1

Starting Soon: Integrated DNAPL Site Strategy

- Integrated DNAPL Site Strategy at http://www.itrcweb.org/GuidanceDocuments/IntegratedDNAPLStrategy_IDSSDoc/IDSS-1.pdf
- Download PowerPoint file
  - Clu-in training page at https://clu-in.org/conf/itrc/IDSS/
  - Under “Download Training Materials”
- Using Adobe Connect
  - Related Links (on right)
    - Select name of link
    - Click “Browse To”
  - Full Screen button near top of page
- Follow ITRC

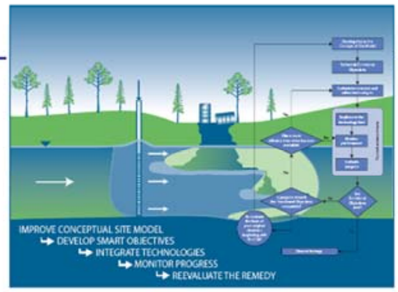
No associated notes.

2

Welcome – Thanks for joining this ITRC Training Class

ITRC Internet-based training and Technical and Regulatory Guidance

Integrated DNAPL Site Strategy



Sponsored by: Interstate Technology and Regulatory Council (www.itrcweb.org)
Hosted by: US EPA Clean Up Information Network (www.cluin.org)

Sites contaminated by chlorinated solvents present a daunting environmental challenge, especially at sites with dense nonaqueous phase liquid (DNAPL) still present. Restoring sites contaminated by chlorinated solvents to typical regulatory criteria (low parts-per-billion concentrations) within a generation (~20 years) has proven exceptionally difficult, although there have been successes. Site managers must recognize that complete restoration of many of these sites will require prolonged treatment and involve several remediation technologies. To make as much progress as possible requires a thorough understanding of the site, clear descriptions of achievable objectives, and use of more than one remedial technology. Making efficient progress will require an adaptive management approach, and may also require transitioning from one remedy to another as the optimum range of a technique is surpassed. Targeted monitoring should be used and re-evaluation should be done periodically.

This ITRC Integrated DNAPL Site Strategy (IDSS-1, 2011) technical and regulatory guidance document will assist site managers in development of an integrated site remedial strategy. This course highlights five important features of an IDSS including:

1. A conceptual site model (CSM) that is based on reliable characterization and an understanding of the subsurface conditions that control contaminant transport, reactivity, and distribution
2. Remedial objectives and performance metrics that are clear, concise, and measureable
3. Treatment technologies applied to optimize performance and take advantage of potential synergistic effects
4. Monitoring based on interim and final cleanup objectives, the selected treatment technology and approach, and remedial performance goals
5. Reevaluating the strategy repeatedly and even modifying the approach when objectives are not being met or when alternative methods offer similar or better outcomes at lower cost

This IDSS guidance and training is intended for regulators, remedial project managers, and remediation engineers responsible for sites contaminated by chlorinated solvents. Because the subject matter is complex, this guidance assumes a functional understanding of the field and is targeted towards experienced users; however, novices will benefit through descriptions and references of the latest evolution of site characterization challenges; realistic planning of site restoration; evolving treatment techniques; and evaluating, monitoring and interpreting mass transport in the subsurface aqueous and vapor phases. While the primary focus of the document is on DNAPL sites, other types of contaminated sites (e.g. petroleum, mixed contaminants, etc.) can use the same fundamental process described in this guidance.

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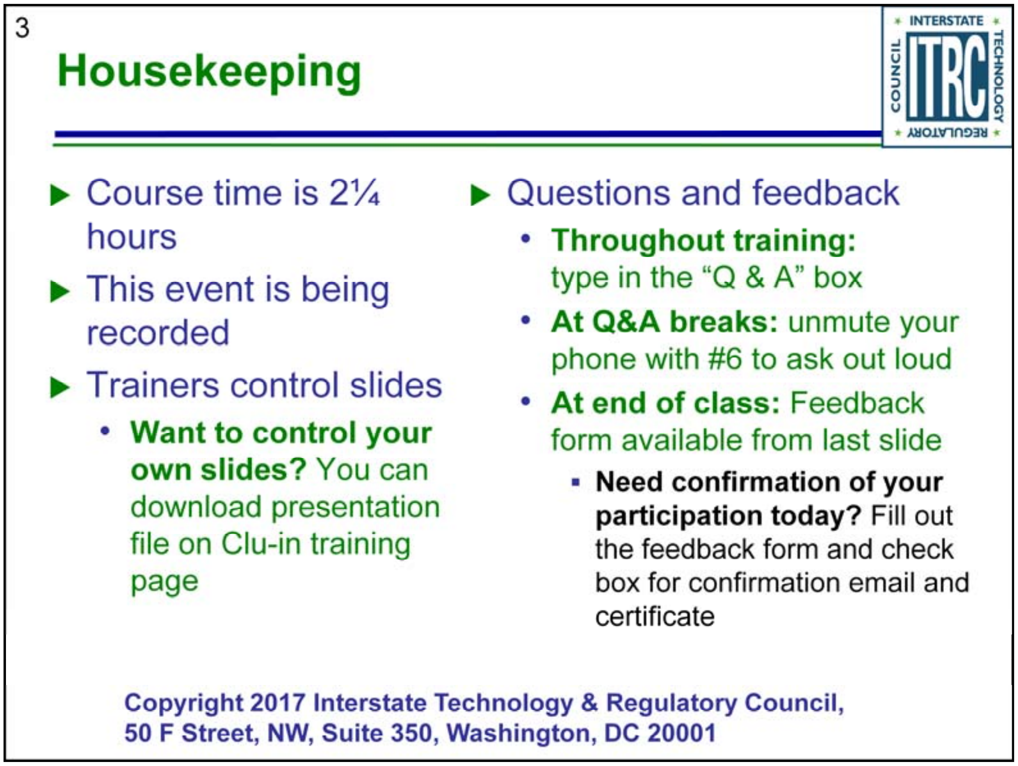
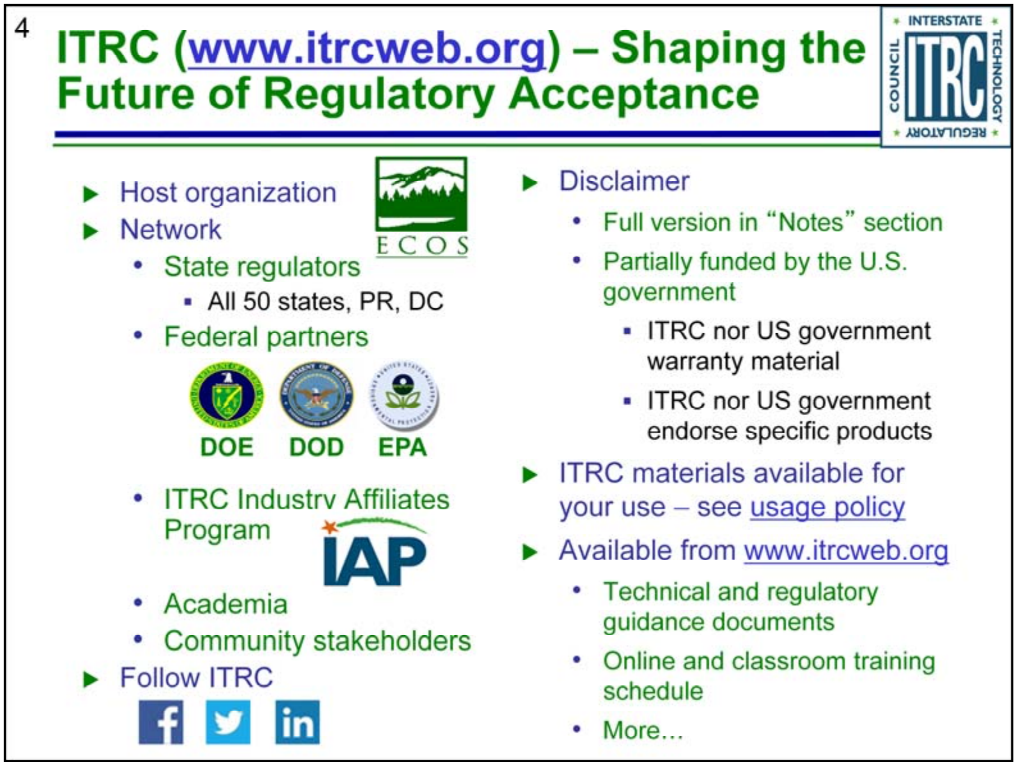


Although I'm sure that some of you are familiar with these rules from previous CLU-IN events, let's run through them quickly for our new participants.

We have started the seminar with all phone lines muted to prevent background noise. Please keep your phone lines muted during the seminar to minimize disruption and background noise. During the question and answer break, press #6 to unmute your lines to ask a question (note: *6 to mute again). Also, please do NOT put this call on hold as this may bring unwanted background music over the lines and interrupt the seminar.

Use the "Q&A" box to ask questions, make comments, or report technical problems any time. For questions and comments provided out loud, please hold until the designated Q&A breaks.

Everyone – please complete the feedback form before you leave the training website. Link to feedback form is available on last slide.



The Interstate Technology and Regulatory Council (ITRC) is a state-led coalition of regulators, industry experts, citizen stakeholders, academia and federal partners that work to achieve regulatory acceptance of environmental technologies and innovative approaches. ITRC consists of all 50 states (and Puerto Rico and the District of Columbia) that work to break down barriers and reduce compliance costs, making it easier to use new technologies and helping states maximize resources. ITRC brings together a diverse mix of environmental experts and stakeholders from both the public and private sectors to broaden and deepen technical knowledge and advance the regulatory acceptance of environmental technologies. Together, we're building the environmental community's ability to expedite quality decision making while protecting human health and the environment. With our network of organizations and individuals throughout the environmental community, ITRC is a unique catalyst for dialogue between regulators and the regulated community.

For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the "contacts" section at www.itrcweb.org. Also, click on "membership" to learn how you can become a member of an ITRC Technical Team.

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Alex MacDonald is a senior engineer in the technical support section of the Cleanup Unit at the Central Valley Regional Water Quality Control Board in Rancho Cordova, California. He has worked at the Water Quality Control Board since 1984. He primarily works on cleanup of the Aerojet site in Rancho Cordova, California and other nearby sites such as McClellan Air Force Base. Alex has also worked on cleanup at underground and above ground storage tanks sites; permitting and inspection of landfill and waste disposal to land sites; regulating application of biosolids sites; regulating NPDES sites that include wastewater treatment plants, power plants, industrial facilities, and groundwater treatment facilities; and permitting and inspecting dredging projects. Alex was a member of the ITRC Perchlorate team. Alex earned a bachelor's degree in Civil/Environmental Engineering from Stanford University in Palo Alto , California in 1977 and a master's degree in Civil/Environmental Engineering from Sacramento State University in Sacramento, California in 1987.

Ryan A. Wymore, P.E., rejoined CDM Smith in Denver, CO in 2015. He serves as a national resource for evaluation, selection, and implementation of remediation strategies and solutions. Ryan has specialized in innovative groundwater remediation technologies, particularly bioremediation, monitored natural attenuation and chemical oxidation. Previously, he work at Geosyntec Consultants in 2014-2015, CDM Smith from 2005-2013, at North Wind Inc. from 2001-2005, and at the Idaho National Laboratory from 1998-2001. He has given over eighty presentations at various local, regional, national, and international symposia and meetings. Since 2002, he has worked with various ITRC teams that addressed DNAPLs, bioremediation, enhanced attenuation, and Environmental Molecular Diagnostics. He was an instructor on the ITRC Internet-based training courses: DNAPL Performance Assessment, Bioremediation of DNAPLs, and Integrated DNAPL Site Strategy. Ryan earned a bachelor's degree in Biological Systems Engineering from the University of Nebraska-Lincoln in 1997 and a master's degree in Civil/Environmental Engineering from the University of Idaho in Moscow, Idaho in 2003. He is a registered Professional Engineer in the state of Idaho and Colorado in the environmental discipline.

Trevor King is a Remediation Technical Lead with AECOM DNAPL team in Pennsylvania. He has global experience in the planning, implementing and management of environmental and DNAPL remediation projects. He has extensive experience in the development of characterization and closure strategies for soil and groundwater remediation projects, and implementing cost effective remedial actions. Since 1993, Trevor has planned, implemented, and managed a wide variety of environmental projects in New Jersey, Pennsylvania, Florida and Puerto Rico. His experience includes project management, developing conceptual site models in support of remedy selection, developing remedial objectives and site closure strategies for remediation projects, and regulatory and client interface. Trevor has two pneumatic fracturing technology patents. His current company-wide responsibilities include project management and remedial strategy and technology evaluations at a national as well as the regional level. Trevor has been active in the ITRC since 2007 and has contributed, as a team member, to three ITRC DNAPL documents. He earned a bachelor's degree in mechanical engineering from the University of Wolverhampton in Wolverhampton, England in 1983 and a master's degree in environmental engineering from New Jersey Institute of Technology in Newark, New Jersey in 1993. He is a Professional Engineer in environmental engineering in Delaware.

Dr. Dan Bryant, Ph.D., is In-Situ Remediation Practice Leader for Woodard & Curran in East Windsor, New Jersey. Dan has worked in the field of in-situ chemical and biological remediation methods since 1997. Dan holds three patents related to biological and chemical in-situ treatment technologies of organic and inorganic contaminants in soil and groundwater. Dan is particularly involved in design and implementation of in-situ chemical oxidation projects in the U.S. and Europe. Dan has contributed to the ITRC since 2008 as a member of the Integrated DNAPL Site Strategies team. Dan earned bachelor's and master’s degrees in geology from the University of Florida in Gainesville, Florida in 1988 and 1990, respectively, and a Ph.D. in geology from Columbia University in New York City, New York, in 1995.

Aaron B. Cohen is a Project/Contract Manager at the Florida Department of Environmental Protection (FDEP) in Tallahassee, Florida. Aaron has worked with the Hazardous Waste Cleanup Section since 1998. He supervises and coordinates the cleanup of chlorinated solvent and hazardous waste sites within the Florida Drycleaning Solvent Cleanup Program, the State-funded Hazardous Waste Program, and Superfund. Prior to FDEP, Aaron worked for eight years in the environmental consulting field with ABB Environmental and Levine Fricke. Aaron has been active in the ITRC since 2008 when he joined the ITRC DNAPL Team. Aaron earned a bachelor’s degree in History from Davidson College in Davidson, North Carolina in 1988.

Dr. Tamzen Macbeth is a Vice President at CDM Smith out of Helena, Montana. She has worked for CDM since 2009. Previously, she worked for 7 years at North Wind Inc. Tamzen is an environmental engineer with an interdisciplinary academic and research background in microbiology and engineering. She specializes in the development, demonstration and application of innovative, cost-effective technologies for contaminated groundwater. Specifically, she is experienced in all aspects of remedies from characterization to remediation for DNAPLs, dissolved organic, inorganic, and radioactive contaminants under CERCLA and RCRA regulatory processes. She has expertise in a variety of chemical, biological, thermal, extraction and solidification/stabilization remediation techniques as well as natural attenuation. Her current work focuses developing combined technology approaches, and innovative characterization techniques such as mass flux and mass discharge metrics. Since 2004, Tamzen has contributed to the ITRC as a team member and instructor for the ITRC’s Bioremediation of DNAPLs, Integrated DNAPL Site Strategy, Molecular Diagnostics and DNAPL Characterization teams. Tamzen earned a bachelor's degree in Microbiology in 2000 and a master’s degree in Environmental Engineering in 2002 both from Idaho State University in Pocatello, Idaho, and a doctoral degree from in Civil and Environmental Engineering in 2008 from the University of

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The Problem…

Are you tired of throwing money and time at your chlorinated solvent sites with little improvement in return?

Are you achieving your cleanup goals and/or objectives?

Is it time to think about making a change in your remedial approach?

If you are like most of us the answer is probably, "yes"

If you answered YES to the questions above, then boy do I have the guidance document for you!

7

Are You Dealing with These Common Site Challenges?

- Incomplete understanding of DNAPL sites
- Complex matrix – manmade and natural
- Unrealistic remedial objectives
- Selected remedy is not satisfactory

Oh, what to do? Oh, what to do?

No associated notes.

ITRC IDSS Team

- **States**
  - California
  - Delaware
  - Florida
  - Maine
  - Minnesota
  - Massachusetts
  - Vermont
  - Virginia
  - Utah
- **Universities**
  - Colorado State
  - Tufts Univ.
  - Yale
  - U. of New Mexico
- **Federal Agencies**
  - NAVFAC
  - NFESC
  - AFCEE
  - EPA
  - SERDP
  - DOE
- **Community Stakeholders**
  - Mtn Area Land Trust
  - Yale
- **Industry**
  - Arcadis
  - Trihydro Corporation
  - Battelle
  - Burns and McDonnell Engineering
  - CDM Conestoga-Rovers & Assoc
  - Dajak
  - Fishbeck, Thompson, Carr & Huber
  - Geo-Cleanse Int, Inc.
  - Geosyntec
  - GSI Environmental
  - JRW Bioremediation
  - Kleinfelder
  - Langan Engineering
  - Microseeps
  - Porewater Solutions, Inc
  - RegTech
  - T. H. Wiedemeier Assoc.

It took a large effort from many people to develop this tool to assist site managers in the development of an integrated site remedial strategy. The list of organizations on this slide highlights the diversity and expertise of our team members.

Team initially formed in 2007 and kicked off in 2008 - comprised of a mix of State, Federal and Private entities, as well as academic and community interests.

Great mix of professionals that look at contaminant issues from differing points of view and for different client interests.

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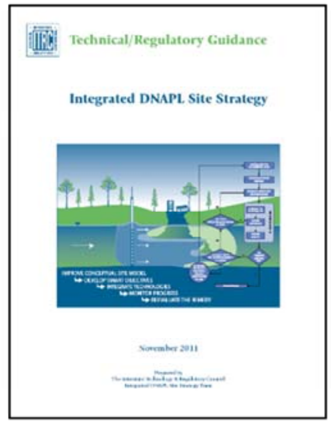
The Solution is an Integrated DNAPL Site Strategy (IDSS)

- Comprehensive site management
- When can you develop an IDSS?
  - Anytime!
- Who should use this IDSS?
  - Experienced practitioners and regulators



ITRC Technical and Regulatory Guidance Document:
Integrated DNAPL Site Strategy (IDSS-1, 2011)

The ITRC Integrated DNAPL Site Strategy technical and regulatory guidance document – sometimes we will refer to it as the "Tech Reg" serves as the basis for this training class. As we move through the presentation you will see references to chapters, sections, tables, flow charts as other information to this document. If you haven't already we encourage you to download a copy and use it to help you with your DNAPL sites.

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An Integrated DNAPL Site Strategy

- Conceptual site model
  - Chapter 2
- Remedial objectives
  - Chapter 3
- Remedial approach
  - Chapter 4
- Monitoring approach
  - Chapter 5
- Evaluating your remedy
  - Chapter 6

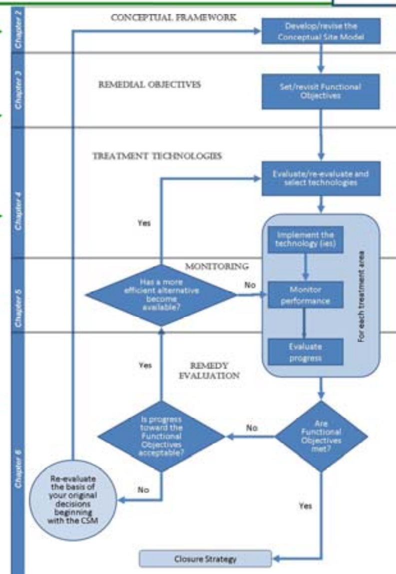

Figure 1-1 Integrated DNAPL Remediation Decision-making

ITRC IDSS-1, Figure 1-2

The IDSS guidance will improve the management of any remedial project

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After this Training You Should be able to:

- Apply the ITRC document to develop an Integrated DNAPL Site Strategy
- Understand the advantages of establishing SMART objectives and how to develop SMART objectives
- Understand how to monitor technology performance
- Effectively consider how to couple and transition treatment technologies
- Troubleshoot your remedial approach

No associated notes.

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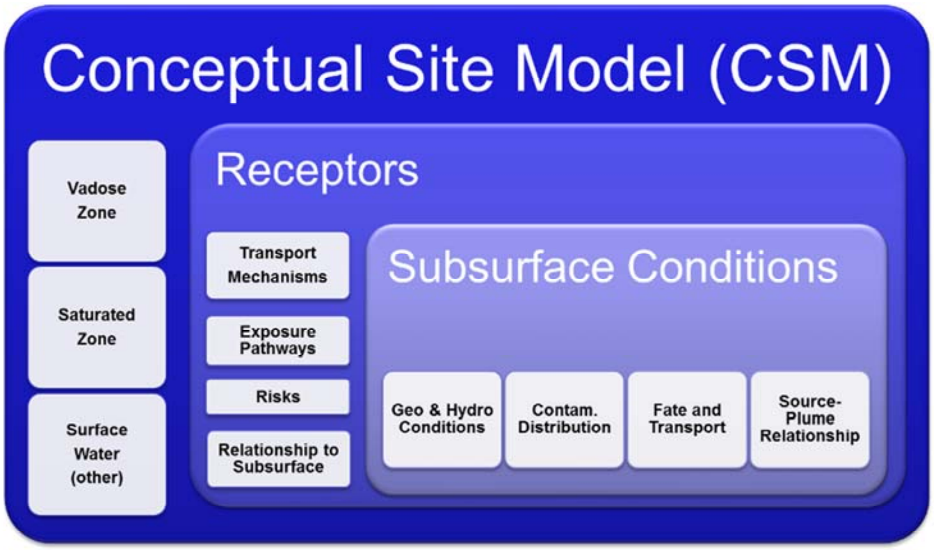
Chapter 2: Conceptual Site Model (CSM)



The IDSS document is process-oriented, and the process starts with the CSM and then loops back to it as new information is available.

CSM – cant solve the problem if you don't understand the problem.

CSM is an organized set of ideas about a site – encompasses key elements.

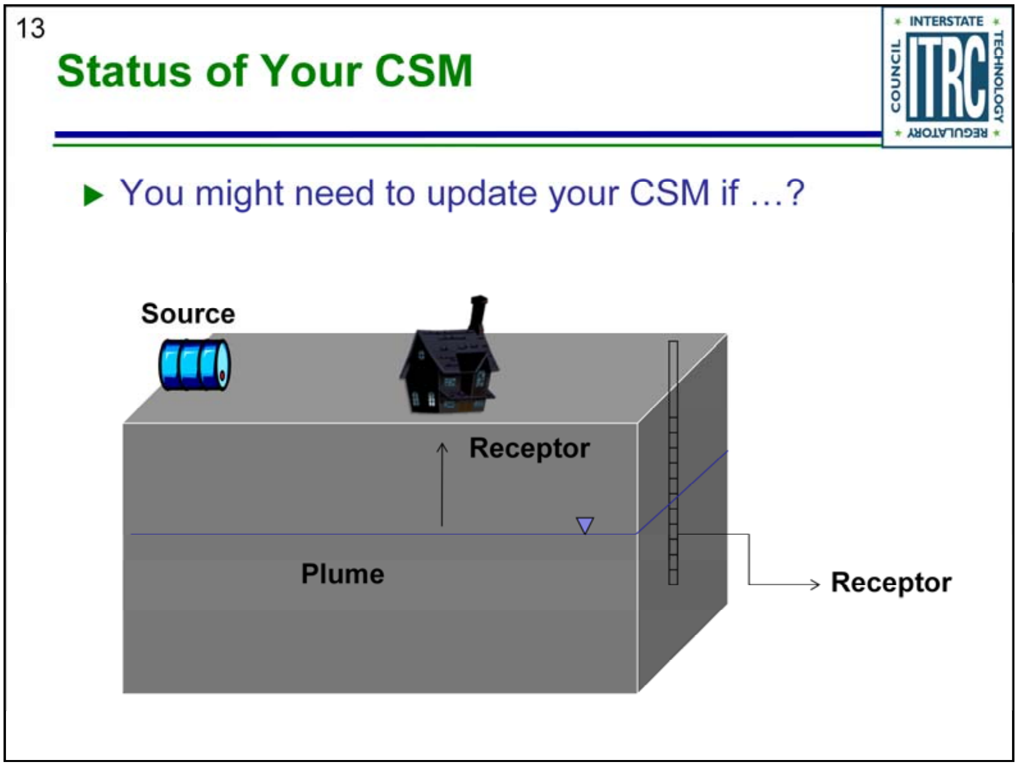
Can be presented graphically and/or in a variety of ways

CSM can be challenging to develop

CSM is needed to support developing remedial objectives

To develop and work with a CSM as a living tool, it is necessary to understand some of the basic science and the dynamics of how DNAPLs and plumes behave in the subsurface.

We are not going to get too bogged down in risk evaluation methods, etc. – just focusing on DNAPL sites and the unique aspects.



The current site understanding is “Black Box”

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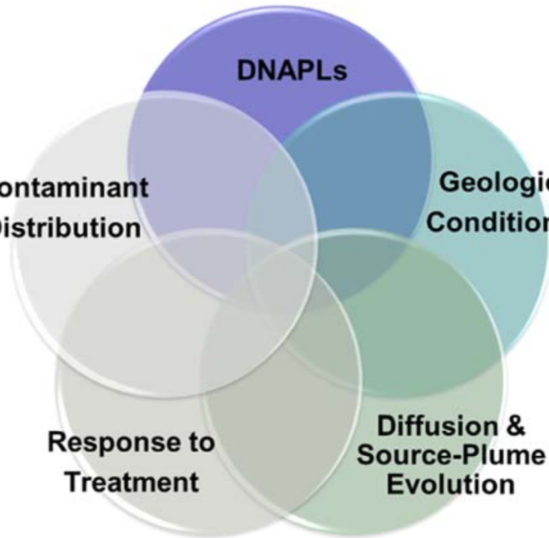
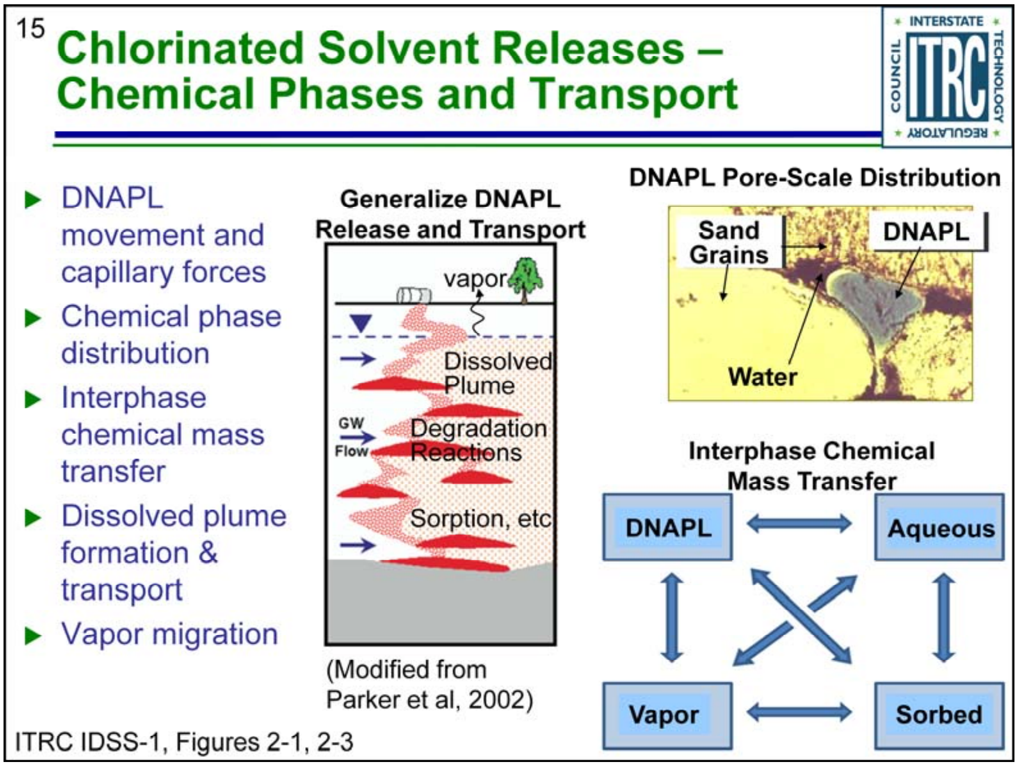
Technical Concepts We Will Cover Related to CSM



What you currently think about your CSM might change after today's presentation, so please stay with us and follow along.



A CSM has to account for the physics and chemistry of a subsurface release. “If we don’t understand the problem, we probably can’t solve the problem.”

Main Processes in Chlorinated Solvent Releases include:

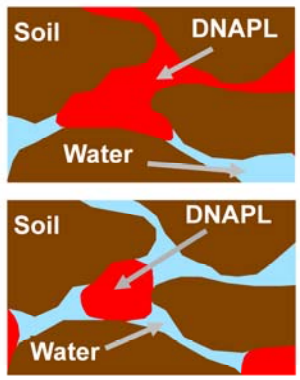
-DNAPL movement and all related capillary phenomena

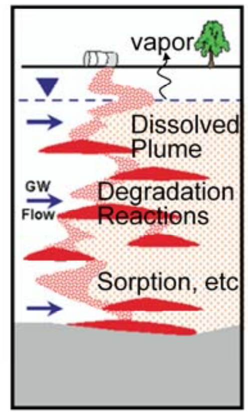
-interphase chemical mass transfer – where is your mass?

-put it all together in 3-Dimensions and include transport and reactions.

Mobile DNAPL vs. Residual DNAPL

- Mobile DNAPL
  - Interconnected separate phase that is capable of migrating
- Residual DNAPL
  - Disconnected blobs and ganglia that are not capable of migrating





(Modified from Parker et al, 2002)

ITRC IDSS-1, Figure 2-2

Need to consider the DNAPL itself:

-Is DNAPL present?

-Even when present will be very hard to identify.

-Just because you can't find it doesn't mean it isn't there.

-DNAPL "pools" are rare – we are more concerned with the question of DNAPL saturation and residual vs. mobile DNAPL.

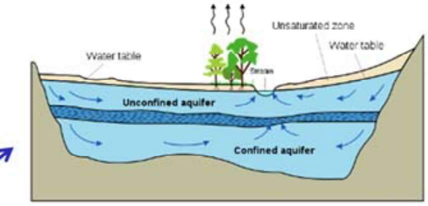
-Mobile DNAPL = interconnected at pore scale

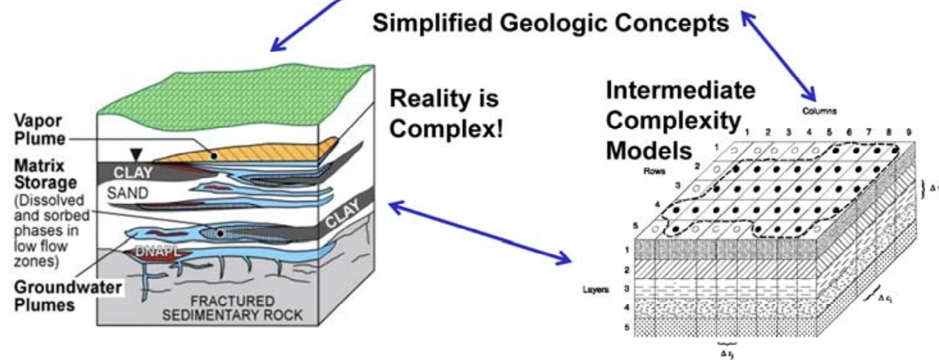
-Residual DNAPL (immobile) = disconnected blobs and ganglia

-Either Mobile or Residual DNAPL is a challenge for cleanup

Importance of Geologic Heterogeneity

- Tools and concepts commonly applied often underrepresent the actual complexity of DNAPL sites





ITRC IDSS-1, Figure 2-4

Describe how this affects your CSM and importance for decision making.

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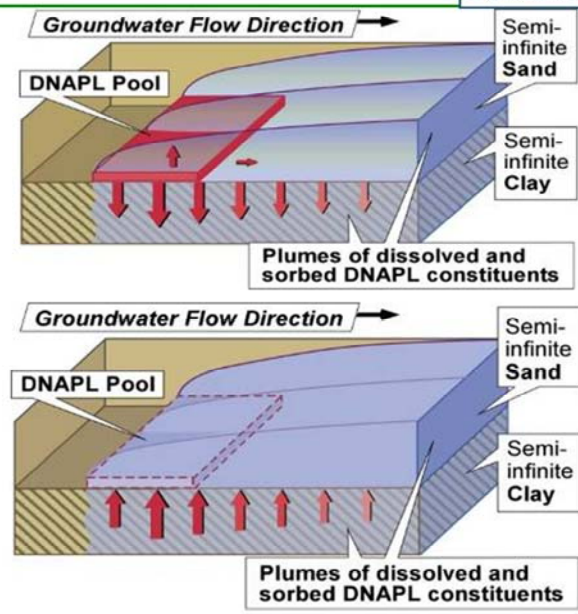
Basic Concept – Contaminant Diffusion

- Early time = diffusion into low permeability zones
- Late time = diffusion out of low permeability zones ***"back-diffusion"***



ITRC IDSS-1, Figure 2-5 & 2-6

No associated notes.

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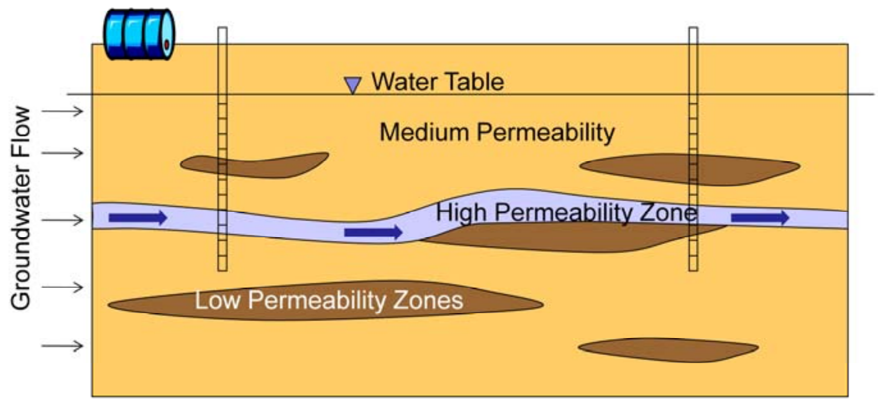
Geologic X-Section: Setting the Stage for a DNAPL Release

Key Point: Groundwater flux is dominant in high-permeability zones
Groundwater velocity in high-permeability zones >>> average value



Highly simplified illustration of heterogeneous geology

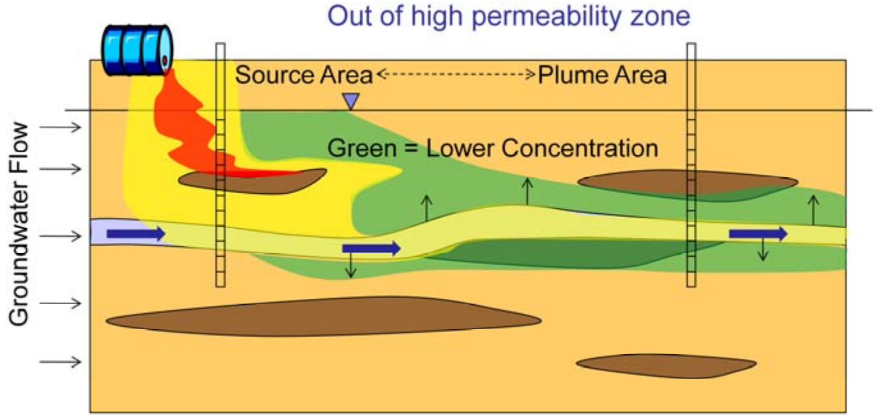
No associated notes.

20

Source-Plume Evolution: Early Stage

Dominant **Early** Stage Process:

Diffusion from high to low concentration
Out of high permeability zone



Highly simplified illustration of heterogeneous geology

Don't actually see many DNAPL releases in "early stage". Usually after 10-20 years you have moved into middle or late stage, but early stage is important to understand as the starting point.

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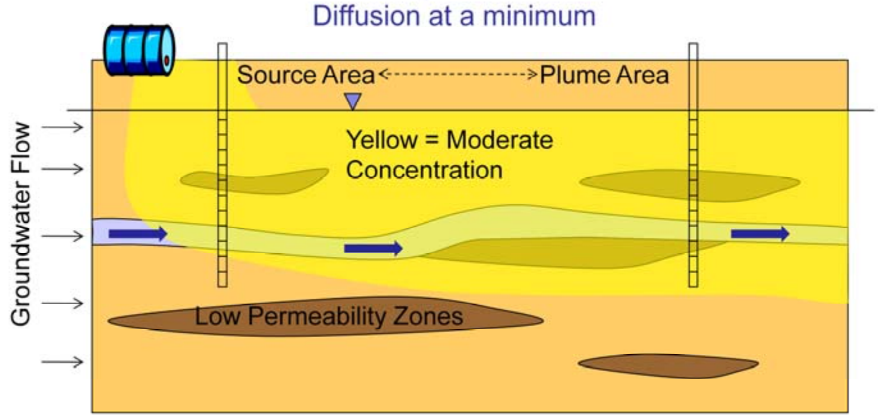
Source-Plume Evolution: Middle Stage

Dominant **Middle** Stage Process:

Relatively uniform contaminant distribution

Diffusion at a minimum



Highly simplified illustration of heterogeneous geology

No associated notes.

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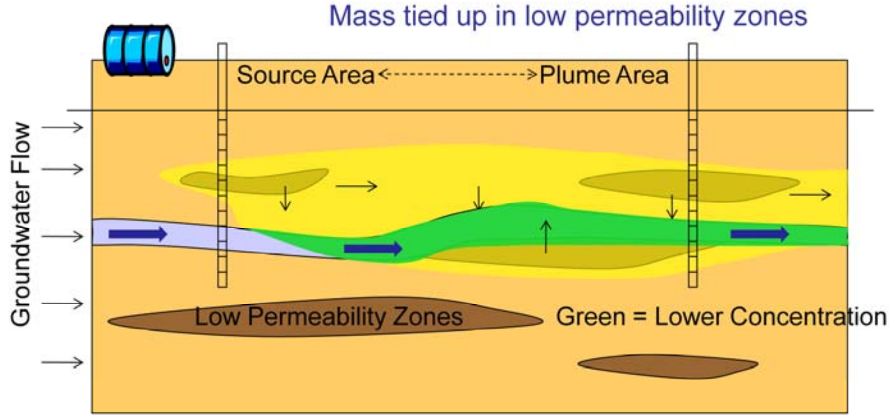
Source-Plume Evolution: Late Stage

Dominant **Late** Stage Process:

Diffusion out of low permeability zones

Mass tied up in low permeability zones



Highly simplified illustration of heterogeneous geology

Can evaluate this by looking in detail at vertical delineation with respect to geologic variability. Is contaminant concentration higher in low perm zones?

Examples –

Simple = using vertical delineation with PID readings

More complex = downhole real time instruments such as MIP.

So, think about if there is data at your site that you can go back and reevaluate? Do you have data gaps? Why is it important…. Next slide.

23

Plume Response to *In Situ* Source Treatment

- Response is dependent on stage of plume evolution
- Is contaminant mass accessible to treatment?
- In-situ treatment often preferentially treats high permeability zones
- “Back-diffusion” controls plume response

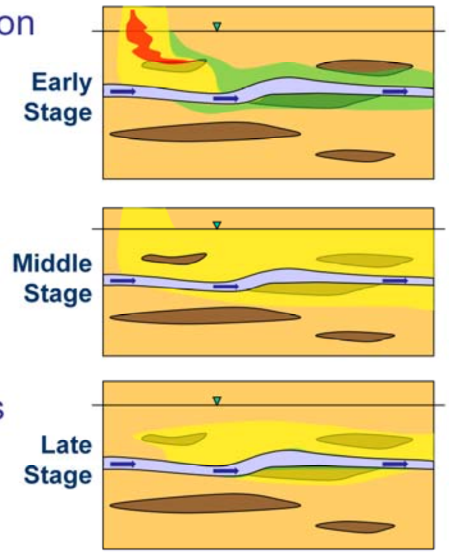


Figure represents simplified treatment result where more transmissive zone is preferentially treated.

Early Stage – Biggest bang for the buck on improvement in plume condition because diffusion out of transmissive zones has been minimal at this stage. But, we may not have treated the high concentration source unless it was specifically targeted for treatment.

Middle Stage – Worst scenario for potential back-diffusion because a large reservoir of moderate concentrations exists over a large volume that may not have been accessible to treatment.

Late Stage – Still potential for back diffusion but less so than middle stage because contaminant mass reservoir in the inaccessible zones has been depleted somewhat.

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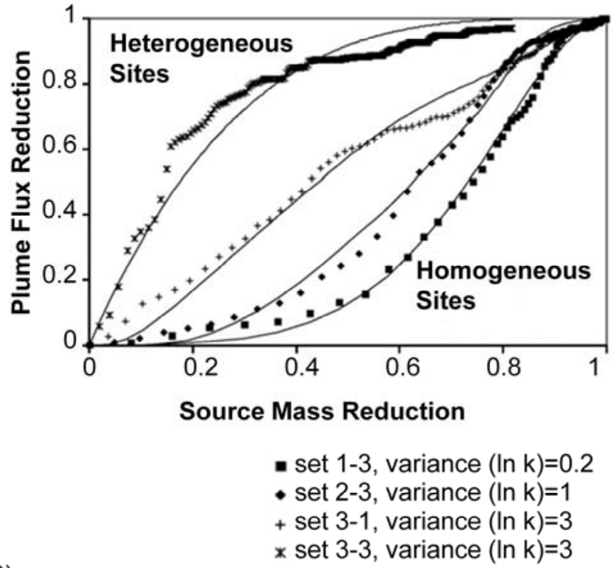
Plume Response to Source Treatment

- Mass flux vs. concentration basis
- Heterogeneous sites – greater plume response
- Homogeneous sites – lesser plume response
- Tools – EPA REMChlor (Falta et al, 2007)

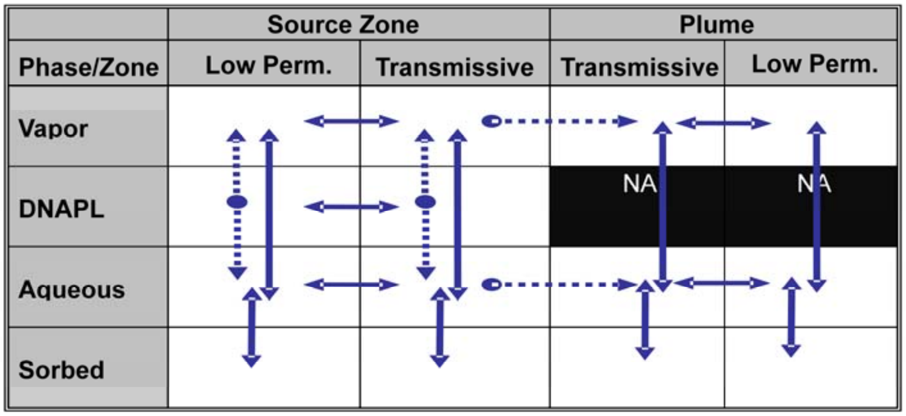


Modified from Basu, et al. (2008)

Basu et al., 2008. "Simplified contaminant source depletion models as analogs of multiphase simulators" Journal of Contaminant Hydrology 97 (2008) 87–99.

14-Compartment Model

- "Compartment" consists of chemical phase within either the source zone or plume and in either transmissive or low permeability zone
- Highly conceptualized depiction of potential for contaminant mass flux between compartments



ITRC IDSS-1, Table 2-2 from Sale and Newell, 2011

No associated notes.

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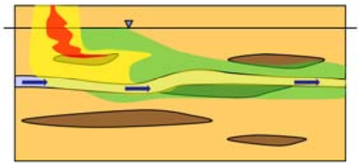
14-Compartment Model

- Relative aqueous phase equivalent concentrations
- Not mass based

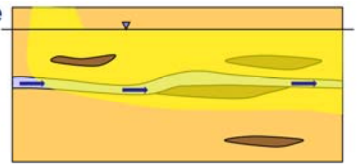
Early Stage

	SOURCE		PLUME	
Zone/Phase	Low Permeability	Transmissive	Transmissive	Low Permeability
Vapor	LOW	MODERATE	LOW	LOW
DNAPL	LOW	HIGH		
Aqueous	LOW	MODERATE	MODERATE	LOW
Sorbed	LOW	MODERATE	LOW	LOW



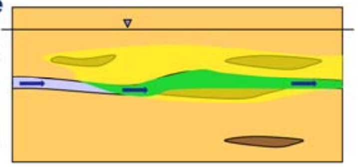
Middle Stage

	SOURCE		PLUME	
Zone/Phase	Low Permeability	Transmissive	Transmissive	Low Permeability
Vapor	MODERATE	MODERATE	MODERATE	MODERATE
DNAPL	MODERATE	MODERATE		
Aqueous	MODERATE	MODERATE	MODERATE	MODERATE
Sorbed	MODERATE	MODERATE	MODERATE	MODERATE



Late Stage

	SOURCE		PLUME	
Zone/Phase	Low Permeability	Transmissive	Transmissive	Low Permeability
Vapor	LOW	LOW	LOW	LOW
DNAPL	LOW	LOW		
Aqueous	MODERATE	LOW	LOW	MODERATE
Sorbed	MODERATE	LOW	LOW	MODERATE



ITRC IDSS-1, Table 2-3 from Sale and Newell, 2011

Relative aqueous phase equivalent concentrations

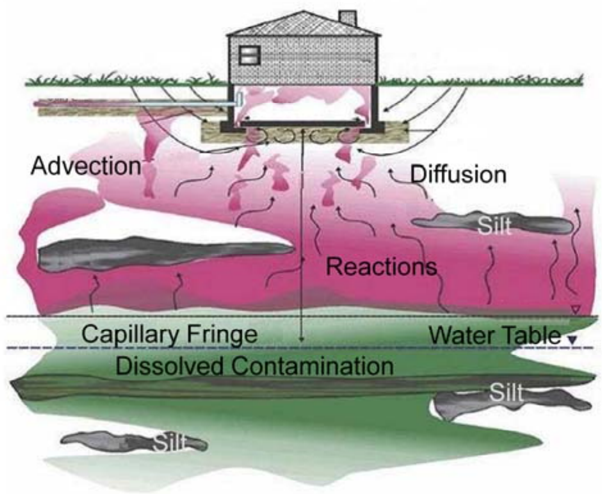
Shows equilibrium tendencies and relative MOVEMENT OF CONTAMINANT between phases

Not mass based

Does not show relative CONTAMINANTMASS DISTRIBUTION between chemical phases of in different compartments

CSM for Soil Gas / Vapor Intrusion Pathway

- Vapor risk may be driver
- Key element of CSM
- Common approach - reverse calculate groundwater cleanup target
- KEY ISSUE - Clear understanding of treatment process and groundwater-vapor relationship
- CAUTION - Equilibrium assumptions vs. non-equilibrium conditions



ITRC IDSS-1, Figure 2-10, Conceptual Model for subsurface vapor pathways (EPA, 2002)

No associated notes.

28

CSM Concepts Wrap Up

- Do you really understand?
  - Source-plume relationships
  - Transport processes and exposure pathways
  - Stage of source / plume evolution
  - How exposure concentrations will respond to treatment
- If we don't understand the problem, we probably can't solve the problem
- More information available in ITRC's technical and regulatory guidance Integrated DNAPL Site Characterization and Tools Selection (ISC-1, 2015)
  - Document: http://www.itrcweb.org/DNAPL-ISC_tools-selection/
  - Training: http://www.clu-in.org/conf/itrc/IDSC/

There is always more to know, but…

Do you think you can formalize your CSM?

Are there areas of your site where you need to question your assumptions?

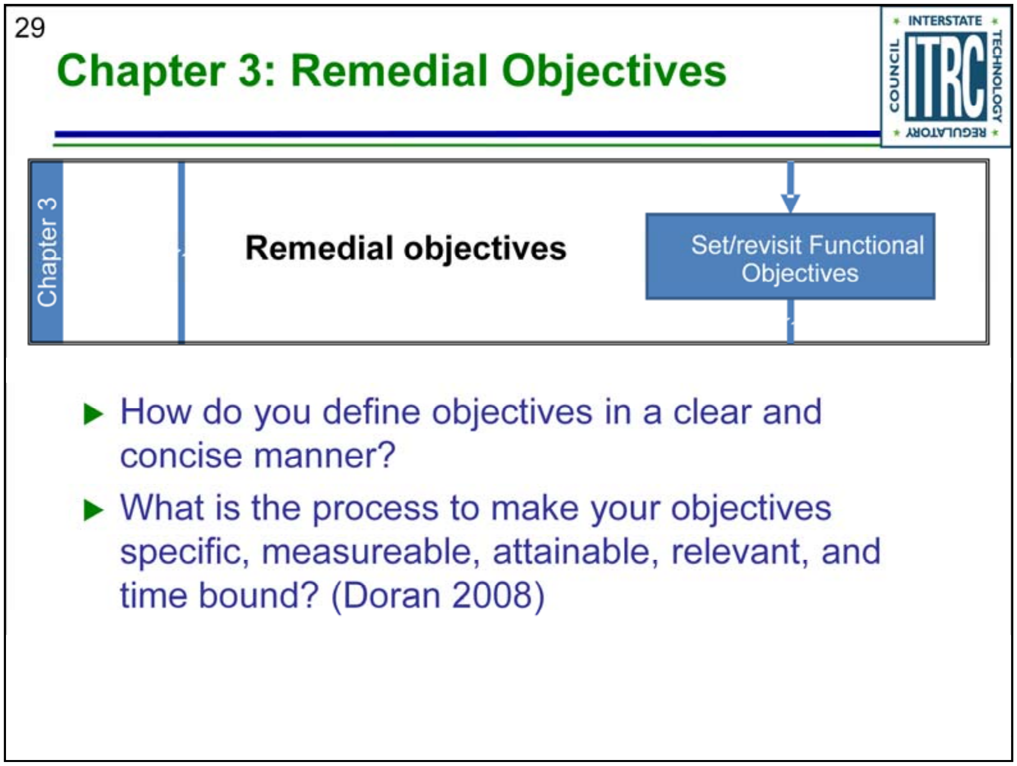
Do you think you can update your CSM?

Make this work for you, develop your CSM using any combination of graphics, maps, cross sections, data, etc.

Refer to ITRC MASS FLUX document: ITRC Use and Measurement of Mass Flux and Mass Discharge (MASSFLUX-1, 2010)

http://www.itrcweb.org/guidancedocument.asp?TID=82

Now… will briefly discuss a tool that can help in organizing your CSM and that is used later in this presentation.



SMART remedial objectives: Specific, Measureable, Attainable, Relevant, Time-bound

Stakeholder and SMART Attributes – Community stakeholders have had concerns that viable approaches are rarely chosen. Applying SMART Attributes to Functional objectives may alleviate some concern as a viable approach with long term (absolute) objectives and reasonable (functional) objectives which can be used by all parties concerned.

The specific diagnostic questions give a succinct direction to the stakeholder as to what should be asked and addressed.

30

Types of Objectives

- Absolute objectives
  - Based on broad social values
    - Example: protection of public health and the environment
- Functional objectives
  - Steps taken to achieve absolute objectives
    - Example: reduce loading to the aquifer by treating, containing, or reducing source

At most sites, the ultimate objective of site restoration is to achieve MCLs in all impacted media, but this objective is often technically and/or economically impracticable within “reasonable” time frames.

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Functional Objectives Should be SMART

SMART means:

- Specific
  - Objectives should be detailed and well defined
- Measureable
  - Parameters should be specified and quantifiable
- Attainable
  - Realistic within the proposed timeframe and availability of resources
- Relevant
  - Has value and represents realistic expectations
- Time-bound
  - Clearly defined and short enough to ensure accountability

SMART acronym was develop by the American Management Association (AMA) to recognize good objectives.

Stakeholder and SMART Attributes – Community stakeholders have had concerns that viable approaches are rarely chosen. Applying SMART Attributes to Functional objectives may alleviate some concern as a viable approach with long term (absolute) objectives and reasonable (functional) objectives which can be used by all parties concerned.

The specific diagnostic questions give a succinct direction to the stakeholder as to what should be asked and addressed.

32

Functional Objectives Time Frame

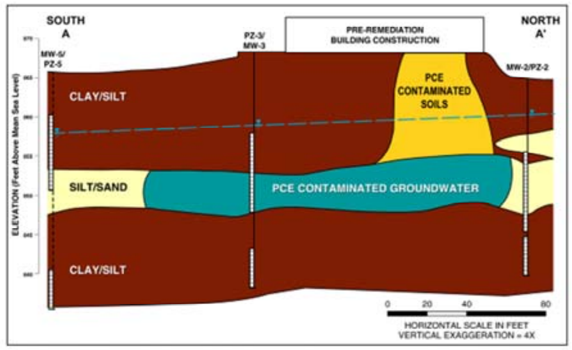
- Time frame should accommodate
  - Accountability
  - Natural variation of contaminant concentration and aquifer conditions
  - Reliable predictions
  - Scientific understanding and technical ability
- Team suggests 20 years or less for Functional Objectives

Site management and active remediation timeframe may continue much longer

No associated notes.

Example Site

- Potential future indoor and outdoor air risk due to PCE in vadose zone and groundwater
- PCE in groundwater is a potential drinking water risk
- PCE in soils is a contact risk
- PROPOSAL– Redevelop the property with no environmental restrictions



- CLEANUP –
  - 40 µg/kg PCE in soil – indoor air, ambient air and dermal exposure
  - 8 µg/L PCE in groundwater – indoor and ambient air
  - 5 µg/L PCE in groundwater – drinking water MCL

ITRC IDSS-1, Figure 2-12

Cleanup value for PCE in soil that was protective of indoor air was determined to be 40 µg/kg, which was also protective for dermal exposure and ambient air exposure.

Cleanup value of PCE in groundwater that was protective of indoor air was determined to be 8 µg/L.

Cleanup value for PCE in groundwater as a drinking water source was selected to be the drinking water standard of 5 µg/L.

Achieving these cleanup values would allow unrestricted use of the site – enhancing the value of the property and a goal of the developer.

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Developing a Functional Objective for the Example Site

- Absolute Objectives:
  - Protection of human health and the environment
  - Redevelop the Mall Area
- Generic Functional Objective - Not SMART
  - Vapor Intrusion Indoor Air Objective – Soils Pathway
  - Reduce concentrations of volatile organics in the vadose zone that will allow a "No Further Action" for unrestricted use, with no engineering or administrative controls required

One of several Functional Objectives. Notice that it does not meet the SMART criteria. Must now take this an make it meet the SMART criteria

SMARTify the Functional Objective

- SMART Functional Objective
  - Reduce concentrations of volatile organics in the vadose zone to less than 40 µg/kg within 6 months that will allow a "No Further Action" for unrestricted use, with no engineering or administrative controls required
- Meets SMART Criteria
  - Specific – Yes, 40 µg/kg
  - Measureable – Yes, confirmation samples
  - Achievable – Yes, excavation or SVE or ISCO
  - Relevant – Yes, intended use of property
  - Time-bound – Yes, 6 months

The 6 month criteria was a driver provided by the developer who needed to meet a specified schedule for redeveloping the mall.

Higher concentrations might have been left in place if engineering controls and deed restrictions were to be part of the cleanup decision making. The developer wanted no such restrictions.

Questions & Answers

Follow ITRC

- ► Conceptual site model
- ► Remedial objectives

Question and Answer Break

- ► Remedial approach
- ► Monitoring approach
- ► Evaluating your remedy

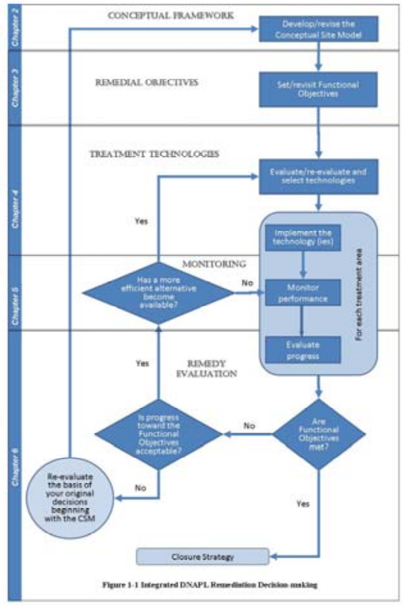
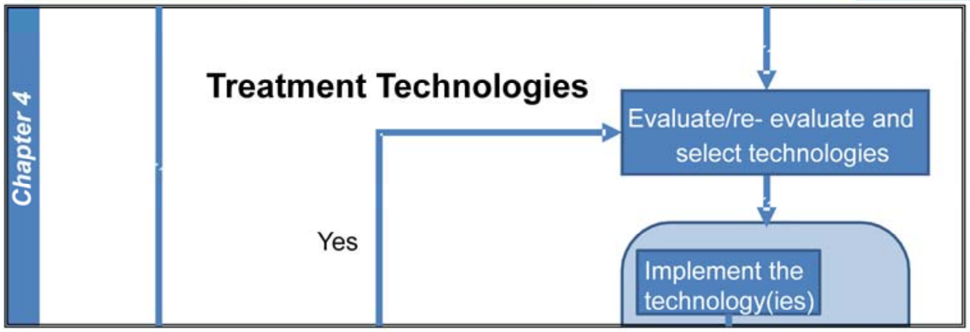


Figure 1-1 Integrated DNAPL Remediation Decision making

ITRC IDSS-1, Figure 1-1

No associated notes.

Chapter 4: Treatment Technologies



- How do you to avoid the trap of relying on a single remedial technology that won't do the job?
- How do you consider site characteristics and site goals when deciding on technologies?
- How could multiple technology selection and integration help you reach your functional objectives?

No associated notes.

Four Parts to Section 4

- Remediation technologies and assessing performance (Section 4.1)
- Coupling technologies (Section 4.2)
- Transitioning to other technologies (Section 4.3)
- Example (Section 4.4)

No associated notes.

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Treatment Technologies

- Good summary of key technologies and performance
- No discussion of technology niches or sweet spots
  - Other technology guides are available
  - No universal consensus by IDSS team
- How to fit technologies into 14-Compartment Model
  - Need to estimate future performance
  - Use Orders of Magnitude (OoMs)

No associated notes.

Table 4.1: Note the ITRC Publications!

Technology Category	Example Technologies	Example Reference
Physical Removal	Excavation	NAVFAC, 2007
	Multiphase Extraction	USACE, 1999
	Thermal Conductivity/ Electrical Resistance Heating	Johnson et. al., 2009
Chemical/ Biological	*In Situ* Chemical Oxidation	ITRC ISCO-2, 2005
	In Situ Chemical Reduction	Liang et. al., 2010
	In Situ Bioremediation	ITRC BIODNAPL-3, 2008
	Monitored Natural Attenuation	ITRC EACO-1, 2008
Containment	Pump and Treat	USEPA, 1999
	Low-Permeability Barrier Walls	NRC, 1997
	Permeable Reactive Barriers	ITRC PRB-5, 2011
	Solidification/Stabilization	USEPA, 2009; ITRC S/S-1, 2011

ITRC IDSS-1, Table 4-1

Some technologies may fit in more than one Technology Category.

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Adding Technologies to the 14-Compartment Model

ZONE / PHASE	Source						Plume					
	Low Permeability			Transmissive			Transmissive			Low Permeability		
	Before	Tech. Perf	After	Before	Tech. Perf	After	Before	Tech. Perf	After	Before	Tech. Perf	After
Vapor	2	?		3	?		1	?		1	?	
DNAPL	0	?		0	?		*not applicable*					
Aqueous	1	?		2	?		2	?		1	?	
Sorbed	3	?		3	?		2	?		1	?	

KEY:

- (red) Equivalent aqueous conc. ~ 1000 µg/l - ***HIGH*** *CONC.*
- (orange) Equivalent aqueous conc. ~ 100 µg/l - ***MODERATE*** *CONC.*
- (yellow) Equivalent aqueous conc. ~ 10 µg/l - ***MODERATE*** *CONC.*
- (green) Equivalent aqueous conc. ~ 1 µg/l - ***LOW*** *CONC.*

You Do These:

- ? Needs anticipated Orders of Magnitude reduction (OoMs)
- Simple Subtraction: (Before) – (Tech. Performance) = After

Technologies can be overlain on the 14-Compartment Model in order to determine if a technology is likely to achieve goals and to choose between technologies. This requires an order-of-magnitude assessment of the anticipated amount of COC reduction.

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Order of Magnitude are Powers of 10
Why Use OoMs for Remediation?

- Hydraulic conductivity is based on OoMs
- VOC concentration is based on OoMs
- Remediation performance (concentration, mass, Md) can be also evaluated using OoMs….
  - 90% reduction: **1** OoM reduction
  - 99.9% reduction: **3** OoM reduction
  - 70% reduction: **0.5** OoM reduction (use equation 4.1.1)
- Example:
  - Before concentration 50,000 ug/L
  - After concentration 5 ug/L
  - Need **4 OoMs** (99.99% reduction)

Section 4.1.1 has a formula that converts before-and-after concentration data to OoMs.

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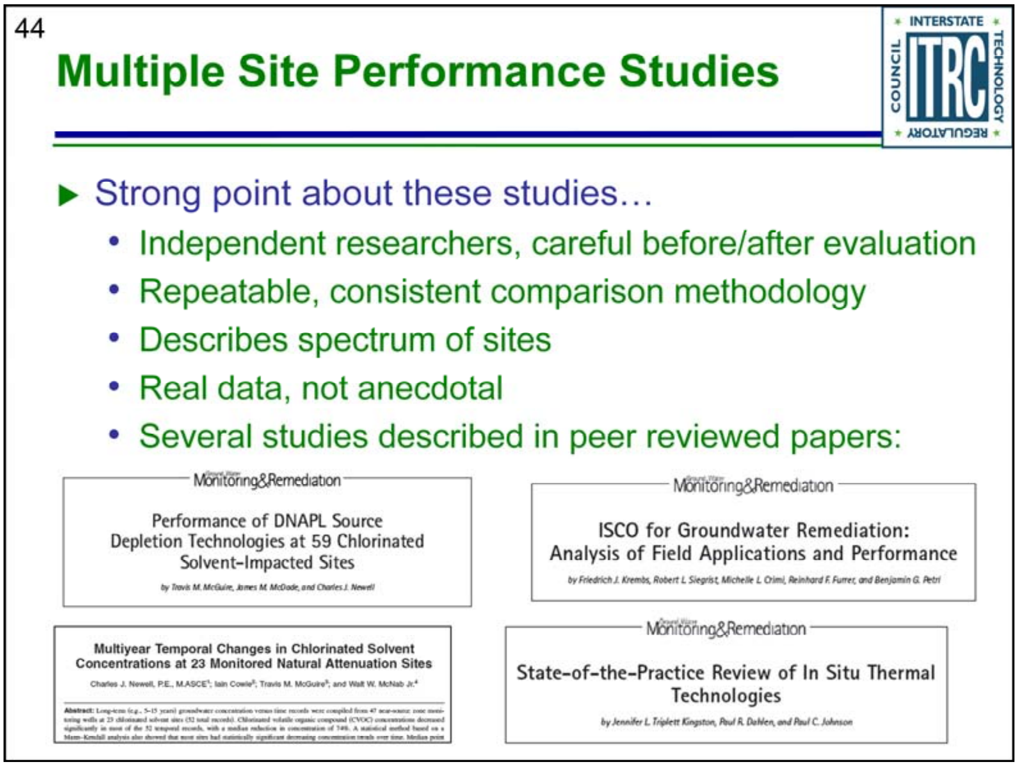
Where Do You Get OoMs?

- Option 1: Your experience/knowledge
- Option 2: Data from the scientific literature
  - Multiple site studies
  - Recently released ESTCP's "DNAPL Test" System http://projects.geosyntec.com/DNAPL/dnapltest.aspx
- Option 3: Consult technology specialists / technology vendors

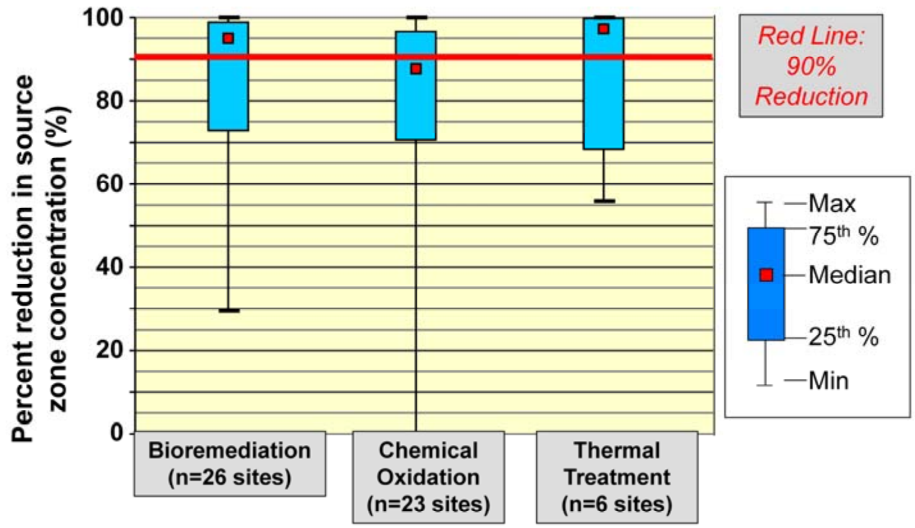
OoMs!

A practitioner's knowledge of site conditions coupled with experience using a technology under those types of conditions often provide the best source of OoMs. However the scientific literature and the opinions of technology specialists are also important resources to consider.



Full references of these and other studies are included in the document.

Results from 59-Site Study

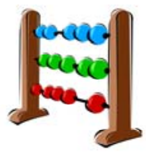


McGuire et al., 2006

Box plots are used to present average results as well as to express the amount of variability in the results. Wide variability may indicate that a technology must be designed and applied thoughtfully considering site-specific conditions.

Others Say Use Caution….

- Not site specific
- Some lump pilot scale, full scale
- May not account for intentional shutdowns (i.e. they stopped when they got 90% removal)
- Don't account for different levels of design/experience
- We are a lot better now….



Multi-site studies also of important limitations to recognize, emphasizing caution in just using performance data without considering the site-specific issues.

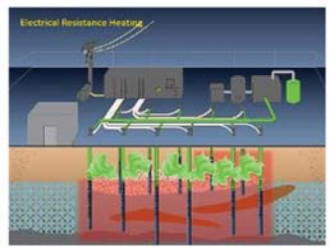
Technology Category 1: Remove Physical Removal

- Excavation

- Thermal remediation
  - Reduction in source concentration Detailed study of 14 Sites[1]

    ≤ 1 OoMs at 9 sites

    ≥ 2 OoMs at 4 sites



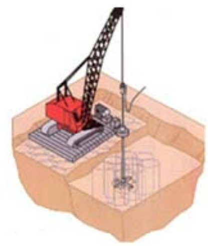
[1]Kingston et al, 2010

Concentration reduction (shown as OoMs) on this slide are from a multiple site study.

Technology Category 2: <u>React</u> Chemical / Biological

- *In-situ* chemical oxidation
  - Median **0.3 OoMs** for *CVOCs*[1]
  - This and other studies*: rebound more prevalent for ISCO than other technologies*

- *In-situ* chemical reduction
  - Deep soil mixing "ZVI Clay" Process: Median **1.7 OoMs**[2]



[1]Krembs et al., 2010
[2]Olsen and Sale, 2009

Concentration reduction (shown as OoMs) on this slide are from two multiple site studies.

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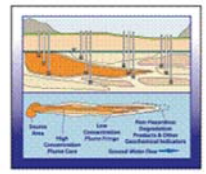
Technology Category 2: React Chemical / Biological (continued)

- Enhanced bioremediation
  - Median **1.3 OoMs** for *Parent*[1]
  - Median **0.4 OoMs** for *Total CVOCs*

- Monitored natural attenuation (MNA)
  - Median **0.6 OoMs** over average of nine years of MNA at 26 "low-risk" CVOC sites[2]
  - Sole remedy at 30% of 45 chlorinated MNA sites[3]

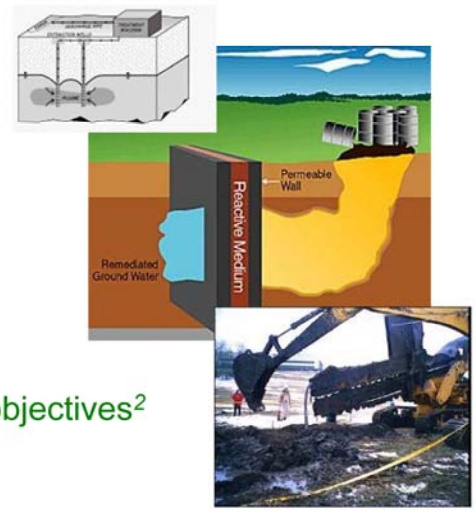


[1]McGuire et al., 2006
[2]Newell et al., 2006
[3]McGuire et al., 2004

Concentration reduction (shown as OoMs) on this slide are from multiple site studies. The OoMs reduction for MNA is over an average 9-year treatment period.

Technology Category 3: Contain

- Pump and treat
- Permeable reactive walls
  - Zero Valent Iron Walls: Median **0.8 OoMs** TCE from six sites[1]
- Low-permeability barriers
  - 83% of sites met design objectives[2]
- Solidification/stabilization

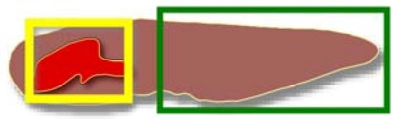


[1]Liang et al., 2010
[2]U.S EPA, 1998

Concentration reduction (OoMs) from multiple site studies. The ZVI permeable reactive wall data is derived from only from six sites, and represents change in groundwater concentration from upgradient to downgradient wells.

Technology Coupling (Section 4.2)

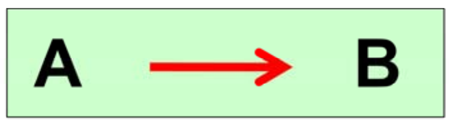
- Three types: *temporal, spatial, simultaneous*
- IDSS team experience most common approaches:
  - Intensive technology followed by passive
  - Different technology for Source versus Plume
  - Any technology followed by MNA
- In past, "opposing" combinations (ISCO then bio) were thought to be permanent. *This has proven to not be the case.*



No associated notes.

Rationale for Coupling Technologies

- Contaminant mass, fluxes, concentration, and other factors change over time
- Remediation objectives can change as regulations and understanding or risk changes
- Multiple contaminants or classes may be present



No associated notes.

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Technology Compatibility Matrix

- Compatibility matrix of 9 technologies
- Examples:
  - **"Generally Compatible"**
    - Thermal followed by *In Situ* Bio:
      - Potentially synergistic
      - Microbes population may be reduced
      - But then rapid recovery
  - **"Likely Incompatible"**
    - *In Situ* Reduction followed by In-Situ Oxidation
      - Destruction of both reagents
  - **"Potentially Compatible but Not An Anticipated Couple"**
    - Bio followed by Surfactant Flushing
      - Would probably work, but unlikely to be coupled

ITRC IDSS-1, Table 4-2

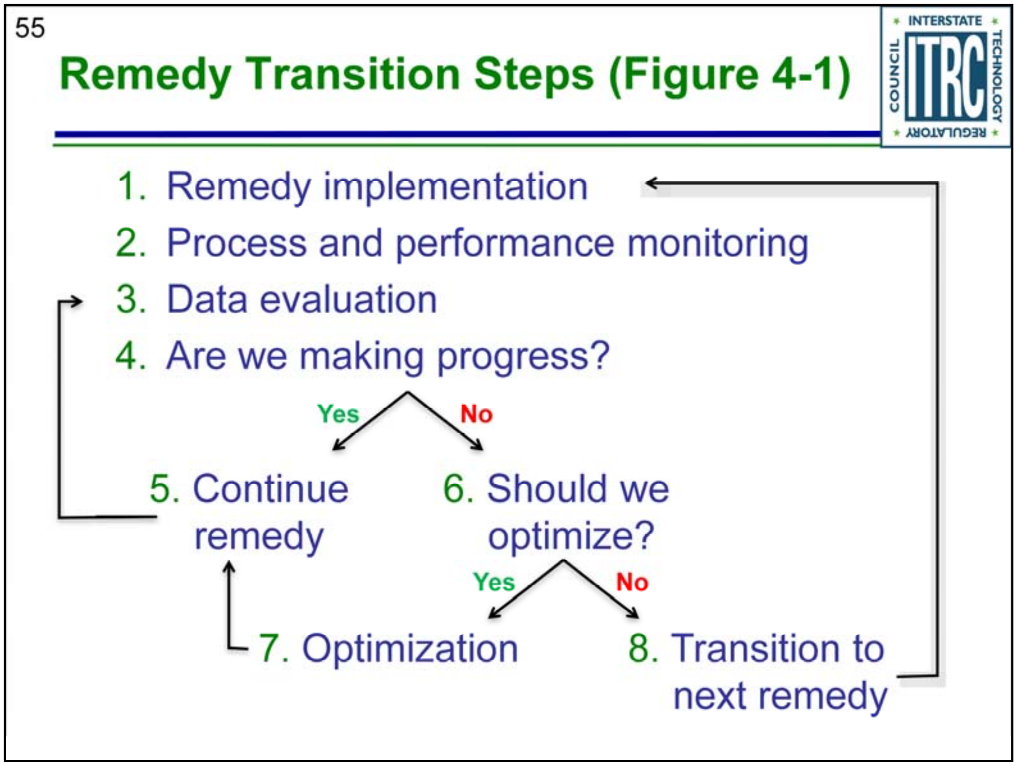
The IDSS team assessed each potential coupling for compatibility. The notes associated with the matrix provide details on the logic of how each couple was assessed for compatibility.

Transitioning Between Technologies (Section 4.3)

Potential Transition Triggers:

- Contaminants concentrations
  - Most likely to be contacted by the public or environment
  - Concentrations in a single key phase
- Contaminant phase (particularly free phase)
- Contaminant lineage, parent vs. daughters
- Site conditions created during method execution
- Cost per unit of contaminant destroyed

No associated notes.



This is an adaptation of the process developed to guide the transition from any aggressive remedy to MNA that was developed by the ITRC (ITRC EACO-1, 2008). Also see Section 6 for a detailed discussion of considerations for transitioning between technologies.

ITRC Technical & Regulatory Guidance for Enhanced Attenuation of Chlorinated Organics (EACO-1, 2008)

http://www.itrcweb.org/guidancedocument.asp?tid=50

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An Example to Pull It All Together (Section 4.4)

We want to couple:

- 14-Compartment Model
- OoMs
- Remedy Performance

To answer the question:

- Will I reach my objectives?

No associated notes.

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Source Area Excavation

ZONE / PHASE	Source					
	Low Permeability			Transmissive		
	Before	*Tech. Perf*	After	Before	*Tech. Perf*	After
Vapor	2	**3**	0	3	**3**	0
DNAPL	0	**3**	0	0	**3**	0
Aqueous	1	**3**	0	2	**3**	0
Sorbed	3	**3**	0	3	**3**	0

Key

Red	Equivalent aqueous conc. ~1000 µg/l
Orange	Equivalent aqueous conc. ~100 µg/l
Yellow	Equivalent aqueous conc. ~10 µg/l
Green	Equivalent aqueous conc. ~1 µg/l

ITRC IDSS-1, Figure 4-2

This is only the “Source” half of the 14-Compartment Model used in the example. Excavation is assumed to completely remove the source, effectively reducing each compartment to zero. In the “Plume” source, excavation will not result in zeroes for each phase.

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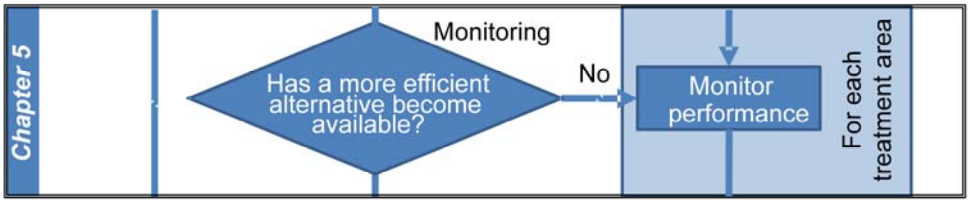
Section 4 Summary

- Three important concepts (Section 4.1)
  - Remediation is an Order of Magnitude (OoM) affair
  - OoMs go into 14-Compartment Model
  - Get OoMs from your experience, multiple site studies, or technology experts
- Coupling technologies (Section 4.2)
  - Examples: Active-then-passive; Source-vs.-plume
  - Use the Compatibility Matrix (Figure 4-2)
- Transitioning (Section 4.3)
  - IDSS flowchart (Figure 4-1) can help

No associated notes.

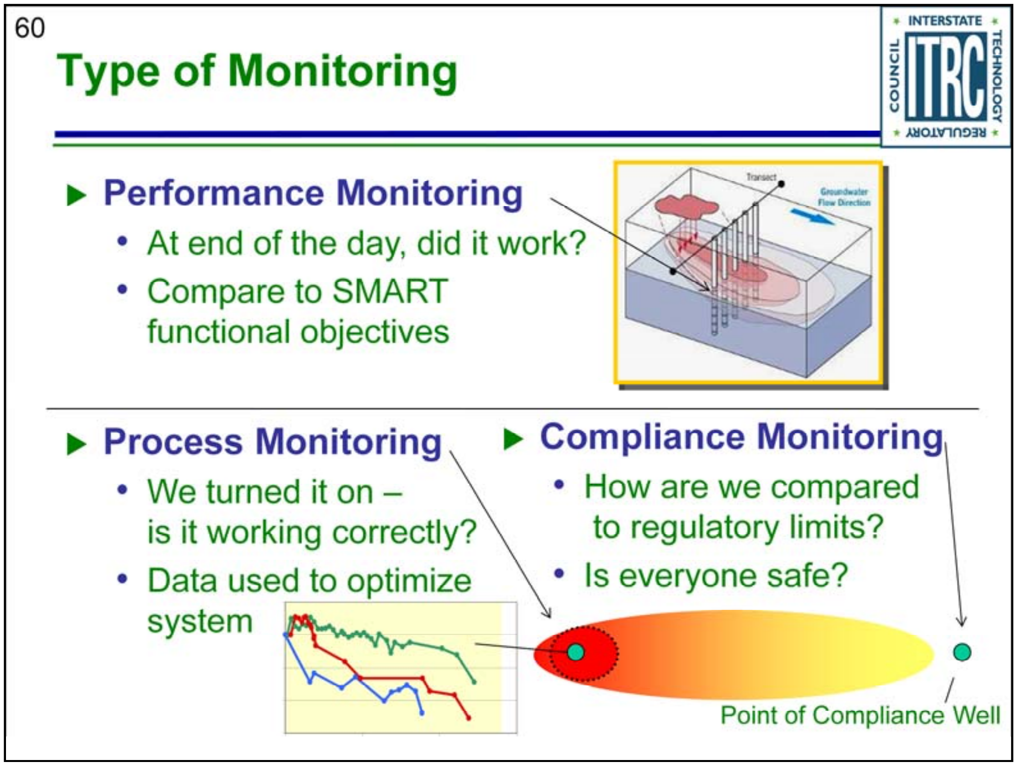
Chapter 5: Monitoring



- How do you design a monitoring program that assesses your progress towards reaching your functional objectives?
- What data should you collect to evaluate remedy performance?

Chapter 5 helps the user determine what data are needed to monitor the site to see if the remedy or remedies are performing as hoped/expected.

Specifically, two main questions are addressed in Chapter 5 (questions on slide).



There are three main types of monitoring: performance, process, and compliance. Each type if shown in the slide with a representative example and typical questions the monitoring should answer.

•Performance monitoring (at the top of the slide) assesses the effectiveness of the remedy in meeting the SMART objectives. The figure shows monitoring wells on a transect through the plume. Is the remedy reducing contaminant concentrations? Or, at the end of the day, is the remedy working?

•For process monitoring (on the left hand side of the slide) – the remedial system is being monitored to see if the system is meeting its functional objectives. For example during an ISCO injection, lots of system parameters are measure – pressures in the lines going into the aquifer with oxidant, flow rates, etc. These types of system parameters need to be monitored to make sure that the remedial system is operating properly or to determine if system performance could be improved. Going back to the ISCO example, is one section of a site more contaminated and need for oxidant or visa versa did one section of the achieve cleanup goals faster than expected? By conducting process monitoring, the remedial system can be optimized in the field using these parameters to improve overall performance.

•Finally compliance monitoring (on the right side of the slide) assess where the contamination levels are in comparison to regulatory limits and helps document the extent of the impact and status of exposure (if that is occurring at the site). These location are often selected through dialogue with stakeholders.

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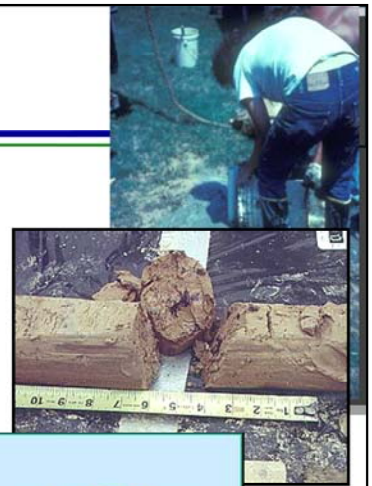
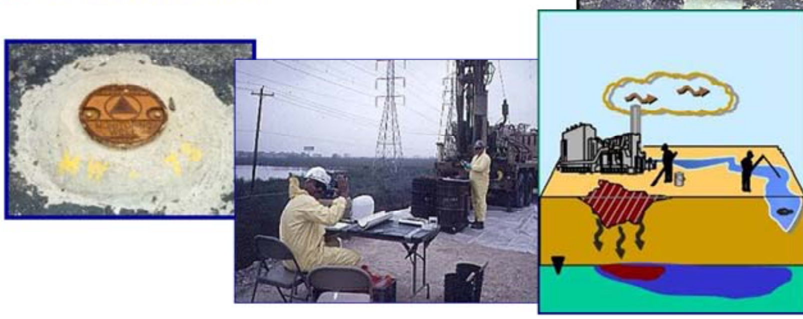
Media to Monitor

- DNAPL (if present)
- Aquifer matrix solids
- Soil gas
- Groundwater
- Surface water





Moving to the type of media to monitor, it is important to refer to the functional objectives – they should specify what media to monitor. The potential different types of media include: DNAPL, Aquifer matrix solids (aka aquifer sediment or soil), Soil Gas, Groundwater and Surface Water.

•DNAPL is often not seen at sites although concentrations can be quite high and indicative of DNAPL.

•Aquifer matrix solids can help in establishing baseline contamination levels. During and after remedial efforts, additional samples can be collected to monitor progress. It should be noted that sample representativeness is a limitation. Often small samples are collected and within these small samples there can be significant heterogeneity.

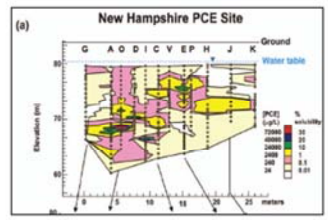
•Soil gas samples are collected if vapor intrusion is pathway of concern and could also be used as a qualitative screening tool to detect DNAPL source areas in the unsaturated zone.

•Groundwater is the ubiquitous media to monitor. Regulations are base on the media and mass flux/mass discharge are measured in these media.

•Surface water can be media to monitor depending on site conditions. For example, when contaminated ground water is discharging to a surface water body.

Metrics

- Concentration → mg/L, mg/kg, ppmv
- Mass of contaminants: → Kilograms
- Mass Flux / Mass Discharge → Grams per m^2 per day / Grams per day



The metrics for monitoring the media on the previous slide are summarized here.

•Concentration can be for groundwater, aquifer matrix soils, or soil gas.

•Mass of contaminants is typically in SI units – kilograms.

•Mass Flux is grams per square meter per day. Integrated over the area, mass discharge is in units of grams per day. For more information on mass flux and mass discharge, please see the ITRC Mass Flux-1 guidance document and training currently being provided.

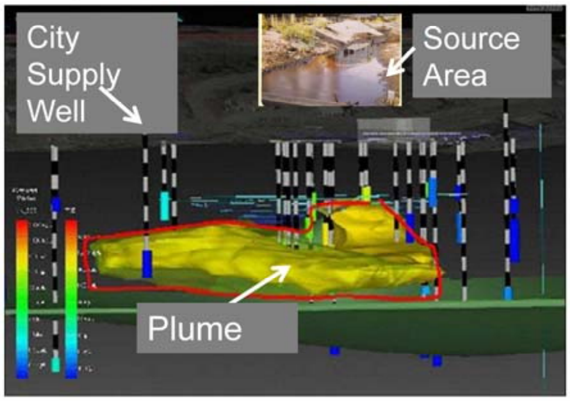
ITRC Use and Measurement of Mass Flux and Mass Discharge (MASSFLUX-1, 2010)

http://www.itrcweb.org/guidancedocument.asp?TID=82

Internet-based training: http://www.cluin.org/conf/itrc/ummfmd/

Data Evaluation

- Key concept: ***Maintaining*** and ***Improving*** the Conceptual Site Model
  - Visualization tools can help
  - Stats help you understand *trends*



After determining what data are relevant to your site, this slide moves into the data evaluation portion of Chapter 5.

•As noted by Chapter 2 speaker, the conceptual site model (CSM) must be maintained and viewed as a living document. As data are collected during remedy implementation, these data should be incorporated in the CSM. This will help improve understand of the site as well as evaluate remedy performance.

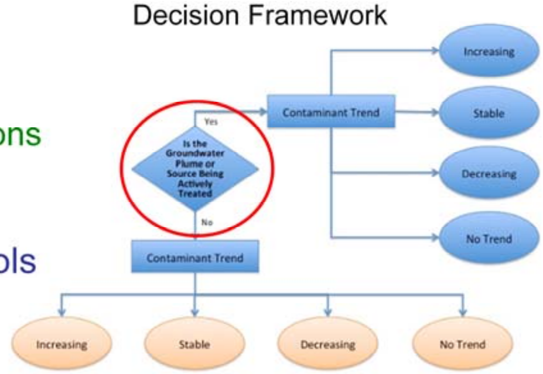
•Visualization tools (as shown here) can help the project team as well as stakeholders better understand the site and its progress over time.

•Additionally, statistics can help identify and determine trends.

Data Evaluation – Trends

- Trends
  - Remediated
  - Not remediated
  - Possible interpretations
  - Types of decisions needed
- Example statistical tools
  - MAROS
    - Free download: www.gsi-net.com
  - Summit monitoring tools
  - GTS algorithm

Decision Framework



ITRC IDSS-1, Figure 5-1

•Trending – One of most common statistical methods; is way to quantitatively describe the rate at which change is occurring

•Establishes rate at which functional objectives are being achieved and be used predicatively to estimate time required to achieve the objective

•Figure is one from the Chapter 5 that illustrates a decision framework from which to begin the data trend interpretation process

Begin at the text box circled in red

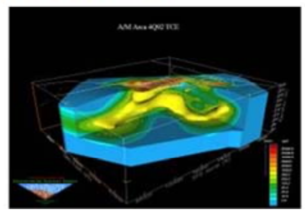
Step 1: Answer the question whether or not plume is being remediated

Step 2: Follow arrow to appropriate contaminant trend; blue - indicating remediation is occurring, or orange - indicating the remediation is not occurring

After establishing the behavior of your monitoring results from this figure you can refer to two tables (5-2 and 5-3) within the document that offer “Possible Interpretations” and “Types of Decisions Needed” based upon the trend.

Modeling for Performance Monitoring

- Source zone models
  - Simulates impact of remediation or MNA on source
- Fate and transport models
  - Evaluates plume stability
- Example:
  - *REMChlor* – Search "REMChlor EPA"
  - *NAS* – Search "Natural Attenuation Software"



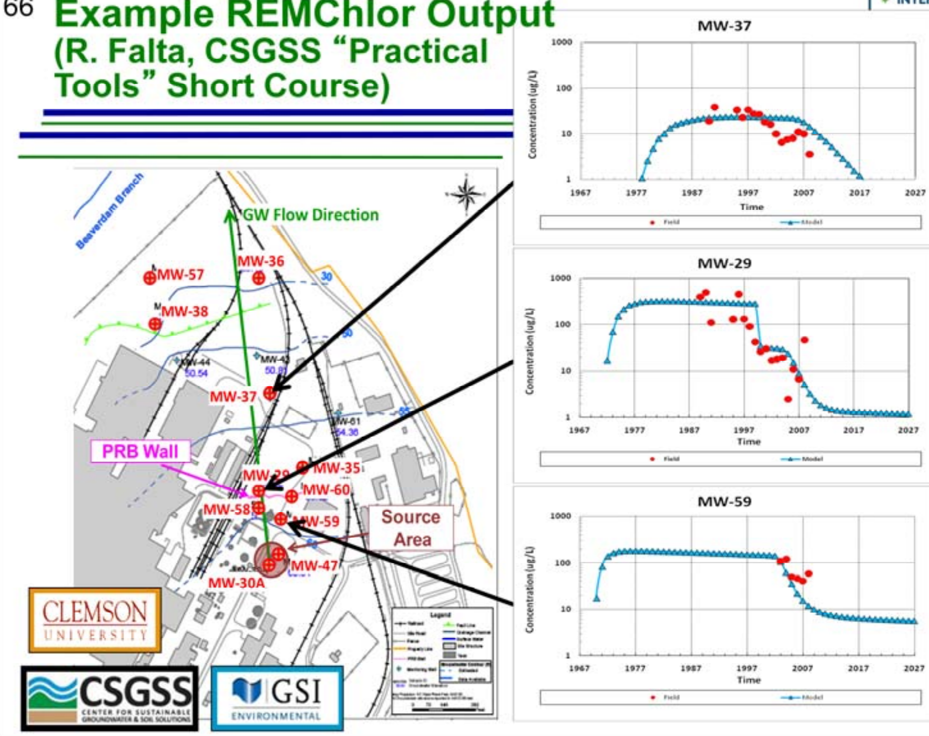
In addition to data trends, modeling the system can be a helpful and informative exercise. The use of modeling results should be used with other data to make an informed decision. Modeling should not be the sole basis for a decision.

•Source zone models can simulate what the impact of remediation on source zone could be.

•Fate and transport models attempt to model or simulate the 2 and 3 D plume movement. Typically, models are used to evaluate plume stability.

•For free model downloads, REMChlor and NAS (Natural Attenuation Software) are available. Each provides similar analyses and require data through the center line of the plume.

Example REMChlor Output (R. Falta, CSGSS "Practical Tools" Short Course)



No associated notes.

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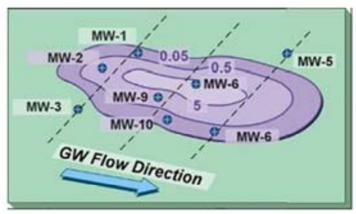
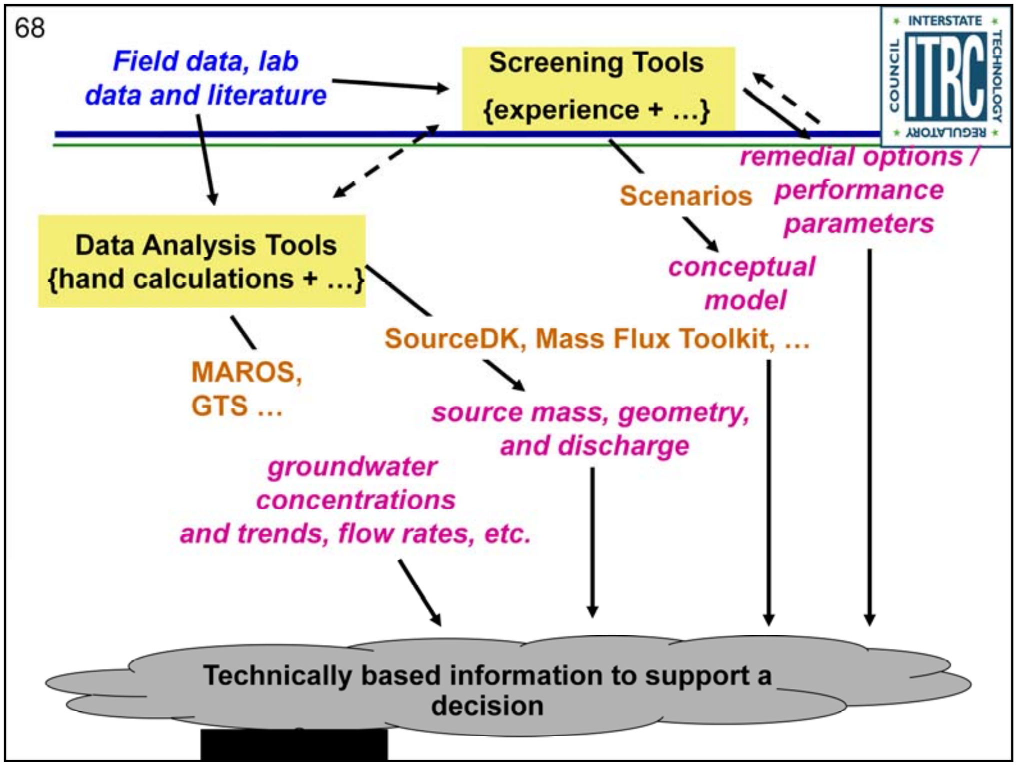
Optimizing Monitoring

- Monitoring network
  - Any redundant wells or data gap area?
- Frequency and duration
  - Do I need to sample quarterly? Lots of research.
- Contaminant and constituent
  - Can 1 or 2 compounds explain the big picture?
- *Key tools:*
  - *MAROS and GTS*



Finally, optimizing monitoring plans must be addressed. Over the timeframe of remedial action operation and into long term monitoring, the monitoring plan should be evaluated. Is the monitoring network still applicable? Are some wells already clean? Do they still need to be monitored? What about the frequency of monitoring? Maybe quarterly sampling isn't required once the plume is decreasing in size. Have the contaminants shifted? Are all analytes required? These are questions that should be asked when compiling monitoring reports and recommendation for changes in the monitoring strategy should be routine.

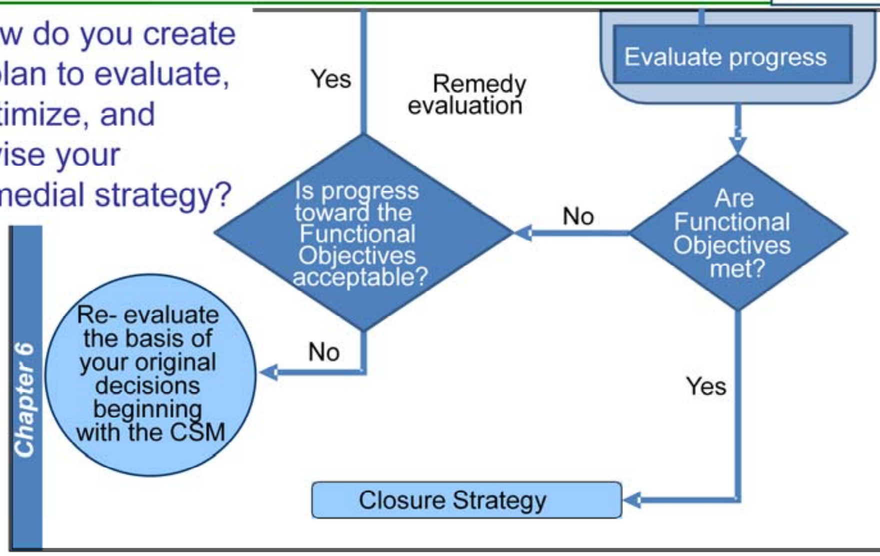
As with modeling, there are several free tools available online – MAROS and GTS are examples.



Finally, the monitoring strategy should oversee the collection of data with the understanding of how the data are to be evaluated. Will screening tools (right side) be used? Are certain parameters needed for the models? Or will Data Analysis Tools be used? Will all these options be used to feed into the cloud?

Chapter 6: Remedy Evaluation

- How do you create a plan to evaluate, optimize, and revise your remedial strategy?

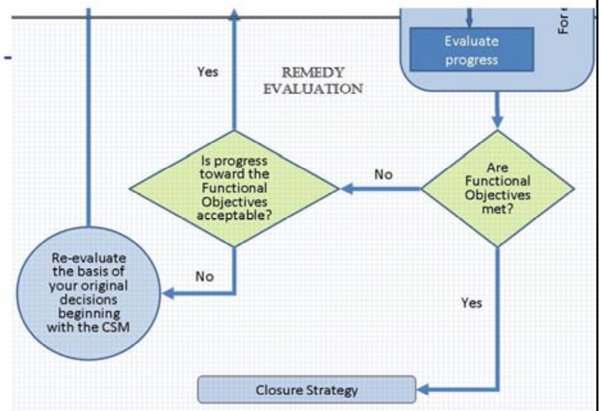


ITRC IDSS-1, Figure 1-2 excerpt

Now that a monitoring strategy has been discussed and the basis of data trends, the entire remedy evaluation can proceed in Chapter 6. As shown in the figure, the feedback loop here asks where the remedial strategy is.

Key Questions to Consider

- Are Functional Objectives being met - is progress acceptable?
- Can you be more efficient?
- How do you trouble-shoot if you are not?



ITRC IDSS-1, Figure 1-2 excerpt

Currently, re-evaluation of sites that are not meeting objectives often focuses on technology application without also re-evaluating whether the CSM or the absolute and functional objectives are impeding measureable progress.

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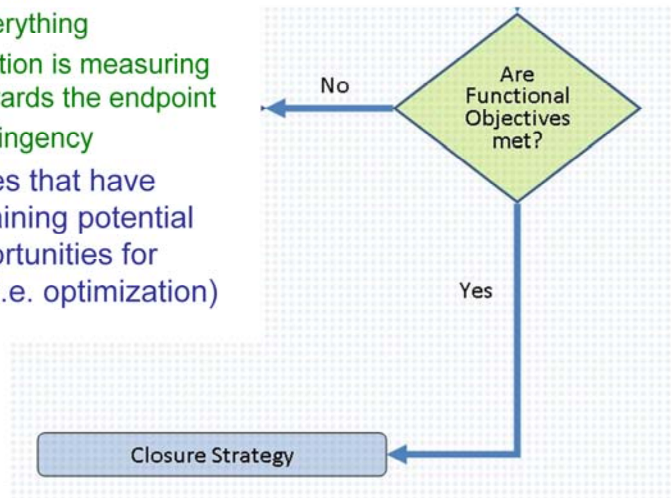
Are Objectives Being Met?

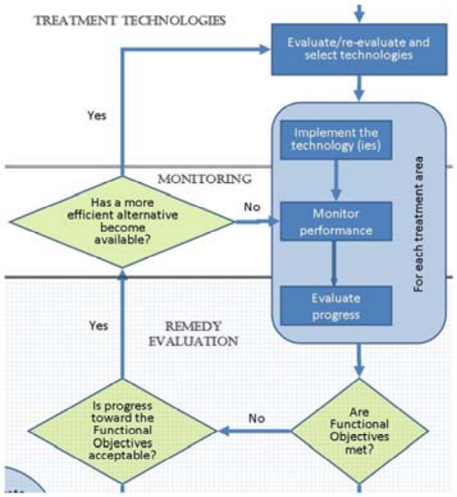
- Periodic evaluation
  - Timing is everything
  - Often evaluation is measuring progress towards the endpoint
  - Plan for contingency
- Identify changes that have occurred, remaining potential risks, and opportunities for improvement (i.e. optimization)



ITRC IDSS-1, Figure 1-2 excerpt

If a CERCAL site, does a 5-yr review provide sufficient time for review? Specifically, can progress be seen during the review? Therefore, review periods need to be consistent with timeframe of the functional objectives.

Remedy Optimization

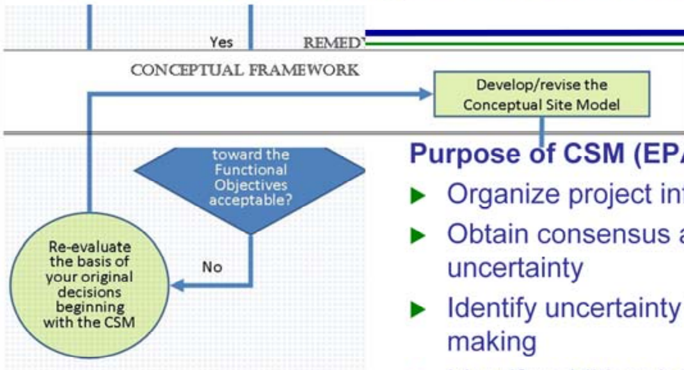


- Advances in long-term site management due to
  1. Dynamic nature of environmental law
  2. Improved technology
  3. Improved understanding of impacts of remedial actions
- Why optimize?
  - Enhanced operation of remedy
  - Cost reduction
  - Change in resource use
- Technology optimization
  - New/better practices
  - Technology advancement
  - Transition technology

ITRC IDSS-1, Figure 1- excerpt

Remedy Optimization important for determining whether best practices have been implemented at the site.

Troubleshooting: Revisit CSM



ITRC IDSS-1, Figure 1-2 excerpt

Purpose of CSM (EPA 2008):

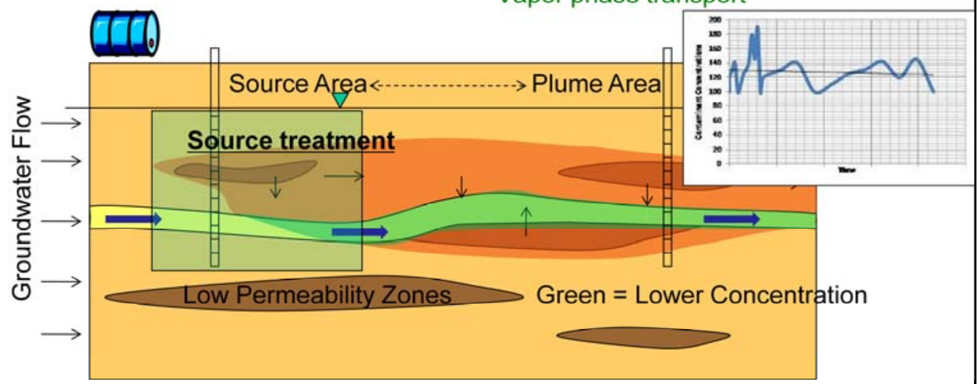
- Organize project information.
- Obtain consensus about sources of uncertainty
- Identify uncertainty that hampers decision-making
- Identify additional data needed to reduce uncertainties or to test assumptions
- Establish basis for
  - Decisions about risk/ remediation/ reuse
  - Decisions regarding remedial cost-effectiveness and efficiency
  - Identifying decision units (i.e., area/volume, or objects treated as a unit)

We start looking at the third question for this chapter. "How do I trouble shoot if the functional objectives are not being met at an acceptable rate?"

Basically, you loop back to the top of the flow chart. Back up to the CSM discussion. Let's revisit the purpose of a CSM. A CSM incorporates all the available information from a site into a common understanding. This common understanding provide the basis for decisions – remedies, need for additional investigation, and recognition of uncertainty at the site.

Troubleshooting: Revisit CSM

- Common inaccuracies
  - 3D delineation
  - Boundary conditions
  - Surface features
  - Multiple / alternate source
  - Age and nature of release
  - Heterogeneity
  - Diffusion
  - Seasonal changes
  - Preferential pathways
  - Vapor phase transport



As CSMs at chlorinated solvent site are complex, minor inaccuracies in one or more elements can be multiplicative and compound the error in understanding the site. Typical components of the CSM related to the source zone and plume structure are listed here. You can see how these items are interdependent.

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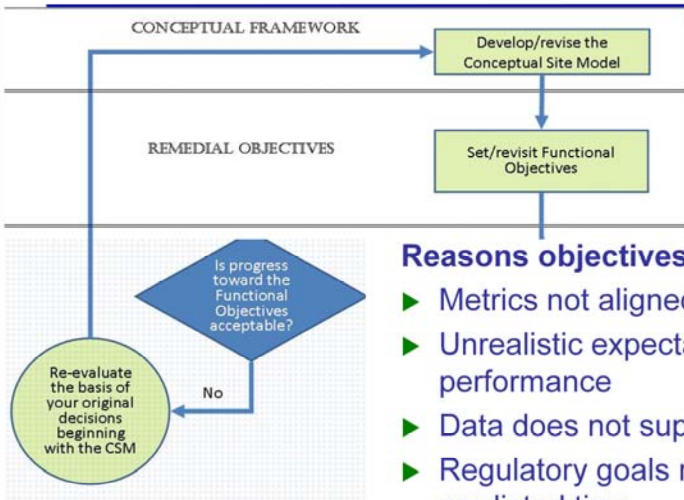
Troubleshooting: Revisit Objectives



ITRC IDSS-1, Figure 1-2 excerpt

Reasons objectives don't work:

- Metrics not aligned with objectives
- Unrealistic expectations of technology performance
- Data does not support objectives
- Regulatory goals not achievable in predicted time
- Lack of interim objectives
- **NEED TO BE SMART**

After addressing concerns in Section 2, let's move to Section 3 and revisit the objectives.

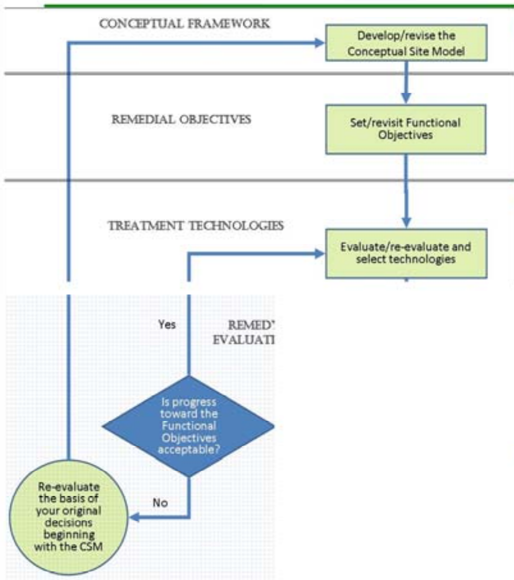
•Metrics – do not mesh with functional objectives or could be miss-applied metrics such as using residential standard in an industrial setting.

•Unrealistic expectation of technology performance – remedies for DNAPL were often developed assuming that ONE technology would achieve closure requirements. But we known now these expectations are often not realistic.

• Data do no support objectives – meaning the data do not help evaluate the objectives or determine if the remedy is approaching the functional objectives.

•Regulatory goals and lack of interim objectives go together in that if goals go beyond a generation (as noted previously in this training), then interim goals should be developed to help track process.

Troubleshooting: Technology

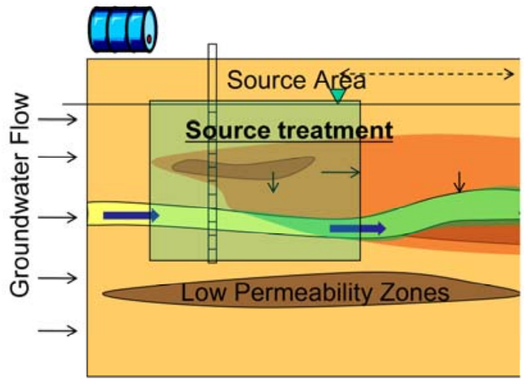


ITRC IDSS-1, Figure 1-2 excerpt

- Technology performance evaluation
  - Expected versus actual performance
- Technology performance expectations
  - Appropriate technologies based on the revised site understanding and the actual performance of technologies already employed
- Technology cessation/ addition/transition –
  - Re-evaluate the technology(ies) in use to other applicable technologies

Once the objectives are all ironed out, begin troubleshooting the technology.

Technology Decisions



- Continue with existing technology
- Optimize existing technology
- Cease operation
- Transition to another approach

The information from the three categories on the previous slide come together to make decision regarding whether to:

Continue with existing technology

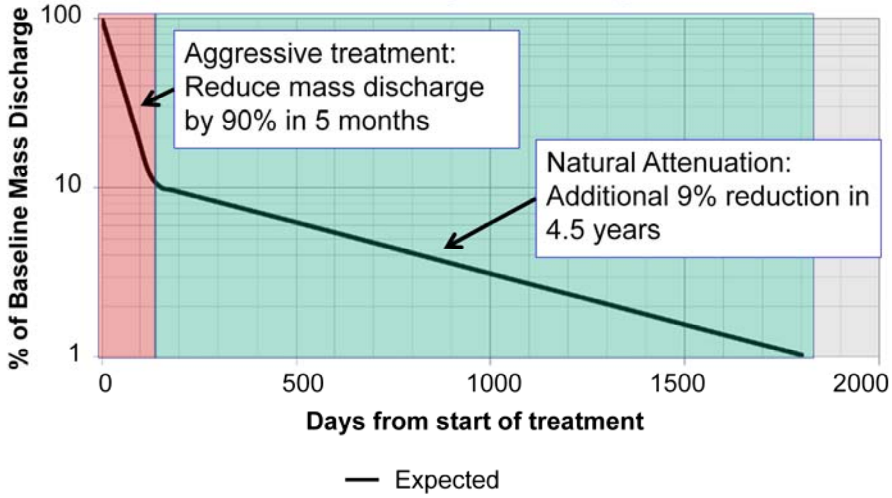
Optimize existing technology

Cease operation

Transition to another approach

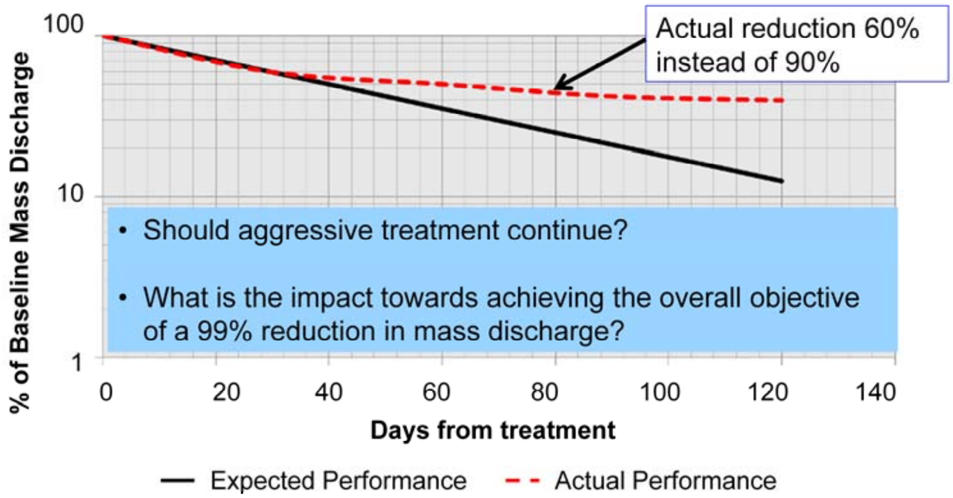
Example: Remedial Decision Making

Overall Objective: Decrease mass discharge from source zone by 99% in 5 years



To illustrate the technology implementation decision points, let’s cover an example.

Actual vs. Predicted Performance



No associated notes.

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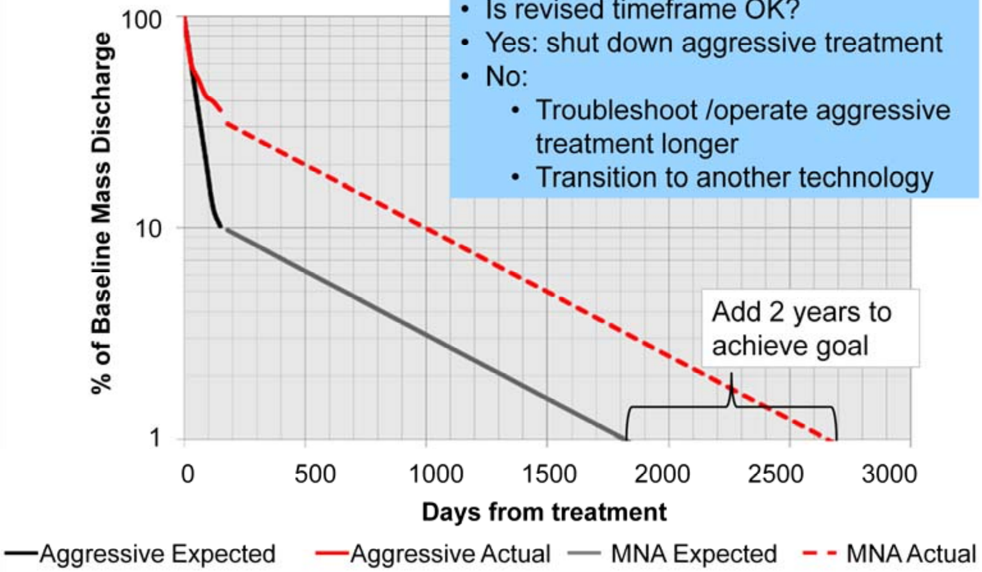
Impact of Reduced Treatment Efficiency and Decision Making

- Is revised timeframe OK?
- Yes: shut down aggressive treatment
- No:
  - Troubleshoot /operate aggressive treatment longer
  - Transition to another technology



No associated notes.

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Remedy Evaluation Summary

- CSM is a living document
- Functional objectives must be SMART
- Plan transitions to other technologies
- Repeated performance evaluation
- Reevaluate your Strategy (IDSS)

No associated notes.

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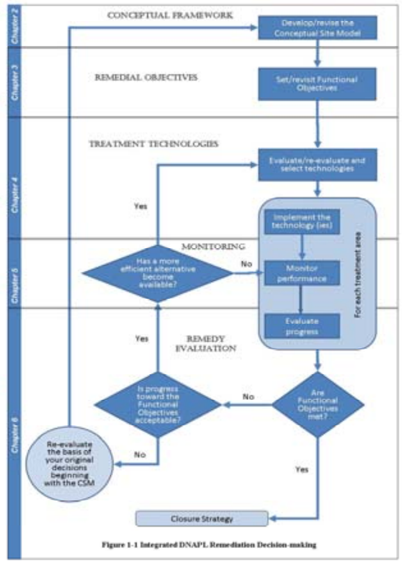
Course Summary: Problem and Solution

- Problem: spending money and time at chlorinated solvent sites with little improvement due to:
  - Incomplete understanding of DNAPL sites
  - Complex matrix – manmade and natural
  - Unrealistic remedial objectives
  - Selected remedy is not satisfactory
- Solution: ITRC guidance documents
  - Today's class on **Integrated DNAPL Site Strategy** (IDSS-1, 2011) – guidance and training
  - **Integrated DNAPL Site Characterization and Tools Selection** (ISC-1, 2015) – guidance and training
  - **Use and Measurement of Mass Flux and Mass Discharge** (MASSFLUX-1, 2010) – guidance and training

No associated notes.

After Today's Class, Apply the ITRC Document to Develop an Integrated DNAPL Site *Strategy*

- Conceptual site model
  - Chapter 2
- Remedial objectives
  - Chapter 3
- Remedial approach
  - Chapter 4
- Monitoring approach
  - Chapter 5
- Evaluating your remedy
  - Chapter 6



ITRC IDSS-1, Figure 1-2

The IDSS guidance will improve the management of any remedial project

Also from ITRC: Integrated DNAPL Site *Characterization*

Integrated DNAPL Site Characterization and Tools Selection (ISC-1, 2015) – guidance and training

Benefits

- More accurate conceptual site models (CSMs)
- Improved predictability of plume behavior and risks
- More defensible knowledge of contaminant distribution
- Facilitates communication
- Reduced uncertainty
- Better performing remedies

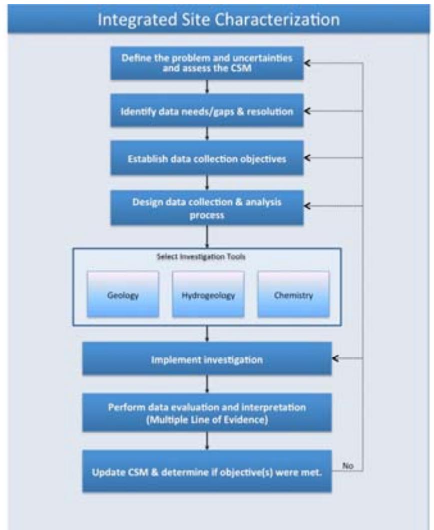


Figure 4-1 Integrated Site Characterization

ITRC ISC-1, Figure 4-1

Benefits of using ITRC Technical and Regulatory Guidance Document: **Integrated DNAPL Site Characterization (ISC-1, 2015)**

Better performing remedies and improved predictability of plume behavior and risks.

Increased spatial precision and accuracy of characterization data, leading to more accurate CSMs.

More defensible knowledge of contaminant distribution.

Improved selection of remedial measures to address subsurface zones that feed plumes and drive up potential exposure.

Use of real-time field screening tools for site characterization that may minimize the number of permanent monitoring wells, thus providing more optimal use of available personnel and financial resources.

Facilitates communication of site conditions and improves enhanced stakeholder understanding and involvement.

Reduced uncertainty in risk evaluation, remedy selection, and site management decisions, leading to better reductions in risk and protection of natural resources.

Use of real-time field screening tools for site characterization that may minimize the number of permanent monitoring wells, thus providing more optimal use of available personnel and financial resources.

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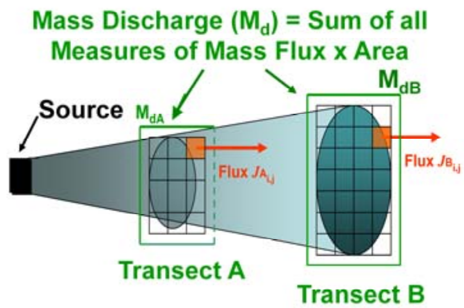
Also from ITRC: Mass Flux and Mass Discharge

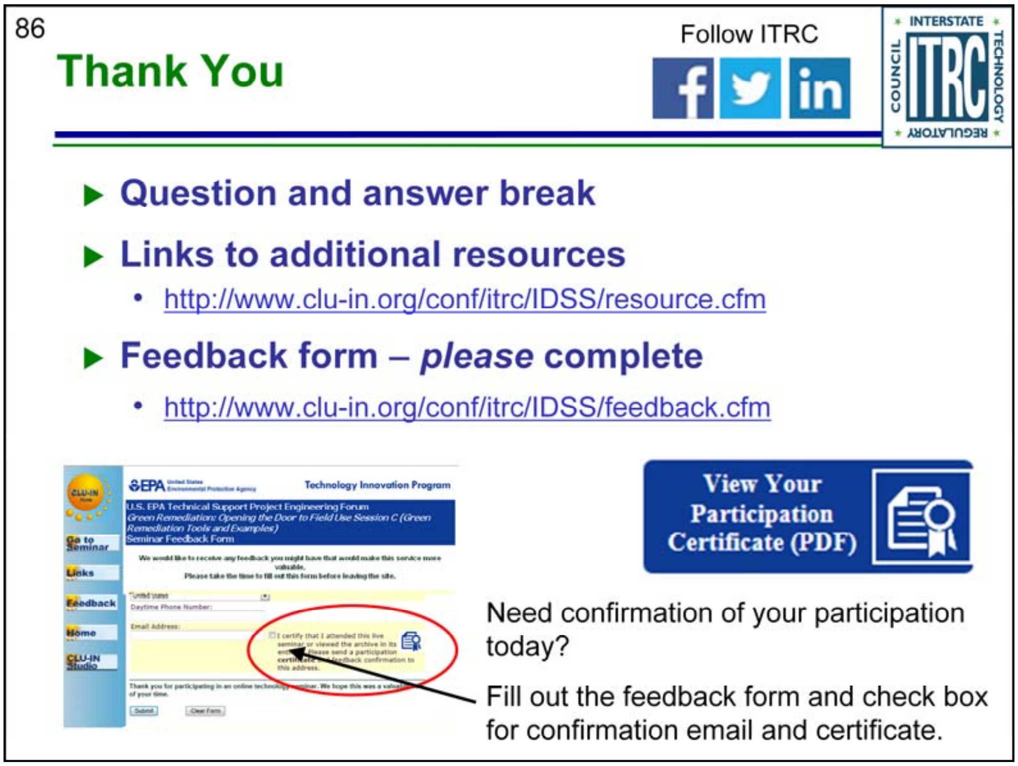
ITRC's Use and Measurement of Mass Flux and Mass Discharge (MASSFLUX-1, 2010) – guidance and training



Benefits

- Estimating mass may
  - Improve conceptual site models
  - Enhance remedial efficiency
  - Refinement of exposure assessment
- More effective site management
- Can use historical data and existing monitoring networks in some cases
- Can enhance compliance measurements

No associated notes.



Links to additional resources:
http://www.clu-in.org/conf/itrc/IDSS/resource.cfm

Your feedback is important – please fill out the form at:
http://www.clu-in.org/conf/itrc/IDSS/feedback.cfm

The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:

✓Helping regulators build their knowledge base and raise their confidence about new environmental technologies

✓Helping regulators save time and money when evaluating environmental technologies

✓Guiding technology developers in the collection of performance data to satisfy the requirements of multiple states

✓Helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations

✓Providing a reliable network among members of the environmental community to focus on innovative environmental technologies

How you can get involved with ITRC:

✓Join an ITRC Team – with just 10% of your time you can have a positive impact on the regulatory process and acceptance of innovative technologies and approaches

✓Sponsor ITRC's technical team and other activities

✓Use ITRC products and attend training courses

✓Submit proposals for new technical teams and projects