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Starting Soon: Remedy Selection for Contaminated Sediments

- ITRC Remedy Selection for Contaminated Sediments (CS-2, 2014) http://www.itrcweb.org/contseds_remedy-selection/
- Download PowerPoint file
  - Clu-in training page at http://www.clu-in.org/conf/itrc/ContSedRem/
  - Under “Download Training Materials”
- Download flowchart for reference during the training class
  - http://www.cluin.org/conf/itrc/ContSedRem/ITRC-SedimentRemedyEvaluation.pdf
- 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.

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Welcome – Thanks for joining this ITRC Training Class

Remedy Selection for Contaminated Sediments

http://www.itrcweb.org/contseds_remedy-selection/

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

The sediments underlying many of our nation's major waterways are contaminated with toxic pollutants from past industrial activities. Cleaning up contaminated sediments is expensive and technically-challenging. Sediment sites are unique, complex, and require a multidisciplinary approach and often project managers lack sediments experience. ITRC developed the technical and regulatory guidance, Remedy Selection for Contaminated Sediments (CS-2, 2014), to assist decision-makers in identifying which contaminated sediment management technology is most favorable based on an evaluation of site specific physical, sediment, contaminant, and land and waterway use characteristics. The document provides a remedial selection framework to help identify favorable technologies, and identifies additional factors (feasibility, cost, stakeholder concerns, and others) that need to be considered as part of the remedy selection process. This ITRC training course supports participants with applying the technical and regulatory guidance as a tool to overcome the remedial challenges posed by contaminated sediment sites. Participants learn how to:

-- Identify site-specific characteristics and data needed for site decision making

-- Evaluate potential technologies based on site information

-- Select the most favorable contaminant management technology for their site

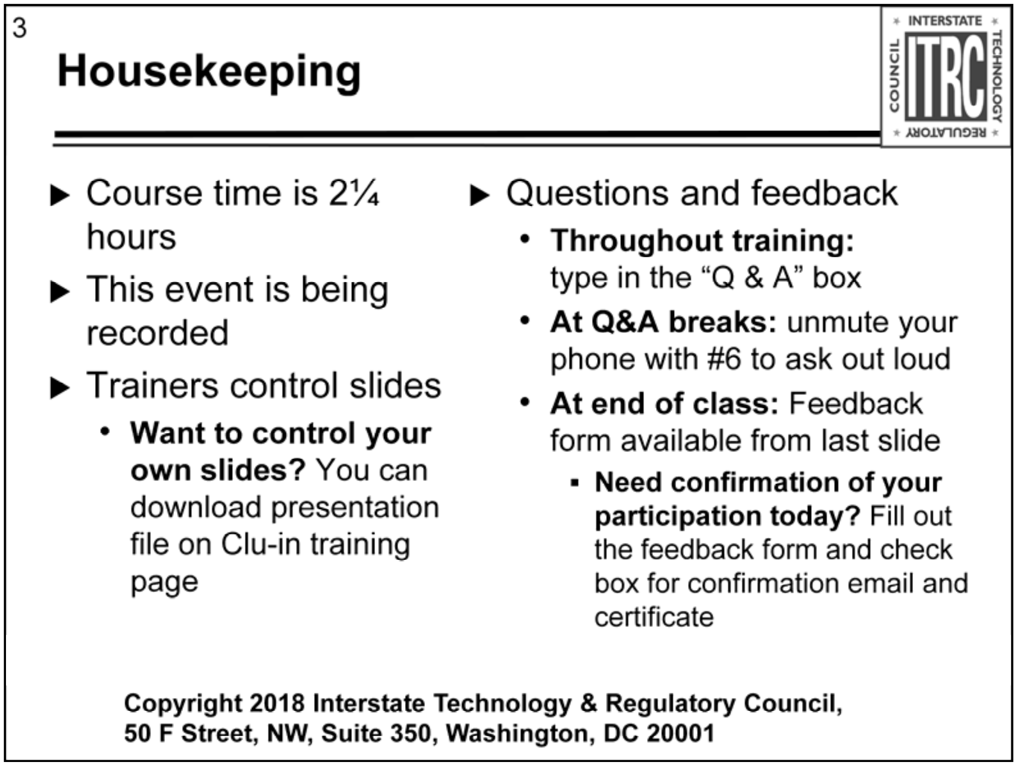
For reference during the training class, participants should have a copy of Figure 2-1, Decision matrix flow chart. It is available as a 1-page PDF at http://www.cluin.org/conf/itrc/ContSedRem/ITRC-SedimentRemedyEvaluation.pdf.

Participants should also be familiar with the ITRC technology and regulatory guidance for Incorporating Bioavailability Considerations into the Evaluation of Contaminated Sediment Sites Website (CS-1, 2011) and associated Internet-based training that assists state regulators and practitioners with understanding and incorporating fundamental concepts of bioavailability in contaminated sediment management practices.

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

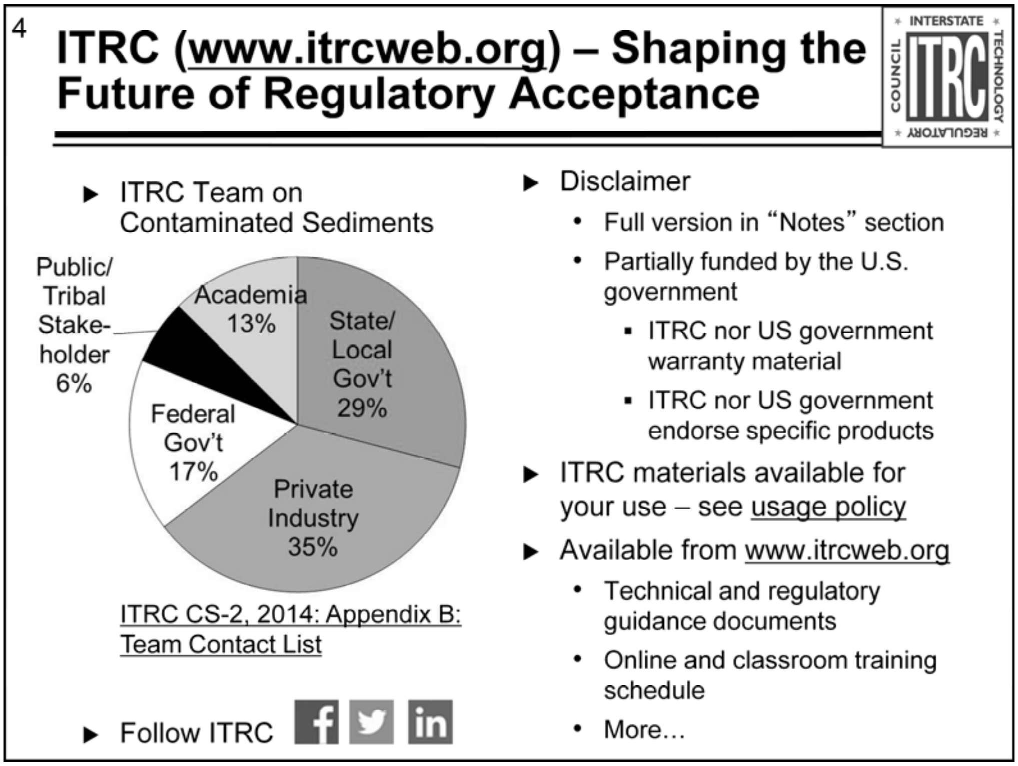


Although I’m sure that some of you are familiar with these rules from previous CLU-IN events, let’s run through them quickly for our new participants.

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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John G. Cargill is a Hydrologist IV with the Delaware Department of Natural Resources and Environmental Control (DNREC) located in New Castle, Delaware. Before joining DNREC in 2005, John worked as a geologist in the private consulting industry, where he became familiar with environmental regulations and guidelines associated with contamination assessment and remediation of various media. In 2005, John relocated to Delaware and was hired as a regulator within the DNREC Site Investigation and Restoration Branch. He oversees contamination assessment and cleanup projects conducted by responsible parties and developers in the State, and also designs and implements State lead assessment and remediation projects, including contaminated sediment projects. John's has been a member of the Contaminated Sediments Team since its inception in 2008, and he became a co-leader of the Team in 2009. His involvement as co-Team Leader has helped him communicate the intricacies of contaminated sediment assessment, and specifically bioavailability assessment concepts, to audiences within the State of Delaware as well as at meetings around the country. His overall goal for the team's product is to help demystify some of the complexities of contaminated sediment and bioavailability assessment and to provide a "tool box" for regulators, consultants and practitioners to help manage the risks associated with contaminated sediments. John earned a bachelor's degree in geology from the University of North Carolina at Chapel Hill in 1994 and a master's degree in coastal geology from the University of South Florida in Tampa in 1996. John is a licensed Professional Geologist and licensed Geotechnical Well Driller in the State of Delaware, and has worked as a licensed geologist in the states of North Carolina, South Carolina, Georgia and Virginia.

Dr. Steve Clough is a Senior Environmental Toxicologist at Haley & Aldrich in Manchester, NH. Since 1988, Steve has performed ecological risk assessments under CERCLA/RCRA, which require detailed exposure assessments that incorporate bioavailability factors and an in-depth knowledge of the physicochemical parameters that affect them. Steve specializes in assessing the impact of point and non-point sources to benthic communities in estuaries, rivers, and streams and has a wide range of experience using both active and passive pore water sampling techniques. In 1996, Steve worked for NCASI, a pulp and paper trade group, where he conducted field studies to evaluate the uptake of extremely persistent hydrophobic compounds into both aquatic and terrestrial food chains (including the calculation of site-specific bioavailability factors). Steve then joined environmental consulting and has conducted numerous multipathway ecological risk assessments that require formulating a Conceptual Site Models, which are subsequently validated in the field by sampling of sediment and biota to determine the actual exposure and risk that environmental chemicals/stressors may pose to key receptors. Steve specializes in the toxicology of metals, routinely presents at scientific conferences, and has been active in ITRC since 2007. Steve earned a bachelor's degree in pathobiology from the University of Connecticut in Storrs, Connecticut in 1976. After managing both mammalian and aquatic toxicology laboratories addressing product development under TSCA, he attended the University of Michigan in Ann Arbor, Michigan where he earned a master's in water quality in 1983 and a Ph.D. in toxicology in 1988. Steve is also certified as a Diplomate of the American Board of Toxicology.

Paul Doody is a Principal Engineer at Anchor QEA, LLC, in Syracuse, New York. Paul has more than 30 years of professional experience, most of which has been specializing in the management and remediation of contaminated sediment. Paul possesses expertise in multiple facets of contaminated sediment management, including remedial investigation and feasibility studies, treatability studies, remedial design, remedial construction oversight and environmental monitoring. Paul is one of the nation's authorities on the dredging of contaminated sediment providing assessment, design, and engineering services related to more than 3 million cubic yards of impacted media at a wide variety of contaminated sediment sites, ranging from small creeks and ponds to complex river systems spanning dozens of miles. His work includes projects in the US and Norway, where Paul is responsible for Anchor QEA's Norwegian subsidiary. Paul has been serving the ITRC on the Contaminated Sediments Bioavailability Team, as well as the Contaminated Sediments Remediation Team. He was the recipient of the ITRC Industry Recognition Award in 2012. Paul earned a Bachelor of Science degree in chemical engineering from Clarkson University, in Potsdam, New York, in 1982 and is a registered Professional Engineer in twelve states.

Eric Blischke is a senior environmental scientist with CDM Smith in Portland Oregon. Eric has over 25 years of remediation experience in the state, federal and private sector. For the past 15 years, Eric's work has focused on contaminated sediments. Eric is currently heading up CDM Smith's sediment program. In this role, Eric is serving as a technical resource for numerous CDM Smith sediment cleanup projects around the country and participates in a variety of national sediment forums. Eric recently served as an instructor for EPA's contaminated sediments workshop that took place at three locations around the country. Eric has been active in the ITRC since 2010 and was the lead author of the decision framework section of the sediment guidance. Prior to joining CDM, Eric served as EPA remedial project manager for the Portland Harbor Superfund Site and was Portland Harbor source control lead for the Oregon Department of Environmental Quality. Eric received his B.S. degree from the University of Michigan in Ann Arbor in 1983 and M.S. degree from the Oregon Graduate Institute in Beaverton in 1992.

Dr. Bhawana Sharma, PhD is an Environmental Engineer with CH2M located in Gainesville, Florida office. Bhawana specializes in sediment capping and has been involved in RCRA and CERCLA remediation projects and GLNPO projects for different project stages including site investigation, remedy evaluation and selection, and remedial design and implementation. She primarily works for sediment cap design, modeling, and implementation for in-situ remediation of contaminated sediments. She also works on groundwater and soil remediation projects, evaluates renewable energy resources for sustainable groundwater treatment systems, and manages sites with contaminated groundwater and soil. Bhawana has been contributing to ITRC as a Contaminated Sediments team member since 2010. She has previously served as a team member for ITRC Contaminated Sediments Bioavailability and ITRC Attenuation Processes for Metals and Radionuclides teams and currently serving on Contaminated Sediments Remediation Team. Bhawana has earned a bachelor's degree in Life Sciences from the University of Rajasthan, India in 1999, a master's in Environmental Science from the University of Rajasthan, India in 2001, a master's in Environmental Engineering & Management from the Indian Institute of Technology (IIT) Kanpur, India in 2004 and a PhD in Civil Engineering from the University of New Hampshire in Durham, New Hampshire in 2008.

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Poll Question: What is Your Experience Level with Contaminated Sediment Management?

On a scale of 1 to 5, how much knowledge and experience do you have related to contaminated sediment sites?

1 = sediments expert

3 = some knowledge/confidence

5 = little or no experience

Meco Ditch, Wilmington, Delaware

On behalf of the ITRC Contaminated Sediments Remediation Team I want to welcome everyone to this ITRC Contaminated Sediments Remediation Team Internet Based Training event. I will be your host for this introductory portion of todays event, passing the speaker baton over as we progress.

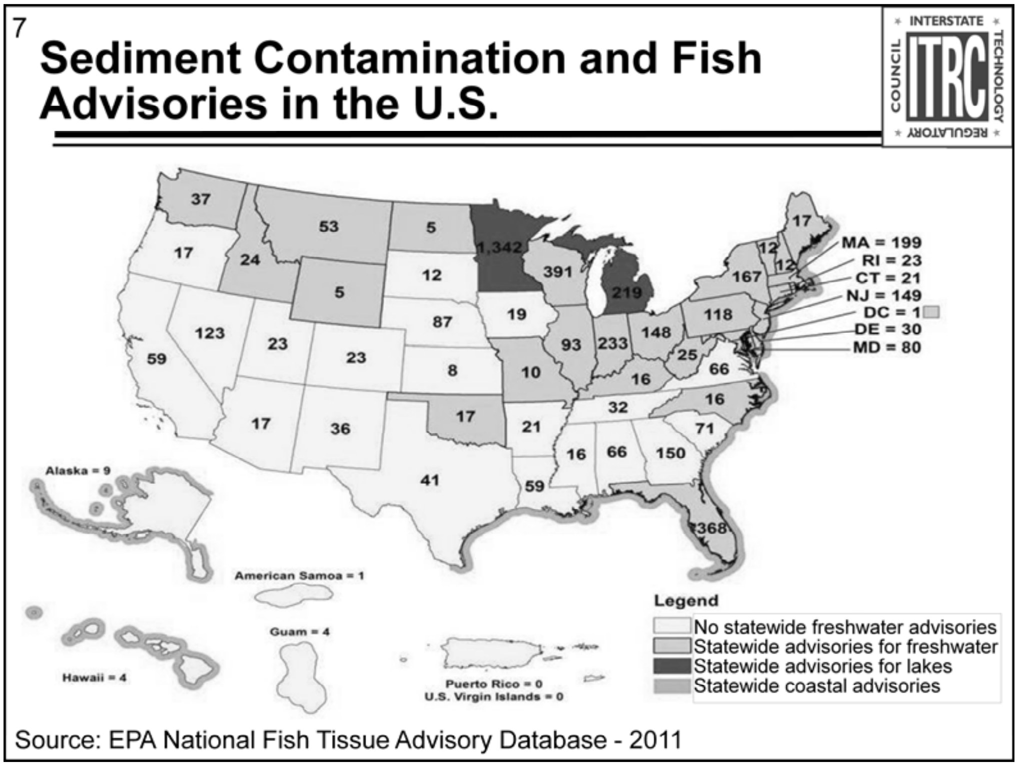
In order to break the ice and get things rolling in a participatory manner we would like to begin by asking a quick “polling question” shown here to determine the relative Sediments Remediation experience level of our audience. This polling question is a quick way for our team and todays presenters to determine the relative experience level of our audience from the starting gate. It provides important information for you too.

While we wait for a moment or two for your responses to be gathered I would to just quickly say that the CS team has developed, what we believe, to be an exciting training event inclusive of information and worksheets to assist you in escalating the efficiency and effectiveness of your contaminated sediments remediation projects.

From the results we see the kind of variation that provides an environment from which greater knowledge will be cultivated.

Now, equally, if not more important, as we go along today. This poll provides, each and every one of you in our audience today, the tool to self-evaluate your knowledge level of CS remediation from the beginning and at the end of todays event. We encourage you to reflect over this very same question… Our ITRC CS Team is confident that during and after this event each of you will gain a more sophisticated understanding of contaminated sediment management and therefore acquire more confidence with which to participate in your very own decision making arena.

Let’s get started…



It is important for us to focus on the numbers…

Fish advisories exist in nearly every state across the nation and elsewhere.

In a majority of these cases, fish advisories exist because of the presence of contaminants in fish tissues. Contaminants such as mercury, PCBs, dioxins, chlorinated pesticides, etc., moving up the food chain is alarming.

It should come as no surprise when we say contaminated sediments act as a source of contamination to overlying surface water and to the biota that live in the surficial sediments that are eaten by higher trophic level species.

A key word of association here is BIOACCUMULATION…a process infinitely connected to BIOAVAILABILITY…

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ITRC Contaminated Sediments – Bioavailability Team

ITRC's Incorporating Bioavailability Considerations into the Assessment of Contaminated Sediment Sites (ITRC CS-1, 2011)

http://www.itrcweb.org/contseds-bioavailability/

Link to the previous Contaminated Sediments Team Document

That document introduces the concept of bioavailability. It contains a wealth of information about how to assess bioavailability when evaluating contaminant exposure pathways at contaminated sediment sites.

Since some remedial approaches (e.g. capping and many in-situ technologies) and remedial technologies aim at reducing risk by addressing the bioavailability of site contaminants, its another resource that we feel you should be aware of.

To add further benefit to this training, some of today's instructors were members of the Bioavailability Team. We have gathered them along with a host of other experts and professionals from across the nation to harvest their knowledge and first hand experiences; to develop and provide this next incredible training event based on our efforts to evolve remediation technology and techniques provided in our guidance document; and to provide a tool for you and others to advance CS remediation decision making processes.

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Why Develop this ITRC Sediment Remediation Guidance?

- Sediment sites are unique and often very complex
  - Multiple sources, contaminants, habitats and waterway use
  - Increased challenges
  - Evaluation and selection of optimal remedy can be complicated
- Absence of remedy selection framework and comparison in current literature
- Move Forward:
  - Advance existing technologies
  - Present new technologies
  - Often requires a multidisciplinary approach

Meco Ditch, Wilmington, DE

Some may ask, why develop an ITRC Guidance Document about Sediment Remediation ?

While, for a few of us, this creates the impulse to respond with…well, to advance technology of course. We believe a more reasoned and valid response is essential.

•Sediment sites are unique and often very complex,

•Potential for multiple sources, contaminants, habitats, waterway use

•Potentially challenging which may drive up the expensive to remediate

•Evaluation and Selecting the optimal remedy can be complicated.

•Remedy selection framework and comparison are absent from current sediment guidance documents

While current guidance documents provide an abundance of good and useful information about technologies they do not provide a comprehensive remedy selection framework – a progressive comparison process

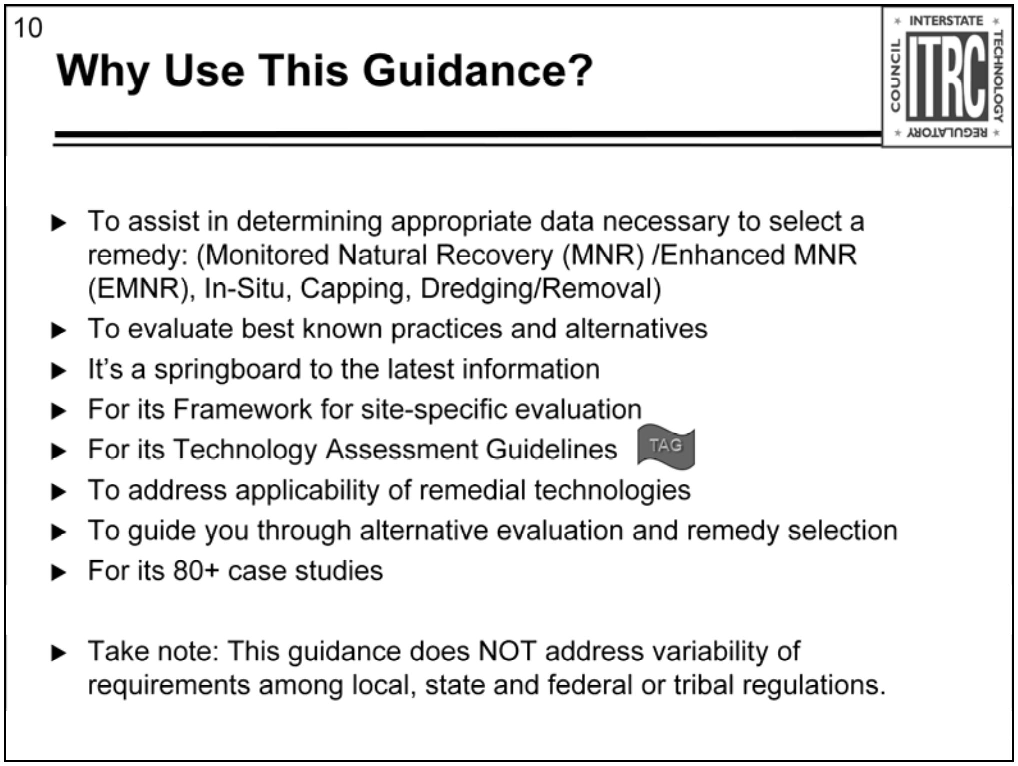
Move Forward:

•to advance existing technologies and present the capabilities of new technologies

•often requires a multidisciplinary approach

Looking back for just a moment to the poll we took at the beginning indicated a lack of experience with remediation of sediment sites, demonstrates the need

Our ITRC CS R Team genuinely believes we are providing valuable, essential information and solutions to these and other obstacles. We encourage you to read, review and reference the guidance document *for* which this training event was developed.



Why use this guidance?

Our team has gathered experts from around the country. We have harvested and documented knowledge from the academic arena, consulting, State and Federal regulators, and community stakeholders to develop the guidance document and bring this training material to you.

We genuinely believe that this guidance document provides each of you with:

•Tools to assist in determining the appropriate data necessary to select a remedy, and

•Advancements in the old and new sediment remediation technologies: MNR/EMNR, In-Situ, Capping, Dredging/Removal

•A platform to the latest information - point, click, go

•A decision framework and downloadable worksheet for site-specific evaluation and data retention

•Technology Assessment Guidelines – including guidance on how to most effectively use them

•The tools necessary to address the applicability of remedial technologies to your site

•The right questions to ask yourself when evaluating alternatives and selecting remedies

•Case studies (88)

As a team, it was impossible to address variability among local, state and federal regulations. Its up to the user to find out if there are state/regional specific items that must be taken into consideration when evaluating technologies.

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Sediment Remedy Evaluation Framework

1. Review characteristics
2. Zone mapping
3. Screening
4. Technology evaluation
5. Develop alternatives
6. Evaluate alternatives

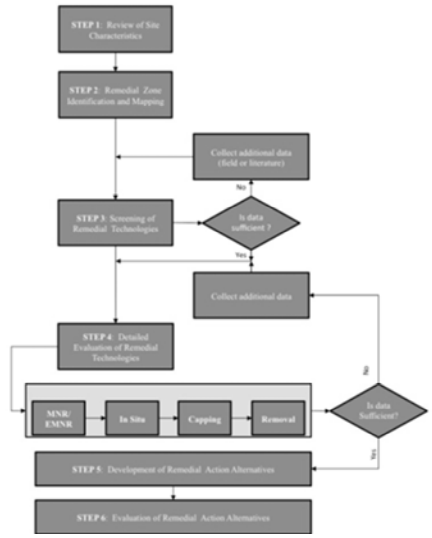

Figure 2-1. Decision matrix flow chart

Provides a 6 step framework for evaluating all sediment remediation technologies based on site-specific data.

The Framework diagram provides navigation through the web-based guidance. This diagram is used throughout this lecture series to allow you to understand your position in the Framework. The Framework contains:

Important Site Characteristics Review
Zone mapping and development
Initial Screening
Detailed Technology Evaluation with Data needs/technology assessment guidelines
Develop alternatives
Evaluate alternatives.

Another advancing feature of our electronic guidance document is the capability to point, click and go to the section of importance to you…that is correct, at your finger tips… point click and go

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Advantages of Web Document

- First and foremost…functionality
  - On-line comprehensive resource
- Technology selection
  - Driven by site-specific data
- Technology Assessment Guidelines TAG
  - Advice from national experts
- Remedial alternative evaluation
  - By zone
  - Technologies in combination
- Site-specific worksheets

Our user friendly on-line comprehensive resource (one stop shop) drives users to information throughout the framework process.

> Technology Overviews: Up to date information driven by site-specific data, and that include Technology Assessment Guidelines.
>
> Remedy Selection Framework: An advanced decision framework that enhances your remedy selection process

•Worksheets that allow the user to document decision points throughout the remedy selection process

•Site-specific data driven technology selection

> •TAGs- where expert experience is noted (describe the linkage from tables to text and explanations)

•Provides information to help develop and evaluate remedial alternatives based on site specific characteristics, including combination remedies (multiple technologies used at a single site).

•Advanced remedy evaluation beyond NCP 9 criteria.

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Advantages of Today's Training

- Provides
  - Overview of full document content
  - Guidance on functionality built into the document
  - Examples and guidance on how to use the decision framework most effectively
- Enables you to ask questions of ITRC Contaminated Sediment Team members about this document . . . . today . . . . using the interactive question pod.

This particular ITRC training event stands out b/c we are providing each of you with:

A complete and thorough overview of the content and functionality of the ITRC Contaminated Sediments – Remediation Team Document

This training provides examples on how to most effectively use the decision framework

This training event also provides you with the opportunity to ask questions of national experts . . . right now!

Note: With your active participation, you can help make future offerings of this training even better.

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What you can do after this training!

- Identify
  - Site characteristics
  - Data needs
- Evaluate
  - Favorable technology(s)
  - Applicable alternatives
- Apply
  - Your expert know-how

NVF-Yorklyn facility, Yorklyn, DE

After today's training event, we expect that you will have the tools available to help you:

IDENTIFY
EVALUTE
APPLY

The more you use the Framework, the more advanced your skills become.

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Assumptions

- Nature and extent of contaminants of concern (COCs) has been characterized sufficiently in conjunction with a conceptual site model (CSM)
- Completed human and ecological risk assessments confirm that site risks are unacceptable
- Other environmental endpoints (receptors) to be protected have been identified
- Contaminant loading has been controlled or determined
- Remedial action objectives (RAOs) have been established with stakeholder input



<u>Assumptions for successful use of this guidance</u>

•The nature and extent of CoCs originating from on-site sources and other on-site characteristics have been characterized sufficiently in conjunction with a CSM to support remedy selection.

•Human health and ecological risk assessments have been completed for the site and have determined that the site poses an unacceptable risk.

•Other environmental endpoints that are to be protected have been identified.

•Contaminant loading by releases from site-related source areas has been controlled or the ongoing contribution of site releases to site sediment contamination has been determined.

•Remedial Action Objectives (RAOs) have been established in concert with stakeholder input.

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Introduction to Example Site

- Hypothetical urban waterway
- Industrial site
  - COCs are PCBs, lead, chlordane
- Multiple site characteristics/features
  - Bulkheads
  - Soft sediments
  - Habitat areas
  - Debris/infrastructure
- Assumptions – remember !
  - Remedial Investigation (RI) completed
  - Remedial action objectives (RAOs) developed
  - Receptors are benthic invertebrates and fish
  - Sources are sufficiently identified, evaluated, and controlled

Example Site

3 of today's presenters will build upon this example during the presentation to illustrate guidance features and the usefulness of the guidance functionality.

How to use the Contaminated Sediment Remedy Selection Framework

How to apply the process to **your** site:

•Identify and establish zones

•Overview of data important when assessing remedial technologies

•How to access current information about sediment remediation technologies

•Gain a better understanding of how site specific characteristics drive selection of remedial technologies

As said earlier, the more you use the Framework, the more advanced your skills will become.

Introduce one of our leading experts, Steve Clough, Risk Assessor with Haley & Aldrich.

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Training Outline

- Introduction
- Remedy Selection and Evaluation Framework
  1. Review of site characteristics
  2. Remedial zone identification and mapping
  3. Screening of remedial technologies
  4. Evaluation of remedial technologies
  5. Development of remedial action alternatives
  6. Evaluation of remedial action alternatives
- Monitoring
- Stakeholder Concerns and Summary

interactive worksheet available for download

This section will cover the first 3 steps of the Rem Selection Framework.

Overall, the framework provides a systematic way of evaluating site-specific data to help identify the most favorable remedial technologies for a particular site.

Accomplished by:

Review of site-characteristics (1)

defining Remedial Zones (2)

preliminary screening (3)

Detailed evaluation of site-specific data (Technology Assessment Guidelines) (4)

Develop of Remedial Action Alternatives (Technology Assessment Guidelines/weight of evidence) (5)

Evaluation of Remedial Action Alternatives (6)

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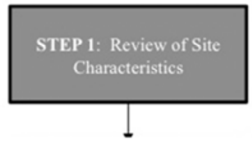
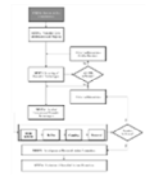
Step 1: Review Site Characteristics

- Often requires additional data

  Supplemental RI or PDIs to support the CSM
  - Physical
  - Sediment
  - Contaminant
  - Land and waterway use





Section 2.4

This document segregates the different Site Characteristics into 4 categories: Physical attributes, Sediment characteristics, Contaminant properties and Land and Waterway use. All four characteristics are not mutually independent and each subcategory, which will be discussed shortly, will help to develop data that will be needed to support the CSM and ultimately make an informed decision on the type of remedial technology.

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Characteristics Considered in Remedy Selection:
Physical

- Infrastructure
  - Bulkheads, pilings
- Bathymetry
  - Debris fields, dams
- Hydrodynamics
  - Tides, scour, channel sinuosity
- Slope stability
  - Littoral zone
- GW/SW interaction
- Habitat
  - Submerged aquatic vegetation

Physical characteristics cover the major morphological features of the Site as well as hydrodynamic forces that shape the contours of the sediment bed. Structures like bulkheads, pilings and debris fields have significant ramifications regarding the removal of sediment. River currents and tidal forces can be severe and strongly influence the bathymetric profile of the sediment bed. Groundwater intrusion can be a confounding factor from the standpoint of source control. Finally, a robust or sensitive habitat, particularly areas that may be difficult or impossible to replace (e.g. SAV), often play a part in determining the what the final remedy will be.

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Characteristics Considered in Remedy Selection:
Sediment

- ▶ Geotechnical
  - Grain size distribution
- ▶ Potential for resuspension
  - SedFlume testing
- ▶ Sediment consolidation
  - Important to cap design
- ▶ Benthic community structure
  - Supports fish and wildlife

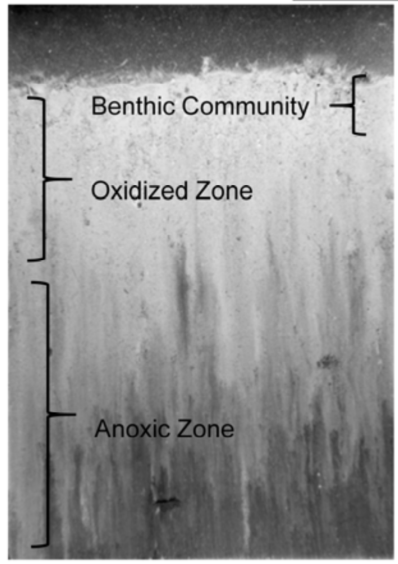

Photo courtesy Germano & Associates, Inc.

The inherent characteristics of the in-place sediments are also very important in shaping engineering decisions. For example, the geotechnical properties of the sediment will obviously affect its stability in terms of resuspension or, if capped, how the sediments will consolidate under various loads. The benthic community structure also serves a critical ecosystem function in terms of serving as a food supply for fish and wildlife. Sediment profile imaging is a technology that takes an 18 cm deep snapshot of the sediment bed. Information on grain size, the depth of the redox zone, and the benthic community can all be observed in a single photograph, such as the one seen on the right side of this slide.

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Characteristics Considered in Remedy Selection:

Contaminant

- ▶ Background
- ▶ Upstream influences
- ▶ Contaminant type
- ▶ Ebullition
- ▶ Distribution
- ▶ Bioavailability
- ▶ Exposure
- ▶ Bioaccumulation
- ▶ Biomagnification

The type, nature and extent of contamination is also a critical component that is largely addressed in the RI and risk assessment. The choice of remedy, however, will take into account most of the characteristics listed here. For example, if the flux of PCBs coming onto a site from background sources is significant (e.g. CSOs), there is clearly no advantage to capping PCB-laden sediments if the cap will just become recontaminated. Bioavailability is also rarely taken into consideration during initial investigations. If porewater testing, could show, for example, that metals in bulk sediment are not bioavailable, then it could be shown that the risk was severely overestimated and MNR might be a more feasible remedy.

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Characteristics Considered in Remedy Selection: Land and Waterway

- Current and anticipated use
  - Land
  - Waterway
- Site access
- Watershed characteristics
- Sensitive habitat and species
- Cultural/archeological resources

Included marshes as a sensitive habitat and point out that ESA is an important receptor to be considered.

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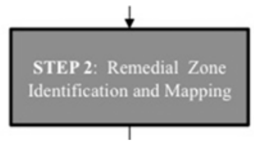
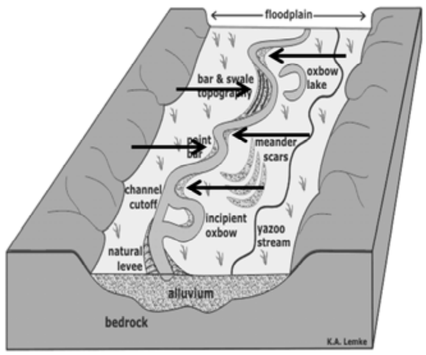
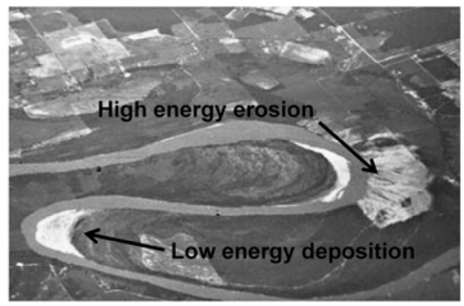
Step 2. Remedial Zone Identification and Mapping

- May help support the development of multiple remedial alternatives.
- Identify zones based on site-specific characteristics (e.g. lower energy deposition vs. higher energy erosion)







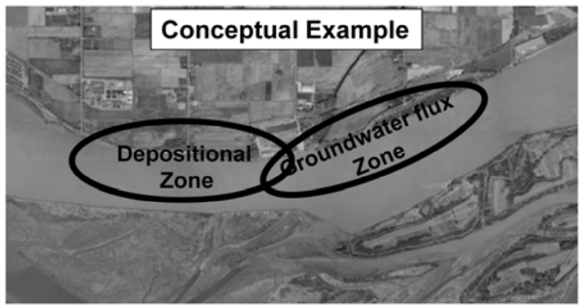
Section 2.5

Zone identification allows the investigator to identify areas that may 1) may not need remediation 2) may need some type of obvious remedial activity (e.g. hot spots) and/or 3) might require a either a combination of activities or a novel treatment (e.g. use of an adsorbent in situ). The example below is instructive in that the location of a facility on a waterway is often a critical factor in the initial identification of zones. Either the natural morphology of a river may favor the deposition of cleaner upstream sediments or perhaps the hydrodynamics around the facility may favor both a depositional zone and a scour area. For example, several facilities on the Hudson River consist of filled areas that induce powerful complex eddies because they are located in tidal zones with diurnal water level changes of up to 2 feet.

24

Approach for Zone Identification

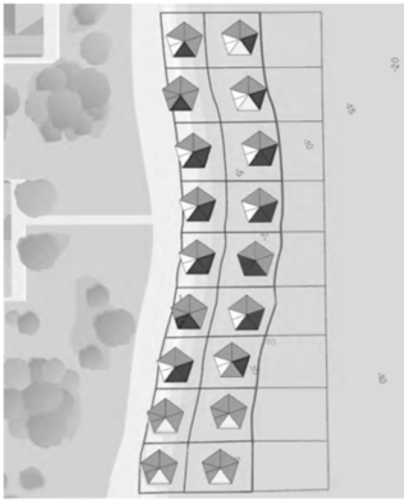
- Start with identification of contaminant distribution
- Evaluate other distinguishing characteristics
- Number of zones will always be site-specific (i.e. very simple to highly complex, depending on lines-of-evidence)



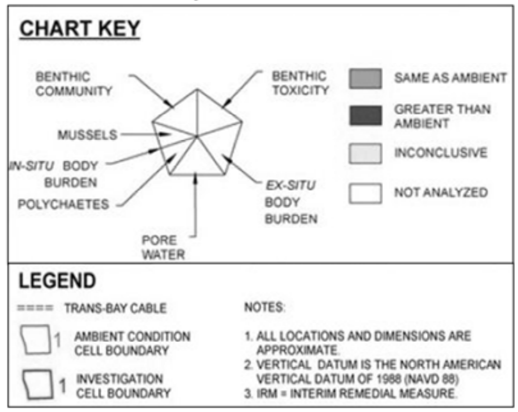
A good place to start is how are the contaminants distributed both horizontally and vertically. This process should already have been developed in the RI/risk assessment process. But comparison to PRGs or even Sediment Quality Values will give the investigator a good start to defining what zones might be amenable to MNR, what zones may need an active remedy, and what zones may need a combination of technologies which are addressed in this ITRC technical guidance document.

25

Zone Delineation Example



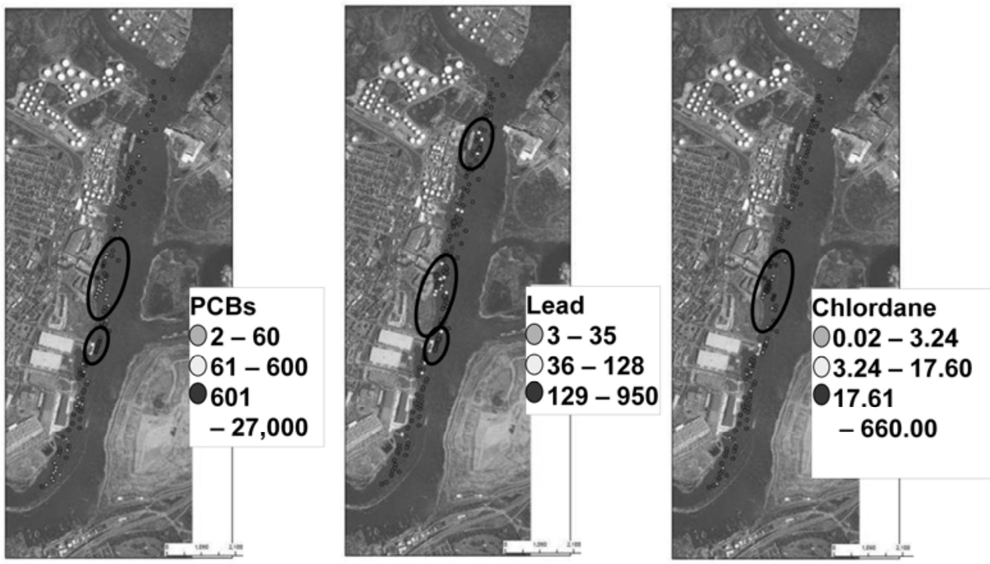
- Simple grid, uniform bathymetry
- Multiple lines-of-evidence (MLE): Porewater and biological responses of various metrics used to determine mixed remedy



This is an example of an MGP site that was investigated on the west coast, where the initial zone delineation was based on a grid that was initially developed based on nearshore concentrations that were closest to the source vs. offshore concentrations that were more representative of “local conditions” (i.e. contaminated with PAHs derived from the urban nature of the bay). Additional investigations used information from ITRCs bioavailability document to generate biological data that allowed decisions to be made based on bioaccumulation in caged mussels and native macroinvertebrates, as well as the response of organisms in sediment toxicity tests. The biggest surprise was the presence of a clear succession being developed by sea pens, which are pollution-sensitive organisms.

26

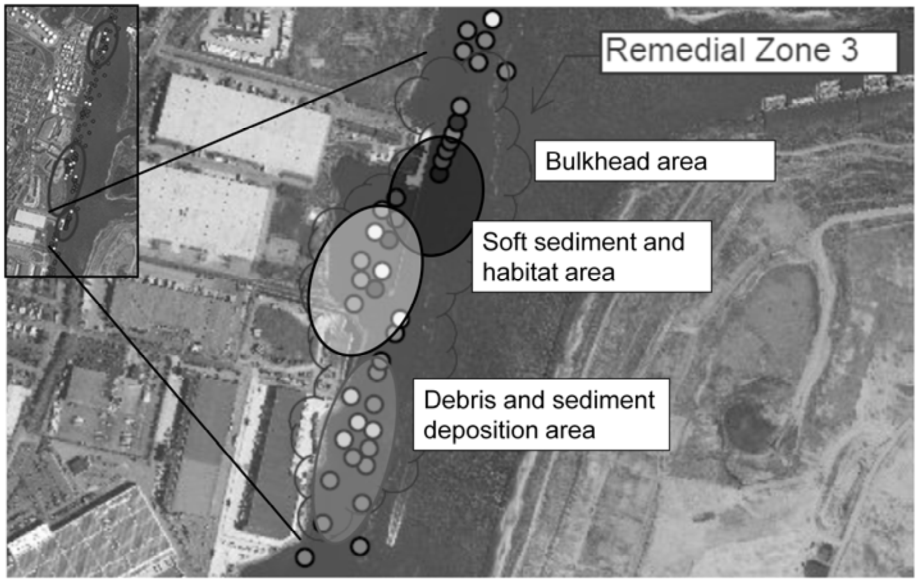
Example Site: Benchmark Screening



Moving forward, we will be using a Case Study from the state of New Jersey to illustrate various concepts when developing a contaminated sediment remedy. The aerial photographs below show the distribution of PCBs, lead and chlordane at an urban manufacturing site. Note that, based on comparison to sediment screening benchmarks, the higher concentrations tend to generally overlap each other. A decision cannot be made, however, based on concentration alone because other factors, such as site access, navigation, or sediment stability may come into play as multiple lines-of-evidence are become more developed.

27

Example Site:
Continuing Example with Only Zone 3



A comparison to sediment quality benchmarks is only one metric used in multiple lines of evidence approach. Other physical characteristics of the Site and characteristics of the sediment bed must be carefully evaluated. For the remainder of this presentation we are going to drill down on Zone 3 as an example of how to apply other sediment remedial technologies. This area will help to illustrate the complexities that may be involved beyond the assessment of horizontal and vertical nature and extent of contamination.

28

Step 3: Screening of Remedial Technologies

- Table 2-3 provides a downloadable spreadsheet containing questions pertaining to each remedial technology
- Filling the cells with specific data will help you evaluate remedial technologies and determine their applicability
- The exercise may also help eliminate one or more technologies from further consideration

Section 2.6

No associated notes.

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Initial Screening of Remedial Technologies Worksheet

- Table 2-3: spreadsheet with questions on each remedial technology (a process of elimination)

Initial Screening of Remedial Technologies Worksheet

Conditions that support a decision to retain a remedial technology for further consideration.		Condition Present?	Confidence (High, Medium, Low)?	Comment
Monitored Natural Recovery	Concentrations of COCs in sediment and tissue are decreasing at a rate to meet RAOs within an acceptable time frame.	◉ Yes ○ No	○ High ◉ Medium ○ Low	Trend over several decades is encouraging. Data is not frequent enough, however, to declare a high level of confidence.
	Low concentrations (relative to cleanup goals) are present over large areas at the site.	○ Yes ◉ No	◉ High ○ Medium ○ Low	Cannot state that concentrations, relative to PRGs, are "low."
	Net sediment deposition rates are adequate to consider natural sedimentation as a reasonable alternative to meet RAOs.	◉ Yes ○ No	○ High ◉ Medium ○ Low	Site is classified as "depositional" on State maps but the rate of deposition is not yet known.
	There is evidence that contaminants are degrading to less toxic constituents, the COCs are known to degrade, or natural sequestration is making contaminants less biologically available.	◉ Yes ○ No	○ High ○ Medium ◉ Low	Levels of TOC are, based on historical data, elevated enough (often >3%) to potentially bind persistent organic compounds making them less bioavailable.
	Dispersion of contaminants is occurring quickly enough to meet RAOs in an acceptable time frame, and is consistent with RAOs (e.g., if RAOs allow for off site migration of contaminants).	○ Yes ◉ No	◉ High ○ Medium ○ Low	There is no evidence that POCs are dispersing and that, if they were, that it would occur within an "acceptable" time frame.
	Based on these conditions, should MNR be retained for further consideration?(YES/NO)?	◉ Yes ○ No	◉ High ○ Medium ○ Low	Fairly confident that once the sediment is cleaned up to PRGs, the deposition of naturally occurring suspended sediment would keep concentrations low.

No associated notes.

30

Rows for Enhanced Monitored Natural Recovery (EMNR)

Initial Screening of Remedial Technologies Worksheet

	Conditions that support a decision to retain a remedial technology for further consideration.	Condition Present?	Confidence (High, Medium, Low)?	Comment
Enhanced Monitored Natural Recovery	Enhancing one or more MNR processes (e.g., accelerate the sedimentation rate by application of a thin layer cap to reduce the concentration of the COC in the bioavailable layer) is expected to cause RAOs to be reached within a reasonable time frame.	◉ Yes ○ No	○ High ◉ Medium ○ Low	Reasonably confident that a TLC would reduce COCs over Zone 3.
	Enhancing one or more MNR processes is compatible with current and future land and waterway use.	◉ Yes ○ No	○ High ◉ Medium ○ Low	Yes, MNR is certainly feasible knowing the nature of Zone 3 and the extent of COCs.
	Characteristics of the site do not inhibit or prevent placement of enhancement materials.	◉ Yes ○ No	○ High ◉ Medium ○ Low	Applicable to Zone 3, medium score since located in an urban setting.
	Sediment conditions are stable enough for the emplaced material to remain in place and be effective.	◉ Yes ○ No	◉ High ○ Medium ○ Low	Overall, Zone 3 is a depositional environment and deep enough so that boat traffic or ice scour would not jeopardize emplaced material.
	Based on these conditions, should enhanced MNR be retained for further consideration? (YES/NO)?	◉ Yes ○ No	○ High ◉ Medium ○ Low	

No associated notes.

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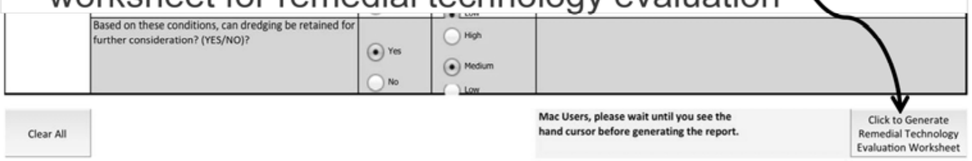
Screening Worksheet – Table 2-3

- Work through the Initial Screening tab which also includes questions addressing
  - In situ treatment
  - Conventional capping
  - Amended capping
  - Dry excavation
  - Wet excavation (dredging)
- Bottom of spreadsheet generates next worksheet for remedial technology evaluation

Click to Generate Remedial Technology Evaluation Worksheet



No associated notes.

32

Training Outline

- Introduction
- Remedy Selection and Evaluation Framework
  1. Review of site characteristics
  2. Remedial zone identification and mapping
  3. Screening of remedial technologies
  4. Evaluation of remedial technologies
  5. Development of remedial action alternatives
  6. Evaluation of remedial action alternatives
- Monitoring
- Stakeholder Concerns and Summary

interactive worksheet available for download

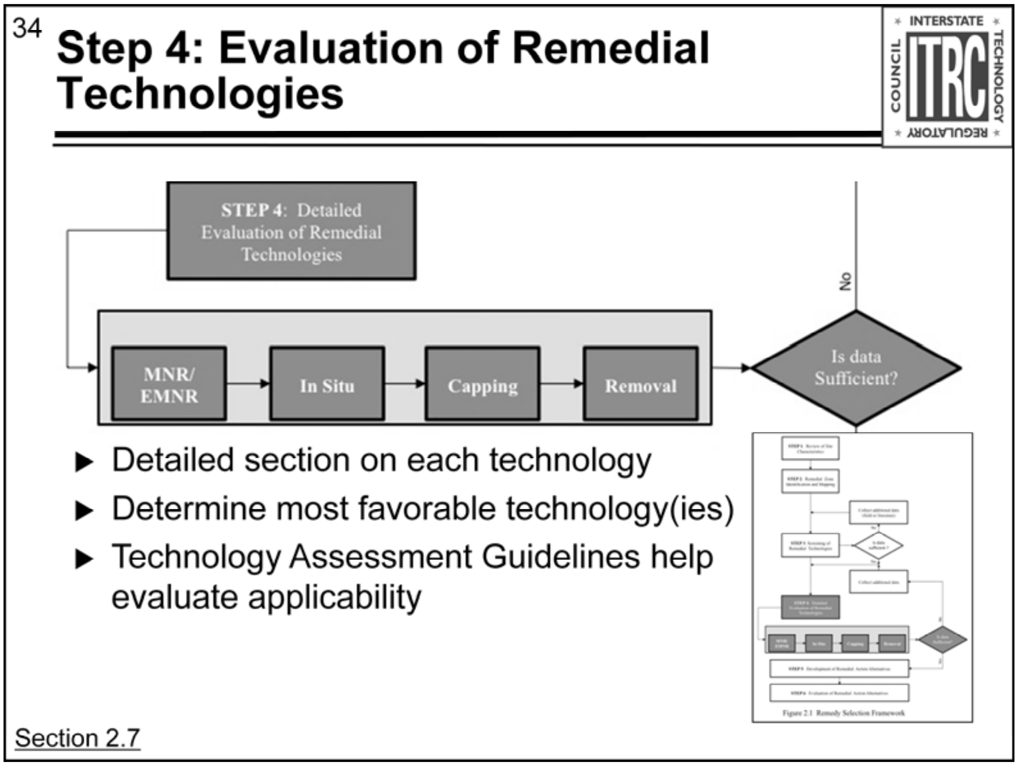
This section will cover the evaluation of remedial technologies using site-specific data and an assessment of effectiveness and implementability.

33

Poll Question: What technologies have you utilized in your work?

- Monitored natural recovery
- Enhanced monitored natural recovery
- In situ treatment
- Conventional caps
- Amended (reactive) caps
- Hydraulic dredging
- Mechanical dredging
- Excavation (dry)

No associated notes.



Determine which technology(ies) are most favorable based on site specific conditions

Detailed section on each technology type

Technology Assessment Guidelines help assess applicability and potential effectiveness and implementability of each technology

Weight of evidence approach

35

Technology Summary

- Monitored Natural Recovery (MNR) and Enhanced MNR (EMNR) (Section 3)
- In-situ treatment (Section 4)
- Conventional and amended Capping (Section 5)
- Removal (Section 6) – hydraulic, mechanical and dry excavation
- Each section
    - Describes technology
    - Recent developments
    - Technology Assessment Guidelines TAG
    - Case Studies

Brief introduction of each technology and section of guidance where additional details are provided. The general content of the technology sections is also provided

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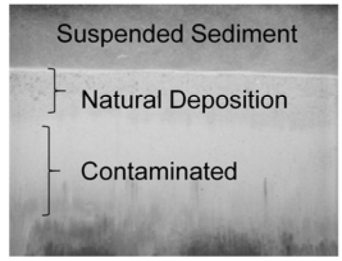
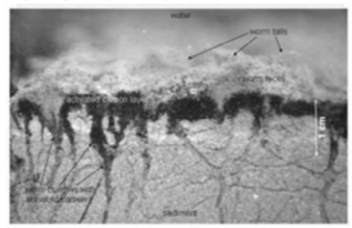
Monitored Natural Recovery (MNR) & Enhanced MNR (EMNR)

- MNR
  - Relies on natural processes: burial, mixing, dispersion, degradation
- EMNR
  - Uses the application of technologies to enhance natural recovery processes
    - Thin layer cap
    - Amendments



Mixing of Activated Carbon (AC) Layer by Bioturbation



Section 3

MNR relies on natural processes to decrease chemical concentrations in sediment to acceptable levels within a reasonable time frame.

Natural processes that contribute to MNR may include sediment burial, sediment erosion/dispersion, and contaminant sequestration/degradation (for example, precipitation, adsorption, or transformation).

EMNR uses the application of technologies to enhance the natural recovery processes

EMNR examples include thin layer cap or more recently introduction of carbon sequestration material.

Lower graphic:

- Side view of a lab microcosm 2 days after placing a layer of AC on sediment
- AC is slowly worked into the sediment through bioturbation

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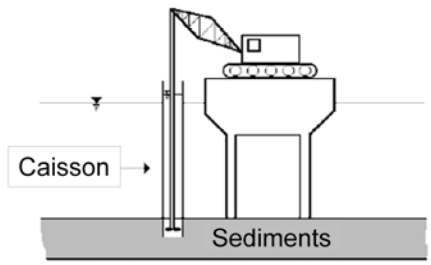
In Situ Treatment

- Treatment approaches
  - Biological, chemical, physical
- Combinations
- Keys to success
  - Proper amendment selection
  - Delivery method
  - Recognize limitations
- Evolving technology
  - Activated carbon developed
  - Solidification/stabilization in Gowanus Canal Record of Decision (ROD)



Source: Clu-in.org

Section 4

In situ sediment treatment involves the application and/or mixing of a ‘treatment amendment’ into the sediment environment.

Treatment Amendments (Materials) Methods…and an example, to be brief

Biological- bioaugmentation, biostimulation:

bioaugmentation - addition of cultured microorganisms directly on or into the sediment to initiate or enhance the degradation and or transformation of specific contaminants

biostimulation - addition of nutrients to stimulate existing microorganisms

Chemical-Transformation, degradation

Physical-Sorption, stabilization

Combinations: In practice, application of in situ treatment can incorporate combinations of the above as well as other remedial technologies including dredging, capping and monitored natural recovery.

For example, it is possible to utilize in situ treatment approaches below a cap or combined with enhanced monitored natural recovery to accelerate the recovery.

Keys to success: proper amendment evaluations, selection and delivery – delivery includes amendment placement and mixing (natural, mechanical)

38

Capping

- Placement of clean material over sediment in order to:
  - Stabilize
  - Isolate contaminated sediment
  - Physically separate benthic community from sediment
- Armoring to protect cap may be necessary
- Amendments available
- Habitat considerations

Section 5

Defined as the Placement of a Clean Layer of Material Over Contaminated Sediment

Stabilize, Prevent Re-suspension/Transport

Isolate Contaminated Sediment

Prevent Benthic Community From Coming into Contact With Contaminated Sediment

Armoring to protect cap may become necessary

Habitat and micro-ecosystems need to be taken into consideration

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Removal

- Most common technology employed
  - Dredging
    - Hydraulic
    - Mechanical
  - Excavation
- Support processes
  - Dewatering/ conditioning
  - Transport
  - Disposal
  - Beneficial use
- 4 Rs: resuspension, residuals, release & risk

Section 6

Sediment removal has been the most common technique employed to date, with over 30 years field experience removing contaminated sediments in the United States

There are three basic removal techniques used, including:

- hydraulic dredging,
- mechanical dredging and
- excavation or removal "in the dry".

Each is described in detail in the guidance

Once sediment is removed there are a number of important supporting processes required to transport, condition and dispose of the sediments.

This is where most of the costs with removal are.

Beneficial use has seen limited use with contaminated sediment but there is desire to continue to explore opportunities.

40

Technology Assessment Guidelines

- Quantitative and qualitative guidelines of characteristics provided in technology sections
- Based on simplified models, relationships and experience
- Site-specific information

Intended to be used as practical guidelines in a weight of evidence approach, not as pass/fail criteria

Quantitative and qualitative guidelines provided for each characteristic in four technology sections

Based on simplified models, relationships and experience that help to evaluate the potential effectiveness and feasibility of remedial technologies using site-specific information

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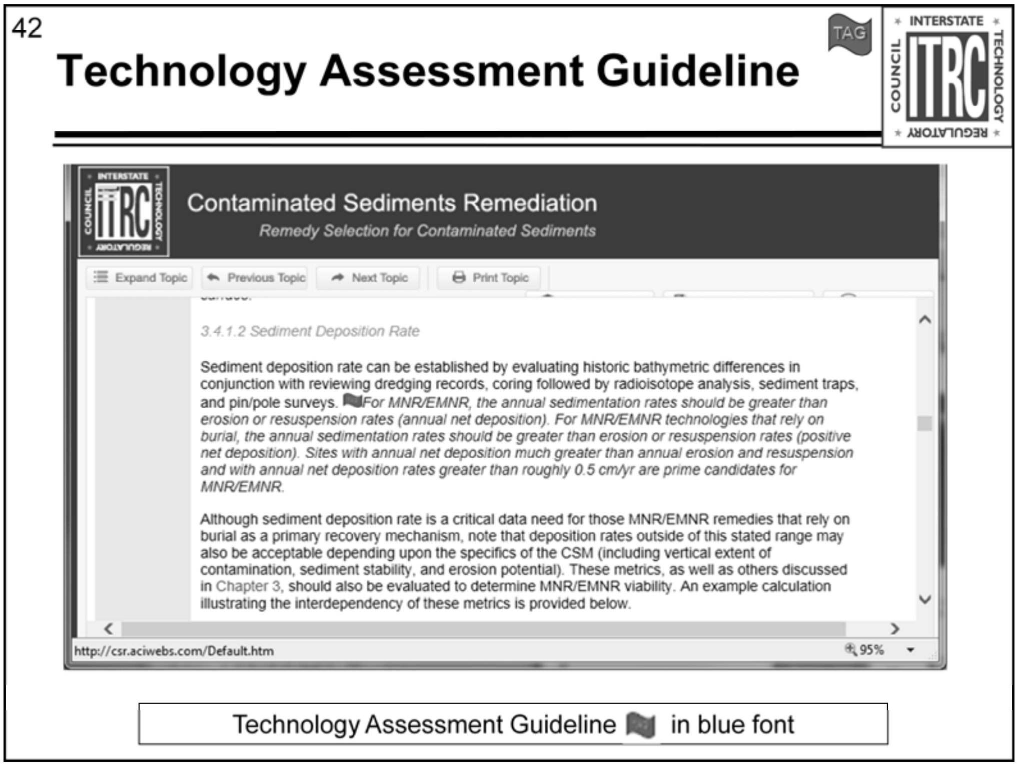
Technology Evaluation

Table 2-4. Summary of key site characteristics for remedial technologies and links to Technology Assessment Guidelines

	Monitored Natural Recovery		In situ Treatment	Capping		Removal		
Characteristic	MNR	eMNR		Conventional Capping	Amended Capping	Dredging		Excavation
						Hydraulic	Mechanical	
A. Physical Characteristics								
Sediment Stability	H 3.4.1.1	H 3.4.1.1	H 4.4.1.5	M 5.15.5	M 5.15.5	L 6.6.1		L 6.6.1
Sediment Deposition Rate	H 3.4.1.2	H 3.4.1.2	M 4.4.1.4	M 5.15.2	M 5.15.2	L 6.6.2		L 6.6.2
Bedded Sediments	3.4.1.3	H 3.4.1.3	H 4.4.1.10	M 5.15.1	M 5.15.1	L 6.6.3		L 6.6.3
Water Depth, Site Bathymetry	M 3.4.1.4	M 3.4.1.4	H 4.4.1.9	H 5.15.3	H 5.15.3	H 6.6.4	H 6.6.4	H 6.6.4
In-water and Shoreline Infrastructure	M 3.4.1.5	M 3.4.1.5	M 4.4.1.6	M 5.15.4	M 5.15.4	H 6.6.5	H 6.6.5	H 6.6.5
Presence of Hard Bottom	M 3.4.1.6	M 3.4.1.6	L 4.4.1.7	L	L	H 6.6.6	H 6.6.6	H 6.6.6

A table is provided in the guidance that provides a couple key functions, including:

1. Summarizes the relative importance of each physical characteristic, sediment characteristics, contaminant characteristics, land and waterway uses
2. Provides a linkable roadmap to a detailed discussion of each characteristic for each technology
3. Indicates which characteristics have technology assessment guidelines (see thumb symbol, for now)
4. Explain H, M, L for sediment stability as an example.
5. Can click on sub-section numbers to be taken to the related discussion within section 3, 4, 5 or 6.



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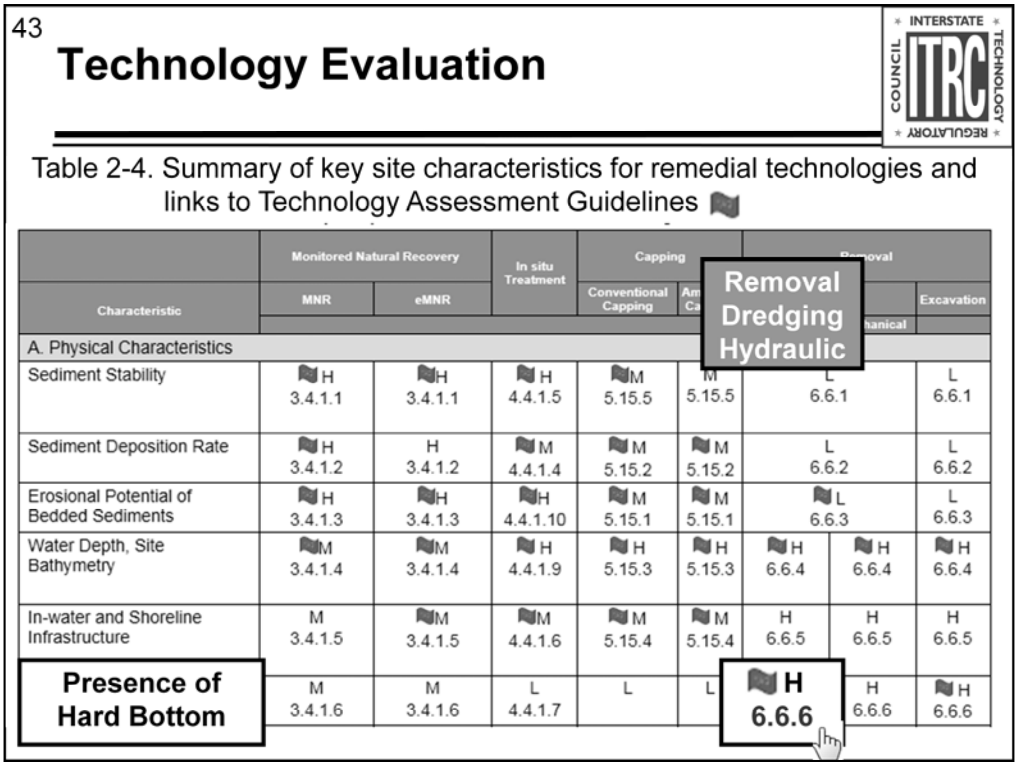

Characteristic	Monitored Natural Recovery: MNR	Monitored Natural Recovery: eMNR	In situ Treatment	Capping: Conventional Capping	Capping: Am Ca	Removal: Dredging Hydraulic	Removal: Dredging hanical	Removal: Excavation
A. Physical Characteristics								
Sediment Stability	H 3.4.1.1	H 3.4.1.1	H 4.4.1.5	M 5.15.5	M 5.15.5	L 6.6.1		L 6.6.1
Sediment Deposition Rate	H 3.4.1.2	H 3.4.1.2	M 4.4.1.4	M 5.15.2	M 5.15.2	L 6.6.2		L 6.6.2
Erosional Potential of Bedded Sediments	H 3.4.1.3	H 3.4.1.3	H 4.4.1.10	M 5.15.1	M 5.15.1	L 6.6.3		L 6.6.3
Water Depth, Site Bathymetry	M 3.4.1.4	M 3.4.1.4	H 4.4.1.9	H 5.15.3	H 5.15.3	H 6.6.4	H 6.6.4	H 6.6.4
In-water and Shoreline Infrastructure	M 3.4.1.5	M 3.4.1.5	M 4.4.1.6	M 5.15.4	M 5.15.4	H 6.6.5	H 6.6.5	H 6.6.5
Presence of Hard Bottom	M 3.4.1.6	M 3.4.1.6	L 4.4.1.7	L	L	H 6.6.6	H 6.6.6	H 6.6.6

A table is provided in the guidance that provides a couple key functions, including:

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3. Indicates which characteristics have technology assessment guidelines (see thumb symbol, for now)
4. Explain H, M, L for sediment stability as an example.
5. Can click on sub-section numbers to be taken to the related discussion within section 3, 4, 5 or 6.

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Technology Assessment Guideline

TAG

Contaminated Sediments Remediation

Remedy Selection for Contaminated Sediments

Expand Topic | Previous Topic | Next Topic | Print Topic

6.6.6 Presence of hard bottom

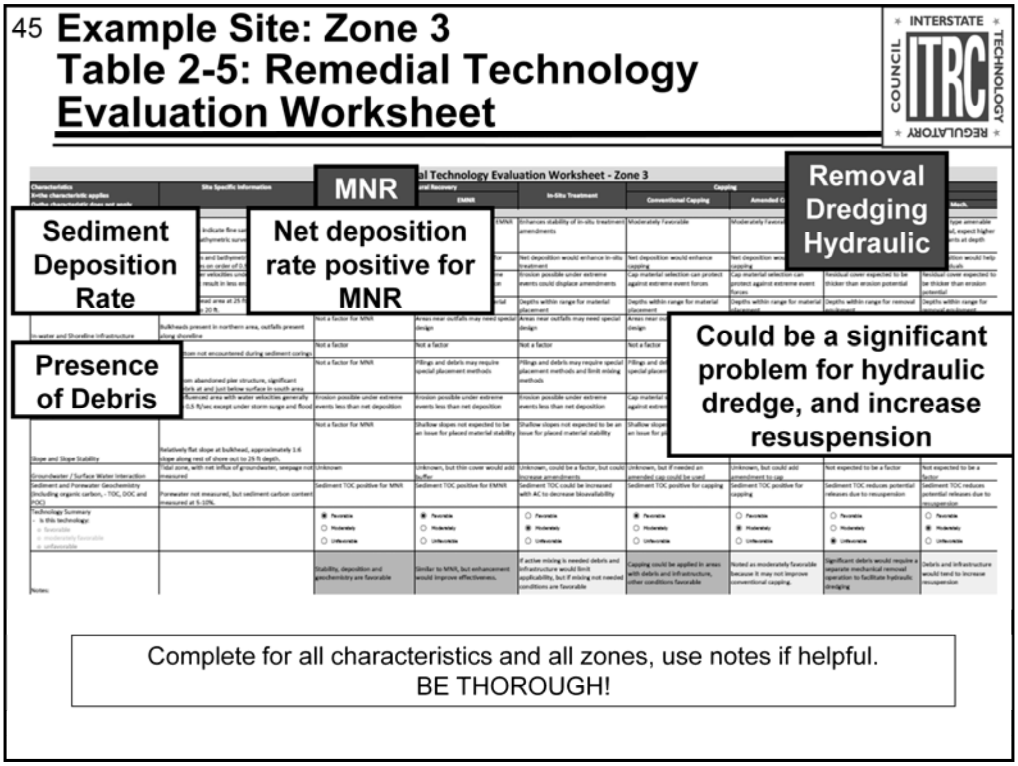
The presence of a hard bottom can limit the ability to establish effective containment during removal. (i.e., if sheet piling is contemplated) depending on the composition and configuration of the hard bottom. Contaminated sediment overlying bedrock or glacial till could present a challenge to certain dredging equipment. *Contaminated sediment lodged in crevices in bedrock can be impractical to remove.*

For hydraulic dredging, the presence of a hard bottom underlying the contaminated sediment limits the ability to over-dredge into a relatively clean surface, and can also increase the magnitude of generated residuals and undisturbed residuals. For mechanical dredges the presence of hard bottom typically leads to greater amounts of generated residuals and resuspension, due to over-dredging difficulties and the higher energy required to remove the more consolidated underlying material. On the other hand, a hard bottom below contaminated sediment will tend to limit over-excavation of material. *Attempting to re-dredge residuals on top of hard bottom using either mechanical or hydraulic dredges has been shown to be less effective in reducing contaminant concentrations, but plain suction dredges can more effectively capture generated sediments*and*residuals from a hard bottom.*

Mechanical leverage of an excavator during excavation facilitates more accurate removal and can remove hard material with less sediment loss.

Technology Assessment Guideline in blue font

No associated notes.

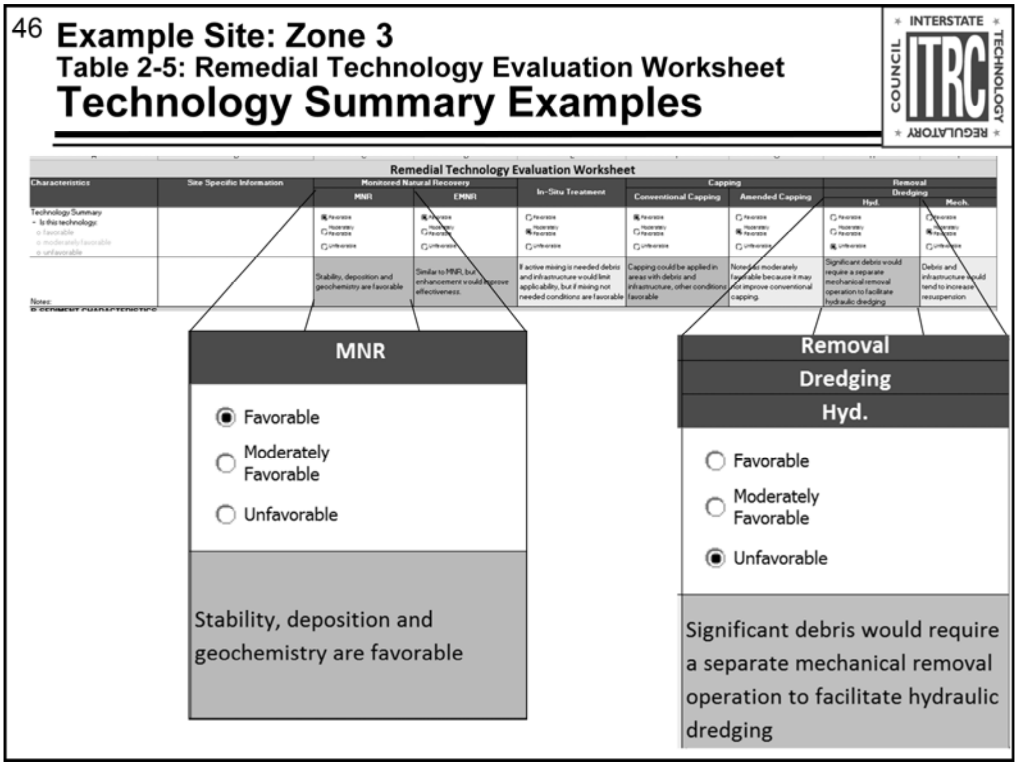


Populate with physical and sediment characteristics.

Complete one for each remedial zone.

Summarize the degree to which each technology is favorable

Use most favorable approaches in the next step – development of remedial action alternatives



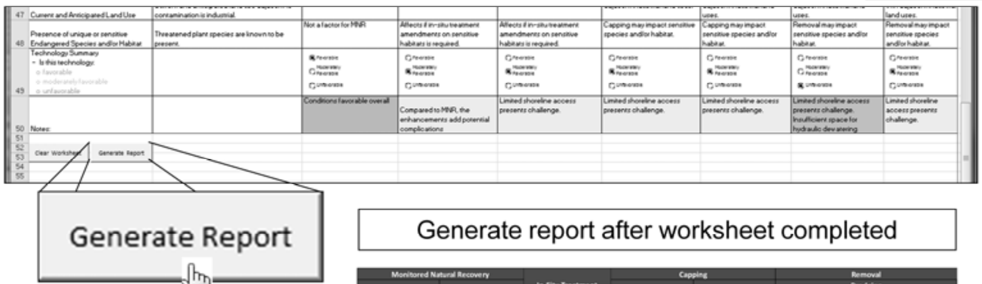
Populate with physical and sediment characteristics.

Complete one for each remedial zone.

Summarize the degree to which each technology is favorable

Use most favorable approaches in the next step – development of remedial action alternatives

47 **Example Site: Zone 3**
Table 2-5: Remedial Technology Evaluation Worksheet



Generate report after worksheet completed

Monitored Natural Recovery		In-Situ Treatment	Capping		Removal	
					Dredging	
MNR	EMNR		Conventional Capping	Amended Capping	Hyd.	Mech.
A.PHYSICAL CHARACTERISTICS						
Stability, deposition and geochemistry are favorable	Similar to MNR, but enhancement would improve effectiveness.	If active mixing is needed debris and infrastructure would limit applicability, but if mixing not needed conditions are favorable	Capping could be applied in areas with debris and infrastructure, other conditions favorable	Noted as moderately favorable because it may not improve conventional capping.	Significant debris would require a separate mechanical removal operation to facilitate hydraulic dredging	Debris and infrastructure would tend to increase resuspension
B.SEDIMENT CHARACTERISTICS						
Conditions are favorable	EMNR would improve MNR favorability and would help protect during resuspension events	Conditions are favorable	Special design considerations needed for soft sediments, and porewater expression during consolidation	Similar to conventional capping	Increased resuspension expected due to sediment characteristics	Increased resuspension expected due to sediment characteristics
C.CONTAMINATION CHARACTERISTICS						
Moderate favorability due to ebullition, and contaminant recalcitrance	Moderate favorability due to ebullition, and contaminant recalcitrance	AC could reduce bioavailability but low target cleanup levels	Contaminant characteristics are favorable for capping	Same as conventional capping, but could improve with addition of carbon	Higher conc at depth and low cleanup levels limit effectiveness of dredging	Higher conc at depth and low cleanup levels limit effectiveness of dredging
D. LAND AND WATERWAY USE CHARACTERISTICS						
Conditions favorable overall	Compared to MNR, the enhancements add potential complications	Limited shoreline access presents challenge.	Limited shoreline access presents challenge.	Limited shoreline access presents challenge.	Limited shoreline access presents challenge. Insufficient space for hydraulic dewatering	Limited shoreline access presents challenge.

Evaluation Report. More information in next section

Click on Generate Report to develop a summary graphic with notes, color coded

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Questions and Answers

Follow ITRC

No associated notes.

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Training Outline

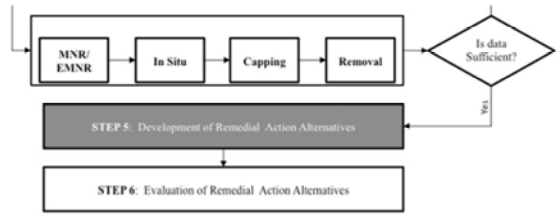
- Introduction
- Remedy Selection and Evaluation Framework
  1. Review of site characteristics
  2. Remedial zone identification and mapping
  3. Screening of remedial technologies
  4. Evaluation of remedial technologies

     interactive worksheet available for download
  5. Development of remedial action alternatives
  6. Evaluation of remedial action alternatives
- Monitoring
- Stakeholder Concerns and Summary

No associated notes.

50

Step 5: Development of Remedial Action Alternatives



- Evaluate remedial technologies based on site specific characteristics
- Technologies deemed most favorable based are assembled into remedial action alternatives
- Remedial alternatives can be assembled for single or multiple zones

Section 2.8

Remedial technologies are evaluated based on site specific characteristics with respect to their ability to achieve remedial action objectives

Technologies deemed most favorable are assembled into remedial action alternatives

Remedial alternatives can be assembled for a single zone or multiple zones

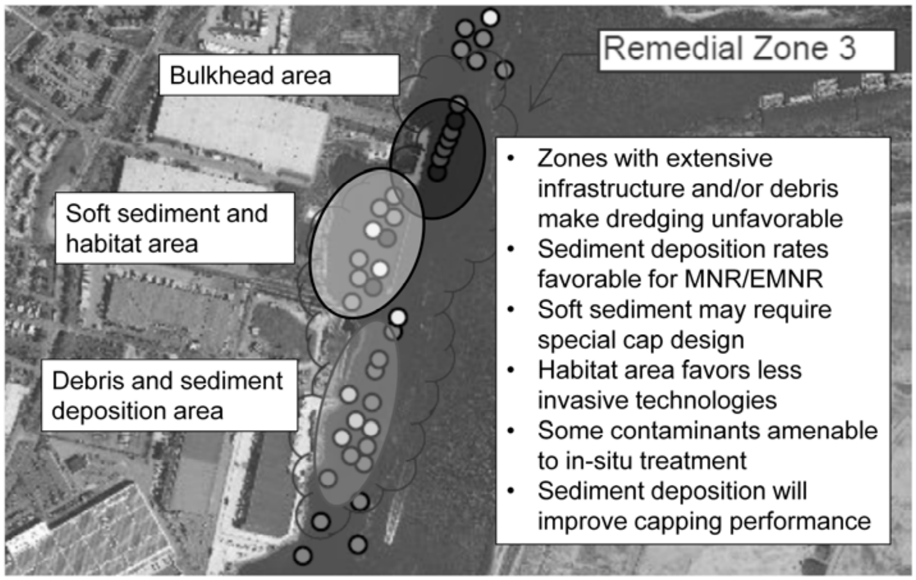
51 **Example Site:**
Review – Identification of Remedial Zones

- Initial identification is based on contaminant distribution
  - Three areas identified
- Refine remedial zones based on site specific conditions
  - Remedial Zone 1 – no subdivision needed
  - Remedial Zone 2 – three sub zones identified based on contaminant type, groundwater discharge and habitat considerations
  - Remedial Zone 3 – three sub zones identified based on infrastructure, sediment strength and presence of debris
- Focus on Remedial Zone 3

Review. Summarize process for initially identifying remedial zones based on contaminant distribution and then refining based on site specific characteristics related to the effectiveness and implementability of remedial technologies.

52 **Example Site:**

Remedial Zone 3 – MNR/EMNR and Capping Favored



This remedial was subdivided into three zones based on infrastructure, sediment strength, presence of debris and sediment deposition rate. Presence of bulkheads screens out removal. Soft sediments may require special considerations during capping – e.g., preloading. Sediment deposition and presence of debris favors capping and MNR/EMNR.

Key characteristics include:

Physical Characteristics

- Deposition rate
- Bulkhead
- Debris

Sediment Characteristics

- Sediment strength

Contaminant characteristics

- Amenable to in-situ treatment

Land and Waterway Use Characteristics

- Habitat area
- Navigation requirements

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Example Site: Review - Technology Screening

Technology	Remedial Zone 3 Bulkhead Area	Remedial Zone 3 Soft Sediment Habitat Area	Remedial Zone 3 Debris and Deposition Area
MNR	Retained	Retained	Retained
EMNR	Retained	Retained	Retained
In-Situ Treatment	Retained	Retained	Retained
Conventional Capping	Retained	Retained	Retained
Reactive Capping	Retained	Retained	Retained
Excavation (Dry)	Eliminated	Eliminated	Eliminated
Dredging (Wet)	Retained	Retained	Retained

In remedial zone 1, capping and in-Situ Treatment were eliminated due to navigation requirements and potential for propwash induced erosion.

In remedial zone 2, capping and removal eliminated due to impacts on habitat

In remedial zone 3, removal eliminated due to bulkhead stability

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Example Site: Results of Technology Evaluation

Monitored Natural Recovery		In-Situ Treatment	Capping		Removal	
					Dredging	
MNR	EMNR		Conventional Capping	Amended Capping	Hyd.	Mech.
A.PHYSICAL CHARACTERISTICS						
Stability, deposition and geochemistry are favorable	Similar to MNR, but enhancement would improve effectiveness.	If active mixing is needed debris and infrastructure would limit applicability, but if mixing not needed conditions are favorable	Capping could be applied in areas with debris and infrastructure, other conditions favorable	Noted as moderately favorable because it may not improve conventional capping.	Significant debris would require a separate mechanical removal operation to facilitate hydraulic dredging	Debris and infrastructure would tend to increase resuspension
B.SEDIMENT CHARACTERISTICS						
Conditions are favorable	EMNR would improve MNR favorability and would help protect during resuspension events	Conditions are favorable	Special design considerations needed for soft sediments, and porewater expression during consolidation	Similar to conventional capping	Increased resuspension expected due to sediment characteristics	Increased resuspension expected due to sediment characteristics
C.CONTAMINATION CHARACTERISTICS						
Moderate favorability due to ebullition, and contaminant recalcitrance	Moderate favorability due to ebullition, and contaminant recalcitrance	AC could reduce bioavailability but low target cleanup levels	Contaminant characteristics are favorable for capping	Same as conventional capping, but could improve with addition of carbon	Higher conc at depth and low cleanup levels limit effectiveness of dredging	Higher conc at depth and low cleanup levels limit effectiveness of dredging
D. LAND AND WATERWAY USE CHARACTERISTICS						
Conditions favorable overall	Compared to MNR, the enhancements add potential complications	Limited shoreline access presents challenge.	Limited shoreline access presents challenge.	Limited shoreline access presents challenge.	Limited shoreline access presents challenge. Insufficient space for hydraulic dewatering	Limited shoreline access presents challenge.

No associated notes.

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Example Site: Remedial Alternative Development

- Consider a range of alternatives covering retained remedial technologies
  - MNR/EMNR, treatment, reactive and conventional capping and mechanical dredging effective for Remedial Zone 3
- Remedial alternatives should be evaluated to ensure that they meet RAOs
  - MNR generally does not meet RAOs within a reasonable time frame for Remedial Zone 3
- The most favorable alternatives should be retained for detailed analysis
  - Dredging along bulkhead is not implementable

No associated notes.

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Example Site:
Remedial Alternative Development

Remedial Zone	Treatment and MNR/EMNR Based	Capping and Treatment Based	Dredging and Capping Based
Remedial Zone 3 – Bulkhead Area	In-Situ Treatment	Conventional Cap	Reactive Cap
Remedial Zone 3 – Soft Sediment	In-Situ Treatment	Conventional Cap	Dredge and cap residuals
Remedial Zone 3 – Depositional Area	EMNR	In-Situ Treatment	Conventional Cap

Based on the evaluation of specific technologies, alternatives can be assembled ranging from most aggressive to least aggressive. These alternatives will undergo the detailed and comparative evaluation of alternatives. This will allow consideration of factors such as cost, degree of risk reduction and permanence.

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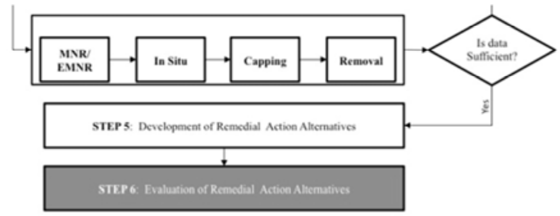
Step 6: Evaluation of Remedial Action Alternatives



- Evaluate remedial action alternatives according to appropriate regulatory framework
- Typically requires evaluation of
  - Long-term effectiveness, short-term impacts, implementability and cost
  - Exact criteria is dependent on regulatory requirements
- Incorporate modifying criteria
  - community concerns and sustainability

Section 2.9

As mentioned previously, assembled alternatives are evaluated consistent with the regulatory framework the site is being investigated and remediated under. While there are differences between the various state cleanup programs and the EPA CERCLA process, there are some similarities. Most require consideration of long-term effectiveness (risk reduction), short term impacts (implementation risk) and costs. In addition, there may be modifying criteria such as community acceptance that result in refinements to the preferred cleanup approach.

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Evaluation Principles and Criteria

- Focus on achieving RAOs and net risk reduction
  - Estimate degree of risk reduction at completion and over time
  - Recognize that MNR is likely a component of all sediment remedies
- Maximize long term risk reduction while minimizing short term impacts
  - Active remediation can increase short term impacts
  - Less aggressive alternatives may not achieve long term remedial goals

Evaluate the ability the technology to meet remedial action objectives. Does the cleanup protect human health and the environment and, if MNR is a component of the cleanup, how long will it take.

Evaluate reduction in fish tissue and/or sediment concentrations to acceptable levels. Balance short term effects associated with dredging and capping against increased long-term effectiveness

In-water sources of sediment contamination that represent a long-term threat or may be an ongoing source of contamination

External sources of sediment contamination such as stormwater discharges, bank erosion or advective groundwater transport

Predictions of long-term risk reduction, time to achieve remedial goals and estimates of MNR effectiveness are all uncertain. Consider multiple lines of empirical and predictive evidence.

Examine incremental cost differences in relation to incremental differences in effectiveness.

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Risk Reduction and Remedial Action Objectives (RAOs)

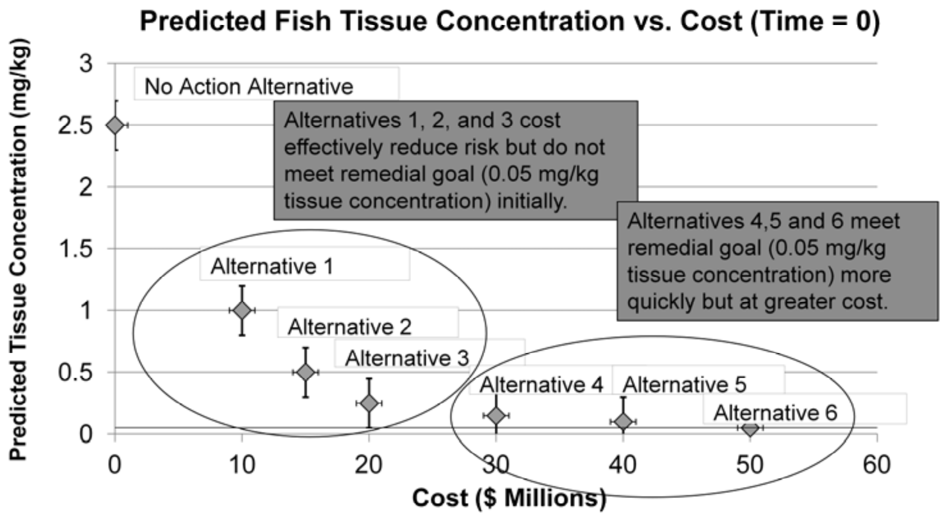

Figure 2-2. Risk reduction (represented by fish tissue concentration) versus cost of various alternatives. Source: Modified from Bridges et al. 2012, Figure 1.

Chart presents predicted fish tissue levels for each alternative.

Measures ability to meet RAO, risk reduction and cost effectiveness.

Note the uncertainty in the predicted fish tissue levels as well as the costs of the remedy.

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Risk Reduction and RAOs: Years to Achieve Protectiveness

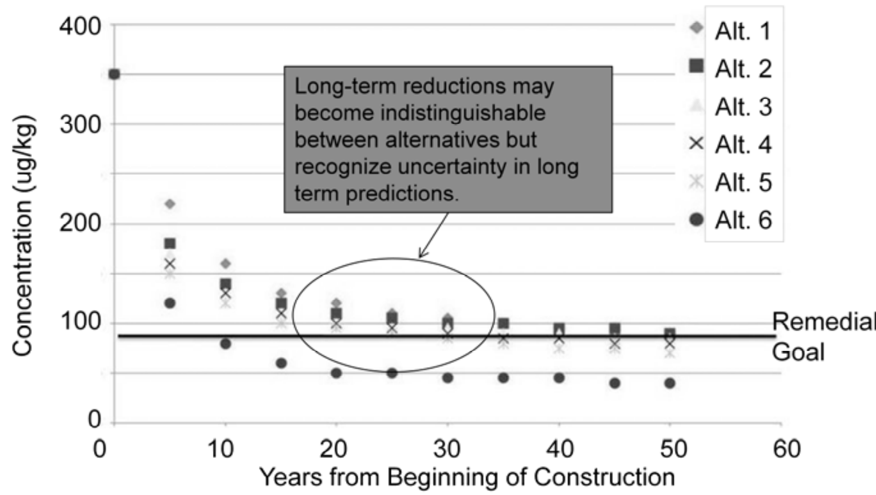

Figure 2-4. Estimated final concentration of COPC after implementation to demonstrate long-term effectiveness of each alternative

Consider the time to protectiveness. How much is it worth to shorten the timeframe given the uncertainties in our predictions and the increased implementation risk associated with more aggressive remedies?

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Evaluation Principles and Criteria

- Address areas of contamination that may be an ongoing source
  - Address in-water sediment sources that limit MNR effectiveness
  - Addressing more in-water sediment sources through active remediation will generally increase the effectiveness of MNR
- Acknowledge and manage uncertainty
  - Adaptive management frameworks
  - Interim and contingent remedies
- Balance cost against overall effectiveness
  - Costs should be proportional to overall effectiveness

Evaluate the ability the technology to meet remedial action objectives. Does the cleanup protect human health and the environment and, if MNR is a component of the cleanup, how long will it take.

Evaluate reduction in fish tissue and/or sediment concentrations to acceptable levels. Balance short term effects associated with dredging and capping against increased long-term effectiveness

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Examine incremental cost differences in relation to incremental differences in effectiveness.

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Weighted Benefits and Associated Cost by Alternative

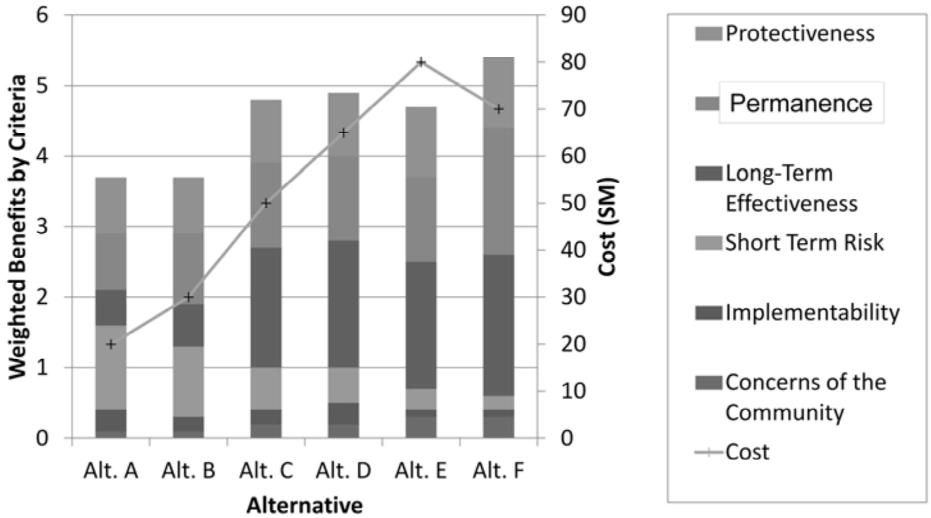

Figure 2-5. Weighted benefits and associated cost by alternative.

Here is a generic example of how benefits can be weighed against cost. It should be noted that the measure of benefits has a certain amount of subjectivity and that different stakeholders weigh the benefits differently. However, this can still be a useful exercise because the most costly cleanup approach may not have the greatest net benefit as can be seen from Alternative E.

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Evaluation Principles and Criteria

- Address specific regulatory requirements
  - Threshold, balancing and modifying criteria
- Manage risk
  - Uncertainty and cost
- Recognize role of complementary regulatory programs to address watershed contributions
- Incorporate green and sustainable remediation concepts
  - Environmental, social, and economic impacts
  - See also ITRC's Green and Sustainable Remediation: A Practical Framework (GSR-2, 2011)
- Incorporate habitat and resource restoration
  - Mitigation and restoration

Reduction in toxicity, mobility and volume through treatment and compliance with ARARs under CERCLA

Compatibility with future site use

Long-term monitoring and adaptive management to address uncertainty (may include contingencies and triggers)

State and Tribal acceptance

Community acceptance
Considers lifecycle costs
ESA or CWA mitigation and/or integrated NRDA restoration activities
Background concentrations that may limit effectiveness and broader watershed wide voluntary or regulatory initiatives

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Example Site: Remedial Alternative Evaluation

Remedial Zone	Preferred Alternative	Evaluation Outcome
Remedial Zone 3 – Bulkhead Area	Conventional Cap	Conventional cap is sufficient to meet RAOs. In-situ treatment may not achieve RAOs due to low target cleanup levels.
Remedial Zone 3 – Soft Sediment	In-Situ Treatment	In-situ treatment will meet cleanup goals, reduces short term habitat impacts, and is easily implementable.
Remedial Zone 3 – Depositional Area	EMNR	EMNR will achieve cleanup goals, is implementable and cost effective.

Finally, once the evaluation has been completed, a preferred alternative can be selected as the site remedy. In this case, we have selected different technologies for different areas based on site specific characteristics which influence long term and short term effectiveness, implementability and cost.

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Training Outline

- Introduction
- Remedy Selection and Evaluation Framework
  1. Review of site characteristics
  2. Remedial zone identification and mapping
  3. Screening of remedial technologies
  4. Evaluation of remedial technologies
  5. Development of remedial action alternatives
  6. Evaluation of remedial action alternatives
- Monitoring
- Stakeholder Concerns and Summary

interactive worksheet available for download

This section will cover the first 3 steps of the Rem Selection Framework.

Overall, the framework provides a systematic way of evaluating site-specific data to help identify the most favorable remedial technologies for a particular site.

Accomplished by:

Review of site-characteristics (1)

defining Remedial Zones (2)

preliminary screening (3)

Detailed evaluation of site-specific data (Technology Assessment Guidelines) (4)

Develop of Remedial Action Alternatives (Technology Assessment Guidelines/weight of evidence) (5)

Evaluation of Remedial Action Alternatives (6)

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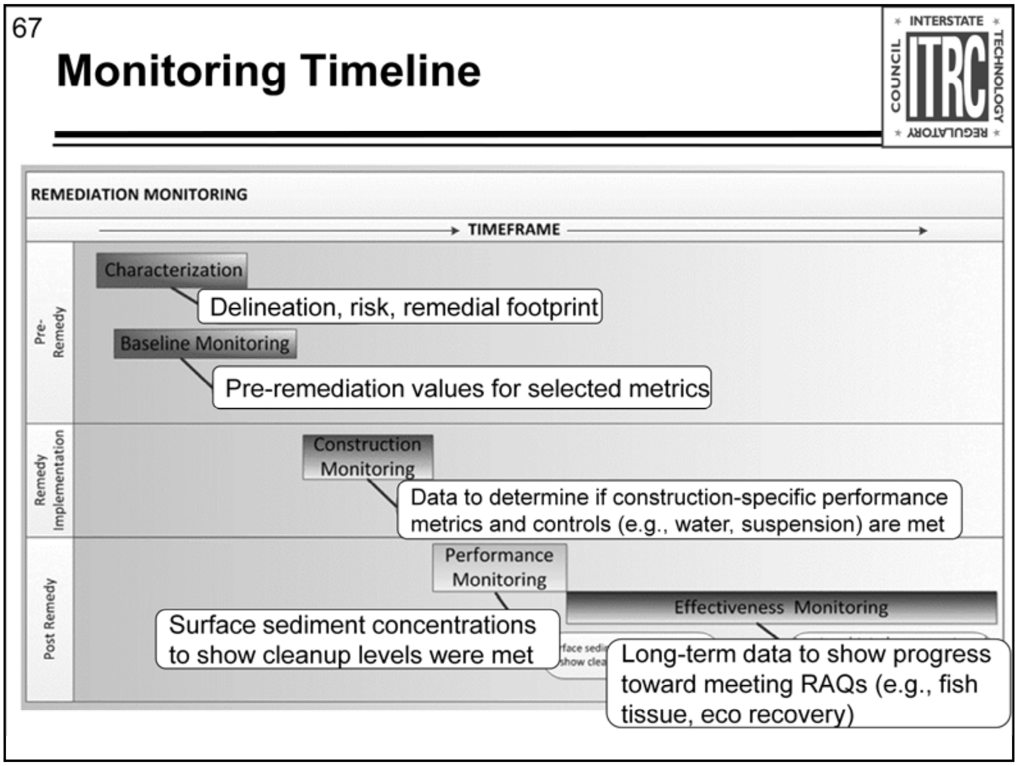
Monitoring: Critical Component of any Remedial Action

- Understand baseline conditions
- Measure important variables during construction
  - For example: turbidity associated with resuspension during remedy implementation
- Determine whether remedy performed as expected
  - For example: surface sediment concentrations post remedy
- Evaluate effectiveness
  - For example, reduction in fish tissue concentrations over time

Section 7

From the very beginning, the Sediment Remediation group recognized that monitoring would be a key element of any remediation alternative; and that planning for and implementing an effective monitoring plan should be part of this guidance. What follows is the ITRC recommended planning approach. It is based on EPA's Data Quality Objectives Process, but also incorporates the EPA sediment remediation, Navy sediment guidance and other resources.

Monitoring will be required at each phase of the operation – before clean up, during construction, post remediation and long term.



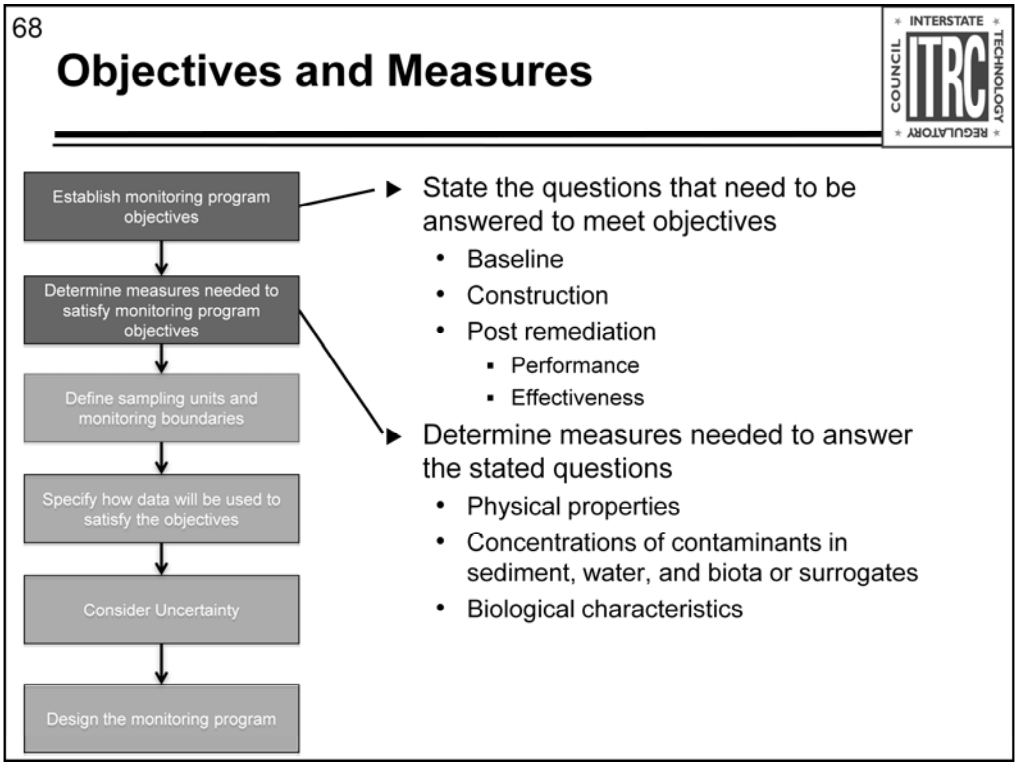
This figure shows how monitoring fits into the overall timeframe.

Note that prior to considering remedial alternatives, a characterization effort, usually as part of a Remedial Investigation, will have taken place. These data may, or MAY NOT be adequate to understand baseline (pre-remedy) conditions. Baseline monitoring requires pre-remediation values for the SELECTED METRICS.

For example, if the planning team selects an advanced measurement method for long term monitoring such as a semi-permeable membrane sampler, or elects to use caged clams or other organisms to measure the ability of the remedy to limit bioavailability of contaminants; it will be critical to obtain measurement using these selected measures prior to remedy implementation.

Alternatively, if the planning team decides to utilize composite sampling, or sampling of a specific layer of sediment, that was not characterized in this manner for the RI, such samples should be collected to establish a baseline, so that we are not trying to compare post remedy data to a different type of data collected during the RI.

We will talk more about construction, performance and effectiveness monitoring as we continue through this presentation.



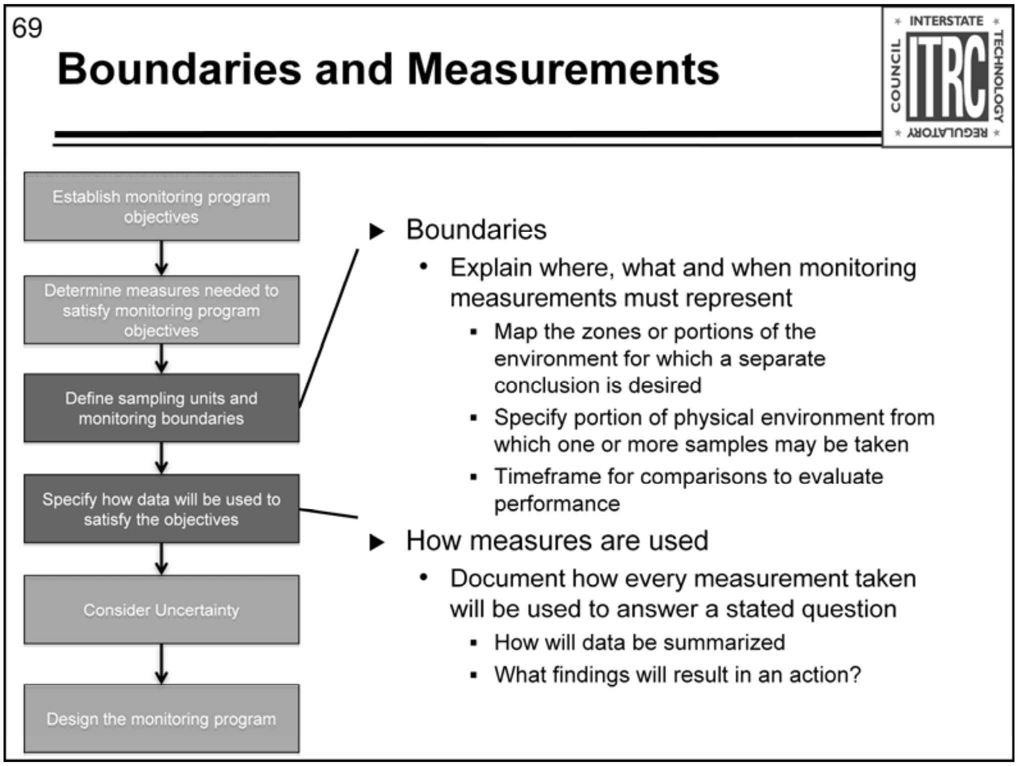
In this slide, we introduce the six step planning process which starts by having the planning team document their monitoring program objectives.

Objectives should be established for each of the phases of monitoring previously shown: Baseline, Construction, and Post Remediation (performance and effectiveness monitoring)

We recommend that the objectives be stated as specific questions that will be answered using the monitoring data to be collected.

Once these questions are stated; the process requires the planning team to determine the specific measurements that will be needed to answer the questions.

In general, these measurements will include: Physical properties (in sediment and surface water); Concentrations of contaminants (in sediment, SW, Biota or surrogates); and Biological characteristics. In many cases the measures will involve bioassays that can be used to demonstrate reductions in bioavailability and/or toxicity before, during and after remedy implementation. The specific questions and associated measures selected are highly dependent on the unique conditions at a site, but we will provide some general examples in a few minutes.



Following the EPA systematic DQO planning process, the next step in planning a monitoring program is to specify the BOUNDARIES by explaining WHERE, WHAT and WHEN monitoring measurements must REPRESENT.

This step can be tricky and is not as straight forward as it may sound.

The team should map each of the remediation zones or other portions of the environment for which separate conclusions are desired. This will ensure that adequate data is collected from each such area to support the evaluation of trends over time.

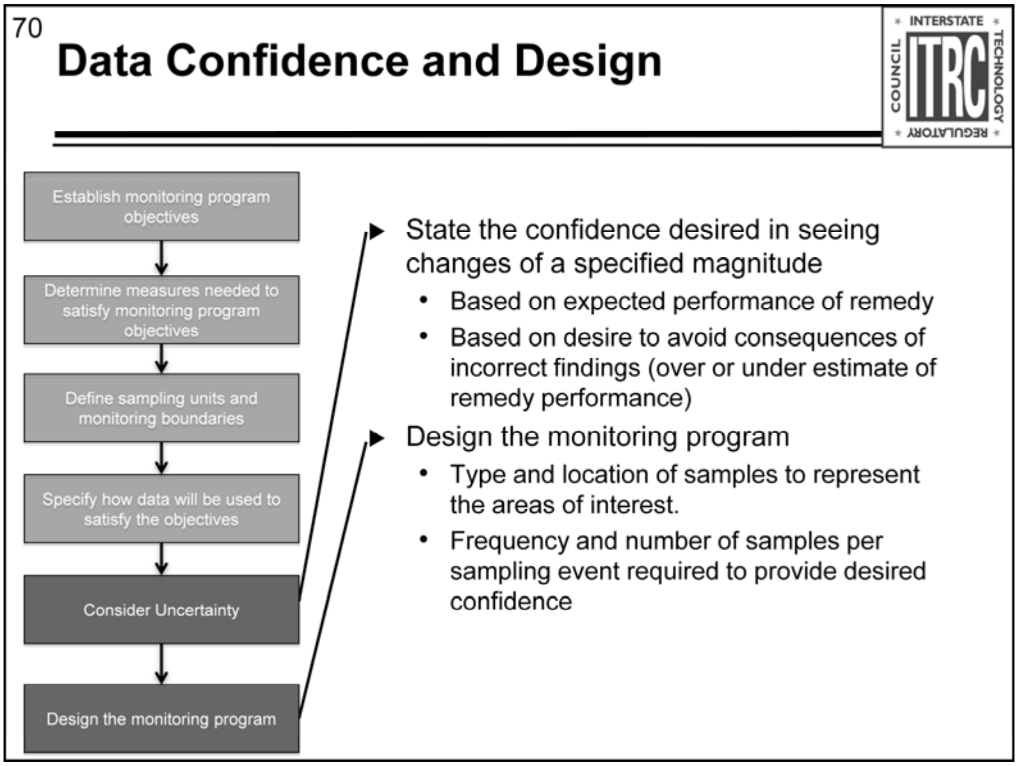
In addition, the team needs to specify clearly what portion of the physical environment will be sampled. We recommend you go through this exercise BEFORE you start actually designing the type, location and number of samples.

For example: top 10 cm of sediment within a specific area, or sediment cores down to some depth, with subsamples taken from specified intervals, or alternatively surface water taken from specified depths, or pore water extracted from sediment samples at specified depths. Care should be taken to think ahead – to ensure samples will be collected that are useful in answer the stated questions. For example if a cap is placed over the site, is the goal to be able to compare the concentrations in the new surface sediment (cap material) to the previous surface?

It is also very important to consider the temporal component of the problem and plan ahead to ensure samples taken before, and after remediation represent the same seasonal patterns. The concentrations of some contaminants are highly dependent on season and related temperature – for example methyl mercury production often spikes as temperatures rise and oxygen gets depleted. Comparing MeHg from the early summer prior to remediation, and mid-winter post remediation could lead to conclusions that are not really related to the remedy performance.

Once spatial and temporal boundaries are defined, explain how the measurements (identified in step 2), taken within the specified boundaries will be used to answer the specific questions. This includes what statistical summaries (e.g., means, medians, UCLs) that will be calculated with the data, and how these summary statistics will be employed. Common examples include trend plots to demonstrate decreases in specific media (e.g., surface sediment, surface water or biological tissue) over time. It is helpful to think about what findings may lead to specific actions… for example what might lead to a conclusion that additional capping material is needed?

What finding might result in deciding that the time between monitoring data collection can be extended (e.g., go to every other year vs every year), or dropped altogether?



Moving along – still in the planning process – and prior to the nitty gritty exercise of determining the number, location and type of samples… the ITRC approach asks the planning team to CONSIDER UNCERTAINTY.

This is often the point in the DQO process where teams roll their eyes – but it's critical to think about in order to have a defensible basis for the design of the monitoring program.

For monitoring we recommend that the team STATE THE CONFIDENCE they want in being able to "see" changes of a specified magnitude. What reductions (e.g., in surface sediment concentrations and biological tissues) are MEANINGFUL – and therefore you would want to be able to reveal inconclusively with your data? This may look like: the team wants to be able to see a 25% reduction with 90% confidence. These specifications allow statisticians to determine the required sample size (given the inherent variability of the system) needed. It's not a guarantee, since it is based on the historical understanding of variability, but it goes a long way towards optimizing the sampling plan, which is the next and final step in the process.

Now that you have specified what questions you want data to answer, what measurement will be taken, what these measurement need to represent (spatially and temporally), how data will be used to answer the questions and how much confidence you want in the comparisons you will make, it is time to run the statistical models to determine the optimal number of each type samples to take and from where in the environment to take them. The statistics involved are beyond the scope of the IRTC guide, but references are provided, and there are a number of available tools (such as VSP) that are available to help.

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Example Monitoring Measures

Monitoring Phase	Monitoring Objectives	Monitoring Measures and Example Measurements: Chemical	Physical	Biological
Baseline Monitoring	Establish site-specific baseline conditions prior to remedial action	**Sediment, Pore Water, Water Column, Tissue -** contaminant concentrations; bioavailability / bioaccumulation; equilibrium partitioning of contaminants; geochemical profile: suspended solids, AVS-SEM, TOC, DO, chloride, phosphate, sulfate, nitrate, nitrite, ammonia, etc.	**Sediment** - grain size, bathymetry, drift **Porewater** - expression **Water column** - temp, turbidity, demand analyses	**Aquatic, Benthic and Shoreline Habitats** - habitat type and quality, species biodiversity, community populations, contaminant bioaccumulation impacts
Construction Monitoring	Removal /isolation / reduction in contaminant concentrations; control of sediment resuspension; achievement of project-specific criteria (e.g., dredge depth, cap thickness, project schedule/budget)	**Sediment, Water Column -** resuspension of solids, basic water quality parameters	**Sediment** - cap, dredge, or sedimentation thickness (as appropriate) by side scan sonar, bathymetry **Water quality** - changes in temp, turbidity, pH, DO	**Habitat Impacts -** presence of endangered species, noise impacts during bird nesting or fish migration/spawning windows
Long-Term Monitoring of Remedy Performance and Effectiveness	Achievement of project-specific remedial action criteria within project time schedule; improvement of human health and environmental quality; restoration / rehabilitation of natural resources	**Sediment, Pore Water, Water Column, and Tissue -** decreasing trend in surface sediment/pore water/surface water contaminant concentrations and/or bioavailability over time, decrease in tissue concentrations for eco receptors, stabilization of geochemistry	**Sediment** - changes in grain size, bathymetry, drift, resuspension over time **Porewater** - changes in expression, contaminant equilibrium partitioning **Water quality** - changes in turbidity, DO, BOD, ORP	**Habitat Rehabilitation and Restoration -** aquatic, benthic and shoreline surveys of species biodiversity, species diversity and mortality, population size, aquatic toxicity, bioaccumulation impact, sustainability, and habitat quality

This chart is intended to illustrate what might come out of the first few steps of the process: showing objectives, and measurements that might relate to the different phases of monitoring. It’s helpful to see something like this to get a down-to-earth understanding of what might come out of the planning discussions.

It’s also useful to realize that the questions being asked change from phase to phase, and in particular post- remediation to realize there are different questions immediately following remediation (e.g., did a cap of the specified thickness get uniformly applied) or conversely, did dredging remove the contaminated layer) versus down the road (e.g., are the concentrations in fish tissue beginning to come down as a result of remediation).

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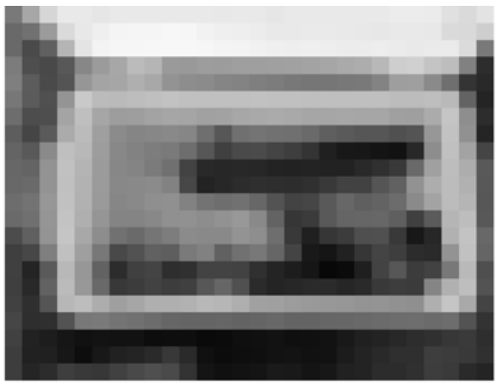
Poll Questions

- Have you been involved in assessing performance based on fish tissue analyses?
  - Yes
  - No

- If you have been involved in a fish tissue analysis, did it include...
  - Mercury
  - Methylmercury
  - Neither



No associated notes.

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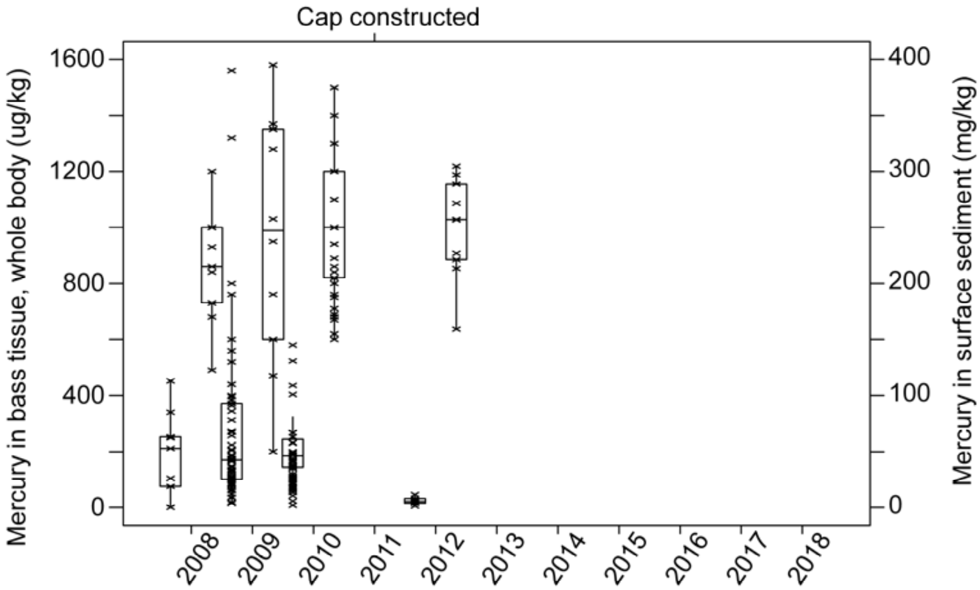
Mercury Remediation Monitoring
Fish Tissue and Surface Sediment



To close, the following side by side box plots are presented. These kinds of data summaries should have been envisioned during planning and samples taken that represent the specific area of interest – so that meaningful comparisons can be made over time (in this case sediment in early summer and fish in the fall).

Note the concentrations in red on the left side of the dotted line (pre remediation) – versus the right side (post remediation) that demonstrate sediment concentrations were reduced.

Note the blue – fish tissue data – showing that the year following remediation, fish tissue has not decreased.

Tracking these two media over time, will allow us to see if the remedial action has achieved the goal of reducing fish tissue concentrations..

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Stakeholder Concerns – Chapter 8

- Public Trust Doctrine
  - State governments must manage and protect certain natural resources for the sole benefit of their citizens, both current and future.
  - The public resource concept is therefore critical to remedial decisions at sediment sites.
- Risk reduction alone may not return the resource to fishable and swimmable conditions, which are the goals of the Clean Water Act
- Partnerships on remedial decisions are beneficial
- A long-term view of water shed is beneficial

Section 8

The National Pollution Discharge Elimination System (NPDES) is one of many examples of how the science behind watershed management works to achieve the goals and principles that form the basis of the PTD model for protection and management of water resources. Multiple impacts from contaminated sediments in a regional water shed, especially bioaccumulative compounds, can contribute to regional fish consumption advisories.

- Sediment resources are managed and protected for the benefit of citizens, both current and future.

•Risk reduction alone may not be capable and cannot always achieve the important goal of the Clean Water Act, which is to return the resource to a fishable and swimmable condition.
•Responsible parties, State and Federal clean up agencies, Local government, wildlife & Fisheries/watershed managers & local stakeholders are examples of who should be brought into the remedial decision discussions.
•A long-term view of the resource, locally and regionally needs to be part of the decision making processes

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Stakeholder Concerns – Watershed View

- Bioaccumulative and endocrine disruptor compounds are significant contributors to regional sediment impacts and fish advisories. (e.g. Great Lakes, Chesapeake, coastal fisheries systems)
- Groundwater and sediment interactions transport contamination to aquatic environments (i.e. hyporheic zone)
- A clean sediment environment is equally important for economic, recreational, and subsistence fishing for tribal and community health

- **See Chapter 8 for additional information**

A properly functioning hyporheic zone is a significant component of water shed health because it is an important component of productive stable aquatic ecosystems. Restoring the sediment and terrestrial habitat is an important aspect of all sediment remedies from the stakeholder perspective.

(see *Ground Water And Surface Water: A Single Resource*, USGS 1998). The habitat generated by the interaction of saltwater, brackish water, and freshwater in the rivers and estuaries of the Gulf, East, and Pacific coasts are essential for species that reside in these ecosystems. The restoration and preservation of this zone of interaction is of great importance. Habitat restoration, both aquatic and terrestrial are extremely important to consider as part of a remedial strategy. A properly functioning hyporheic zone maintains watershed health and regional water quality while providing the aquatic habitat for a healthy and sustainable eco-system.

Evaluating all sites from a regional or larger watershed management viewpoint should be part of the decision process because the cumulative impact of multiple sites in a water shed can seriously impair the regional aquatic ecosystem as well as human health, especially with respect to bioaccumulative and endocrine disruptor compounds. Groundwater provides a significant contribution to the Great Lakes system. In Lake Michigan alone, 78% of the water in the lake has its origin as base flow from the tributaries. This means that 78% of the water in Lake Michigan had to pass through sediment prior to becoming surface water. For further discussion, please read the Stakeholder section where this is discussed more thoroughly. These same interactions drive regional coastal ecosystems where sediments interface with brackish and salt water tidal ebb and flow. These processes move and re-distribute bioaccumulative contaminants as well.

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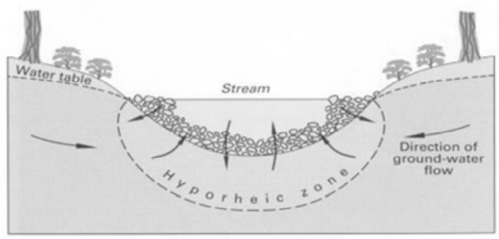
Stakeholder Concerns – Regional Ecosystems

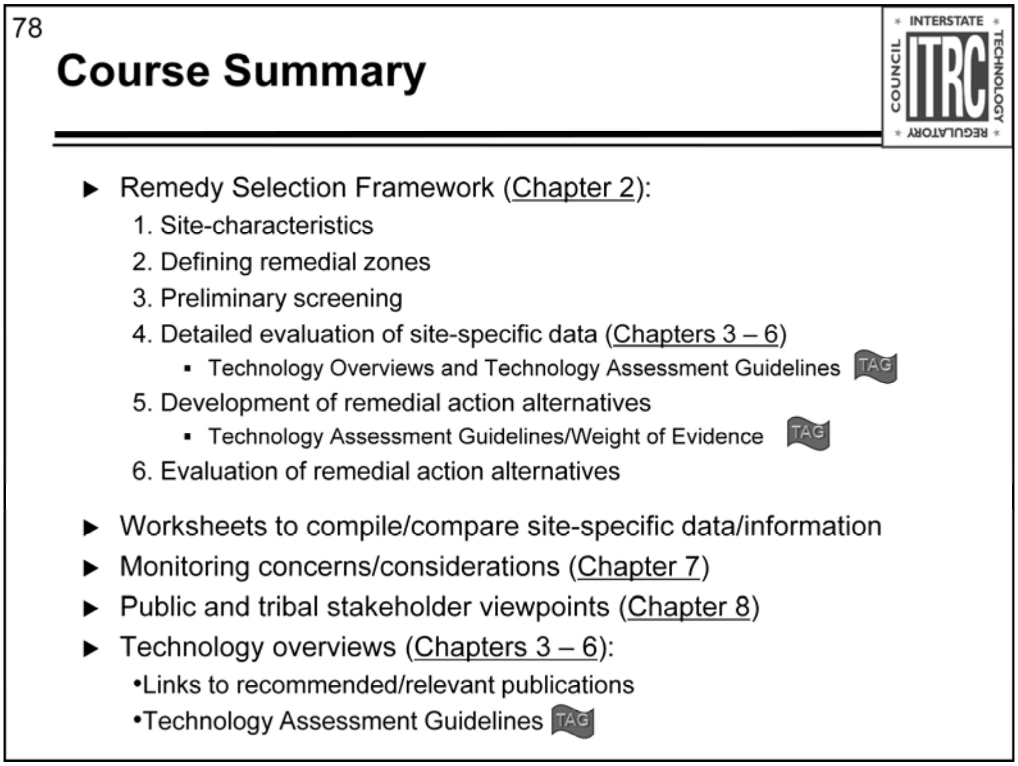
- Cumulative impact of multiple sediment sites affect regional aquatic ecosystems.
- Clean sediments form the base of a sustainable food web for aquatic organisms, wildlife, and people.



- Identify and engage stakeholders early and often !

Regional water shed issues, Great Lakes fish advisories, coastal ecosystems, Chesapeake, important fisheries and economic issues etc. cannot be ignored

Communicating with tribes and stakeholders early in the remedial process helps to develop a shared, resource-driven discussion early in the process and form a cooperative basis for remedy selection and implementation.



In brief… we've only scratched the surface of what's included in the web-based guidance document today. Go to the document to learn more about:

Remedy Selection Framework:

(1) Site-characteristics

(2) Defining Remedial Zones

(3) Preliminary screening

(4) Detailed evaluation of site-specific data (TOs and Technology Assessment Guidelines)

(5) Development of remedial action alternatives (Technology Assessment Guidelines/Weight of Evidence)

(6) Evaluation of remedial action alternatives

Worksheets to compile/compare site-specific information

Monitoring considerations

Public and Tribal stakeholder viewpoints

Technology overviews:

Links to recommended/relevant publications

Technology Assessment Guidelines

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Course Summary (Continued)

- Advantages of the Guidance:
  - Online and interactive…point, click…go
  - Covers all available remedial technologies
  - Technology selection/evaluation is driven by site-specific data
  - Provides Technology Assessment Guidelines TAG to inform technology evaluations
  - Case Studies
- NOW – we believe you have enhanced decision making capabilities to better:
  - Identify essential site specific data and information
  - Evaluate the particulars of technologies
  - Apply current and emerging methods and technologies

Advantages of the Guidance:

Online interactive guidance…point, click…go

Technology selection/evaluation is driven by site-specific data

Covers all available remedial technologies

Provides Technology Assessment Guidelines to inform technology evaluations

Case Studies

NOW- You are now better able to:

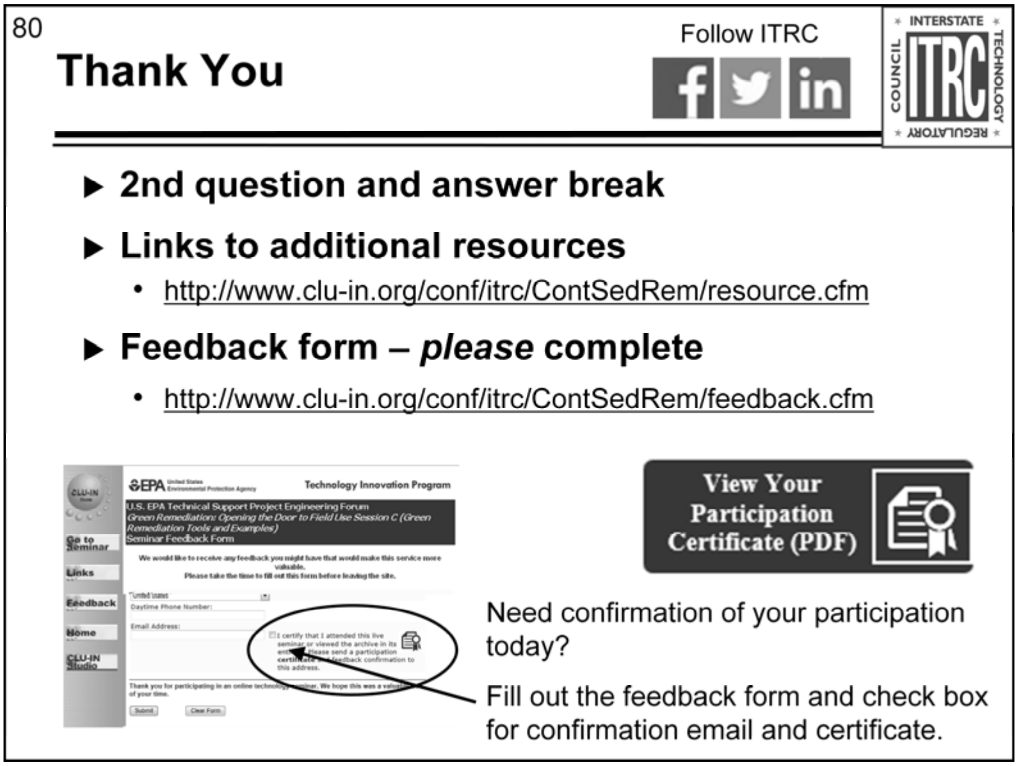
Identify

Evaluate

Apply

Explicitly state actions for the audience (e.g., use the ITRC Technical and Regulatory Guidance document)

Future activities of the ITRC team



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

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

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