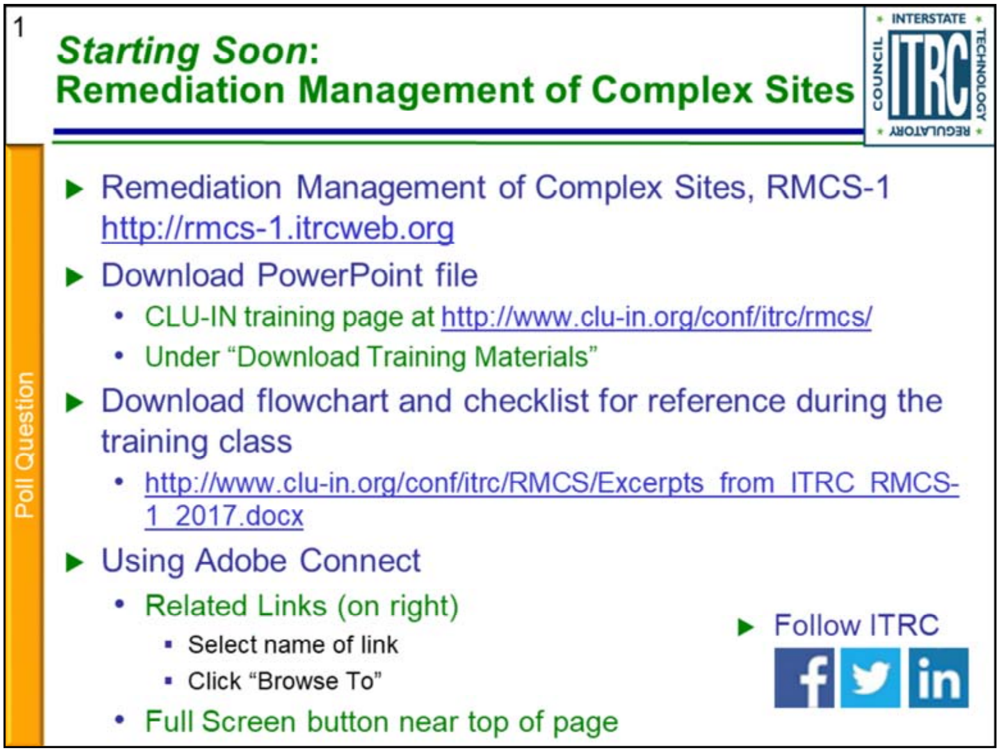


Poll: Have you worked on a complex site?

Yes

No

Not sure

Poll: What makes a site complex?

Geologic conditions

Hydrogeologic conditions

Geochemical conditions

Contaminant-related conditions

Large-scale

Surface access

Long remedial time frames

Overlapping regulatory responsibilities and changing regulations

Setting achievable site objectives

Maintaining effective institutional controls

Changes in land use

Funding considerations

Other

Training Overview - Remediation Management of Complex Sites (RMCS-1)

http://rmcs-1.itrcweb.org

At some sites, complex site-specific conditions make it difficult to fully remediate environmental contamination. Both technical and nontechnical challenges can impede remediation and may prevent a site from achieving federal- and state-mandated regulatory cleanup goals within a reasonable time frame. For example, technical challenges may include geologic, hydrogeologic, geochemical, and contaminant-related conditions as well as large-scale or surface conditions. In addition, nontechnical challenges may also play a role such as managing changes that occur over long time frames, overlapping regulatory and financial responsibilities between agencies, setting achievable site objectives, maintaining effective institutional controls, redevelopment and changes in land use, and funding considerations.

This training course and associated ITRC guidance: Remediation Management of Complex Sites (RMCS-1, 2017), provide a recommended holistic process for management of challenging sites, termed "adaptive site management." This process is a comprehensive, flexible, and iterative process that is well-suited for sites where there is significant uncertainty in remedy performance predictions. Adaptive site management includes the establishment of interim objectives and long-term site objectives that consider both technical and nontechnical challenges. Periodic adjustment of the remedial approach may involve multiple technologies at any one time and changes in technologies over time. Comprehensive planning and scheduled evaluations of remedy performance help decision makers track remedy progress and improve the timeliness of remedy optimization, reevaluations, or transition to other technologies/contingency actions.

By participating in this training course we expect you will learn to apply the ITRC guidance document to:

- Identify and integrate technical and nontechnical challenges into a holistic approach to remediation
- Use the Remediation Potential Assessment to identify whether adaptive site management is warranted due to site complexity
- Understand and apply adaptive site management principles
- Develop a long-term performance-based action plan
- Apply well-demonstrated techniques for effective stakeholder engagement
- Access additional resources, tools, and case studies most relevant for complex sites
- Communicate the value of the guidance to regulators, practitioners, community members, and others

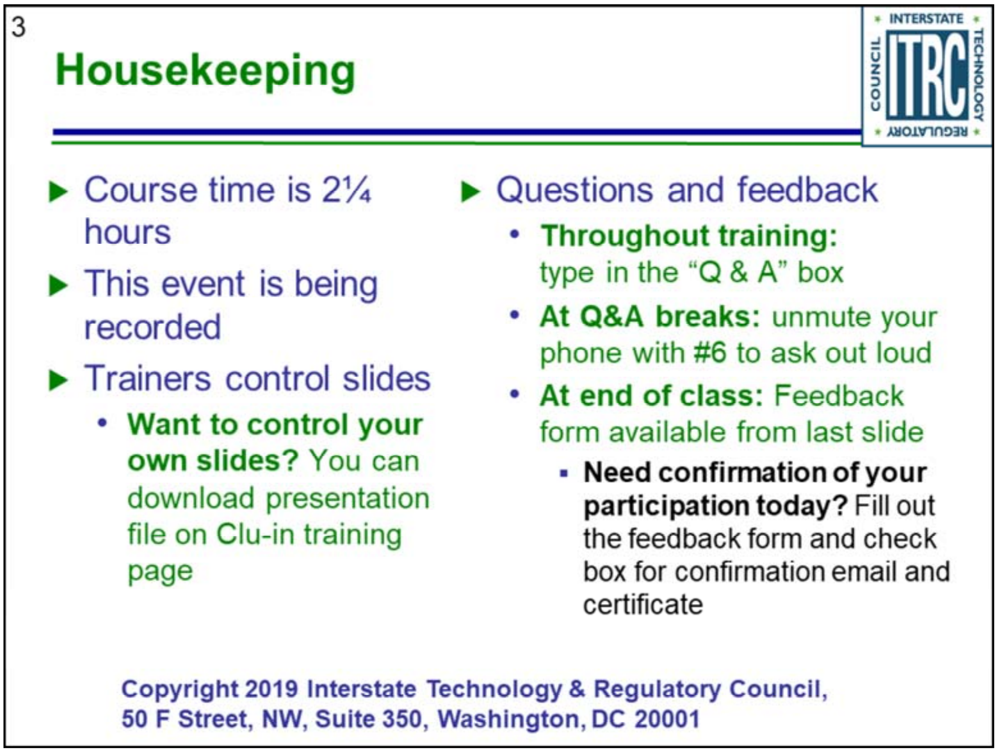
Ultimately, using the guidance that can lead to better decision making and remediation management at complex sites. The guidance is intended to benefit a variety of site decision makers, including regulators, responsible parties and their consultants, and public and tribal stakeholders.

Case studies are used to describe real-world applications of remediation and remediation management at complex sites. Training participants are encouraged to view the associated ITRC guidance Remediation Management of Complex Sites (RMCS-1, 2017) prior to attending the class.

ITRC (Interstate Technology and Regulatory Council) www.itrcweb.org

Training Co-Sponsored by: US EPA Technology Innovation and Field Services Division (TIFSD) (www.clu-in.org)

ITRC Training Program: training@itrcweb.org; Phone: 402-201-2419

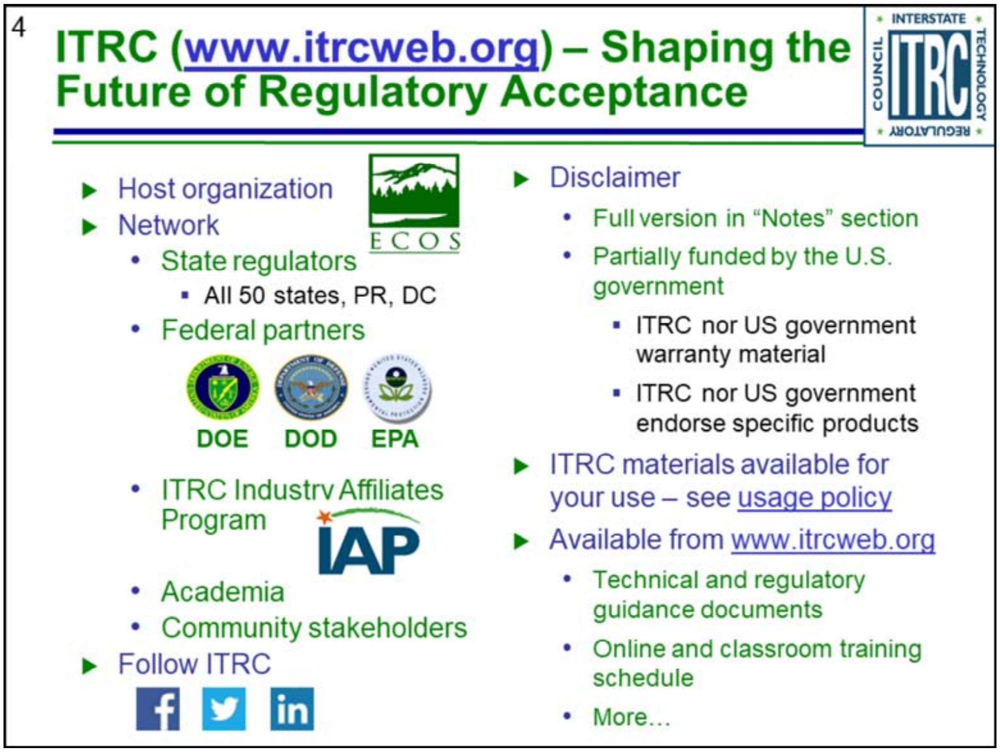


Notes:

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.



Notes:

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.

John Price III is the Tri-Party Agreement Section Manager for the Washington Department of Ecology in Richland, Washington. John has worked with the Nuclear Waste Program since 2000. John administers the Federal Facility Agreement and Consent Order for the US Dept of Energy Hanford site in WA state, and is his program's tribal liaison to three tribal nations with ceded rights at the Hanford site. He supervises a ten-person team including five hazardous waste compliance inspectors and two Natural Resource Damage Assessment specialists. He has over 35 years experience cleaning up radioactively contaminated sites in 17 states. John was an ITRC team member for Determining Cleanup Goals at Radioactively Contaminated Sites: Case Studies (2002), and since 2014 has been a team leader for Remediation Management of Complex Sites. John earned a bachelor's degree in Hydrology from the University of Arizona in Tucson, Arizona in 1979 and holds Washington licenses in Geology and Hydrogeology.

Roy Thun is a Senior Environmental Specialist with GHD, Santa Clarita, California. Since 1987, Roy has built his expertise as an accomplished environmental portfolio manager and complex site strategy expert working in both environmental consulting and a Fortune 100 energy company. His expertise includes developing integrated site strategies and closure options for complex sites, CERCLA, stakeholder engagement, multi-party site coordination, consent decree negotiations, application of institutional controls, NRD negotiations, and independent review. Roy co-leads GHD's complex site strategy reviews, helping clients find cost-effective, reasonable & attainable remedial objectives and timelines for their sites. Roy is the Program Advisor for ITRC's TPH Risk Evaluation at Petroleum Contaminated Sites and current member of the ITRC PFAS team. He previously participated on ITRC's Long-Term Contaminant Management Using Institutional Controls team. Roy is also a contributor to several ASTM environmental liability standards. Roy earned a bachelor's of science degree in geology from California State University Northridge in 1988 and a master's in business administration (MBA) from Pepperdine University in Los Angeles, California in 1995. Roy is a Professional Geologist, ISI Envision Sustainability Professional (ENV. SP), and Los Angeles County Metro Sustainability Council Member.

Charles (Chuck) J. Newell, Ph.D., P.E. is a Vice President of GSI Environmental Inc. in Houston, Texas and has worked for GSI since 1989. His professional expertise includes site characterization, groundwater modeling, non-aqueous phase liquids, risk assessment, natural attenuation, bioremediation, non-point source studies, software development, and long-term monitoring projects. He is a member of the American Academy of Environmental Engineers, a NGWA Certified Ground Water Professional, and an Adjunct Professor at Rice University. He has co-authored five U.S. EPA publications, eight environmental decision support software systems, numerous technical articles, and two books: Natural Attenuation of Fuels and Chlorinated Solvents and Ground Water Contamination: Transport and Remediation. He has taught graduate level groundwater courses at both the University of Houston and Rice University. He has been awarded the Hanson Excellence of Presentation Award by the American Association of Petroleum Geologists, the Outstanding Presentation Award by the American Institute of Chemical Engineers, and the 2001 Wesley W. Horner Award by the American Society of Civil Engineers (for the paper, "Modeling Natural Attenuation of Fuels with BIOPLUME III"). Chuck was cited as the Outstanding Engineering Alumni from Rice University in 2008 and for the ITRC Environmental Excellence Award in 2016. He earned a bachelor's degree in Chemical Engineering in 1978, a master's degree in Environmental Engineering in 1981, and a Ph.D. in Environmental Engineering in 1989, all from Rice University in Houston Texas. Chuck is a professional engineer registered in Texas.

Michael Truex is a Senior Project Manager at Pacific Northwest National Laboratory (PNNL), Richland, Washington. Since 1992 he has worked in remediation research and field applications. Mike's experience includes work at Department of Energy (DOE), Department of Defense (DoD), and private remediation sites. Major programs include support to the DOE Hanford Site providing technical and programmatic support for assessing and implementing improved remediation and characterization technologies. Mike has also been a principle investigator for multiple treatability tests at the Hanford site. He has managed and participated in large programs providing technical support to the DoD installations and has been a co-principle investigator for multiple remediation technology demonstration projects funded through the DoD. In addition to authoring numerous journal articles and technical reports, Mike has also authored multiple technical guidance documents. He led publication of technical guidance documents for performance assessment of soil vapor extraction systems and for pump-and-treat remediation. He has also authored and contributed to documents that provide guidance for Monitored Natural Attenuation, evaluation of contaminant transport in the vadose zone, and development of conceptual models. Mike has contributed to the Remediation Management of Complex Sites ITRC team. He earned a bachelor's degree in mechanical engineering from the University of Illinois in Champaign-Urbana, IL in 1986 and a master's degree in environmental engineering from Washington State University in Pullman, WA in 1991.

Dr. Samuel L Brock retired January 2019 as the Subject Matter Expert for Toxicology for the Environmental Management Directorate, Technical Support Division of the United States Air Force Civil Engineer Center, San Antonio, Texas. As the Subject Matter Expert, his responsibilities included resolving problems or issues impacting toxicology and risk assessment concerning the conditions and vulnerabilities of systems extending across the Air Force and DoD. Responsibilities also included developing and advocating for required technical courses in conjunction with the Air Force Institute of Technology (AFIT) and/or other schools. He served as an invited Instructor at the Air Force Institute of Technology, Wright Patterson AFB, OH, from 2003 through 2015 and he was an internet-based training Instructor on the ITRC Project Risk Management for Site Remediation technical guidance from 2011 through 2014 as well as Remediation Management of Complex Sites technical guidance from 2018 and continues as an "Emeritus" trainer. He represented the Air Force on working groups developing National and DoD guidance on remediation risk management, explosive risk assessment, vapor intrusion, and bioavailability of contaminants in soil and sediments. Sam has been a member of the ITRC Remediation Risk Management Team, the ITRC Green and Sustainable Remediation Team; the Remediation Management of Complex Sites Team and currently, the Implementing Advanced Site Characterization Tools Team. Sam regularly presented at professional meetings and technical forums on remediation topics. His recent work included supporting DoD Materials of Emerging Regulatory Interest working groups and Military Family Housing Privatization Initiative activities addressing persistent legacy pesticides in soil. Sam developed and deployed an initiative software-enabled process to implement principles and practices for Remediation Management of Complex Sites across the Air Force Enterprise portfolio of difficult, high cost sites. Sam received a Doctorate in Veterinary Medicine from Purdue University in West Lafayette, Indiana in 1970 and a Master of Public Health, Epidemiology from University of North Carolina in Chapel Hill in 1976. He is a Licensed Veterinarian in Texas and is certified by the American College of Veterinary Preventive Medicine.

6

The Challenge – Meeting Site Objectives at Complex Sites

- Complete remediation (no use restrictions) is a significant challenge at complex sites
- ITRC team definition of a complex site:
  - Remediation progress is uncertain and remediation may not achieve closure or even long-term management within a reasonable time frame
  - "Reasonable time frame" for restoring resources to beneficial use is subject to interpretation and depends on site circumstances

ITRC RMCS-1 Executive Summary

No associated notes

7

The Challenge – Meeting Site Objectives at Complex Sites

Aerial view of the Rocky Flats Site, Colorado
ITRC RMCS-1 Figure 15 (DOE 2017)

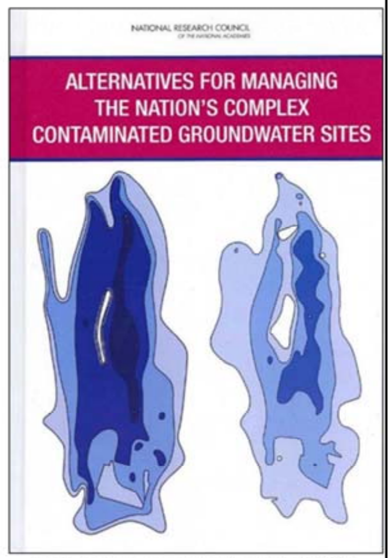
Delineating TCE plume in a residential area near Middlefield-Ellis-Whisman (MEW) Site, California
ITRC RMCS-1 Figure 12 (CPEO 2016b)

No associated notes

8

Complex Sites Nationwide

- National Research Council reported contaminant levels at 126,000 sites inhibit site closure
- Roughly 10% are “complex”
- Cost to complete = $127 billion
- Clear need for additional guidance



National Research Council, 2013

No associated notes

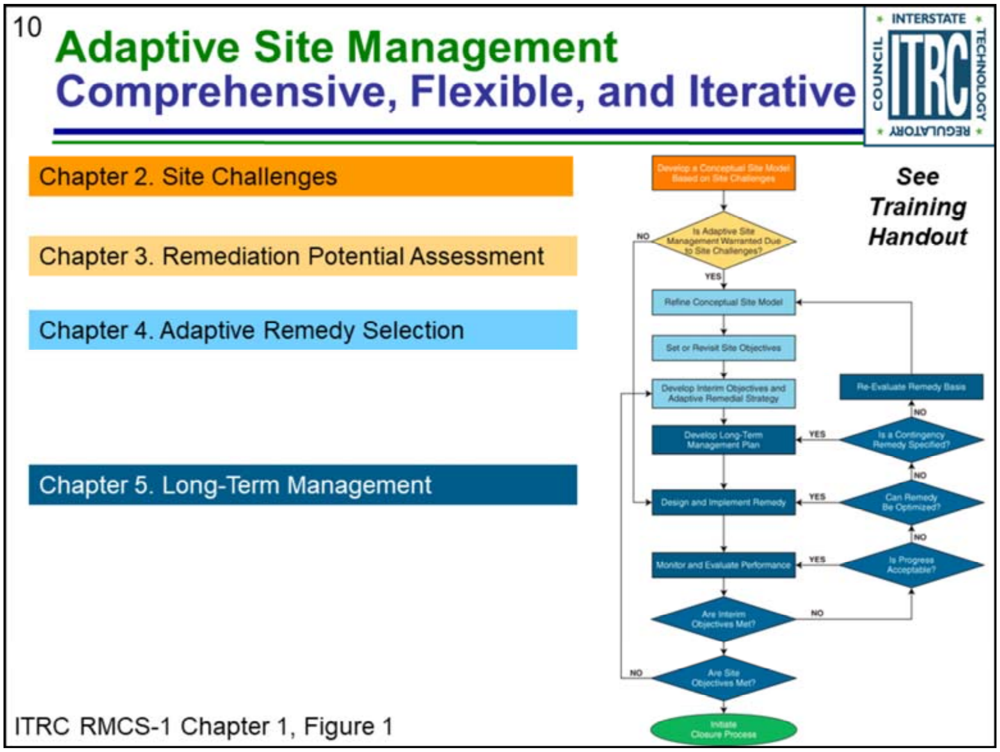
9

ITRC Guidance for Complex Sites

- Recommended process for complex sites
  - Adaptive site management
- Consolidates existing guidance, best practices, tools, and technologies
- 16 case studies - real-world applications

ITRC Technical and Regulatory Guidance
Remediation Management of Complex Sites
RMCS-1
http://rmcs-1.itrcweb.org

No associated notes



A full-page version of this flowchart is included in the ITRC RMCS-1 Excerpts document that was provided with registration information

11

Benefits of Adaptive Site Management

- Maintain protection of human health and the environment and fulfill regulatory obligations
- Base decisions on robust conceptual site models
- Streamline decision making and save costs
- Demonstrate interim progress that leads to long-term results
- Reduce barriers to using available remedial approaches
- Return sites to beneficial reuse

No associated notes

12

Case Study: Naval Air Station Jacksonville, Florida, Operable Unit 3

- Used adaptive site management
  - Discontinued interim remedial actions
  - Refined conceptual site model
  - Determined key exposure pathways
  - Adopted a risk-based remedial approach
- Several pilot studies, innovative tools and technologies

ITRC RMCS-1, Figure 28

No associated notes

13

Key to Your Success
Engage Stakeholders

- Stakeholders include citizen and Tribal communities, environmental advocacy members, and members of the affected public
- Methods for stakeholder involvement
  - Existing cleanup program processes
    - Restoration Advisory Board/stakeholder meetings
    - Public outreach and community meetings
  - Planning process
  - Adaptive site management

ITRC RMCS-1, Chapter 7

No associated notes

14

Case Study: Stakeholder Involvement at Middlefield-Ellis-Whisman Site

- Community members are constructive partners in decision-making
- Model permit process for cooperation between regulators and local land use planning jurisdictions

Vapor intrusion study area at Middlefield-Ellis-Whisman (MEW) site, California
ITRC RMCS-1, Figure 10, CPEO 2016a

No associated notes

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After Today's Training We Expect You Will Be Able To:

- Identify and integrate technical and nontechnical site challenges presented by complex sites
- Use the Remediation Potential Assessment
- Apply adaptive site management principles
- Develop a long-term performance-based action plan
- Effectively engage stakeholders
- Access additional resources
- Communicate the value of this guidance

No associated notes

16

Today's Road Map

- Site challenges
- Remediation Potential Assessment
- Questions and answers
- Adaptive remedy selection
- Long-term management
- Preparing you to take action
- Questions and answers

No associated notes

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Site Challenges
Learning Objective

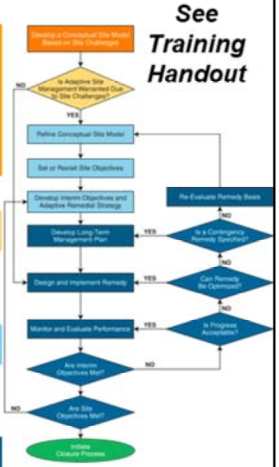
Chapter 2. Site Challenges

Identify and integrate technical and nontechnical site challenges into a holistic approach to remediation

Chapter 3. Remediation Potential Assessment

Chapter 4. Adaptive Remedy Selection

Chapter 5. Long-Term Management

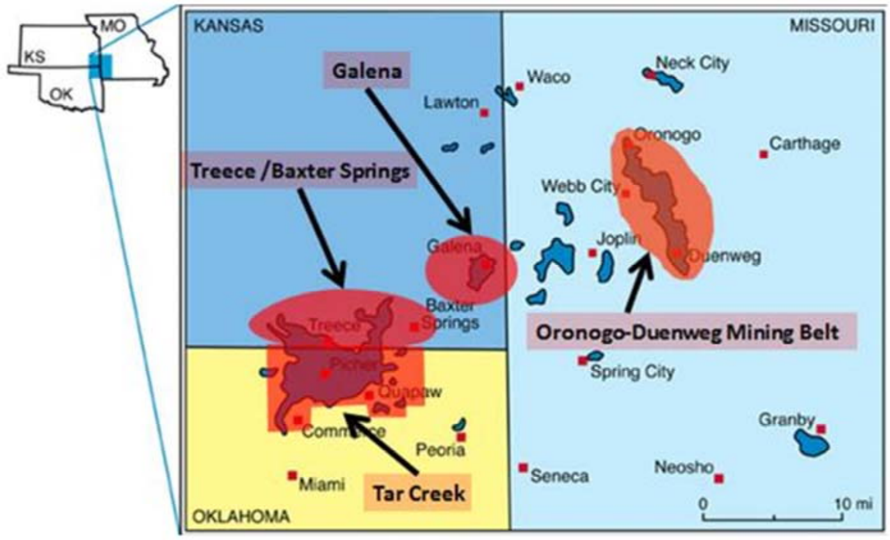


See Training Handout

ITRC RMCS-1, Figure 1

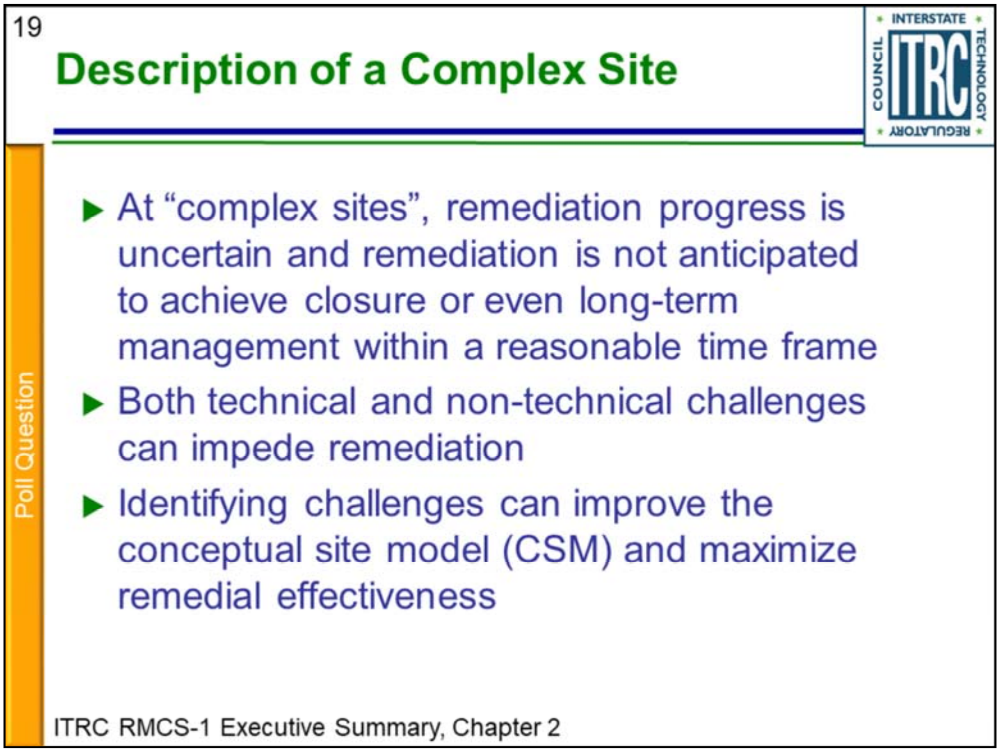
No associated notes

Complex Site?



ITRC RMCS-1, Figure 37, modified from Kansas Geological Survey, 2001

No associated notes

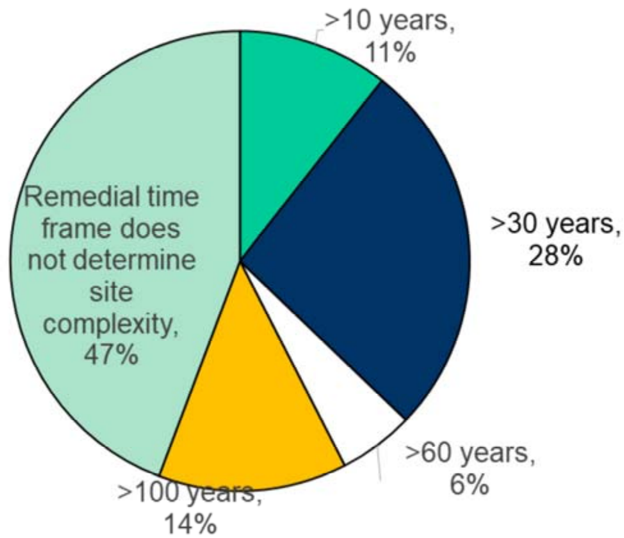


Poll: Which remediation time frame usually makes for a complex site?

- >10 years
- >30 years
- >60 years
- >100 years
- Time frame does not determine site complexity

20

ITRC Survey Results: Diversity of Responses – Remedial Time Frame



ITRC RMCS-1, Table 1

No associated notes

21

Identify Site Challenges

Technical Examples

- Geologic
- Hydrogeologic
- Geochemical
- Contaminant-related
- Large-scale

Non-Technical Examples

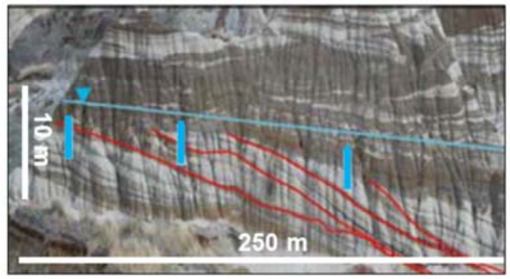
- Site objectives
- Changes over long time frames
- Regulatory
- Institutional controls
- Land use
- Funding

No associated notes

22

Identify Technical Challenges
Geologic Conditions

- Geologic heterogeneity/ preferential flow paths
- Fractured bedrock
- Karst bedrock
- Low-permeability media



Clay units (dark colored) dip from upper left to lower right, an example of stratigraphic heterogeneity Photo courtesy of Hubbard 2015

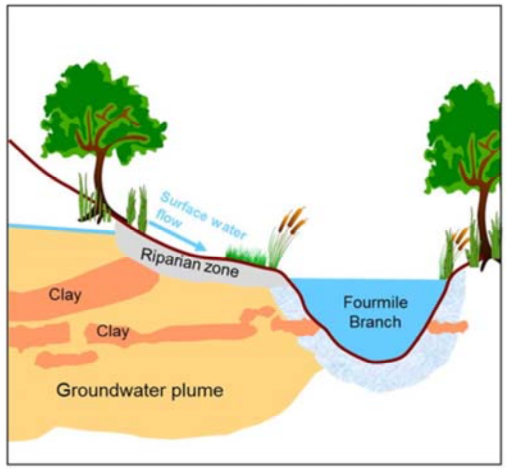
ITRC RMCS-1 Table 2

No associated notes

23

Identify Technical Challenges
Hydrogeologic Conditions

- Extreme or variable groundwater velocities
- Fluctuating water table
- Deep contamination
- Surface water and groundwater interactions and impacted sediment



Surface water/groundwater interactions downgradient of F-Area, Savannah River Site, South Carolina

No associated notes

24

Identify Technical Challenges
Geochemical Conditions

- Extreme geochemistry
  - Alkalinity, pH, redox conditions, salinity, ionic strength, hardness
- Extreme groundwater temperatures
  - Geothermal sources
  - Low temperatures, permafrost

Low temperatures decrease biological activity at North Pole Refinery, Alaska, Redbullet16 / Wikimedia Commons

ITRC RMCS-1, Table 2

No associated notes

25

Identify Technical Challenges
Contaminant-Related Conditions

- Light or dense nonaqueous phase liquids (LNAPL or DNAPL)
- Recalcitrant contaminants
- High concentrations or multiple contaminants
- Emerging contaminants

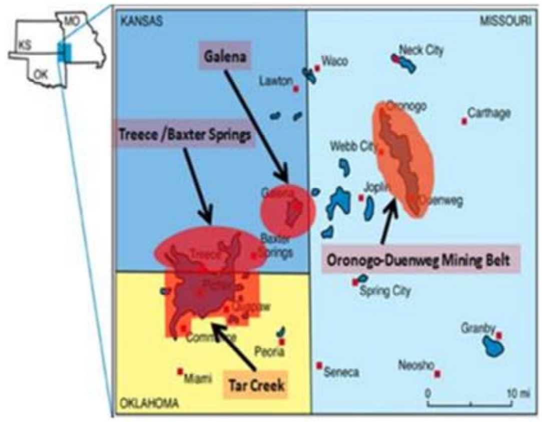
ITRC RMCS-1, Table 2; ITRC ISC-1 2015; ITRC IDSS-1 2015; ITRC Fractured Rock and PFAS Team Fact Sheets, 2017

No associated notes

26

Identify Technical Challenges
Large-Scale Sites

- Location and extent of contamination
- Depth of contamination
- Number, type and proximity of receptors
- Extensive or comingled plumes



ITRC RMCS-1, Table 2 and Figure 37, modified from Kansas Geological Survey, 2001

No associated notes

27

Technical Challenges Case Study: UGI Columbia Gas Site, Pennsylvania

Google Maps 2017

- Residual tar in river sediments, groundwater and deep in fractured bedrock
- Tar will slowly dissolve over centuries

No associated notes

28

Identify Non-Technical Challenges

- Site objectives
  - Changing site objectives
  - Societal expectations
  - Green and sustainable remediation
- Managing changes over long time frames
  - Phased remediation
  - Future use
  - Site management
- Regulatory
  - Federal and state cooperation
  - Changing laws and regulation
  - Orphan sites
  - Contaminants without regulatory guidance/criteria

ITRC RMCS-1, Table 3; ITRC GSR-2

No associated notes

29

Identify Non-Technical Challenges

- Institutional controls
  - Tracking and managing
  - Enforcing
  - Long-term management
- Land use
  - Changing land, water use
  - Multiple owners
  - Site access
- Funding
  - Lack of funds, political influence on program funding

Deer graze on Rocky Flats National Wildlife Refuge in Colorado
Footwarrior, Wikimedia Commons

ITRC RMCS-1, Table 3; ITRC IC-1, 2016

No associated notes

30

Non-Technical Challenges Case Study: Velsicol Site, Michigan

ITRC RMCS-1 Figure 46, Heidlauf 2017

- Contaminated city wells and Pine River
  - DNAPL pools 100 feet deep
- Livestock impacts and community economic hardship
- Limited funding prompted stakeholder involvement

No associated notes

31

Conceptual Site Model Maturity

General Environmental Cleanup Steps	CSM Life Cycle
Site Assessment	Preliminary CSM ↓ Baseline CSM
Site Investigation and Alternatives Evaluation	↓ Characterization CSM Stage
Remedy Selection	↓ Design CSM Stage
Remedy Implementation	↓ Remediation / Mitigation CSM Stage
Post-Construction Activities	↓ Post-Remedy CSM Stage
Site Completion	↓

Conceptual → Quantitative

USEPA, 2011a. Environmental cleanup best practices: Effective use of the project life cycle conceptual site model. EPA 542-F-11-011.

No associated notes

32

Site Challenges Summary

- Complex sites typically have multiple challenges
- Both technical and non-technical challenges can impede remediation
- Identifying them can improve the conceptual site model and maximize remedial effectiveness

No associated notes

33

Today's Road Map

- Introduction
- Site challenges
- Remediation Potential Assessment
- Questions and answers
- Adaptive remedy selection
- Long-term management
- Preparing you to take action
- Questions and answers

No associated notes

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Remediation Potential Assessment
Learning Objective

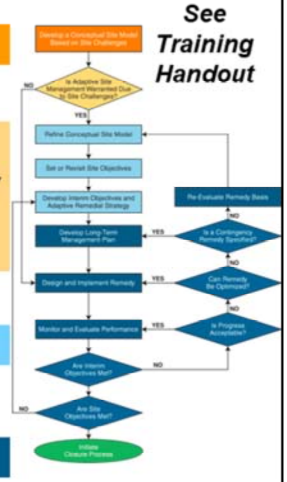
Chapter 2. Site Challenges

<u>Chapter 3. Remediation Potential Assessment</u>

Use the Remediation Potential Assessment to identify whether Adaptive Site Management is warranted due to site challenges

Chapter 4. Adaptive Remedy Selection

Chapter 5. Long-Term Management



See Training Handout

ITRC RMCS-1, Figure 1

No associated notes

35

Remediation Potential Assessment Process and Outcome

Process

- Screening tool uses weight-of-evidence approach to assess if site is likely to achieve remedial objectives in a reasonable time frame
- Basis for aligning expectations with actual remediation potential
- Promotes effective and transparent interaction

Outcome

- Site objectives are attainable OR
- Remediation potential is low – consider adaptive site management

ITRC RMCS-1, Figure 1

No associated notes

36

"Can You Get There?"

- Small, shallow site
- Sandy water bearing unit
- Low concentrations
- Benzene (attenuates fast)
- Very little non-aqueous phase liquid

Source: DanTD / Wikimedia Commons

No associated notes

37

"Can You Get There?"

- Small, shallow site
- Sandy water bearing unit
- Low concentrations
- BTEX (attenuates fast)
- Very little NAPL

- Large site, deep contamination
- Much of source under buildings
- Sand, silt, fractured clays
- Not much biodegradation
- Need > 99.9% reduction

Sources: DanTD / Wikimedia Commons, GSI Environmental

No associated notes

38

Remediation Potential Assessment Purpose

- Intended to inform the remedial decision process and determine if adaptive management process is beneficial
- Can allow for greater transparency and facilitate future reviews of the process
- Flexible process that can be modified as appropriate for the site

No associated notes

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Remediation Potential Assessment (RPA)

DOES:

- Allow flexibility and site-specific input in an iterative process
- Require detailed supporting data on the nature and extent of contamination
- Consider remediation potential of individual factors in context of other pertinent factors

DOES NOT:

- Provide a means to avoid requirements
- Evaluate whether a site is complex
- Directly consider cost
- Produce a default decision

No associated notes

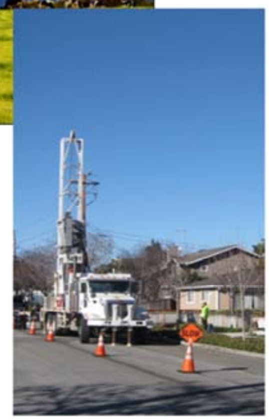
40

Remediation Potential Assessment
Key Criteria (Pre-Remedy)

8 Questions…

1. How difficult is it to work at the surface of the site?

Martin Abegglen / Wikimedia Commons



ITRC RMCS-1 Figure 12, CPEO, 2016b

No associated notes

41

Remediation Potential Assessment
Key Criteria (Pre-Remedy)

8 Questions…

1. How difficult is it to work at the surface of the site?

Laurent Deschodt / Wikimedia Commons

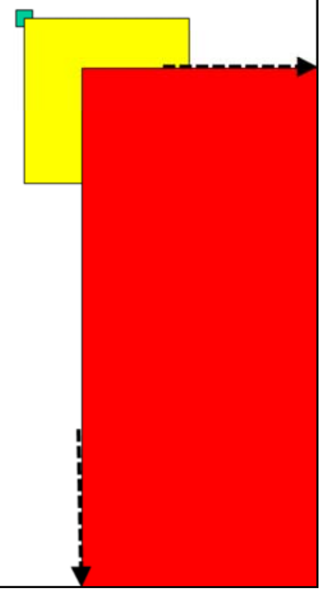
2. How difficult is it to drill at the site?

Wilson44691 / Wikimedia Commons

No associated notes

Remediation Potential Assessment
Key Criteria (Pre-Remedy)

3. What is the scale of the source zone or plume?



No associated notes

43

Remediation Potential Assessment
Key Criteria (Pre-Remedy)

3. What is the scale of the source zone or plume?
4. What contaminant concentration reduction is needed?

90% ?

99% ?

99.9% ?

99.99% ?

No associated notes

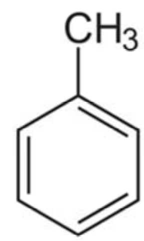
44

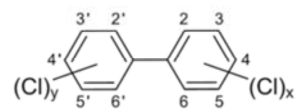
Remediation Potential Assessment
Key Criteria (Pre-Remedy)

3. What is the scale of the source zone or plume?

4. What contaminant concentration reduction is needed?

5. Do the key site constituents readily attenuate relative to the travel time to receptors?





Sources: Dschanz / Wikimedia Commons; Public Domain

No associated notes

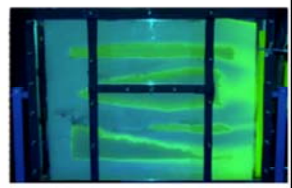
45

Remediation Potential Assessment
Key Criteria (Pre-Remedy)

3. What is the scale of the source zone or plume?
4. What contaminant concentration reduction is needed?

Al Silonov / Wikimedia Commons

5. Do the key site constituents readily attenuate relative to the travel time to receptors?
6. Does difficult-to-remove mass exist at the site?

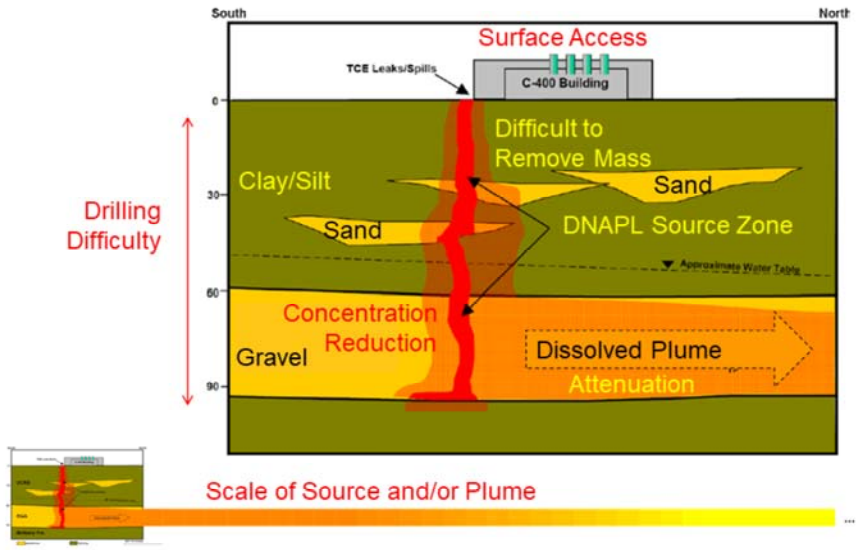


L. Donor., T. Sale, CSU

No associated notes

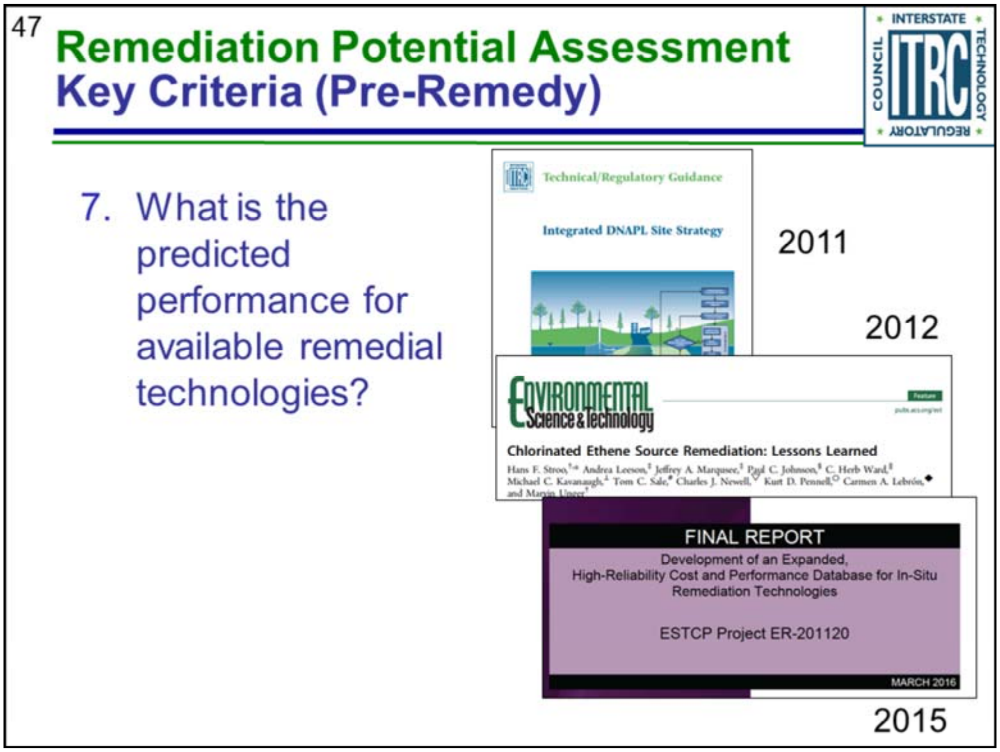
46

Case Study: Paducah Gaseous Diffusion Plant, Kentucky



ITRC RMCS-1, Figure 43 (DOE 2010a)

No associated notes



Full references:

Stroo, H.F., A. Leeson, J.A. Marqusee, P.C. Johnson, C.H. Ward, M.C. Kavanaugh, T.C. Sale, C.J. Newell, K.D. Pennell, C.A. Lebron, and M. Unger. 2012. “Chlorinated Ethene Source Remediation: Lessons Learned.” *Environmental Science and Technology* 46:6438-6447.

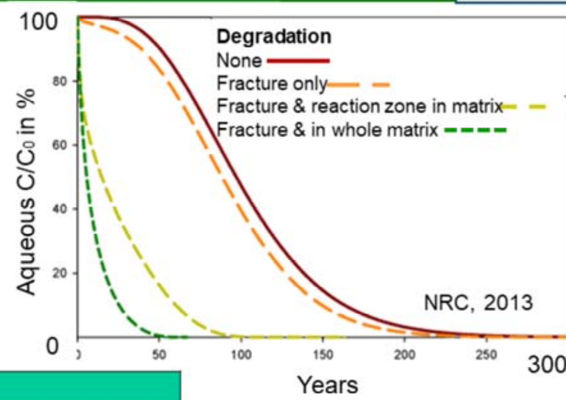
McGuire,Travis ; Adamson,David ; Newell,Charles ; Kulkarni,Poonam, 2016. Development of an Expanded, High Reliability Cost and Performance Database for In Situ Remediation Technologies. ESTCP Project Report ER-201120. http://www.dtic.mil/get-tr-doc/pdf?AD=AD1024199

ITRC. 2011. Integrated DNAPL Site Strategy. IDSS-1.

48

Remediation Potential Assessment
Key Criteria (Pre-Remedy)

8. What is the predicted time frame for achieving interim and site objectives?



Model/Analysis
USEPA REMChlor or REMFuel Model
Natural Attenuation Software
Matrix diffusion
Concentration vs. time First order rate calculations

No associated notes

49

Remediation Potential Assessment
Matrix of Evaluation Criteria

- Evaluate each criteria as high, moderate or low
- Weight criteria to reflect relative importance
- Assess conclusion

Evaluation Criteria	Likelihood of Achieving Remediation Objectives		
	High	Moderate	Low
Access	✓		
Drilling feasibility	✓		
Scale		✓	
Concentration reduction			✓
Attenuation	✓		
Difficult-to-remove mass			✓
Technology performance	✓		
Time frame		✓	
Total checked:	4	2	2

ITRC RMCS-1, Table 7

No associated notes

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Remediation Potential Assessment
Matrix of Evaluation Criteria

- Evaluate each criteria as high, moderate or low
- Weight criteria to reflect relative importance
- Assess conclusion

Evaluation Criteria	Likelihood of Achieving Remediation Objectives		
	High	Moderate	Low
Access		✓	
Drilling feasibility	✓		
Scale		✓	
Concentration reduction			✓
Attenuation		✓	
Difficult-to-remove mass			✓
Technology performance			✓
Time frame			✓
Total checked:	1	3	4

ITRC RMCS-1, Table 7

No associated notes

51

Remediation Potential Assessment
Key Criteria (Post-Remedy)

- Has the existing remedy been effectively operated and maintained?
- Are aquifer conditions or contaminant sources adequately characterized? Have they changed?
- Are concentrations reductions occurring at the rate anticipated?
- Does the selected remedy adequately address contaminants and/or hydrogeologic conditions?
- Can interim and/or site objectives (and contaminant-specific cleanup levels) be met with other technologies within a reasonable time frame?

No associated notes

52

Remediation Potential Assessment Summary

- Screening tool - provides a valuable process; does not produce a default decision
- You answer eight technical questions and use Weight-of-evidence to assess if site is likely to achieve remediation objectives
- Allows flexibility and site-specific input in an iterative process
- Goal: Determine if…
  - Site objectives are likely attainable OR
  - Remediation potential is low – Adaptive Site Management will be important

No associated notes

Q&A Break

Follow ITRC

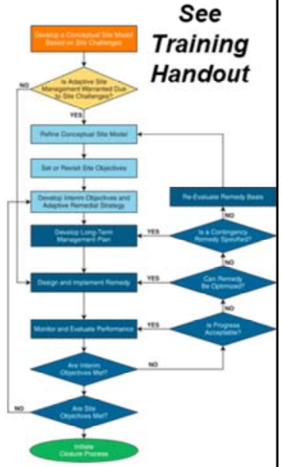
Chapter 2. Site Challenges

Chapter 3. Remediation Potential Assessment

Chapter 4. Adaptive Remedy Selection

Chapter 5. Long-Term Management

See Training Handout



No associated notes

54

Today's Road Map

- Site challenges
- Remediation Potential Assessment
- Questions and answers
- Adaptive remedy selection
- Long-term management
- Preparing you to take action
- Questions and answers

No associated notes

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Learning Objective

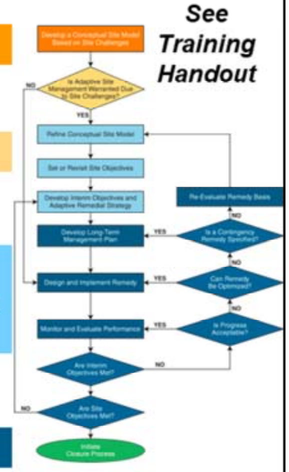
Chapter 2. Site Challenges

Chapter 3. Remediation Potential Assessment

Chapter 4. Adaptive Remedy Selection

Understand and apply adaptive site management principles

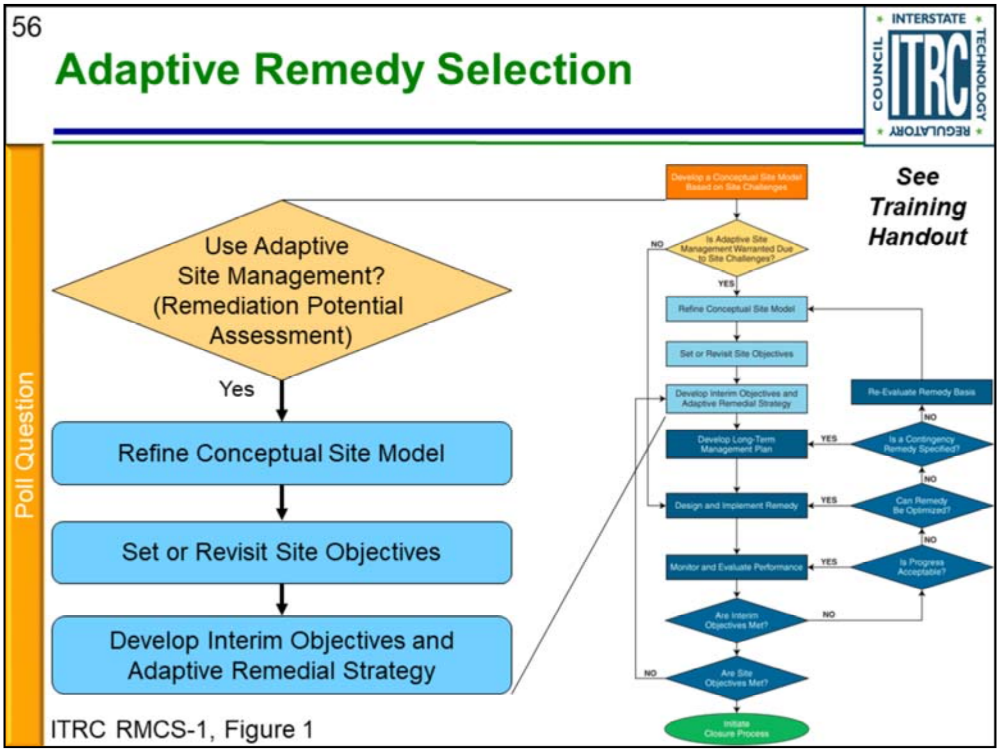
Chapter 5. Long-Term Management



See Training Handout

ITRC RMCS-1, Figure 1

No associated notes



Poll: Did a remedy at your complex site fail to meet expectations?

- Yes
- No
- Too soon to tell
- Other

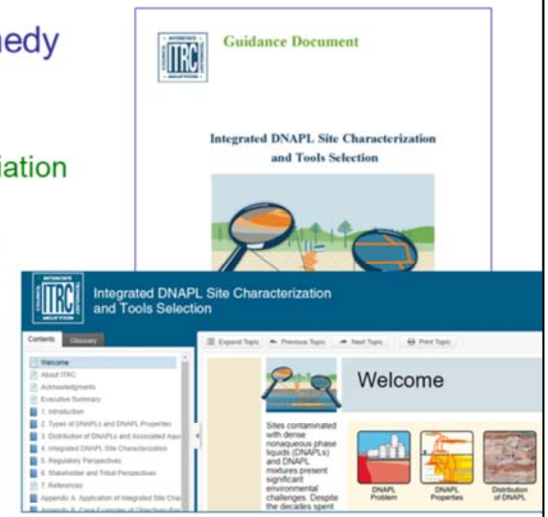
Poll: If yes, what actions were taken? (select all that apply)

- Remedy optimization
- Contingency remedy implemented
- Site characterization
- Technology testing
- Modified site objectives
- Other

57

Refine Conceptual Site Model

- Prior to revisiting remedy
  - Are site challenges described?
  - What inhibited remediation progress?
  - What are data gaps?
- Tools for remedy evaluation



ITRC ISC-1 2015
http://www.itrcweb.org/DNAPL-ISC_tools-selection/

ITRC RMCS-1, Appendix B

No associated notes

58

Conceptual Site Model
Australia Case Study

Phase	Source		Proximal Plume		Distal Plume	
Permeability/ Transmissivity	Low	High	Low	High	Low	High
Soil vapor						
DNAPL			NA	NA	NA	NA
Groundwater						
Sorbed						

LEGEND
Equivalent aqueous concentration (mg/L)

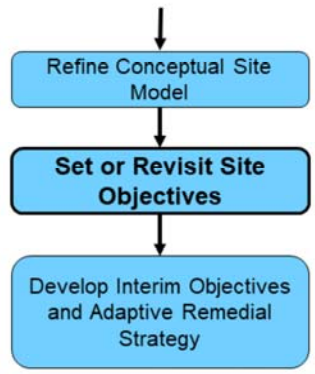
- HIGH (>1,000)
- MODERATE/HIGH (100-1,000)
- MODERATE (10-100)
- LOW (1-10)
- NOT APPLICABLE (NA)

20-Compartment model summarizing the conceptual site model of contaminant mass at the site. ITRC RMCS-1, Figure 69 and Appendix B

No associated notes

Set or Revisit Site Objectives

- **Site objectives** are overall remedial expectations, including protecting public health and the environment
- **Set** site objectives
  - Consider complexities
  - Consider different geologic or operable units, source area and plume -- "site segments"
- **Revisit** site objectives
  - If progress is insufficient despite optimization



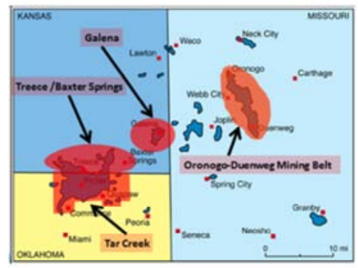
ITRC RMCS-1, Figure 1

No associated notes

Site Objectives at Complex CERCLA Sites

Poll Question

- Protect human health and environment
- Meet Applicable or Relevant and Appropriate Requirements (ARARs) or criteria for ARAR waiver
  - Inconsistent application of state standards
  - Fund balancing
  - Equivalent performance
  - Interim measures
  - Greater risk
  - Technical impracticability (TI)



TI waiver at Tri-State Mining District (Oklahoma, Kansas, Missouri)

CERCLA - Comprehensive Environmental Response, Compensation and Liability Act

ITRC RMCS-1 Chapter 4, 40 CFR 300.430(f)(1)(ii)(C), USEPA 1993, 2012

Poll: Have you evaluated the applicability of an ARAR waiver?

Yes

No

Considered but did not formally evaluate

Poll: What approach was selected following the evaluation?

ARAR waiver

Another approach

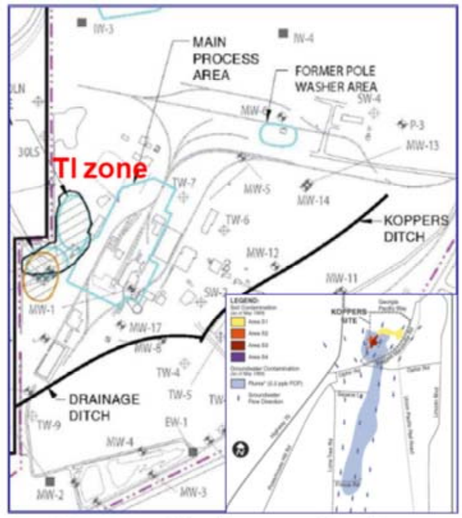
Unknown

Not applicable

61

Case Study: ARAR Waiver at a Wood Treatment Facility, Oroville, California

- Complexities
  - Recalcitrant creosote and pentachlorophenol DNAPL
  - Drinking water aquifer
- Record of Decision amendment included TI waiver
  - Groundwater goal within 4-acre area is containment, not restoration



TI zone at the Koppers Oroville, California wood treatment facility

ITRC RMCS-1 Figure 7, USEPA 2013a

No associated notes

62

CERCLA Sites
Alternate Concentration Limits

- Alternate concentration limits can be used in groundwater only if
  - Groundwater discharges to surface water
  - No statistically significant increase in concentrations downstream
  - No exposure to off-site contaminated groundwater prior to discharge
- No recent case studies identified

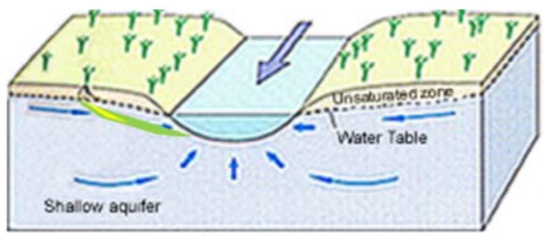


Image from U.S. Geological Survey

CERCLA Section 121(d)(2)(B)(ii), USEPA, 2005b

No associated notes

63

RCRA and Other State Programs
ITRC Survey

- Team surveyed states about their approaches
  - RCRA, Brownfields, Underground Storage Tank programs
  - Responses from 40 states
- Does your state allow the following to meet site objectives…
  - …as a primary means?
  - …after the original selected remedy fails to reach site objectives within the planned remedial time frame?

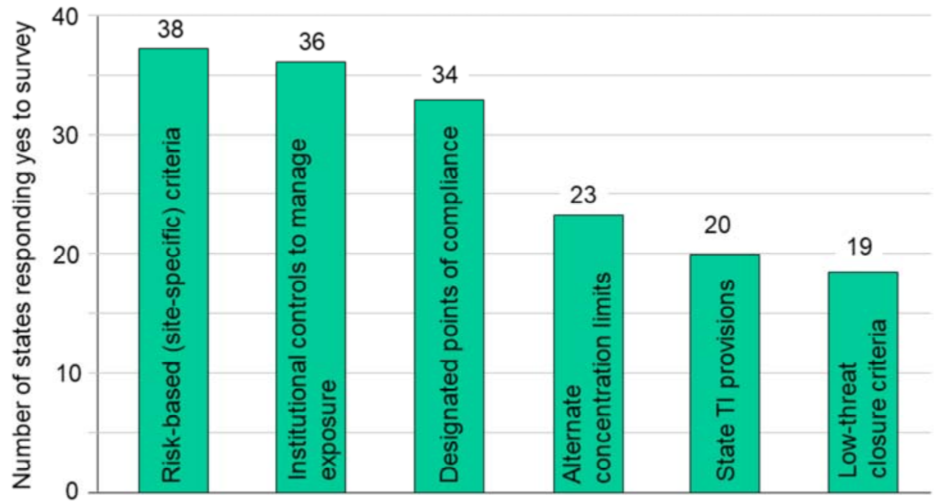
ITRC RMCS-1 Figures 3-4, Appendix A

RCRA – Resource Conservation and Recovery Act (for hazardous waste management)

No associated notes

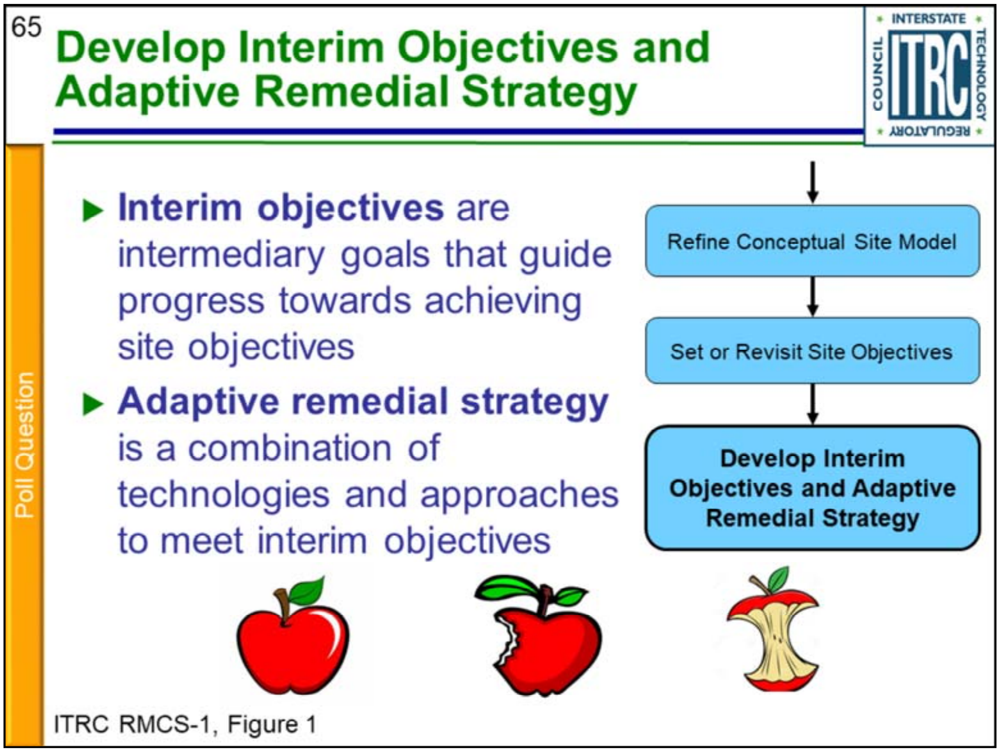
64

RCRA and Other State Programs



ITRC RMCS-1 Figures 3-4, Appendix A

No associated notes



Poll: Restore groundwater to beneficial uses - Site Objective or Interim Objective?

- Site objective
- Interim objective
- Not sure

Poll: Reduce mass flux off site by 50% within five years so that hydraulic control is no longer needed - Site Objective or Interim Objective?

- Site objective
- Interim objective
- Not sure

66

Interim Objectives

- Should be Specific Measurable Attainable Relevant and Timebound (SMART)
  - Contaminant mass flux or discharge decrease by [x]% within [#] years
  - Target degradation rates met within [#] years
  - Capping to prevent direct exposure
- Guide short-term decisions and actions
  - Optimization
  - Technology transitions
- Meeting interim objectives → progress

ITRC IDSS-1, 2011; ITRC MASSFLUX-1, 2010

No associated notes

67

Select Adaptive Remedial Strategy
Step 1. Identify Options

- Biological treatment
- Chemical treatment
- Thermal treatment
- Removal
- Enhanced extraction
- Source flux reduction
- Contaminant mass flux reduction
- Pump and treat
- Permeable reactive barriers
- Enhanced attenuation
- Monitored natural attenuation
- Hydraulic containment
- Passive hydraulic barrier
- Discharge zone treatment
- Vapor intrusion mitigation
- Institutional controls
- Alternative water supply

Options	Description and References
In situ biological treatment	Applying an amendment into the aquifer to bioremediate a targeted volume (ITRC 2002, 2008, Parsons 2004, USEPA 2000, DOE 2002)
Source flux reduction	Applying remediation or containment to reduce the flux of contaminants moving from the source zone to the plume (ITRC 2008b, 2010b, Looney et al., 2006)
Institutional controls	Applying administrative restrictions to prevent contaminant exposure or other actions that would negatively impact contamination (USEPA 1997a, 2009b, 2010a, ITRC 2016b)

ITRC RMCS-1 Table 10 for complete listing

No associated notes

68

Select Adaptive Remedial Strategy
Step 2. Compare Remedial Approaches

- Follow regulatory process
  - Assess using threshold and balancing criteria for CERCLA, RCRA sites
- Additional considerations due to complexities
  - How does each remedial approach address complexities?

CERCLA Nine Criteria

Threshold Criteria
1. Overall protection of human health and the environment
2. Compliance with ARARs

Balancing Criteria
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility or volume
5. Short-term effectiveness
6. Implementability
7. Cost

Modifying Criteria
8. State acceptance
9. Community acceptance

40 CFR 300.430(e)(9)(iii)

No associated notes

69

Select Adaptive Remedial Strategy
Step 2. Compare Remedial Approaches

- Additional considerations
  - Level of confidence in ability to implement remedy
  - Synergy with other technologies/approaches
  - Adaptability over time
  - Information gained to improve future decisions
  - Robustness of design including interim objectives, metrics, and performance monitoring data
  - Other

www.clipartpanda.com

ITRC RMCS-1 Appendix B

No associated notes

70

Select Adaptive Remedial Strategy
Step 3. Remedy Selection

- Prepare a matrix of site objectives and remedies for each area of the site

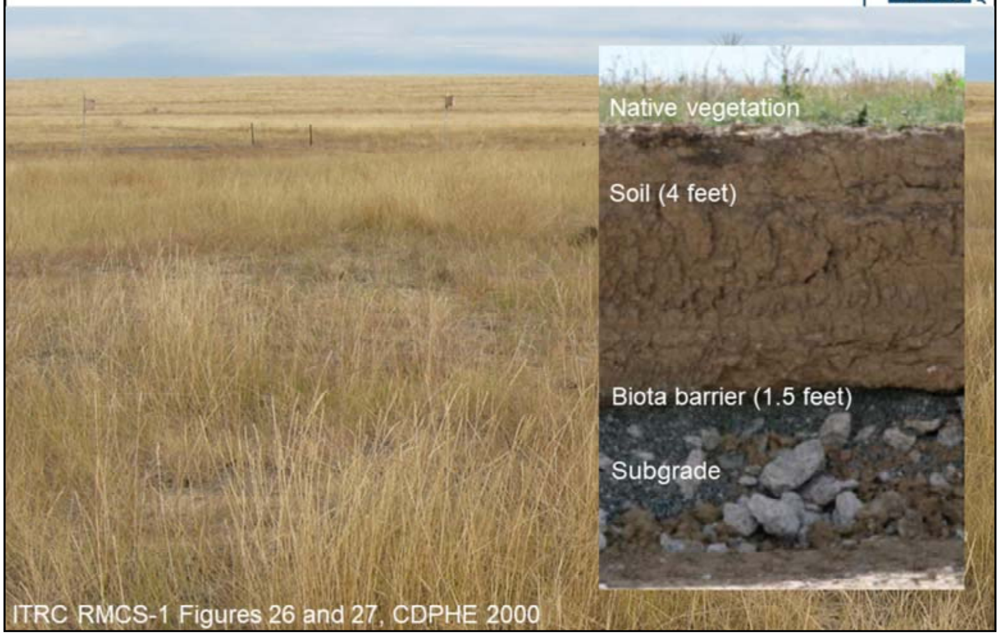
Site Objectives	Selected Remedy	
	Source	Plume
Objective #1	Technology 1 Technology 2	Technology 1 Technology 3
Objective #2		
Objective #3		

ITRC RMCS-1, Table 11

No associated notes

71

Case Study: Rocky Mountain Arsenal, Colorado



No associated notes

72

Rocky Mountain Arsenal, Colorado
Remedy Components

Site Objectives	Selected Remedy	
	On-Site	Off-Site
Source removal and treatment	Waste and soil treatment, stabilization Excavation Groundwater extraction and treatment	Off-post groundwater intercept and treatment system
Containment	Boundary treatment systems Slurry walls Stabilization/capping	Boundary treatment systems
Protection of human health and ecology	Capping Land use restrictions Unexploded ordnance disposal Alternate water supply	National wildlife refuge Deed restrictions Long-term monitoring Five-year reviews Trust for potable water supply and distribution Medical monitoring Biomonitoring Trust for long-term O&M

No associated notes

73

Document Remedial Approach

- Articulate how components work together
- For each component of the remedial approach
  - Describe technology
  - State interim objectives
  - State how the performance will be evaluated (performance metrics)
- Follow regulatory program requirements for documentation
- Can facilitate remedy transitions

H'arnet / Wikimedia Commons

No associated notes

74

Engaging Stakeholders and Tribes
Stakeholder and Tribal Perspectives

- Stakeholder and Tribal concerns and values
- Gathering and organizing information
- Creating a forum
- Influencing decisions
- Advisory boards
- Technical assistance

SanjibLemar / Wikimedia Commons

ITRC RMCS-1 Chapter 7

No associated notes

75

Engaging Stakeholders and Tribes
Responsible Party Perspectives

- Seek out community members
- Provide them with tools to participate constructively
- Build trust for effective outreach
- Organize public meetings
- Share technical documents, information
- Work with media

Energy.gov / Wikimedia Commons

ITRC RMCS-1 Chapter 7

No associated notes

76

Summary
Adaptive Site Management Principles

- Refine conceptual site model
- Set or revisit site objectives
  - Survey highlights flexibility of some state programs in setting or revisiting site objectives
- Build adaptive remedial strategy
  - May need multiple technologies, phases for each site area
  - Set interim objectives to guide remedial progress
- Repeat process if remedy is not on track

No associated notes

77

Today's Road Map

- Site challenges
- Remediation Potential Assessment
- Questions and answers
- Adaptive remedy selection
- Long-term management
- Preparing you to take action
- Questions and answers

No associated notes

78

Learning Objective

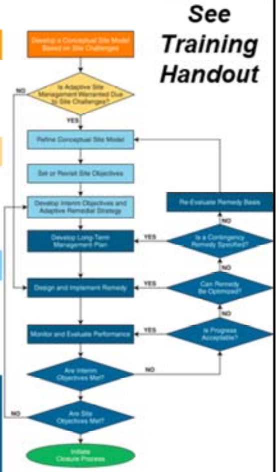
Chapter 2. Site Challenges

Chapter 3. Remediation Potential Assessment

Chapter 4. Adaptive Remedy Selection

Chapter 5. Long-Term Management

Develop a long-term performance-based action plan



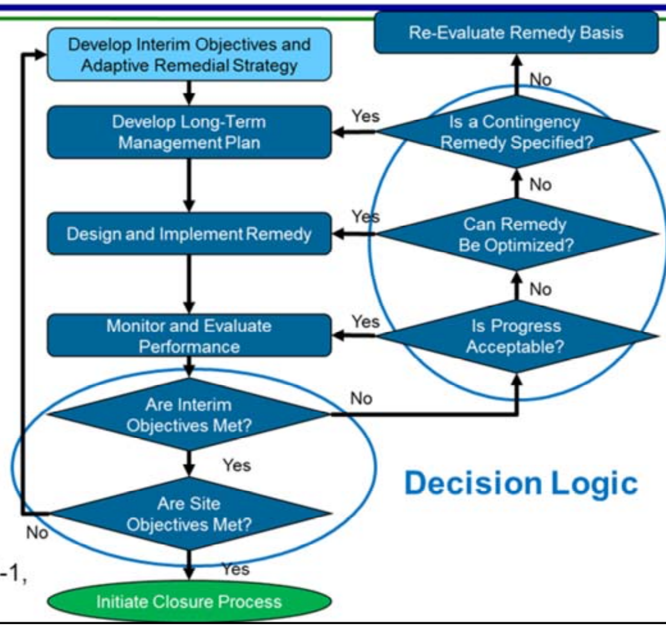
See Training Handout

ITRC RMCS-1, Figure 1

No associated notes

79

Adaptive Site Management



ITRC RMCS-1, Figure 1

No associated notes

80

Develop Long-Term Management Plan
Purpose and Value

- Learn via process (living site-specific document)
  - Identify weak links
  - Inform decision makers
  - Engage stakeholders

- Provide a completion strategy (many decades)
- Document remedy expectations and progress
- Expedite remedy re-evaluations and transitions
- Make timely remediation management decisions

No associated notes

81

Develop Long-Term Management Plan
Plan Components

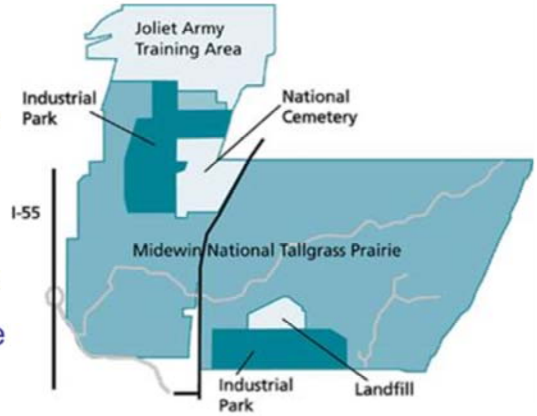
- Completion strategy
- Description of the selected remedy
- Expected performance over time
  - Performance model predictions
- Timeline and criteria for monitoring and periodic evaluations
- Decision logic for remedy transitions
- Project risks and uncertainty

No associated notes

82

Develop Long-Term Management Plan
Completion Strategy

- Path to achieve site objectives
  - Likely iterative for complex sites
  - Collaborative process
- Consider options to maximize future land use
- Consult relevant guidance



Map of proposed future uses for Joliet Army Ammunition Plant, Illinois (ITRC RMCS-1 Figure 36)

Examples: ITRC RPO-3, USEPA 2014. Groundwater remedy completion strategy

A compendium of tools, approaches and models is provided as Appendix B

83

Develop Long-Term Management Plan
Project Risks and Uncertainty

- Process to identify and respond to key project risk events
  - Identify and assess potential project risks
  - Actions to reduce risk (e.g., filling a data gap)
  - Use contingency planning tools

Technical/Regulatory Guidance

Project Risk Management for Site Remediation

March 2011

Download risk register template:
https://clu-in.org/conf/itrc/rrm/ExampleRRMForms.docx

ITRC RRM-1, 2011
http://www.itrcweb.org/GuidanceDocuments/RRM-1.pdf

No associated notes

84

Develop Long-Term Management Plan
Describe the Selected Remedy

- Remedy for each site segment (e.g., plume, source area, off-site plume)
- Interim objectives, performance metrics
  - May need to set these during long-term management phase
  - Time frame predicted to meet interim objectives
- Maintenance and monitoring considerations

No associated notes

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Develop Long-Term Management Plan
Example Description - Selected Remedy

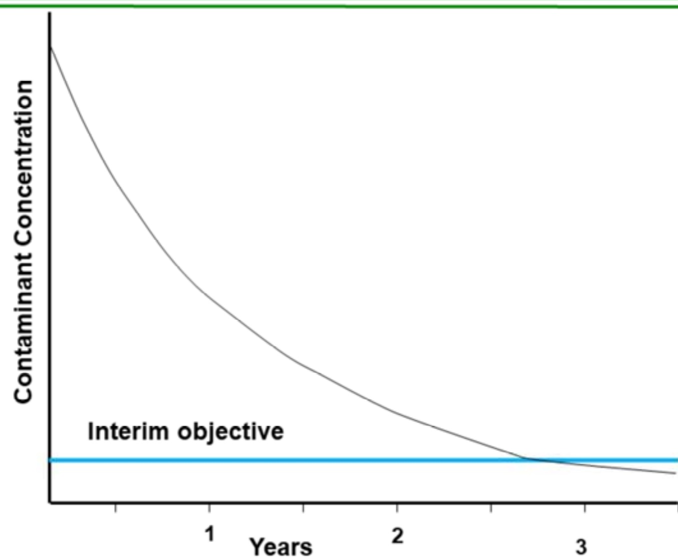
Site Objective	Remedy Component	Interim Objective/ Performance Metric
Remediate contamination	In situ treatment	Reduce contaminant concentrations by 1 order of magnitude
Control migration	In situ treatment	Reduce mass flux from the source area by 80%
	Pump and treat	Demonstrate capture using multiple lines of evidence
Prevent exposure	Engineering controls	Maintain engineering controls and fencing per operation and maintenance plan
	Institutional controls	Deed restriction for land and groundwater use

ITRC RMCS-1 Table 12; ITRC IC-1 2016

No associated notes

86

Develop Long-Term Management Plan
Example - Performance Model Prediction



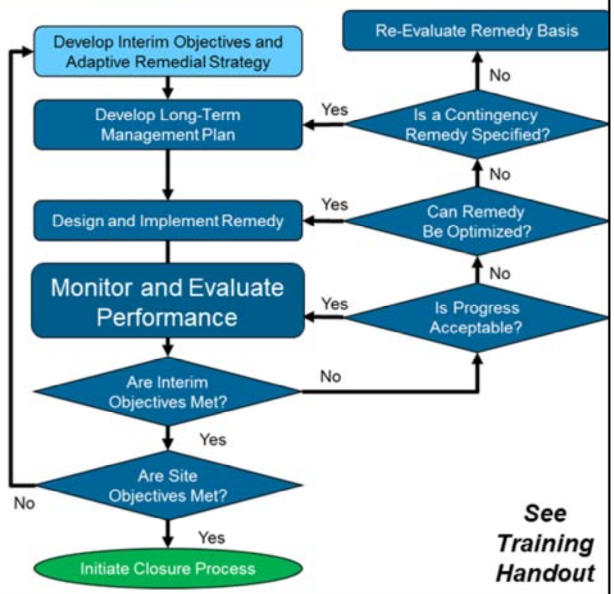
ITRC RMCS-1, Figure 6; ITRC GRO-1, 2016; ITRC GSMC-1, 2013

No associated notes

87

Monitor and Evaluate Performance

- Schedule for monitoring and periodic evaluations stated in long-term management plan
- Monitoring program aligned with performance objectives



See Training Handout

No associated notes

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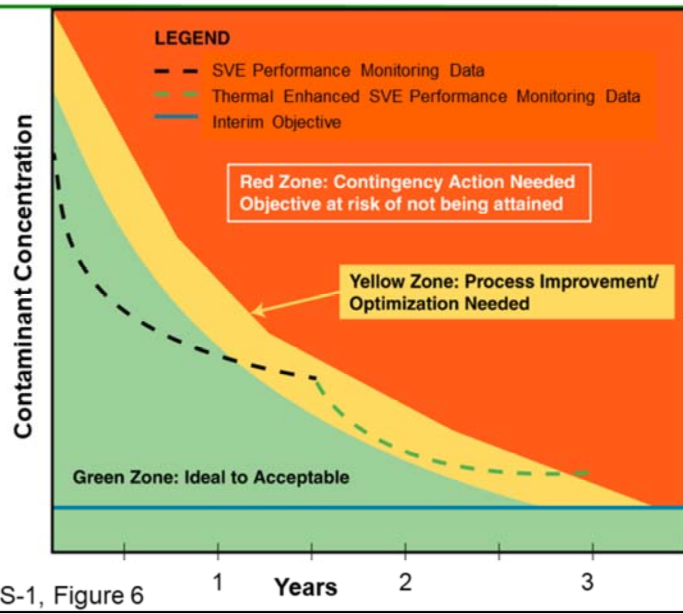
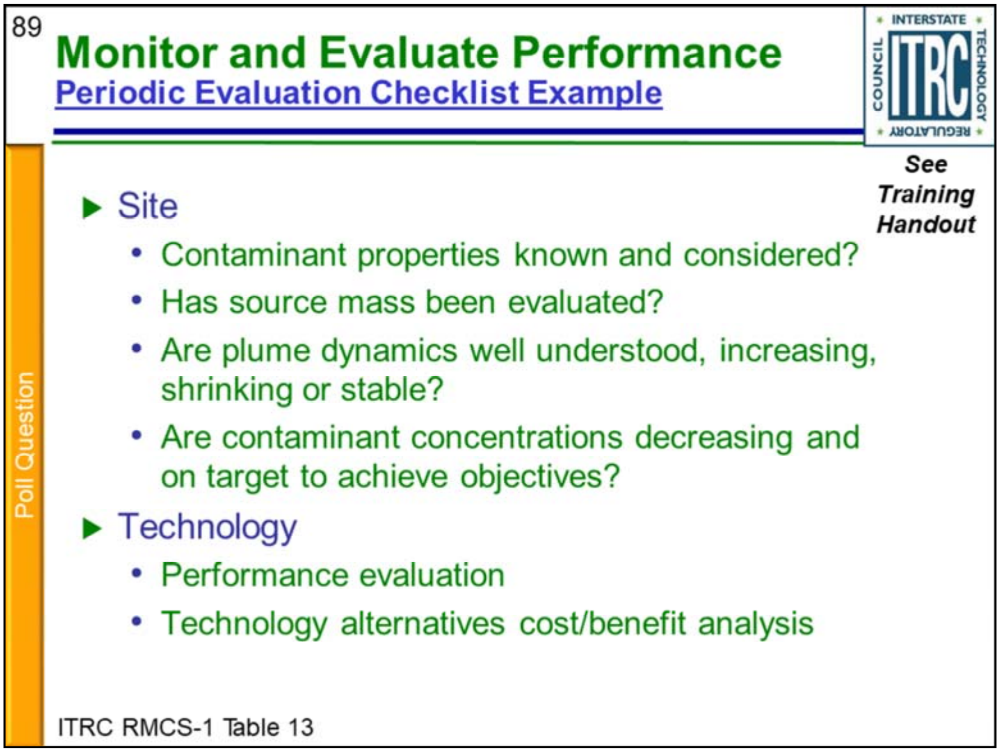
Monitor and Evaluate Performance
Compare Actual and Predicted Performance



ITRC RMCS-1, Figure 6

SVE – Soil vapor extraction

No associated notes



Full checklist is in the guidance/can be downloaded under Links to Additional Materials

Poll: When is the best time to review technology performance in detail?

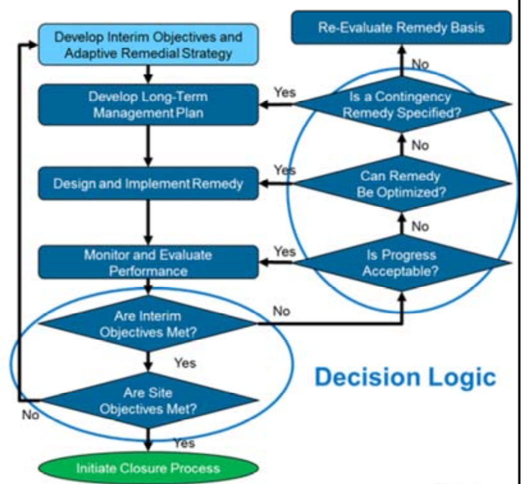
- After every monitoring event
- During every periodic evaluation
- Only if technology fails to make progress towards interim objective
- After an interim objective has been met

90

Decision Logic

Potential Outcomes of Periodic Evaluations

- Remedy/remedy phase is complete OR
- Remedy is on track OR
- Optimization is needed OR
- Revised remedial approach is warranted



See Training Handout

ITRC RMCS-1, Figure 1

No associated notes

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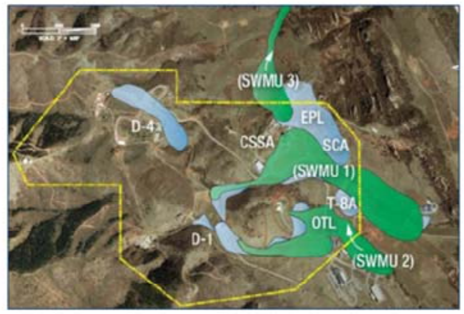
Example: Reaching Technology Limits at a Colorado Site

- TCE and NDMA in fractured rock 125 feet deep
- Enhanced in situ bioremediation for TCE
  - Reached asymptotic concentrations above action levels
- Pilot studies of other technologies ineffective
- Transitioned to MNA and institutional controls



Trichloroethylene (TCE) in bedrock (blue) and alluvial (green) aquifers after in situ bioremediation (Image from Brock 2012)

NDMA – N-nitrosodimethylamine

No associated notes

92

Long Term Management Summary

- Value of a plan
- Plan components
- Monitor and evaluate performance
- Follow decision logic

ITRC RMCS-1, Chapter 5

No associated notes

Today's Road Map

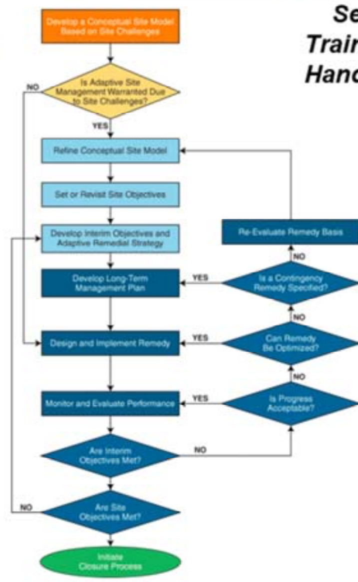
- Site challenges
- Remediation Potential Assessment
- Questions and answers
- Adaptive remedy selection
- Long-term management
- Preparing you to take action
- Questions and answers

No associated notes

Our Opportunity to Improve

Poll Question

- Science and technology give us options for challenging sites
- A robust and iterative conceptual site model is key to success
- Consensus-driven interim objectives help us make progress
- Adaptive site management facilitates finding an achievable path to common goal



See Training Handout

Poll: Would you recommend using Adaptive Site Management at your sites?

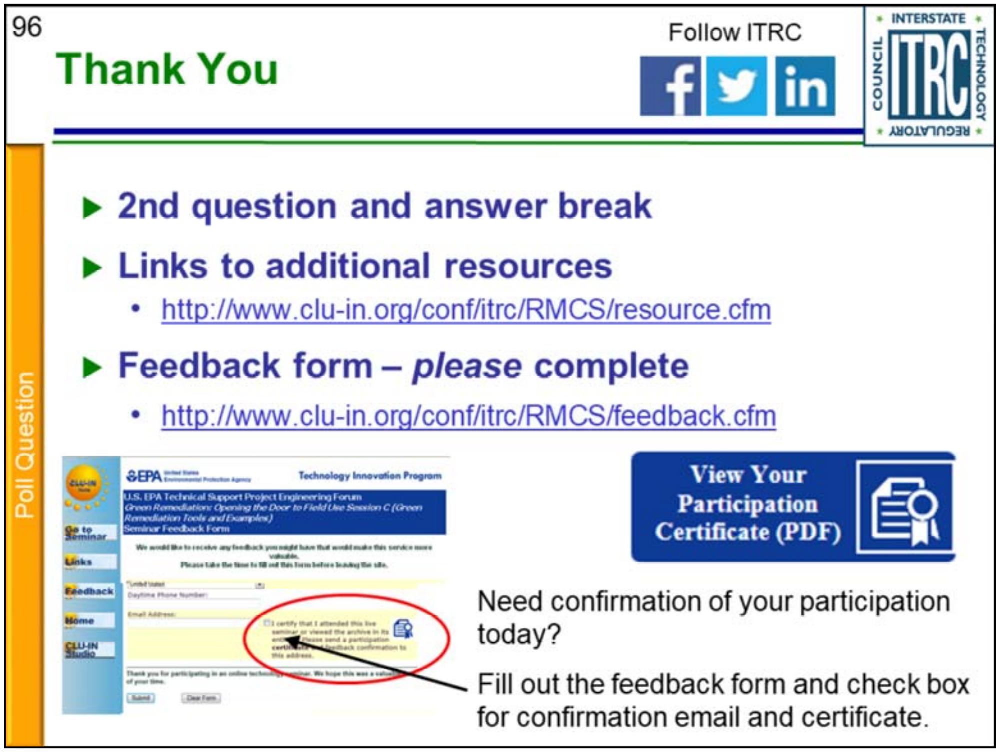
- Yes
- No
- Unsure – Need to learn more

95

What Actions Can You Take To Make Progress at Complex Sites?

- Use and encourage use of the ITRC Guidance
- Know your site – technical and non-technical challenges
- Assess the remediation potential at your site(s)
- Apply adaptive site management principles
- Get your stakeholders involved early and develop consensus-based interim objectives
- Schedule periodic evaluations of remedy performance to track remedy progress and make improvements

No associated notes



Poll:

Would you recommend using Adaptive Site Management at your sites?

- Yes
- No
- Unsure – Need to learn more

Links to additional resources:

http://www.clu-in.org/conf/itrc/RMCS/resource.cfm

Your feedback is important – please fill out the form at:

http://www.clu-in.org/conf/itrc/RMCS/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