approach for Site Cleanup), pages 18-19

Describes how to manage decision uncertainty with the Triad approach.

[Sampling, Characterization and Monitoring (SCM-1)]

Executive Summary, page iii

Describes what the Triad approach is and what the document contains to help implement it.

[Sampling, Characterization and Monitoring (SCM-3)]

Section 2.1 and Section 2.2 (Triad Approach)

What is Triad and why implement it?

Data Management

Data are measurements or information that describe environmental processes, location, or conditions; ecological or health effects and consequences; or the performance of environmental technology. The resources on this page include best practices for data management planning, data quality, and data evaluation.

Environmental Data Management Best Practices (EDM-1)
Provides a series of fact sheets and case studies that summarize the latest science, engineering, and technologies surrounding environmental data management best practices.

Groundwater Statistics and Monitoring Compliance (GSMC-1)
Section 6 (Data Management Considerations)
Describes how input data files should provide statistical analysis deliverables (in electronic format) to allow for verification and cross-checking with different models.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Section 11.3 (Data Evaluation)
Review of data evaluation factors and planning considerations for data usability.

Remediation Process Optimization (RPO-5)
Data from Field, pages 3-4
Each aspect of the environmental monitoring program, from sample collection to data management must address and meet applicable quality standards.

Soil Background and Risk (SBR-1)
Section 8.2 (Conceptual Site Model and Data Quality Objectives)
A systematic planning process is a key step in developing a successful sampling and analysis program to ensure the appropriate sampling, analyses, and data evaluations are conducted to meet program objectives.

Soil Background and Risk (SBR-1)
Section 10 (Analytical Methods)
A critical component in establishing soil background, whether it be default or site-specific, is to ensure that the soil samples are analyzed by laboratory methodologies that generate high-quality analytical data that meet the data quality objectives (DQOs) of the soil background study and are comparable to the site data being evaluated.

Unexploded Ordnance (QCMR-1)
Section 1 (Introduction)
Explains the decision logic used throughout a munitions response (MR) project and assists in developing the Quality Assurance and Quality Control (QA/QC) activities that ensure quality data and confidence in decisions.

Petroleum Vapor Intrusion (PVI-1)
Section 4.3 (Step 6)
Describes common data quality issues and factors to be considered to determine that data quality objectives have been met and data are usable to evaluate the vapor intrusion pathway.

Petroleum Vapor Intrusion (PVI-1)
Appendix G.1.3
Describes the process of defining project goals and data quality objectives when planning an environmental investigation.

Type of Site

The type of facility can direct the investigation. Types include brownfields, underground storage tanks, and mining.

- Brownfields
- Dry Cleaners
- Landfills
- Mining Sites
- Munitions
- USTs

Brownfields

A brownfield is a property that may undergo expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.

An Overview of Land Use Control Management Systems (BRNFLD-3)
Section 3 (State and Federal Environmental Program Brownfield Initiatives)
Provides information and how brownfields apply to a wide variety of sites, including industrial properties, old gasoline and service stations, vacant warehouses, former military installations, former dry cleaning facilities, other related commercial services, landfills, scrap yards, and other properties affected by the release or suspected release of hazardous substances or petroleum products.

Integrated DNAPL Site Characterization (ISC-1)
Figure 4-3 (Project Life Cycle)
Figure showing how the conceptual site model for a brownfield investigation changes over time

Sampling, Characterization and Monitoring (SCM-1)
Section 2.4 (Triad Approach Perspective)
Discussion of how the end use of a site (brownfields) will inform the systematic project planning and project decisions.

Dry Cleaners

Dry cleaners are a potentially contaminated site due to the commonly used solvents, perchloroethylene and petroleum solvents.

Integrated DNAPL Site Strategy (IDSS-2)

Dry Cleaner Case Study

PCE contaminated dry-cleaner site, focused on In-Situ Chemical Oxidation, Pump & Treat, and Soil Vapor Extraction remedial technologies.

Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios (VI-1A)

Scenario 2 (Dry-Cleaning Operations in a Strip Mall Near a Residential Neighborhood), pages 9-14

This scenario illustrates a typical assessment of the vapor intrusion risk to adjoining businesses due to tetrachloroethane (PCE) contamination emanating from a dry-cleaner.

Vapor Intrusion Issues at Brownfield Sites (BRNFLD-1)

Section 1 (Introduction)

This document discusses the concept of vapor intrusion, the type of contaminants that may pose a risk of vapor intrusion, and the steps that can be taken to control or abate these risks which can apply to dry cleaner sites.

Landfills

Permitted facilities that can receive municipal, industry, and hazardous waste.

Alternative Landfill Technology Documents

ITRC Summary Page

A series of documents that addresses regulatory and technical obstacles that inhibit the use of alternative landfill covers, bioreactor landfills, and a process to optimize post-closure care of landfills.

Alternative Final Landfill Covers (ALT-2)

Section 1 (Introduction)

Information for decision makers associated with the plan development, review, and implementation of alternative final covers (AFCs), which may also be referred to in this text as alternative covers, alternative landfill covers, or ET (evapotranspiration covers).

Incremental Sampling Methodology (ISM-2)

Section 3.1.6.3 (Case Study)

Case study for using systematic planning for a site with a landfill.

Mining Sites

The process of excavation from which ore, rock, or minerals can be extracted. The absence of routine mined-land reclamation, remediation, and restoration have led to legacy sites with significant environmental and human health impacts.

ITRC Mining Waste Landing Page

ITRC Summary Page

Understanding of the mining industry's issues and introduces some of the innovative solutions to historical and current industry environmental problem.

Mining Waste Treatment Technology Selection (MW-1)

Decision Tree

Designed to guide users to a set of treatment technologies that may be useful in managing a particular mine waste site.

Attenuation Processes for Metals and Radionuclides (APMR-1)

Section 1.1.1 (Types of Sites)

Various sites have been identified as having metal and/or radionuclide contamination from a wide variety of waste release scenarios, mining is just listed as one of the types of sites that contains metal and radioactive contamination.

Munitions

A munitions response area is a defense site that is known or suspected to contain unexploded ordnance, discarded military munitions, or munitions constituents such as ammunition, bombs, grenades, mines, missiles, and rockets.

Unexploded Ordnance (UXO-6)

Section 1 (Introduction), paragraphs 1 and 2

Overview of what munitions response areas (MRAs)/ munitions response site (MRS) are and the need to clean them up.

Attenuation Processes for Metals and Radionuclides (APMR-1)

Section 1.1.1 (Types of Sites)

Various sites have been identified as having metal and/or radionuclide contamination from a wide variety of waste release scenarios, deposition of spent and waste deposition from the production of nuclear weapons is listed here.

Small Arms Firing Range (SMART-1)

Section 1 (Introduction) and 2 (Site Characterization)

This guidance displays an easy-to-follow decision diagram for determining the best ways to do site characterization and remediation alternative at closed small arms firing ranges.

Small Arms Firing Range (SMART-2)

Section 1 (Introduction)

Discusses what is considered a small arms firing range and gives a general overview of the environmental impacts they have.

USTs

An underground storage tank (UST) and associated piping is used to store hazardous and non-hazardous substances such as petroleum at fuel stations and solvents at dry cleaning facilities. Releases from USTs can result in soil and groundwater contamination with LNAPL and DNALP and subsequent vapor intrusion into aboveground structures.

LNAPL-Update (LNAPL-3)
Section 3 (Key LNAPL Concepts)
Provides fundamental LNAPL concepts to understanding the logic used in the development of the tools and key to appropriate application of this guidance.

Remediation Process Optimization (RPO-2)
Example 2 (UST Case Study), pages 8-12
Uses a case example of a UST release to discuss cost savings from additional remedial action.

Vapor Intrusion (PVI-1)
Appendix E (Common Types of Petroleum Sites, Gasoline and Diesel USTs)
This appendix summarizes different features that may influence the potential for petroleum vapor intrusion (PVI).

Site Characterization

The characterization of a project is a comprehensive understanding of the environment and the vectors affecting the environment. This includes the conceptual site model, chemicals of concern, media, risk assessment, investigation methods, and advanced techniques.

- Contaminants
    - Emerging Contaminants
        - 1,4 Dioxane
        - Ethylene Oxide Emissions
        - Per- and Polyfluoroalkyl Substances (PFAS)
        - Microplastics
    - Metals
    - Microorganisms
    - Non-Aqueous Phase Liquid (NAPL)
        - Dense Non-Aqueous Phase Liquid (DNAPL)
        - Light Non-Aqueous Phase Liquid (LNAPL)
    - Pesticides
    - Polycyclic Aromatic Hydrocarbons (PAHs)
    - PCBs
    - Radionuclides
    - SVOCs
    - Unexploded Ordnance
    - VOCs
- Media
    - Air
    - Fractured Rock
    - Geology/Hydrogeology
    - Groundwater
    - Plants
    - Sediment
    - Soil
    - Stormwater
    - Surface Water

        - Tissue
        - Waste
- Investigation Methods
    - Traditional Investigative Techniques
    - Incremental Sampling Methodology (ISM)
    - Direct Push Wells
    - Diffusion/Passive Samplers
- Conceptual Site Model (CSM)
- Advanced Techniques
    - Accelerated Site Characterization
    - Environmental Molecular Diagnostics
    - Geophysical Technologies
    - Groundwater Statistics and Monitoring Compliance
- Risk Assessment
    - Risk Communications
    - Migration Pathways
        - Groundwater Fate and Transport
        - Soil Fate and Transport
        - Vapor Intrusion

Contaminants

- Emerging Contaminants
  - 1,4 Dioxane
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  - Light Non-Aqueous Phase Liquid (LNAPL)
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- PCBs
- Radionuclides
- SVOCs
- Unexploded Ordnance
- VOCs

Emerging Contaminants

Contaminants of Emerging Concern:

Substances and microorganisms including physical, chemical, biological, or radiological materials known or anticipated in the environment, that may pose newly identified risks to human health or the environment (ITRC 2023).

- 1,4 Dioxane
- Ethylene Oxide Emissions
- Per- and Polyfluoroalkyl Substances (PFAS)
- Microplastics

1,4 Dioxane

1,4-Dioxane is a likely human carcinogen that has been used in food additives and laboratory and manufacturing processes. It is also a byproduct of many chemicals used in household products, personal care products, plastics, and polyester, and from the 1950's to 1996.

1,4 Dioxane (14DX-1)
Section 1 (History of Use)
How 1,4-Dioxane was used in the past and how to determine potential sources of 1,4-dioxane.

1,4 Dioxane (14DX-1)
Section 2.0 (Regulatory Framework)
Presents the information about the regulatory framework of 1,4-dioxane.

1,4 Dioxane (14DX-1)
Section 3 (Fate and Transport)
Overview of the chemical and physical properties of 1,4-dioxane and how they impact environmental fate and transport.

1,4-Dioxane (14DX-1)
Section 3.1 (Chemical and Physical Properties) including Table 3-1 to Section 3.1.4
Discusses physical and chemical properties of 1,4-dioxane as well as key properties that are relevant to 1,4-dioxane's fate and transport.

1,4 Dioxane (14DX-1)
Section 4.0 (Sampling and Analysis)
Describes potential sampling concerns when sampling for 1,4-dioxane; identifies the common analytical methods available for 1,4-dioxane in different matrices, including water, solids, and air; and highlights the benefits and limitations of the available analytical methods.

Ethylene Oxide Emissions

Ethylene oxide (EtO) is a flammable, colorless, and reactive gas. It is a synthetic chemical created as a byproduct of human (i.e., anthropogenic) activities or generated as a natural metabolic product of ethylene by microbes, plants, and animals, including humans (i.e., biogenic).

Ethylene Oxide Emissions (EtO-1)
Section 2 (Introduction)
Physical and Chemical Properties of EtO, Production and Use, Emission and Fate, and Health Effects of EtO.

Microplastics

The Microplastics guidance provides an introduction to Microplastics, information on how they move and where you can find them in the environment, sampling and analysis considerations, information on human health and environmental effects, a summary of current laws and regulations, and technologies that can be used to abate and mitigate Microplastics in the environment. Case studies are also included in the document.

Microplastics (MP-1)

Per- and Polyfluoroalkyl Substances (PFAS)

PFAS are a large and complex class of anthropogenic compounds whose prevalence in the environment are an emerging, worldwide priority in environmental and human health.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Naming Conventions – Section 1 (Introduction)
Addresses naming conventions of some of the most commonly reported PFAS based on historical use, current state of science research related to environmental occurrence, and available commercial analyses.

Per- and Polyfluoroalkyl Substances (PFAS-1)
History of Use – Section 1 (Introduction)
Provides a summary of the discovery and application of PFAS, emergence of known health effects, reduction in PFAS production/use, and environmental impacts.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Fate and Transport – Section 1 (Introduction)
Focuses on how the unique chemical and physical properties of PFAS affect their behavior in the environment.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Site Characterization and Media – Section 1 (Introduction)
Provides an overview of site characterization for PFAS and media-specific occurrence of PFAS.

Aqueous Film Forming Foam (AFFF)

Aqueous Film Forming Foam (AFFF) is a highly effective firefighting product intended for fighting high-hazard flammable liquid fires that also impacts the environment.

PFAS Fact Sheet
This fact sheet outlines methods to properly identify, handle,

store, capture, collect, manage, and dispose of AFFF to limit potential environmental impacts.

AFFF Training Video

The purpose of this video is to assist AFFF users, first responders, and regulators with understanding foam formulations, mechanisms for releases to the environment, and best management practices.

Metals

Chemical elements, often naturally occurring, that are defined by their ability to conduct heat and electricity and easily form positive ions.

Metals in Soil (MIS-1 – MIS-6)

ITRC Metals Summary Page

Information on soil washing and the emerging technologies of phytoremediation, electrokinetics, and in situ stabilization/in-place inactivation.

Small Arms Firing Range (SMART-1)

Section 2 (Site Characterization)

Describes the approach to site characterization of a small arms firing range and includes determining range history, range design considerations and layout, sample collection and analysis, and risk assessment.

Small Arms Firing Range (SMART-2)

Section 1.1 (Problem Statement), Table 2-1

This section and table provide information about the metals commonly associated with range activities at small arms firing ranges.

Attenuation Processes for Metals and Radionuclides (APMR-1)

Section 2.1.2 (Aqueous Speciation) through 2.1.7 (Geochemical Gradients), pages 12-22

Good General description of pH, ORP, eH and how that impacts groundwater plumes.

Microorganisms

Microorganisms can be used as a remediation technology to address hazardous substance releases.

1,4 Dioxane (14DX-1)
Section 6.0 (Remediation and Treatment Technologies)
Provides details on the most commonly used treatment technologies (including microorganisms) as well as information on popular technologies that aren't the best choice for 1,4 dioxane. The information includes treatment selection and treatment options for drinking water, wastewater, residential, soil, and both in situ and ex situ groundwater.

In Situ Bioremediation (ISB-6)
Section 2.3.4 (Bioaugmentation), page 30-123
Provides information about microorganisms that have been used to promote cometabolism of chlorinated solvents as well as bioaugmentation considerations.

In Situ Bioremediation (ISB-8)
Section 1.3.1. (Micoorganisms (or Microbes))
Describes the use of microorganisms in bioremediation and describes both the aerobic and anaerobic biochemical reactions that occur.

In Situ Bioremediation (ISB-8)
Section 3.3 (Contaminant Transformations/Microorganisms), pages 21-24
Describes the chemical transformations that occur with and without biological activity. Characterization of the microbial community indigenous to the contaminated site can aid in bioremediation.

Non-Aqueous Phase Liquid (NAPL)

Non-aqueous phase liquids (NAPLs) are common contaminants that are insoluble in water.

Remediation Management of Complex Sites (RMCS-1)
Section 2.1.4.1
This section discusses contaminant-related conditions that may contribute to a site being considered complex including the presence of NAPLs, recalcitrant contaminants, high concentrations or multiple contaminants, and emerging contaminants

- Dense Non-Aqueous Phase Liquid (DNAPL)
- Light Non-Aqueous Phase Liquid (LNAPL)

Dense Non-Aqueous Phase Liquid (DNAPL)

Dense non-aqueous phase liquids (DNAPLs) are denser than water and include chlorinated solvents such as tetrachloroethylene and trichloroethylene.

[Dense, Nonaqueous-Phase Liquids (DNAPLs-4)]
Section 2 (Overview of the DNAPL Problem)
This section presents an overview of the DNAPL problem, a general description of DNAPL flow in the subsurface, and describes why conventional approaches to characterizing DNAPL site can be ineffective.

Integrated DNAPL Site Characterization (ISC-1)

Section 2.1;
Section 2.2;
Figure 2-1;
Figure 2-2;
Section 2.3.1;
Section 2.3.3;
Section 2.3.2;
Section 2.3.6;
Section 2.3.7;
Section 2.3.8;
Section 2.4;
Table 2-1;
Section 3.1;
Section 4.2.6;
Section 4.7.3;
Table D-7

This document synthesizes the knowledge of DNAPL site characterization and remediation and provides guidance on simultaneous characterization of contaminant distributions, hydrogeology, and attenuation processes.

Overview of In-Situ Bioremediation of Chlorinated Ethene DNAPL Source Zones (BIODNAPL-1)

Section 2; 3.1; Figure 2-6; Figure 2-7; Table 2-1

These sections introduce biodegradation and the fundamental principles underlying in-situ bioremediation (ISB) of DNAPL source zones, a description of the mechanisms of ISB, a discussion of the approaches of ISB of DNAPL source zones and the advantages and limitations, and the development of a conceptual site model (CSM) as the first step in assessing the applicability of ISB at a DNAPL site.

Light Non-Aqueous Phase Liquid (LNAPL)

Light non-aqueous phase liquids (LNAPLs) are less dense than water; common examples include petroleum products such as gasoline and diesel fuel.

LNAPL-Update (LNAPL-3)
Section 3 (Key LNAPL Concepts)
Provides fundamental LNAPL concepts to understanding the logic used in the development of the tools and key to appropriate application of this guidance.

Petroleum Vapor Intrusion (PVI-1)
Appendix C: General Chemistry
This appendix provides information about the composition and chemistry of petroleum hydrocarbon (PHC) fuels and their vapors.

MTBE and Other Fuel Oxygenates (MTBE-1)
Section 2.2 (Description of Physical and Chemical Properties) through 2.2.1 (Fuel Oxygenates), pages 4-7
More general chemistry, later sections more specific/detailed information on MTBE.

MTBE and Other Fuel Oxygenates (MTBE-1)
Section 2.2.4 (Biodegradation)
Basic chemistry of biodegradation.

Pesticides

Pesticides are a substance or mixture of substances intended for preventing, destroying, repelling, or mitigating pest. Pesticides can contaminate soil, sediments, water, and other vegetation.

1,4-Dioxane (14-DX-1)

Section 1.2.9 (Pesticides)

There is some evidence that past pesticide formulations contained 1,4-dioxane as an inert ingredient, including in the range of 20%–50% of the formulation.

Incorporating Bioavailability Considerations into the Evaluation of Contaminated Sediment Sites (CS-1)

Appendix B- Categories of Contaminants (Pesticides Section)

Discusses general information about pesticide contamination and how it reacts in sediments.

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are stable, neutral, aromatic organic chemicals consisting of numerous carbon atoms configured to form multiple rings. There are more than 10,000 different PAH compounds.

Bioavailability of Contaminants in Soil (BCS-1)
Section 8 (Polycyclic Aromatic Hydrocarbons)
Discusses the properties, sources, and toxicity of PAHs.

Incorporating Bioavailability Considerations into the Evaluation of Contaminated Sediment Sites (CS-1)
Appendix B
Discusses bioavailability of PAHs in sediment.

PCBs

Polychlorinated biphenyls (PCBs) are synthetic organic compounds; there are no natural sources of PCB is the environment. PCB remediation waste can result from a spill, release, or other unauthorized disposal of PCBs.

Incremental Sampling Methodology (ISM-1)
Section 9.1 (Case Study – PCB-Contaminated Landfill), pages 185-186; Appendix C.1, pages C-1 – C-13
These sections present a case study examining the application and comparative findings of incremental sampling methods to discrete sampling methods at a polychlorinated biphenyl (PCB) contaminated landfill.

Incremental Sampling Methodology (ISM-2)
Section 9.4.3 (Stakeholder Perspective)
Provides an example of a successful incremental sampling methodology (ISM) investigation about residential properties being impacted by a landfill and stakeholder involvement.

Phytotechnologies (PHYTO-3)
Section 1.3.3 (Phytoremediation Groundcovers)
Discusses the use of densely rooted groundcover plants and grasses used to phytoremediate contaminants.

Soil Background and Risk (SBR-1)
Section 7.4 (Polychlorinated Biphenyls (PCBs))
Overview of PCBS, their chemical structure, types of Aroclors, congeners and amount chlorinated. Later sections of 7.4 go into analysis techniques.

Solidification/Stabilization (S/S-1)
Section 2.2 (Contaminant Types Treated Using S/S), Table 2-1
Provides information on how broad classes of inorganic and organic chemicals generally response to solidification/stabilization (S/S) treatment.

Radionuclides

Radionuclides are radioactive forms of elements that can occur naturally in the environment or are man-made, either deliverability or as byproducts of nuclear reactions.

Attenuation Processes for Metals and Radionuclides (APMR-1)
Section 2 (Physical Processes, Site Characterization, and Modeling Approaches)
Identifies the geochemical processes that govern the environmental behavior and fate of metals and radionuclides at sites where monitored natural attenuation (MNA) is being considered as a remedial alternative.

Radionuclides (RAD-2)
Section 2.2 (Categories of Radioactive Materials), pages 4-5
Describes the major categories of radioactive materials as defined in DOE’s Radioactive Waste Management Manual (DOE, 2001).

Attenuation Processes for Metals and Radionuclides (APMR-1)
Section 2.1.2 (Aqueous Speciation) through 2.1.7 (Geochemical Gradients), pages 12-22
Good General description of pH, ORP, eH and how that impacts groundwater plumes.

SVOCs

A subgroup of volatile organic compounds that tend to have a higher molecular weight and higher boiling point temperature.

Incremental Sampling Methodology (ISM-2)

Table 5-1 (Sampling Processing and Analysis

Lists several example explosives and SVOCs, their boiling points.

Risk (Risk-3)

Appendix E (Example Risk Presentation Table)

Provides examples of SVOCs and risks.

Unexploded Ordnance

Unexploded ordnance (UXO) is any military munitions or explosive ordnance that remains unexploded by malfunction or design.

Unexploded Ordnance (QCMR-1)
Section 1 (Introduction)
This document highlights the products and performance standards required for all geophysical surveys, explains the decision logic used for an MR project and offers resources for planning and monitoring QA/QC activities to ensure quality data and confidence in decisions. Using this guidance, regulators and stakeholders can quickly review MR project work plans, evaluate the quality of MR work performed, and identify quality goals, steps, and metrics.

Unexploded Ordnance (UXO-6)
Section 1 (Introduction "A Note on Terminology")
FAQ provides information about wide-area assessments for munitions response areas (MRA) known or suspected to contain unexploded ordnance, discarded military munitions, or munitions constituents. An MRA comprises of one or more munitions response sites (MRS).

VOCs

Organic chemicals that have a high vapor pressure at ordinary room temperature.

In Situ Bioremediation (ISB-6)
Table 1, page 2
List of Common Chlorinated Solvents, their abbreviation and formula.

In Situ Bioremediation (ISB-6)
Section 2.1 (Degradation Processes), pages 7-14
Table 6, Analytical parameters used to assess intrinsic bioremediation
Discusses the degradation process of chlorinated solvents including Reductive Anaerobic Dechlorination, Aerobic Cometabolism, Oxidation and Direct Degradation.

Media

- Air
- Fractured Rock
- Geology/Hydrogeology
- Groundwater
- Plants
- Sediment
- Soil
- Stormwater
- Surface Water
- Tissue
- Waste

Air

Ambient and indoor air are potential media that can be impacted by contamination.

1,4 Dioxane (14DX-1)

Figure 5-1: Example of a pictorial exposure pathway CSM for risk assessment.

Shows air transport pathway for a contaminant leaching into soil.

Section 6.1 (Remediation Technologies)

Discusses vapor properties of 1,4-Dioxane and potential air remediation strategies.

Per- and Polyfluoroalkyl Substances (PFAS-1)

Fact Sheet: Site Characterization and Media-Specific Occurrence

Discusses occurrence of PFAS contamination in ambient air (Section 3, page 4).

Innovative Methane Detection Technologies (METHANE-1)

Section 1 (Introduction)

Provides an overview of existing and emerging technologies as well as guidance regarding performance characteristics and parameters to consider in methane detection technologies.

Fractured Rock

Groundwater and contaminant movement in fractured bedrock aquifers primarily occurs through fractures, making sites underlain by fractured rock difficult to characterize and remediate.

Characterization and Remediation of Fractured Rock (FRACTUREDRX-1)
Section 1 (Introduction)
Addresses significant advances in skills, tools, and lessons-learned in understanding contaminant flow and transport in fractured rock environments.

Integrated DNAPL Site Characterization (ISC-1)
Section 3.5 (Considerations in Fractured Rock); Figure 3-5
Describes how DNAPL penetrates into bedrock and migrates generally downward through fracture networks.

Integrated DNAPL Site Characterization (ISC-1)
Section 4.2.7 (Review Existing Fracture Data)
Describes that sufficient data must be acquired to characterize the fractures in terms of spatial orientation, distribution, interconnectivity, and potential for transport or storage of contaminants.

Integrated DNAPL Site Characterization (ISC-1)
Appendix E (Geology), including sections E.3.5; E.3.7; E.3.8; E.3.9; E.3.10; E.4.4; E.4.5
Geologic data provide a means to describe the physical matrix and structure of the subsurface and to classify the sedimentary, igneous, or metamorphic environment. Data related to lithology and distribution of strata and facies changes are generated through a variety of qualitative and quantitative collection tools and methods.

Geology/Hydrogeology

Geology is the characterization of subsurface conditions. Hydrogeology focuses on the distribution and movement of groundwater in the soil and rocks.

Dense, Nonaqueous-Phase Liquids (DNAPLs-4)
Section 3 (Characterizing Sites Contaminated with DNAPLs)
Describes the process for characterizing sites that are contaminated with DNAPLs.

Planning and Promoting Ecological Land Reuse of Remediated Sites (ECO-2)
Section 6.1.2.1 (Hydrology Analysis), page 44
Discusses early stages of planning an ecological reuse project and describes a detailed ecological site characterization.

In Situ Bioremediation (ISB-6)
Section 4.1.3 (Hydrogeologic and Geochemical Characterization)
The implementation of an EISB system should be based on a sound understanding of the geology and hydrogeology of the site.

In Situ Bioremediation (ISB-6)
Section 4.3.3 (Focused Hydrogeologic Study)
The focused hydrogeologic study is designed to determine as much information about groundwater flow and contaminant fate and transport at the selected site as possible.

In Situ Bioremediation (ISB-8)
Section 1.3.3 (Geological Environment)
Discusses how numerous factors affect contaminant distribution in the subsurface.

In Situ Bioremediation (ISB-8)
Section 3.1 (Hydrogeology)
Characterization of the hydrogeology of a site provides a basis for predicting how fluids and solutes move through the

subsurface.

LNAPL-Update (LNAPL-3)

Section 3 **(Key LNAPL Concepts)**

Provides fundamental LNAPL concepts to understanding the logic used in the development of the tools and key to appropriate application of this guidance.

Petroleum Vapor Intrusion (PVI-1)

Appendix D – Checklist, page 139

Petroleum Vapor Intrusion Conceptual Site Model Checklist.

Groundwater

Groundwater is located beneath the land's surface that can be impacted by contamination.

1,4 Dioxane (14DX-1)
Section 3 (Environmental Fate, Transport, and Investigative Strategies)
Discusses groundwater transport of 1,4-dioxane.

Accelerated Site Characterization (ASCT-1)
Section 3 (Direct Sensing)
Information about direct sensing as a groundwater profiling tool.

Accelerated Site Characterization (ASCT-1)
Section 4 (Borehole Geophysical)
Describes borehole geophysical tools and their ability to collect hydrogeologic data.

Dense, nonaqueous-phase liquids (DNAPLs-3)
Section 3.6 (Characterizing Groundwater and Source Water Chemicals)
Characterizing groundwater and source water chemical/fluid properties.

Integrated DNAPL Site characterization (ISC-1)
Section 4.2.6 (Evaluate Groundwater Chemical Signature Data)
Contains information about evaluating groundwater data using chemical signatures instead of chemical concentration.
Table D-2a: Comparison of single-well tests for hydraulic testing.
Table D-6a: Comparison of Discrete groundwater sampling tools.
Table D-6d: Comparison of multilevel sampling tools for groundwater sampling.
Table D-8: Comparison of chemical screening tools for groundwater sampling.
Table D-10: Comparison of stable isotropic and environmental

tracers for groundwater testing.
Section E.4: A description of hydrogeologic parameters that govern groundwater flow.
Section E.5.2: A short description of the value of multilevel monitoring for groundwater chemistry.
Section E.5.3: A description of geochemical parameters as used as water quality indicators.

Integrated DNAPL Site Strategy (IDSS-1)
Section 5.2.4 (Groundwater)
A description of groundwater monitoring programs and the components they should include.

Mass Flux (MASSFLUX-1)
Section 1 (Introduction)
The role of mass flux in contaminant transport in a groundwater plume.

Remediation Management of Complex Sites (RMCS-1)
Section 2.1.2 (Hydrogeologic Conditions)
Discusses the consideration of hydrogeologic conditions when creating a conceptual site model (CSM).

Vapor Intrusion (PVI-1)
Appendix G
Addresses groundwater sampling methods in relation to assessing vapor intrusion conditions.

Plants

A type of media that can take up contamination through their root systems and can be translocated to stems, shoots, leaves, and fruiting bodies.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Section 5.6 (PFAS Uptake into Plants)
Describes how plants can be expected to take some of these compounds up through their root systems.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Section 6.5.1 (Plants)
Details evidence of uptake and accumulation of PFAAs by plants in several settings and applications.

Sediment

Soils derived from wind and water erosion in which their saturated deposition in and along water bodies calls for specific strategies for remediation.

Attenuation Processes for Metals and Radionuclides (APMR-1)

Section 2.2.1 (Technical Resource Document for Monitored Natural Recovery of Contaminated Sediments)

Discusses natural physical, chemical, and biological processes that contribute to recovery processes associated with contaminated sediments.

Integrated DNAPL Site Strategy (IDSS-1)

Section 2.2 (Key Subsurface Transport and Reaction Processes)

Overview of the key transport and reaction processes that occur during and after subsurface releases of chlorinated solvents.

Remediation Management of Complex Sites (RMCS-1)

Section 2.1.2.4 (Surface Water and Groundwater Interactions and Impacted Sediments)

Describes how sediment transport and deposition varies spatially over time and is often challenging to model.

Soil

Soil is the upper surficial layer of earth in which plants grow, consisting of organic matter, clay, and disintegrated rock particles that can be impacted by contamination.

1,4 Dioxane (14DX-1)
Section 3 (Fate and Transport)
Describes 1,4-dioxane fate and transport in soil and investigative strategies for characterization.

1,4 Dioxane (14DX-1)
Table 3-2
Considerations for evaluating media potentially impacted by 1,4-dioxane.

Accelerated Site Characterization (ASCT-1)
Section 3: Describes the applicability and use of direct sensing for soil characterization.
Section 4: Describes borehole geophysics and its applicability for site characterization.
Section 5: Describes surface geophysical tools and their use to evaluate subsurface conditions.

Geospatial Analysis for Optimization (GRO-1)
Case Studies: Lead contamination in Soil
Case study of removal of lead contamination from soil of a former industrial property.

Incremental Sampling Methodology (ISM-1)
Section 2 (Nature of Soil Sampling), pages 10-37
Describes use of incremental sampling in soil sampling.

Incremental Sampling Methodology (ISM-2)
Section 2 (Nature of Soil Sampling)
A broad overview of soil sampling.

Integrated DNAPL Site Characterization (ISC-1)

Table D-4: Comparison of solid media sampling methods.
Table D-8: Comparison of chemical screening tools, including ones that can be used for soil analysis.
Section E.5.1: A short description of soil gas chemistry and their use in DNAPL CSMs.
Appendix I: Reference table of representative natural fraction of organic carbon values for soils, sediments, and rocks.

Integrated DNAPL Site Strategy (IDSS-1)
Section 2.2: Outlines the transport of DNAPL through soil.
Section 4.4.1: Treatment of DNAPL in unsaturated zone soils.
Section 4.1.3: Describes use of chemical and biological remediation technologies for DNAPL in soil and other media.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Figure 5-1: Fate and transport processes for PFAS, including through soil.
Section 5.3.1: Describes diffusion of PFAS in and out of lower permeability materials.
Section 5.3.3: Describes leaching of PFAS from soil into groundwater.
Section 6.2: Media-specific occurrence of PFAS in soil and sediment.

Fact sheet: Site Characterization and Media-Specific Occurrence, page 4
Discusses occurrence of PFAS contamination in soil.

Stormwater

Stormwater reflects rainwater or melted snow that runs off streets, lawns, and other sites that can be a source for contamination.

Stormwater Management (Stormwater-1)
Entire Document / Section 1 (Introduction)
Provides a centralized resource for information on stormwater BMP effectiveness (water quality treatment improvement) and provide the reader with guidance on how to use and implement that information.

Phytotechnologies (PHYTO-3)
Section 1.3.6 (Riparian Buffers)
Describes how as agriculture and urbanization encroach upon downgradient surface water bodies, NPS pollution is often generated in the runoff.

Phytotechnologies (PHYTO-3)
Section 2.4.2.1 (Irrigation Systems, Infiltration Control, and Storm Water Management)
Describes how stormwater (and irrigation) management control features may be designed into the site.

Surface Water

Surface water is a body of water above ground that can include streams, rivers, lakes, wetlands, reservoirs, creeks, and oceans that can be impacted by contamination.

1,4 Dioxane (14DX-1)
Section 1 (History of Use) – 1.4.2 Surface Water
Surface water contamination from 1,4-dioxane primarily originates from diverse industrial and municipal sources, including industrial and sanitary waste treatment discharges, surface runoff from impacted sites, and groundwater discharge to surface water.

1,4 Dioxane (14DX-1)
Section 3 (Fate and Transport) – 3.1.5 Groundwater-to-Surface Water Discharge and Table 3-2
Describes how the interaction between groundwater and surface water can lead to cross-media transfer of contaminants and may accelerate overall transport rates.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Section 3.4;
Figure 5-1;
Section 5.3.3;
Section 6.4;
Section 16

Remediation Management of Complex Sites (RMCS-1)
Section 2.1.2.4 (Site Challenges)
Describes the complex interactions between groundwater and surface water and how these interactions can be influenced by climate, topography, geology, and human activity such as groundwater withdrawal or flood control measures.

Tissue

Tissue (plant or animal) are potential media that can be impacted by contamination.

1,4 Dioxane (14DX-1)
Section 5 (Toxicity and Risk Assessment) – **5.1.3 Biomarkers of Exposure: 1,4-Dioxane Pharmacokinetics and Metabolism**
Describes how metabolic products of xenobiotics are often used as direct measurements of exposure (i.e., biomarkers of exposure).

Per- and Polyfluoroalkyl Substances (PFAS-1)
Section 5.5 **(PFAS Uptake into Aquatic Organisms)**
Details how some PFAS have a propensity to bioaccumulate.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Section 6.5.2 **(Invertebrates)** through Section 6.5.4 **(Vertebrates)**
Provides details about the dynamics of biomagnification through invertebrates, fish, and vertebrates.

Per- and Polyfluoroalkyl Substances (PFAS-1)
Section 15.3 **(Risk Assessment Case Study)**
Details an initial assessment of PFAS impacts at a select group of surface water bodies in New Jersey.

Waste

Human activity that results in the generation of many different types of waste, including municipal solid waste, hazardous waste, industrial non-hazardous waste, agricultural and animal waste, medical waste, radioactive waste, and mining waste. In the context of environmental assessment and remediation, waste material is commonly a potential source of contaminants to the environment.

1,4 Dioxane (14DX-1)
Section 1 (History of Use) – 1.3.2 Landfill Waste and Leachate
Details Landfill waste materials and leachate information.

1,4 Dioxane (14DX-1)
Section 6 (Remediation and Treatment Technologies)
Discusses information about how to handle and treat 1,4-dixoane waste.

Green and Sustainable Remediation (GSR-2)
Section 2 (GRS Planning)
Integrating GSR principles and practices into a project with a discussion on minimizing waste.

Investigation Methods

There are different tools and steps to investigating a release and assessing the fate and transport of the chemicals.

- Traditional Investigative Techniques
- Incremental Sampling Methodology (ISM)
- Direct Push Wells
- Diffusion/Passive Samplers

Traditional Investigative Techniques

Traditional investigative techniques describe common methods for site characterization and investigation.

1,4 Dioxane (14DX-1)
Section 3 **(Environmental Fate, Transport, and Investigative Strategies)**
Summary of relevant site investigation strategy considerations that may be relevant under various regulatory frameworks (e.g., CERCLA, RCRA, and state cleanup programs).

Dense, Nonaqueous-Phase Liquids (DNAPLs-3)
Section 3 (Predesigned Characterization)
Provides a brief summary of the DNAPL source characterization information necessary to design a surfactant or cosolvent flood.

Integrated DNAPL Site Characterization (ISC-1)
Section 4 (Integrated DNAPL Site Characterization)
Describes the process for improving the efficiency and effectiveness of characterization efforts at DNAPL sites.

Mass Flux (MASSFLUX-1)
Section 4 (Measuring Mass Flux and Mass Discharge)
Details the five basic methods used to calculate mass flux and/or mass discharge.

Methane (METHANE-1)
Section 4 **(Technology) –**
Section 4.1.1,
Section 4.2.2, &
Table 5
Provides a brief historical review of methane detection and quantification.

Phytotechnologies (PHYTO-3)

Section 2.2 (Site Assessment) and Table 2-3

Describes that site assessment is critical for the design and installation of a phytotechnology treatment system.

Small Arms Firing Range (SMART-1)

Section 2.6 (Sample Collection and Analysis)

Describes the process for developing a site characterization plan for sample collection and analysis to determine the vertical and horizontal extent and concentrations of the chemical constituents of concern in the environment.

Soil Background and Risk (SBR-1)

Section 3 (Establishing Soil Background)

Includes information on establishing both default soil background and site-specific soil background.

Unexploded Ordnance (UXO-6)

Section 2 (Commonly Used Wide-Area Assessments Technologies)

Discusses technologies that are commercially available with proven performance criteria sufficient for conducting WAA.

Petroleum Vapor Intrusion (PVI-1)

Section 4 (Site Investigation), specifically Section 4.2.2

The five-step process for investigating PVI applies in the event that a building does not satisfy the screening process and allow elimination of the exposure pathway.

Petroleum Vapor Intrusion (PVI-1)

Appendix G (Investigation Methods and Analysis Toolbox)

Describes various sampling and analysis methods available for vapor intrusion investigations.

Vapor Intrusion (VI-1)

Section 3 (Site Investigation Phase)

Describes a 13-step approach to assessing the vapor intrusion pathway with the site investigation phase.

Incremental Sampling Methodology (ISM)

Incremental sampling methodology is a structured composite sampling and processing protocol that reduces data variability and provides a reasonably unbiased estimate of mean contaminant concentration in a volume of soil targeted for sampling.

Incremental Sampling Methodology (ISM-1)

Executive Summary

ISM is a structured composite sampling and processing protocol that reduces data variability and provides a reasonably unbiased estimate of mean contaminant concentrations in a volume of soil targeted for sampling.

Incremental Sampling Methodology (ISM-2)

Section 1 (Introduction)

Describes ISM and how it is applied to sample sites.

Soil Background and Risk (SBR-1)

Section 9.4.3 (Incremental Sampling Methodology)

ISM is a structured sampling and processing protocol that reduces data variability and is a superior methodology to provide an estimate of mean contaminant concentrations in a defined volume of soil.

Direct Push Wells

Direct push technology is a cost-effective alternative to conventional drilling for rapid site characterization of unconsolidated formations.

Advanced Site Characterization Tools(ASCT-1)

Section 3 (Direct Sensing)

This section gives a firm overview with the rest of section 3 links to more specifics on different tools used with direct push to assist with site characterization and investigation.

Dense, Nonaqueous-Phase Liquids (DNAPLs-3)

Section 3.3.2 (Direct Push Technology and Cone Penetrometer Testing)

Good overview of DPT and CPT techniques and why they are useful in the beginnings of site characterization.

Dense, Nonaqueous-Phase Liquids (DNAPLs-4)

Section 5.2 (Characterizing DNAPLs in Unconsolidated Materials), starting page 21

Describes pros and cons of using direct push and discusses characterization in the vadose and saturated zones.

Petroleum Vapor Intrusion (PVI-1)

Appendix G. Investigation Method and Analysis Toolbox, Section G.2.3, page 183 – first bullet

Describes how to get the best results for groundwater vapor intrusion.

Petroleum Vapor Intrusion (PVI-1)

Section G.2.7 and Table G-1

Gives Groundwater sampling methods for vapor intrusion investigations.

Diffusion/Passive Samplers

Diffusive/passive sampling technologies are designed to collect discrete environmental samples without an active collection technique, such as pumping or purging.

Dense, Nonaqueous-Phase Liquids (DNAPLs-5)

Subsection 4.2.2 (Decrease in Dissolved Concentration – Use of Passive Diffusion Bag Samplers)

Describes passive diffusion bag (PDB) sampling accuracy and cost-effective alternative to standard (or low-flow) purge-and-sample techniques for collecting dissolved VOC data at monitoring wells.

Diffusion/Passive Samplers (DSP-1)

Section 1 (Introduction)

Describes how water-filled passive diffusion bag (PDB) samplers are suitable for obtaining concentrations of a variety of volatile organic compounds (VOCs) in ground water at monitoring wells.

Diffusion/Passive Samplers (DSP-3)

Section 1.3 comparison against other means of sampling, Table 1-2 Sampling Comparison

Polyethylene diffusion bag (PDB) samplers are low-density polyethylene bags containing deionized water, used to collect water samples in groundwater wells for laboratory analyses of volatile organic compounds (VOCs).

Conceptual Site Model (CSM)

A conceptual site model (CSM) encompasses the current understanding of a contaminated or potentially contaminated property. A CSM can be a written or graphical representation. A CSM is a valuable decision-making tool used for project planning, data interpretation, and effective communication for project stakeholders and the public.

Risk Assessment (RISK-3)
Section 3.2 (Conceptual Site Model), pages 24-32
The CSM describes the potential chemical sources, release mechanisms, fate and transport pathways, affected environmental media, receptors, and exposure pathways for current and reasonably anticipated activities and land uses.

1,4 Dioxane (14DX-1)
Section 3.2 (Considerations for Developing or Refining a CSM for 1,4-Dioxane)
Describes how a CSM helps develop a holistic understanding of the fate and transport of environmental contaminants as well as the potential risk posed by these compounds.

Green and Sustainable Remediation (GSR-2)
Section 2.1 (Evaluate/Update Conceptual Site Model), page 20
Describes how the CSM synthesizes and summarizes what is already known about a site that is pertinent to decision-making requirements.

Incremental Sampling Methodology (ISM-2)
Section 3.1.2 (DQO step 1: problem formulation (what is the problem, and what decisions need to be made?)
Describes the process for establishing a project planning team and developing a CSM.

Integrated DNAPL Site Strategy (IDSS-1)
Section 2.1 (The Conceptual Site Model)
Describes the CSM process and how it supports characterization

or remediation planning and implementation.

MTBE and Other Fuel Oxygenates (MTBE-1)
Section 3.1 (Conceptual Site Model), pages 16-29
Describes that the development of a conceptual site model (CSM) is a critical component in the site evaluation and cleanup process.

Soil Background and Risk (SBR-1)
Section 8.1 (Conceptual Site Model)
A CSM is the integrated representation of the physical and environmental context, the potential fate and transport of COPC, and the complete and potentially complete exposure pathways associated with each receptor at a cleanup site that is being evaluated.

Unexploded Ordnance (QCMR-1)
Section 3.2 (Conceptual Site Model)
The CSM represents relevant known and hypothetical site characteristics, conditions, and features developed from evidence collected or acquired throughout the project life cycle.

Petroleum Vapor Intrusion (PVI-1)
Step 1 – Develop Preliminary CSM
The preliminary CSM is developed by collecting soil and groundwater data as part of routine initial site investigations.

Vapor Intrusion (VI-1)
Sections 1.2 (Conceptual Model for Vapor Intrusion), Section 1.3 (Defining the Pathway), and Section 2.1 (Developing a Conceptual Site Model)
Describes CSM development for vapor intrusion sites for all building scenarios.

LNAPL Update (LNAPL-3)
Section 4 (LNAPL Conceptual Site Model (LCSM))
Describes the collection of information that incorporates key

attributes of the LNAPL body with site setting and hydrogeology to support site assessment and corrective action decision-making.

Advanced Techniques

At specific sites there may be advanced methods used to investigate the site and describing locations and timing of potential past releases to the environment.

- Accelerated Site Characterization
- Environmental Molecular Diagnostics
- Geophysical Technologies
- Groundwater Statistics and Monitoring Compliance

Accelerated Site Characterization

Site characterization techniques that can be used to generate near real-time information about the nature and extent of contamination at a site.

[Accelerated Site Characterization (ASC-3)]

Technology Description, page 5

This section describes the Site Characterization and Analysis Penetrometer System (SCAPS) Laser-Induced Fluorescence (LIF) technology. SCAPS-LIF is a real-time, in-situ, subsurface, field screening method for petroleum, oil and lubricants (POLs) that contain Polynuclear Aromatic Compounds (PNAs).

[Accelerated Site Characterization (ASC-4)]

Section 2 (Technology Description), page 2

This section describes the HydroSparge VOC Sensor and the Thermal Desorption VOC Sampler, in concert with an ion trap mass spectrometer (ITMS).

[Integrated DNAPL Site Characterization (ISC-1)]

Section 4.0 (Integrated DNAPL Site Characterization), page 53

Integrated site characterization is a process for improving the efficiency and effectiveness of characterization efforts at DNAPL sites.

[Petroleum Vapor Intrusion (PVI-1)]

Appendix G (Investigation Methods and Analysis Toolbox)

This section describes various sampling and analysis methods available for vapor intrusion investigations.

Environmental Molecular Diagnostics

Environmental molecular diagnostic is a collective term that describes a group of advanced and emerging techniques used to analyze biological and chemical characteristics of soil, sediments, groundwater, and surface water.

Environmental Molecular Diagnostics Fact Sheets (EMD-1)
A series of ten (10) fact sheets designed to provide introductory information about and promote awareness of EMDs.

Environmental Molecular Diagnostics (EMD-2)
Environmental molecular diagnostics (EMDs) are a group of advanced and emerging techniques used to analyze biological and chemical characteristics of environmental samples.

Integrated DNAPL Site Characterization (ISC-1)
Table D-9 (Environmental Molecular Diagnostics), page 260
Provide information about EMD and DNAPL sites.

Petroleum Vapor Intrusion (PVI-1)
Table G-5
Matrix of recommendations for various quantitative options to evaluate vapor intrusion.

Geophysical Technologies

Technologies that investigate the storage of contamination in the rock mass.

Dense, Nonaqueous-Phase Liquids (DNAPLs-3)

Section 3.2 (Geosystem Model Development), page 12

Understanding how DNAPL migrates and is trapped in the subsurface is essential to developing the conceptual model needed to guide this type of investigation.

Dense, Nonaqueous-Phase Liquids (DNAPLs-4)

Appendix B

Innovative DNAPL Characterization and Monitoring Tools Matrix.

Unexploded Ordnance (UXO-6)

Section 1.1 (What is wide-area assessment (WAA)?), pages 2-3

Discusses the use one or several technologies to investigate the MRA.

Unexploded Ordnance (UXO-6)

Section 2.3 (Geophysical Sensors), page 7

What geophysical sensors are applicable to wide-area assessment? Geophysical sensors applicable to WAA include magnetometers and EMI instruments.

Unexploded Ordnance (UXO-6)

Figure 2-4, page 8

A helicopter-deployed magnetometer array during a geophysical survey.

Unexploded Ordnance (UXO-6)

Figure 2-5., page 8

A man-portale EMI array during a geophysical survey of statistically based transects.

Groundwater Statistics and Monitoring Compliance

Statistical techniques to evaluate and monitor groundwater at environmental cleanup sites.

Geospatial Analysis for Optimization (GRO-1)
Review Checklist
The purpose of this checklist is to address common questions about geospatial analysis. This checklist can be used to explain the use of geospatial analysis at an environmental site.

Groundwater Statistics and Monitoring Compliance (GSMC-1)
Appendix C
This guidance document explains statistical techniques to evaluate and optimize groundwater monitoring for environmental projects. The primary audience for this guidance is environmental practitioners who have technical and project management experience, but who may not have specific expertise in statistics.

In Situ Bioremediation (ISB-4)
Section 1 (Introduction)
Reviews approaches used to remediate sites contaminated with volatile organic compounds (VOCs) including soil vapor extraction, bioventing, and natural attenuation.

In Situ Bioremediation (ISB-8)
Section 5.4 (Performance Monitoring), page 38
A good understanding of the specific contaminant’s stoichiometry, kinetics, and transformations is essential to develop an appropriate monitoring plan.

Risk Assessment

Human health risk assessment is the process of characterizing the nature and magnitude of health risks (for example, cancer, birth defects, or liver disease) to humans from chemicals and other stressors that may be present in the environment. Risk assessment is an integral component of risk management that provides a scientific and defensible rationale to support decisions for the protection of human health and the environment. Risk assessment is interconnected with risk communication and other components within the interactive process for risk management decision making.

Decision Making at Contaminated Sites: Issues and Options in Human Health Risk Assessment (RISK-3)
Section 1 (Overview of Risk Assessment)
Information to evaluate alternatives to risk assessment default approaches, scenarios, and parameters, thereby promoting greater confidence in the conclusions reached and the actions required.

- Risk Communications
- Migration Pathways
    - Groundwater Fate and Transport
    - Soil Fate and Transport
    - Vapor Intrusion

Risk Communications

As a risk assessment or evaluation is performed it is critical to consider risk communication strategies to ensure interested stakeholders are part of the process and have an opportunity to contribute to the assessment. Furthermore, it is important to consider risk communication strategies through the risk assessment and management phase of addressing your site.

Risk Communications Toolkit (RCT-1)

Section 1 (Introduction)

Effective risk communication provides people the best available scientific, public health, and environmental information about potential hazards so that they can make informed choices.

Migration Pathways

Understanding the existing and potential pathways for exposure to the released chemicals provides an assessment of the risk to human health and the environment.

Environmental fate and transport describes the movement of contaminants through various types of media, including soil, groundwater, surface water, and air. Fate and transport is affected by multiple factors, such as site-specific factors and physical/chemical characteristics of the contaminant.

1,4 Dioxane (14DX-1)

Section 3 (Environmental Fate, Transport, and Investigative Strategies)

Provides an overview of the chemical and physical properties of 1,4-dioxane and discusses the fate and transport processes in the context of these properties.

In Situ Bioremediation (ISB-8)

Section 4.0 (Fate and Transport), pages 25-27

Provides information about stoichiometry and kinetics and how they affect fate and transport in groundwater.

Environmental fate and transport describes the movement of contaminants through various types of media, including soil, groundwater, surface water, and air. Fate and transport is affected by multiple factors, such as site-specific factors and physical/chemical characteristics of the contaminant.

1,4 Dioxane (14DX-1)

Section 3 (Environmental Fate, Transport, and Investigative Strategies)

Provides an overview of the chemical and physical properties of 1,4-dioxane and discusses the fate and transport processes in the context of these properties.

Integrated DNAPL Site Characterization (ISC-1)

Figure 2-1 and Section 2.3.4 (Interfacial Tension and Wettability);

Section 2.3.6 (Viscosity);

Section 2.3.7 (Volatility)

Discussion about DNAPL fate and transport including interfacial tension, viscosity, and volatility.

Integrated DNAPL Site Strategy (IDSS-1)

Section 2.2 (Key Subsurface Transport and Reaction Processes)

Section 2.5.1 (The 14-Compartment Model)

Section 5.4.3 (Mass Flux/Discharge)

Discussion about DNAPL fate and transport in soil.

Overview of In-Situ Bioremediation of Chlorinated Ethene DNAPL Source Zones (BIODNAPL-1)

Section 2.1.3.1 (Dissolution)

Section 2.1.3.2 (Sorption and Adsorption)

Section 2.1.3.3 (Drainable and Residual DNAPL Fractions)

Provides an understanding of partitioning processes is essential in predicting the behavior of contaminants released as a DNAPL.

Per- and Polyfluoroalkyl Substances (PFAS-1)

Section 5 (Environmental Fate and Transport Processes) and Figure 5-1

Provides current information about PFAS fate and transport in the environment.

Phytotechnologies (PHYTO-3)

Section 2.3.3.2 (Fate and Transport Studies)

Discusses fate and transport in phytotechnologies remediation systems.

Small Arms Firing Range (SMART-1)

Section 2.5 (Fate and Transport Considerations)

Discusses fate and transport information and considerations at closed small arms firing ranges sites.

Small Arms Firing Range (SMART-2)

Section 2.1 (Fate, Transport, and Exposure)

Discusses how lead can be dispersed into the environment at ranges.

Vapor intrusion occurs due to the migration of vapor-forming chemicals from any subsurface source into an overlying building.

Petroleum Vapor Intrusion (PVI-1)

Section 2 (Introduction)

VI occurs when vapors from contaminated groundwater or other subsurface sources migrate upward through vadose zone soils and into overlying buildings.

Vapor Intrusion (VI-1)

Section 1.6.3 (Preferential Pathways)

Discussion about vapor intrusion pathways and the permeability of subsurface materials.

Groundwater Fate and Transport

Environmental fate and transport describes the movement of contaminants through various types of media, including soil, groundwater, surface water, and air. Fate and transport is affected by multiple factors, such as site-specific factors and physical/chemical characteristics of the contaminant.

1,4 Dioxane (14DX-1)
Section 3 (Environmental Fate, Transport, and Investigative Strategies)
Provides an overview of the chemical and physical properties of 1,4-dioxane and discusses the fate and transport processes in the context of these properties.

In Situ Bioremediation (ISB-8)
Section 4.0 (Fate and Transport), pages 25-27
Provides information about stoichiometry and kinetics and how they affect fate and transport in groundwater.

Soil Fate and Transport

Environmental fate and transport describes the movement of contaminants through various types of media, including soil, groundwater, surface water, and air. Fate and transport is affected by multiple factors, such as site-specific factors and physical/chemical characteristics of the contaminant.

1,4 Dioxane (14DX-1)
Section 3 (Environmental Fate, Transport, and Investigative Strategies)
Provides an overview of the chemical and physical properties of 1,4-dioxane and discusses the fate and transport processes in the context of these properties.

Integrated DNAPL Site Characterization (ISC-1)
Figure 2-1 and
Section 2.3.4 (Interfacial Tension and Wettability);
Section 2.3.6 (Viscosity);
Section 2.3.7 (Volatility)

Discussion about DNAPL fate and transport including interfacial tension, viscosity, and volatility.

Integrated DNAPL Site Strategy (IDSS-1)
Section 2.2 (Key Subsurface Transport and Reaction Processes)
Section 2.5.1 (The 14-Compartment Model)
Section 5.4.3 (Mass Flux/Discharge)
Discussion about DNAPL fate and transport in soil.

Overview of In-Situ Bioremediation of Chlorinated Ethene DNAPL Source Zones (BIODNAPL-1)
Section 2.1.3.1 (Dissolution)
Section 2.1.3.2 (Sorption and Adsorption)
Section 2.1.3.3 (Drainable and Residual DNAPL Fractions)
Provides an understanding of partitioning processes is essential in predicting the behavior of contaminants released

as a DNAPL.

Per- and Polyfluoroalkyl Substances (PFAS-1)

Section 5 (Environmental Fate and Transport Processes) and Figure 5-1

Provides current information about PFAS fate and transport in the environment.

Phytotechnologies (PHYTO-3)

Section 2.3.3.2 (Fate and Transport Studies)

Discusses fate and transport in phytotechnologies remediation systems.

Small Arms Firing Range (SMART-1)

Section 2.5 (Fate and Transport Considerations)

Discusses fate and transport information and considerations at closed small arms firing ranges sites.

Small Arms Firing Range (SMART-2)

Section 2.1 (Fate, Transport, and Exposure)

Discusses how lead can be dispersed into the environment at ranges.

Vapor Intrusion

Vapor intrusion occurs due to the migration of vapor-forming chemicals from any subsurface source into an overlying building.

Petroleum Vapor Intrusion (PVI-1)
Section 2 (Introduction)
VI occurs when vapors from contaminated groundwater or other subsurface sources migrate upward through vadose zone soils and into overlying buildings.

Vapor Intrusion (VI-1)
Section 1.6.3 (Preferential Pathways)
Discussion about vapor intrusion pathways and the permeability of subsurface materials.

Remediation Phase

The portion of the project life cycle that involves cleaning up the contaminants from the site to improve to human health and the environment. This includes remediation technologies, site strategies, and alternative technologies.

- Remediation Technologies
  - Attenuation
  - Capping
  - Constructed Treatment Wetlands
  - Green/Sustainable
  - In Situ Bioremediation
  - In Situ Chemical Oxidation
  - In Situ Chemical Reduction (ISCR)
  - Permeable Reactive Barriers
  - Physical Removal
  - Phytotechnologies
  - Pump and Treat
  - Soil Vapor Extraction (SVE)
  - Solidification/Stabilization
  - Sorption Technology
  - Thermal Desorption
  - Thermal Remediation
- Remediation / Post Remediation Site Strategies
  - Engineering Controls (ECs)
  - Institutional Controls (ICs)
  - Remediation Process Optimization
  - Risk Management
- Alternative Technologies
  - Alternative Landfill Technologies
  - Best Management Practices
  - Ecological Land Reuse

Remediation Technologies

Remediation technologies exploit chemical and physical properties to immobilize, remove, or destroy the targeted contaminants.

- Attenuation
- Capping
- Constructed Treatment Wetlands
- Green/Sustainable
- In Situ Bioremediation
- In Situ Chemical Oxidation
- In Situ Chemical Reduction (ISCR)
- Permeable Reactive Barriers
- Physical Removal
- Phytotechnologies
- Pump and Treat
- Soil Vapor Extraction (SVE)
- Solidification/Stabilization
- Sorption Technology
- Thermal Desorption
- Thermal Remediation

Attenuation

Remedial strategy focused on naturally occurring substance process to evaluate and enhance the degradation of contaminants over time.

1,4 Dioxane (14DX-1)
Section 6 (Remediation and Treatment Technologies) – 6.5.2.1 Monitored Natural Attenuation
MNA is a remediation technology in which natural processes are used to achieve site-specific objectives.

Attenuation Processes for Metals and Radionuclides (APMR-1)
Section 2.3 (Geochemical Processes), Section 6 (Table 6.1)
Discusses metal solubility, sorption, and bioavailability on metal speciation.

Dense, Nonaqueous-Phase Liquids (DNAPLs-5)
Table 4-1
Discusses natural attenuation on DNAPL sites.

Enhanced Attenuation: Chlorinated Organics (EACO-1)
Section 1.4 (Enhanced Attenuation), Figure 1-2
The entire document provides information about natural attenuation with an introduction to the process in Section 1.4.

In Situ Bioremediation (ISB-2)
Appendix B (Natural Attenuation Position Paper)
Position pager on natural attenuation.

MTBE and Other Fuel Oxygenates (MTBE-1)
Section 4.6 (Monitored Natural Attenuation), page 76-81
MNA is the reliance on naturally occurring subsurface processes to achieve site-specific remediation goals in a reasonable period of time, in the context of a site that is carefully controlled and monitored.

Capping

Technology which covers contaminated sediment with material to isolate the contaminants from the surrounding environment.

Remedy Selection for Contaminated Sediments (CS-2)
Section 5.0 (Conventional and Amended Capping)
Details the process of placing a clean layer of sand, sediments or other material over contaminated sediments in order to mitigate risk posed by those sediments.

Mining Waste Treatment Technology Selection (MW-1)
Capping, Covers, and Grading Section
Provides an overview of capping and describes how capping of solid mining waste is an effective and proven treatment technology.

Sediment Cap Isolation Guidance (SD-1)
Capping Overview (Section 2)
This section describes the different capping objectives, with a focus on the chemical isolation function of the cap, as well as general cap types and configurations. A recommended framework for cap chemical isolation design is also presented in this section.

Sediment Cap Isolation Guidance (SD-1)
Migration Pathways (Section 3.3.1)
The design of a cap to chemically isolate underlying sediment contamination relies on an understanding of contaminant fate and transport processes and methods to attenuate the transport of those contaminants. This section includes an explanation of the processes that control the fate and transport of chemicals and how these processes affect the design of the sediment cap. Strategies to achieve effective cap chemical isolation are also discussed.

Sediment Cap Isolation Guidance (SD-1)
NAPL Considerations (Section 3.4.3)

Where NAPL is present in the sediment, additional characterization is warranted to evaluate whether and where it may impact the chemical isolation design. NAPL mobility and its ability to migrate must be evaluated and quantified (ASTM International’s [ASTM] Standard E3282; ASTM 2022) to determine the magnitude of NAPL that may impact a cap.

Constructed Treatment Wetlands

Man-made biologically active systems such as bogs, swamps, or marshes that are characterized by saturated soil conditions and at least periodic surface or near-surface water designed specifically to treat contaminants in surface water, groundwater, or waste streams.

Mining Waste (MW-1)
Constructed Treatment Wetland
Constructed treatment wetlands are man-made biologically active systems such as bogs, swamps, or marshes that are characterized by saturated soil conditions and at least periodic surface or near-surface water designed specifically to treat contaminants in surface water, groundwater, or waste streams.

Green/Sustainable

Green/sustainable remediation technologies seek to reduce the environmental footprint of site remediation. Goals of green remediation may include reducing total energy use and/or utilizing renewable energy sources; reducing water use; and minimizing greenhouse gas emissions.

Ecological Land Reuse (ECO-2)
Section 2.1 (Using Natural of Ecological Enhancements), Section 2.2 (Natural of Green Remediation Strategies), and Section 5.2 (Selection of Green Verses Traditional Technologies)
Describes the aspects and process for ecological enhancement, a modification to a site which increases and improves habitat for plants and animals while protecting human health and the environment.

Green and Sustainable Remediation (GSR-1)
Section 1 (Introduction)
Descriptions of the green and sustainable remediation holistic approach to site planning, investigation, assessment of remedial alternatives, remedy selection, remedy design, and construction and implementation of the chosen remedy.

In Situ Bioremediation

The use of microorganisms for the degradation of contaminants.

In Situ Bioremediation Page
Information about the biological treatment of contaminants in the subsurface, typically in groundwater.

A Systematic Approach to In Situ Bioremediation in Groundwater (ISB-8)
Section 1.3 (What is In Situ Bioremediation?) and Figure 1-1
Describes the application of biological treatment to the cleanup of contaminants of concern.

In Situ Chemical Oxidation

The injection of oxidant and amendment solutions into a source zone to destroy contaminants through chemical reactions.

Dense, nonaqueous-phase liquids (DNAPLs-5)
Section 5.5 (In Situ Chemical Oxidation)
Describes in situ chemical oxidation of DNAPL products.

A Systematic Approach to In Situ Bioremediation in Groundwater (ISB-8)
Section 10.8.4 (Chemical Processes), page 111
Describes chemical reduction or perchlorate.

Integrated DNAPL Site Strategy (IDSS-1)
Section 4.1.3.1 (In Situ Chemical Oxidation)
Describes in situ chemical oxidation and its applicability to DNAPL sites.

Integrated DNAPL Site Strategy (IDSS-1)
Table 4-2
Technology compatibility matrix for in situ oxidation with other remedial technologies used in tandem.

MTBE and Other Fuel Oxygenates (MTBE-1)
Section 4.4 (Chemical Oxidation), pages 70-73
Provides an overview of in situ chemical oxidation for use in remediation of MTBE.

In Situ Chemical Reduction (ISCR)

Remediation technology applied to chlorinated compounds, petroleum hydrocarbons, and other contaminants including metals and anions, in dissolved, sorbed, and nonaqueous phase forms.

Characterization and Remediation in Fractured Rock (FracRX-1)
Section 6.4.2.3 (Chemical and Biological Technologies)
Details how chemical and biological technologies remediate contamination by transformative and destructive processes.

In Situ Bioremediation (ISB-8)
Section 10.8.4 (Chemical Processes)
Discusses the addition of a chemical reducing agent to the In Situ remediation process.

Permeable Reactive Barriers

A permeable wall built with reactive materials to treat groundwater as it flows through the barrier.

Integrated DNAPL Site Strategy (IDSS-1)
Section 4.1.4.2: Describes PRBs and their use in treatment of DNAPLs.
Section 4.1.4.3: Describes low-permeability barrier walls and their use in treatment of DNAPLs.
Table 4-2: A technology compatibility matrix for PRBs with other remediation technologies.

Mining Waste (MW-1)
Technology overview: Permeable Reactive Barrier Systems
A broad overview of PRB systems and their use in treating mining waste affected sites.

Permeable Reactive Barriers (PRB-4)
This document is a broad overview of PRBs and their design, use, performance assessment, and regulatory considerations.
Section 2.1: Review of treatment processes that are facilitated by PRBs.
Section 4.1: Describes the considerations needed for effectual PRB design.

Permeable Reactive Barriers (PRB-5)
Report of a technology update for prior PRB documents.
Section 1.4: Describes the best use of PRB in tandem with other treatment technologies.
Section 4: Describes reactive media used in PRBs and the treatment processes they facilitate.
Section 5: Design of PRBs and the site characteristics that influence PRB design.
Section 5.4: Use of groundwater, VOC reaction kinetics, and geochemical modeling in PRB design.
Section 7: Performance monitoring design and assessment of PRB

efficacy.

Physical Removal

Removal (i.e., excavation) of contaminated soil or sediment without enhancing contaminant migration or displacement.

Characterization and Remediation in Fractured Rock (FracRX-1)
Section 6.4.2.1 (Physical Removal Technologies)
Provides details on technologies that range from direct physical removal methods such as excavation, to indirect removal methods such as multiphase extraction and thermal treatment (which rely on physical properties of the contaminant, such as volatility, for removal).

Remedy Selection for Contaminated Sediments(CS-2)
Section 6.0 (Removal by Dredging and Excavation)
Dredging or excavation remedies remove contaminated sediment from freshwater or marine water bodies in order to reduce risks to human health and the environment.

Phytotechnologies

Introduction of phytoplankton to a contaminated site for the biotic degradation of the contaminant.

1,4 Dioxane (14DX-1)
Section 6 (Remediation Technologies)
Describes remediation and treatment of 1,4-Dioxane, including the use of phytotechnologies.

1,4 Dioxane (14DX-1)
Section 6.3.1.4 (Phytoremediation)
Use of phytoremediation as a treatment of 1,4-dioxane in unsaturated and saturated soil matrix.

Making the Case for Ecological Enhancements (ECO-1)
Section 2.3 (Using Natural Remediation as a Cleanup Technology)
Discusses the pros of using natural remediation, including phytotechnologies, as a cleanup technology.

Making the Case for Ecological Enhancements (ECO-1)
Appendix D, see specifically 4-6,9-11, 30, 32.
Case Studies of uses of phytotechnologies as remediation.

Planning and Promoting Ecological Land Reuse of Remediated Sites (ECO-2)
Section 2.1 (Using Natural or Ecological Enhancements as a Cleanup Technology)
Discusses phytotechnology as a natural remediation technology including the pros and cons of implementation.

Planning and Promoting Ecological Land Reuse of Remediated Sites(ECO-2)
Section 2.2 (Natural or Green Remediation Strategies)
A short description of various natural/green remediation strategies, including phytotechnologies.

Planning and Promoting Ecological Land Reuse of Remediated Sites(ECO-2)

Appendix C-2

A case study on the implementation of phytotechnology as remediation of a former industrial site in Chattanooga, TN.

Mining Waste (MW-1)

Phytotechnologies Page

A summary of phytotechnologies and their applicability and use in treating mining waste.

MTBE and Other Fuel Oxygenates (MTBE-1)

Section 4.5 (Phytoremediation), pages 73-76

Outlines use of phytoremediation on MTBE-affected groundwater.

Phytotechnologies (PHYTO-3)

This document provides a broad overview of phytotechnologies, their implementation as remediation strategies, and the regulatory, cost, and efficacy considerations of their use.

Table 1-3: A summary table of phytotechnology mechanisms.

Section 1.2: Describes the physiological processes that are the basis of phytoremediation.

Section 1.4: Advantages and limitations of phyotechnologies.

Table 2-2: Checklist of deliverables by phytoremediation project phase

Table 2-4: Site assessment information specific for phytotechnologies.

Section 2.3: Phytotechnological remedy selection based on site characterization.

Figure 2-1: Plant species screening process flow chart for phytotechnology selection.

Figure 2-2: Phytotechnology remedy selection decision tree.

Section 2.4: Design and implementation of phytoremediation treatments.

Section 2.5: Operation, maintenance, and monitoring of phytotechnologies after implementation.

Pump and Treat

Remediation technology that cleans up groundwater contaminated with dissolved chemicals by pumping groundwater from wells to an above-ground treatment system that removes the contaminants.

[Performance-Based Optimization of Pump & Treat Systems]

Section 2 (Life Cycle Optimization)

This document provides an understanding of adaptive management as a key to optimization and presents a technical framework for conducting optimization efforts at P&T sites. While optimization of P&T may not achieve all site goals, this document provides support for transition or termination or both when optimization indicates that P&T may not be the solution, or sole solution, going forward.

[Integrated DNAPL Site Strategy (IDSS-1)]

Section 4.1.4.1 (Pump and Treat)

Provides an overview of pump and treat, its uses, and limitations.

[Overview of Groundwater Remediation Technologies for MTBE and TBA (MTBE-1)]

Section 4.1 (Groundwater Extraction and Aboveground Treatment: Pump and Treat)

Provides and overview of Pump and Treat and its applicability.

[Characterization and Remediation in Fractured Rock (FracRX-1)]

Section 6.4.2.2 (Groundwater Pump and Treat)

Detail pump and treatment systems in sites with fractured bedrock.

Soil Vapor Extraction (SVE)

Soil vapor extraction (SVE) is a remediation technology that is based on the extraction of soil vapor from the subsurface to reduce or eliminate a source of volatile organic compounds (VOCs) in the unsaturated zone.

Vapor Intrusion Mitigation (VIM-1)
SVE Fact Sheet
Details the process SVE remediation technology and how it is used on sites.

Characterization and Remediation in Fractured Rock (FracRX-1)
Section 6.4.2.1 (Vapor and Multiphase Extraction)
Details how vapor extraction is a typical component of thermal remediation methods.

Solidification/Stabilization

A remediation technology that is used to change the physical properties of contaminated media.

1,4 Dioxane (14DX-1)
Section 6.3 (Soil/Vadose Zone Treatment) – Section 6.3.1.3 Solidification and Stabilization
Solidification is a physical immobilization process whereby contaminants are entrapped within the soil matrix by encapsulating contaminated soil particles within a low-permeability solid material.

Integrated DNAPL Site Strategy (IDSS-1)
Section 4.1.4.4 (Solidification and Stabilization) and Table 4-2
"Solidification" refers to processes that change the physical properties of contaminated media by increasing compressive strength, decreasing permeability, and/or encapsulating the contaminants to form a solid material. "Stabilization" refers to processes that involve chemical reactions to reduce the mobility of a waste.

Small Arms Firing Range (SMART-1)
Section 3.3 (Soil Stabilization)
Stabilization/solidification has often been used to change the hazardous characteristic of firing range soil prior to long-term management or to control the solubility of metals in range soil for groundwater protection.

Small Arms Firing Range (SMART-2)
Section 3.7 (Stabilization of Lead Shot and Bullets in Soil) and Section 3.13.3 (Phosphate-Based Stabilization)
Provides information on different types of stabilization plans on small arms firing range sites.

Solidification/Stabilization (S/S-1)
Section 1 (Introduction)

Discusses how S/S technology may be applicable for a wide range of contaminants.

Sorption Technology

Most sorption technologies act like a sponge or a filter, soaking up contaminants until they run out of surface area.

Per- and Polyfluoroalkyl Substances Technical and Regulatory Guidance (PFAS-1)
Section 12.2.1 (Sorption Technologies)
Describes the fundamental science behind sorption technologies and how they have been used for both ex situ and in situ water treatment applications.

Overview of Groundwater Remediation Technologies for MTBE and TBA (MTBE-1)
Section 4.1.6.1 (Liquid-Phase Adsorption Processes)
Provides and overview of Sorption Technologies such as granular activated carbon (GAC) and Resin Adsorption technologies.

Thermal Desorption

A physical separation process by which soils are heated to evaporate organic contaminants.

1,4 Dioxane (14DX-1)

Section 6.3.1.2 (Ex Situ Thermal Desorption)

A summary of Ex Situ Thermal Desorption as a remediation strategy for 1,4-dioxane.

Dense, nonaqueous-phase liquids (DNAPLs-5)

Section 5.3 (Thermally Enhanced Remediation)

Describes thermally enhanced remediation for remediation of DNAPL sites, including monitoring parameters.

Integrated DNAPL Site Strategy (IDSS-1)

Section 4.1.2.3 (Thermal Conductivity and Electrical Resistance Heating)

Summary of thermal conductivity and other thermal technologies use in DNAPL sites both individually and in tandem with other remediation tools.

Integrated DNAPL Site Strategy (IDSS-1)

Table 4-2

A technology compatibility matrix for thermal technologies with other remediation technologies.

Thermal Remediation

Thermal technologies employ differing combinations of temperature, time, mixing and vacuum to remove organic constituents from solids.

Solid Media And Low Level Mixed Waste Contaminated With Mercury And Hazardous Chlorinated Organics (TD-3)

Section 1.5 (Special Considerations for Treating Hazardous Waste)

Thermal desorbers remove organic constituents from solids by raising the temperature of the contaminated material to a sufficiently high level to effect contaminant volatilization and transfer to a gas stream.

Technology Overview of Electrokinetics (Electrokinetics, Mining Waste Team)

Sections 1-6 (Electrokinetics), pages 1-3

The electrokinetic remediation (ER) process removes metals and organic contaminants from low-permeability soil, mud, sludge, and marine dredging.

Remediation / Post Remediation Site Strategies

- Engineering Controls (ECs)
- Institutional Controls (ICs)
- Remediation Process Optimization
- Risk Management

Engineering Controls (ECs)

Engineering controls (ECs) are physical controls or barriers that prevent human exposure to contamination (for example, slurry walls, capping, or vapor intrusion liner).

Long-Term Contaminant Management Using Institutional Controls (IC-1)

Section 1 (Introduction)

Addresses long-term contaminant management using physical controls or barriers to prevent exposure to contaminants.

Mining Waste Treatment Technology Selection (MW-1)

Administrative and Engineering Controls

Describes how engineering controls (ECs) generally consist of physical measures designed to minimize the potential for exposure to contamination by limiting direct contact with contaminated areas.

Institutional Controls (ICs)

Institutional controls (ICs) are administrative or legal controls that prevent unacceptable human exposure to contamination or protect the integrity of an engineering control (ECs) by limiting land or resource use. ICs can supplement ECs, or they may be a stand-alone response.

Long-Term Contaminant Management Using Institutional Controls (IC-1)
Section 1 (Introduction)
Addresses long-term contaminant management using administrative or legal restrictions called institutional controls (ICs).

Permeable Reactive Barriers (PRB-5)
Section 2.8 (Institutional Controls)
Describes how the deployment of a PRB can require the enactment of institutional controls (ICs).

Vapor Intrusion Mitigation (VIM-1)
IC Tech Sheet (Lists 4 Categories of ICs)
Describes the use of remediation systems and institutional controls (ICs) as a means of VI mitigation.

Remediation Process Optimization

The review of processes affecting cleanup effectiveness: cleanup systems, established cleanup levels, established procedures to verify attainment of cleanup goals, and readiness to support a five-year review or any other part of a regulation-mandated process.

Dense, Nonaqueous-Phase Liquids (DNAPLs-5)
Section 5.1 (Remedial Effectiveness and System Efficiency Monitoring), Table 5-2
Discusses two types of performance monitoring: remedial effectiveness monitoring and system efficiency monitoring.

Green and Sustainable Remediation (GSR-2)
Section 1.4.3 (Remediation Process Optimization)
Remediation process optimization (RPO) provides opportunities for applying GSR approaches to existing, already under way, site remediation projects.

Integrated DNAPL Site Strategy (IDSS-1)
Section 5.6 (Monitoring Optimization); Section 6.2 (Remedy Optimization—Can Objectives be Met with Greater Efficiency?); Table 6-2; Section 6.3 (Remedy Evaluation)
Discusses optimizing the monitoring and remedial processes through the cleanup of DNAPL sites.

Mass Flux (MASSFLUX-1)
Section 3.4 (Performance Monitoring and Optimization)
Mass flux/discharge estimates can be used to evaluate changes within the source zone or plume, remedy performance, and system optimization.

Optimizing Injection Strategies and In-situ Remediation Performance (OIS-ISRP-1)
Section 3.1 (The Design Wheel and Optimization Process)

The design wheel involves consideration of the amendment, delivery method, and dose simultaneously throughout the in situ RDC, design, implementation, and monitoring process.

Phytotechnologies (PHYTO-3)
Section 2.3.3.4 (Supplementing or Supplanting Existing Remediation Systems)
Discusses reviewing, updating, and optimizing remediation systems.

Remediation Process Optimization (RPO-1)
Section 3 (Remediation Process Optimization), Figure 3-2
Process elements of an optimization, Table 3-1. Suggested data to be collected for site prioritization.

Remediation Process Optimization (RPO-3)
What Are Common Obstacles to Implementing a Performance-Based Exit Strategy?

Remediation Process Optimization (RPO-7)
Section 3.5 (Remedial Process Optimization)
RPO allows for systematic evaluation and refinement of remediation processes to ensure that human health and the environment are being protected over the long term at minimum risk and cost.

Solidification/Stabilization (S/S-1)
Section 3 (Performance of S/S-Treated Materials) and Section 4 (Performance Specifications in the S/S Design and Implementation Process)
Presents an overview of the material performance goals and the general role of performance specifications in the design and implementation process.

Risk Management

Risk management is the process for managing uncontrollable project activities or circumstances that may result in negative consequences to the environment.

Risk Assessment (RISK-3)

Section 1.2 (Risk Management)

Describes an iterative and interactive framework for risk management consisting of six stages, with risk communication as an important component of all stages.

Risk Assessment (RISK-3)

Section 8 (Risk Management)

Risk management can involve a combination of decisions based on science, policy, and professional judgment, as well as social, political, and economic concerns.

Risk Assessment (RISK-3)

Section 10 (Tribal and Public Stakeholder Perspective)

Human health risk assessment is used to evaluate the probability that exposure to chemicals present in the soil, air, or water at a site can result in adverse human health effects.

Radionuclides (RAD-2)

Section 3 (Radiation Risks), pages 14-30

Understanding the main factors that could potentially vary among sites during the risk assessment process.

Green and Sustainable Remediation (GSR-2)

Section 1.4.5 (Project Risk Management for Site Remediation), page 7

Remediation risk management (RRM) techniques can be used to find project management efficiencies.

Risk Assessment (Risk-2)

Section 1 (Introduction to Risk Assessment)

Includes the background of risk assessment, risk management, uncertainty, and challenges, pages 2-6.

Soil Background and Risk (SBR-1)
Section 4 (Using Soil Background in Risk Assessment)
Describes how default and site-specific background for natural or anthropogenic ambient soil background may be used in human health and ecological risk assessment.

Alternative Technologies

- Alternative Landfill Technologies
- Best Management Practices
- Ecological Land Reuse

Alternative Landfill Technologies

Technologies that are used to support the remediation and closure of landfills.

Alternative Landfill Technology Documents
A series of documents that addresses regulatory and technical obstacles that inhibit the use of alternative landfill covers, bioreactor landfills, and a process to optimize post-closure care of landfills.

Alternative Final Landfill Covers (ALT-2)

Section 1 (Introduction)
Information for decision makers associated with the plan development, review, and implementation of alternative final covers (AFCs), which may also be referred to in this text as alternative covers, alternative landfill covers, or ET (evapotranspiration covers).

Ecological Land Reuse of Remediated Sites(ECO-2)
Section 4.1.3 (Flexibility in State Solid Waste Regulations), page 23
Details federal regulations pertaining to municipal solid waste facilities.

Ecological Land Reuse of Remediated Sites (ECO-2)
Section 8.2 (New Beginnings – The Woodlawn Wildlife Area, Port Deposit, Maryland), page 77
Case study that details the alternative landfill technologies.

Ecological Land Reuse of Remediated Sites (ECO-2)
Appendix C. Case Studies
Case studies that detail the alternative landfill technologies.

Phytotechnologies (PHYTO-3)

Section 1.3.2 (Phytostabilization Covers for Infiltration Control)

Discusses phytostabilization covers for infiltration control on landfills.

Phytotechnologies (PHYTO-3)

Section 1.3.3 (Phytoremediation Groundcovers)

Discusses how densely rooted groundcover plants and grasses can also be used to phytoremediate contaminants on landfills.

Phytotechnologies (PHYTO-3)

Section 2.3.3.4 (Supplementing to Supplanting Existing Remediation Systems)

Discusses vegetative covers for infiltration control as a replacement or supplement to conventional landfill covers.

Best Management Practices

A variety of best management practices related to the consideration of non-technical concepts, optimizing remediation, and enhancing site strategies.

Brownfields (BRNFLD-2)

Section 6 (Liability, Economic, and Social Issues for Consideration)

Discussed in this section are some of the additional considerations that need to be evaluated for a successful cleanup and redevelopment of a contaminated property—liability, economic, and social issues are important criteria that may have an impact on property values as well as the overall cleanup and redevelopment of both BRAC and brownfield properties.

Green and Sustainable Remediation (GSR-1)

Section 1 (Introduction), page 1

Green remediation is the incorporation of environmental best management practices (BMPs) that may be employed during a project, while "sustainable" approaches may consider those emerging techniques that are both economical and capable of achieving significant environmental and social benefits.

Green and Sustainable Remediation (GSR-1)

Section 5.1 (Resources), page 32

Describes several resources and tools available for applying GSR approaches at a variety of site-specific conditions.

Green and Sustainable Remediation: A Practical Framework(GSR-2)

Section 4.6 (Best Practices for GSR Evaluations)

Lists several best practices to keep in mind during any GSR evaluation.

Green and Sustainable Remediation: A Practical Framework (GSR-2)

Table 3-3, page 32
Example of GSR evaluation.

[Remediation Process Optimization (RPO-1)]

Section 3.4.1.2 (Assessing Remedial System Effectiveness), pages 23-25
Discusses the factors that should be evaluated to determine whether the current remedy is suitable (necessary and feasible) for the site conditions and RA objectives.

[Remediation Process Optimization (RPO-3)]

Exit Strategy, pages 2-12
Details the steps of an “exit strategy,” a dynamic and succinct plan for accomplishing specific performance goals within a defined time period to assure protection of human health and the environment.

[Remediation Process Optimization (RPO-6)]

Performance-Based Management, pages 2-5
Details a PBM that is implemented through systematic planning and dynamic decision-logic that is focused on the desired end results.

[Small Arms Firing Range (SMART-2)]

Section 3. (Best Management Practices)
Describes how the selection of the appropriate metal migration prevention method is the key to successful lead management on a range or group of ranges.

Ecological Land Reuse

Ecological land reuse is an alternative to land development following remediation of contaminated sites. An example of ecological land reuse is converting a previously contaminated site into a wildlife habitat.

Making the Case for Ecological Enhancements (ECO-1)

Section 1 (Introduction)

Ecological enhancements considered at the inception of planning for environmental remediation at Superfund, RCRA, and brownfield sites can be a cost effective and efficient way to increase, create, and/or improve wildlife habitat.