
Introduction to Triad
Managing Uncertainty
1-1

Course Objectives

- After completing this course, participants will be able to:
  - » Identify the basic components of the Triad process
  - » Describe the benefits of using the Triad approach
  - » Explain the importance of creating a consensus vision
  - » Describe how dynamic work strategies are designed and implemented

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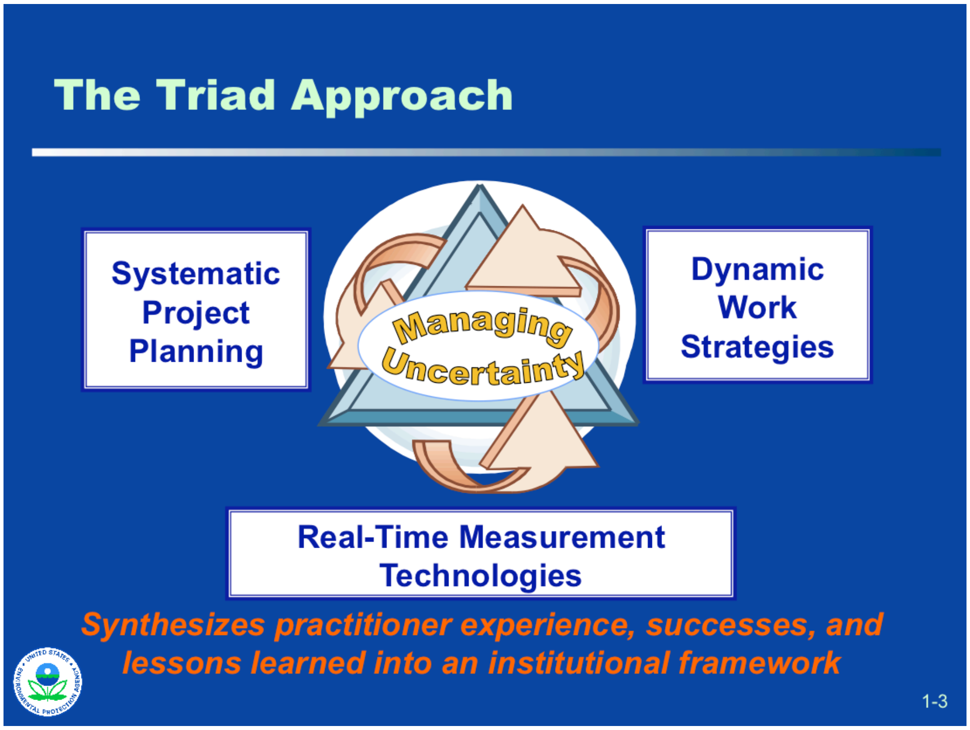
The Triad Approach
Systematic Project Planning
Managing Uncertainty
Dynamic Work Strategies
Real-Time Measurement Technologies
Synthesizes practitioner experience, successes, and lessons learned into an institutional framework
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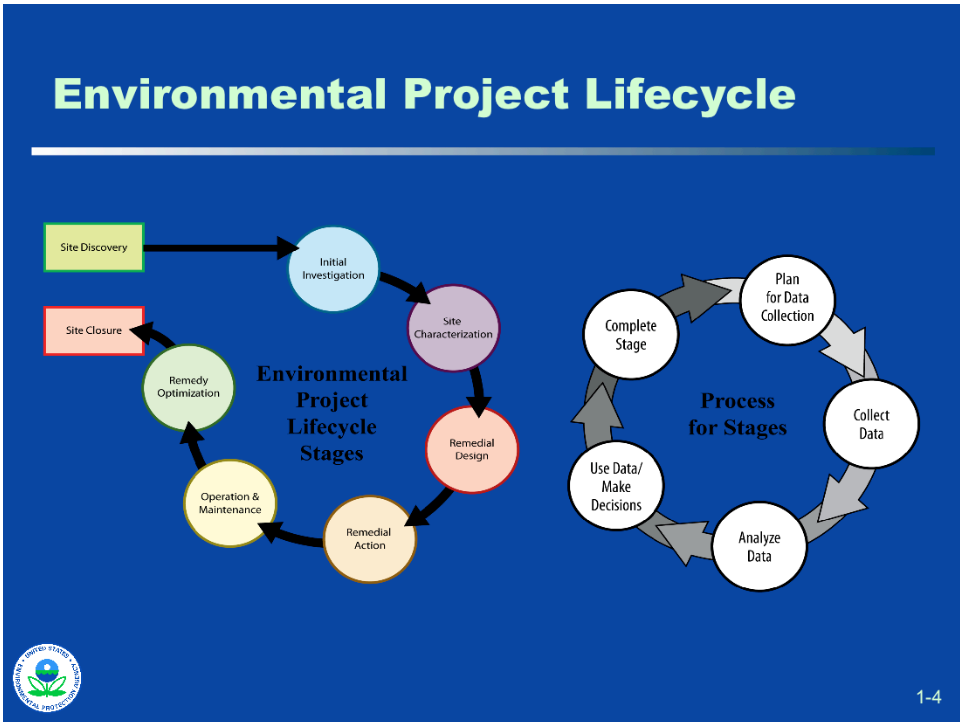
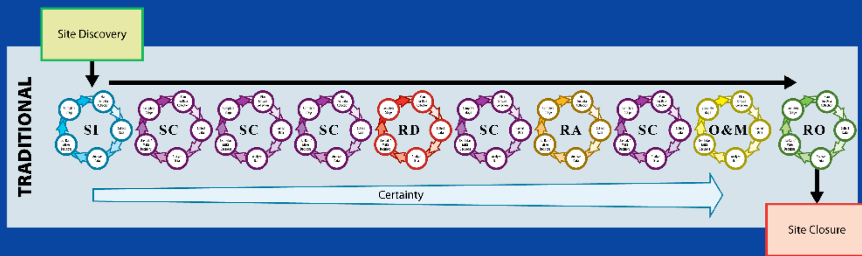

Environmental Project Lifecycle
Site Discovery
Initial Investigation
Site Characterization
Remedial Design
Remedial Action
Operation & Maintenance
Remedy Optimization
Site Closure
Environmental Project Lifecycle Stages
Plan for Data Collection
Collect Data
Analyze Data
Use Data/ Make Decisions
Complete Stage
Process for Stages
1-4

Timeline and Lifecycle Stages with Traditional Approach



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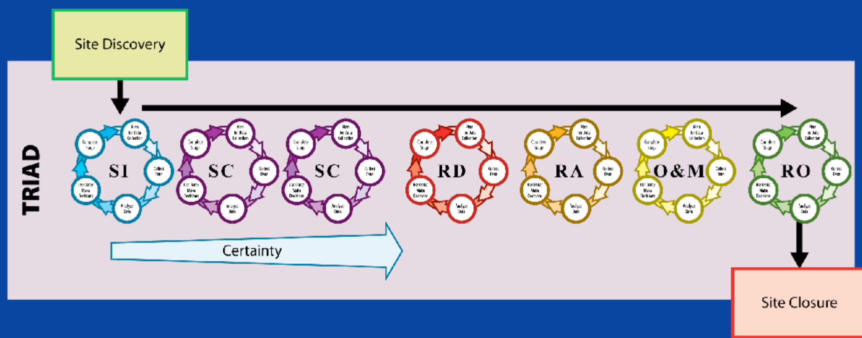
Timeline and Lifecycle Stages with Triad Approach



What is Systematic Planning?

A process for building a consensus vision for conducting environmental investigation and remediation

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Systematic Planning Activities

- Assemble the stakeholders and create a core technical team
- Identify critical decisions to be made
- Define an exit strategy
- Consider regulatory and risk-based criteria
- Develop and agree upon a preliminary CSM and a preliminary work strategy

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Systematic Planning Activities

- Plan demonstrations of method applicability
- Refine the dynamic work strategy
- Plan for real-time data management, assessment, and presentation
- Evaluate and procure applicable technologies and services

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How is Systematic Project Planning Under a Triad Framework Different?

- Initial efforts target development of a preliminary CSM and a preliminary work strategy
- A robust CSM is used to develop the preliminary project design and detailed statement of work
- Stakeholder concerns and specific decision criteria are identified and integrated into streamlined work plans
- Quality assurance and quality control requirements are clearly stated and agreed upon

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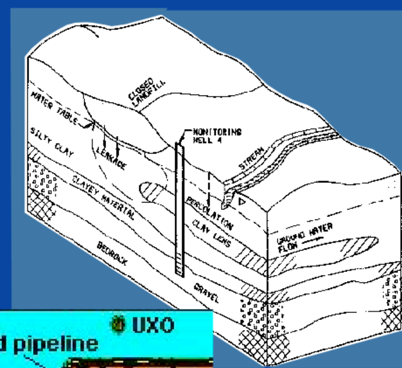
What is a CSM?

- ◆ A written and graphical explanation of what is known about a site
- ◆ Dynamic, living planning tool used throughout project lifecycle
- ◆ The CSM optimizes cleanup efficiency, selected technologies, and monitoring and measurement strategies



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How is the CSM Used?

- A preliminary CSM is used to focus and sequence proposed activities
- A CSM is the poster board upon which data is hung and additional activities optimized
- A CSM becomes a detailed model of the site during cleanup for reuse

When the CSM is complete, so is the project!

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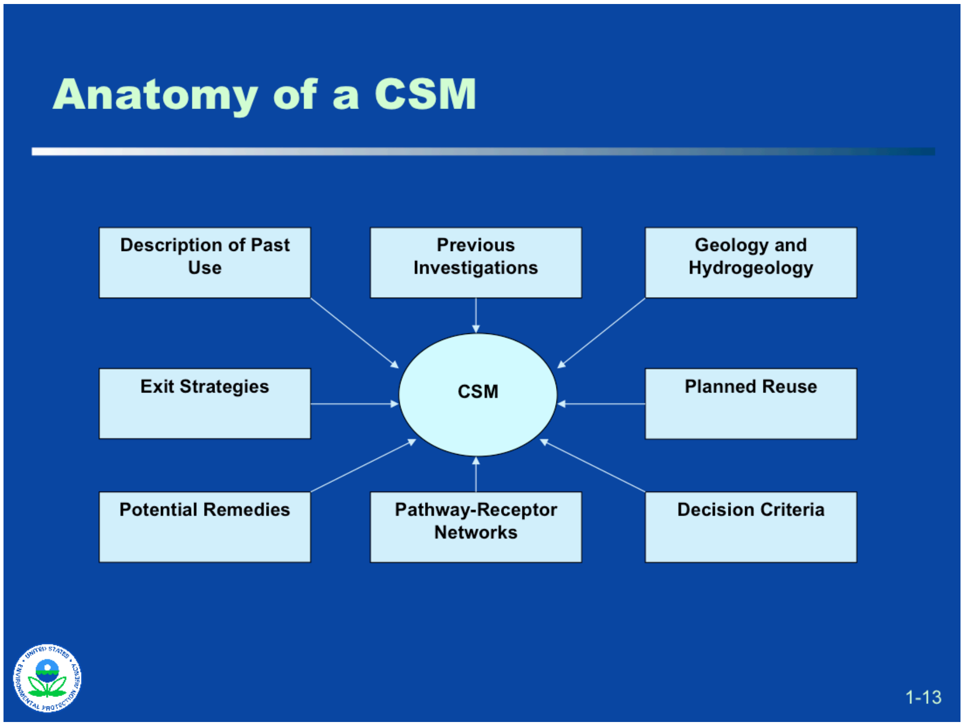
Anatomy of a CSM
Description of Past Use
Previous Investigations
Geology and Hydrogeology
Exit Strategies
CSM
Planned Reuse
Potential Remedies
Pathway-Receptor Networks
Decision Criteria
1-13

Key Concepts of CSM: Planned Reuse

- Can dictate decision criteria
- Is used to focus sampling efforts
  - » CSM or sampling also can change reuse plans
- Can drive nature of the remedy
- Is influenced by property value
- Is affected by public interest

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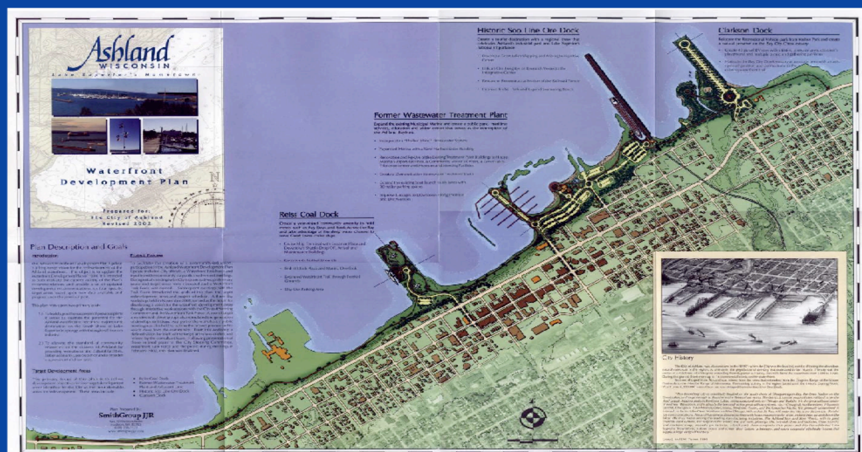
Planned Reuse



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Key Concepts of CSM: Decision Criteria

- Criteria, such as action levels, used to guide the investigation
  - » Field-based decision criteria
  - » Bright line criteria
  - » Risk screening criteria
  - » Judgmental criteria
  - » Regulatory criteria
  - » Risk-based criteria
  - » Remediation goals and sample support

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Decision Criteria and Decision Units

- Decision criteria are applied to specified decision units
- Decision units are defined by spatial dimensions and other physical properties that define the population of interest
- Good statistical sampling design determines an average concentration and its upper confidence limit over a decision unit rather than comparing single grab samples to a “not-to-exceed” criteria

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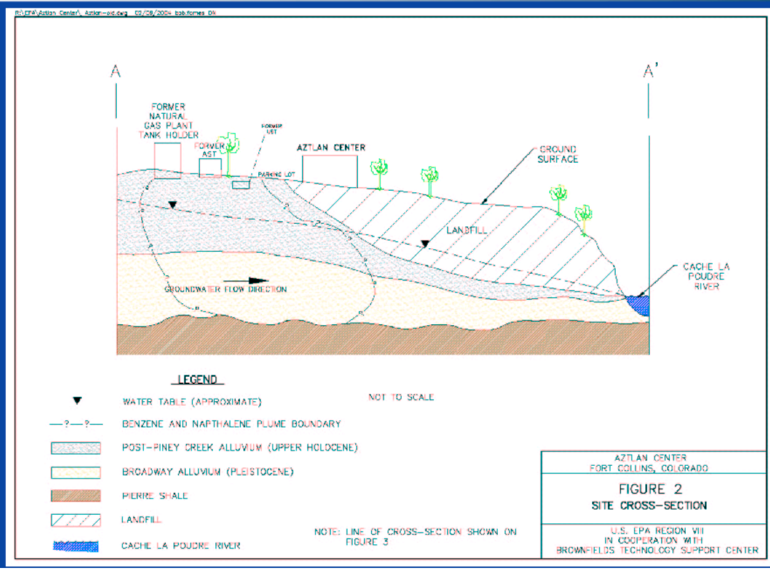
Systematic Planning Example: Preliminary CSM



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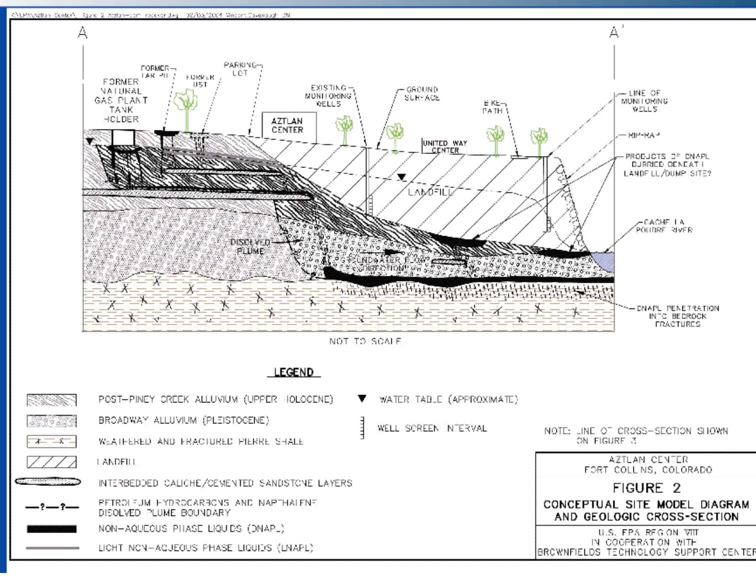
Revised CSM



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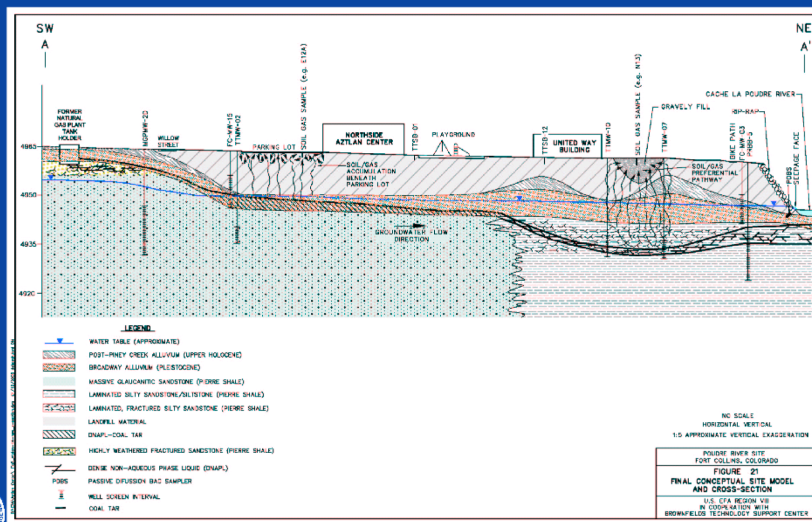
Final CSM



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Exit Strategy

- Formal plan for taking the site from characterization to closure
- Used to actively manage the site and make decisions
  - » Collect data to evaluate remedies
  - » Optimize monitoring
  - » Change system design
- Building consensus vision for an exit strategy

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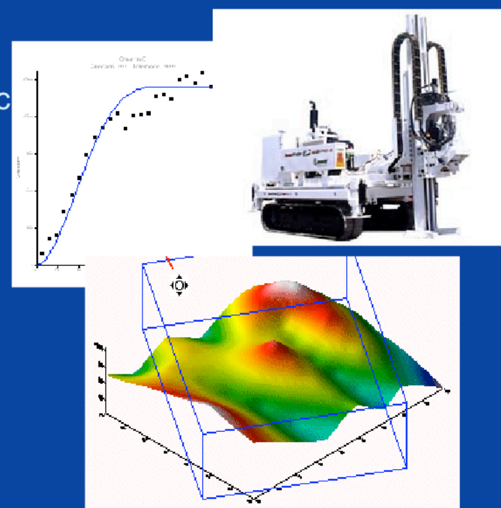
Planning to Manage Risk or Controlling Uncertainty

- Need for real-time measurement technologies and dynamic strategies
- Schedule and cost
- Viability of obtaining Insurance
- Uncertainty of reaching project goals (risk)



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Decision Uncertainty Comes from a Variety of Sources

- Political, economic, organizational, and social uncertainty
  - » Addressed by building consensus vision
- Model uncertainty
  - » Addressed in part by collaborative data
- Data uncertainty
  - » Refers to uncertainty associated with data sets used to support decisions
  - » Addressed by good sampling design

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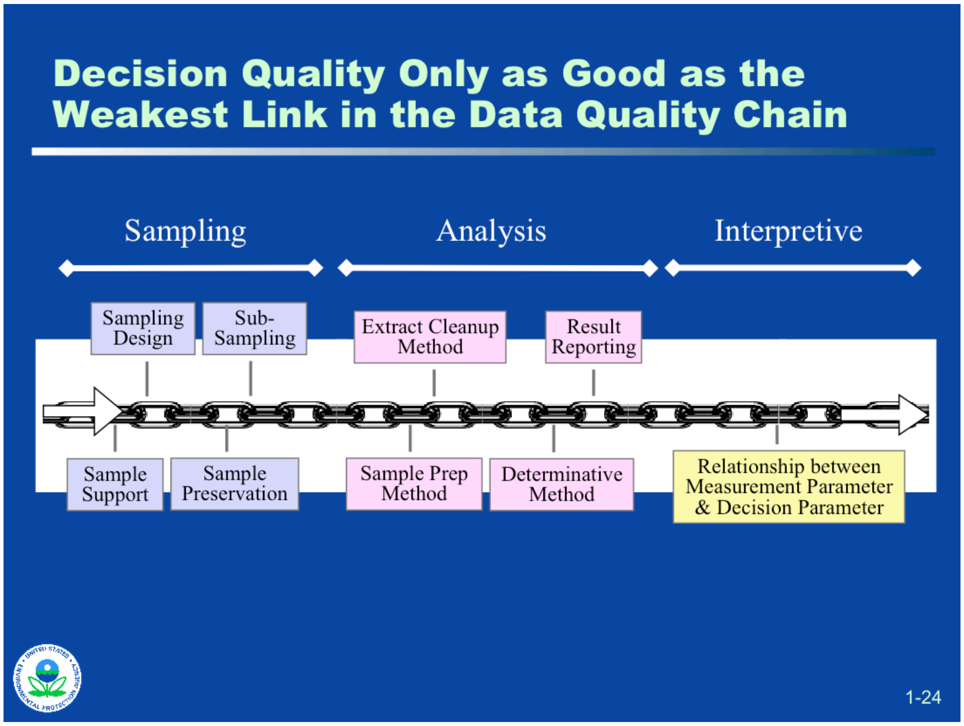
Decision Quality Only as Good as the Weakest Link in the Data Quality Chain
Sampling
Analysis
Interpretive
Sampling Design
Sub-Sampling
Extract Cleanup Method
Result Reporting
Sample Support
Sample Preservation
Sample Prep Method
Determinative Method
Relationship between Measurement Parameter & Decision Parameter
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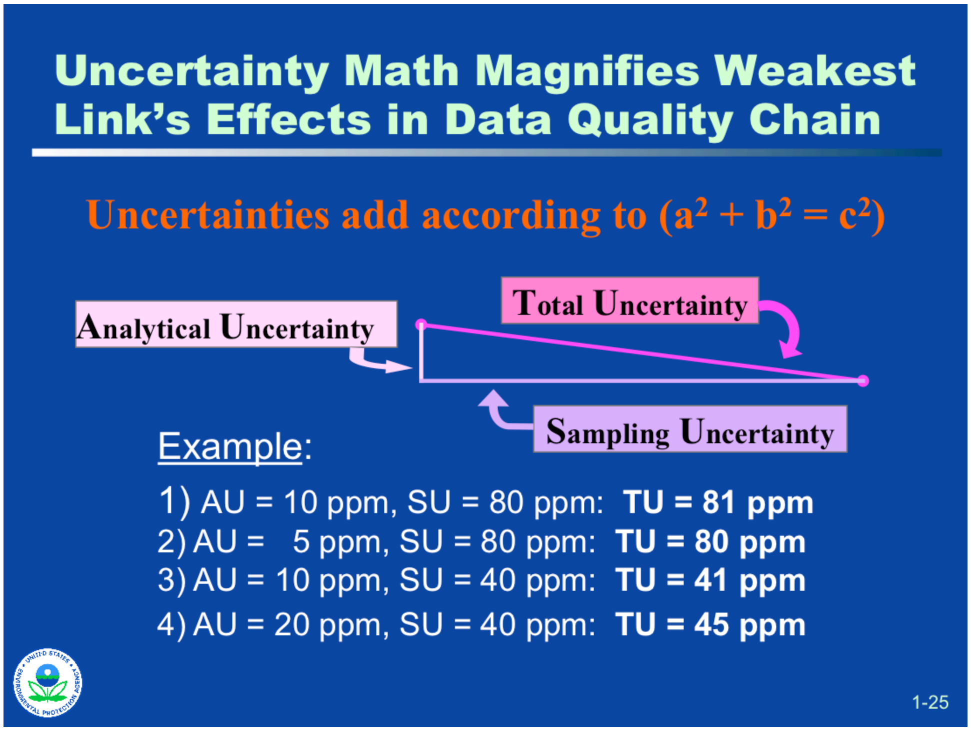

Helping policy-makers to understand the importance of managing sampling uncertainty. (Although presenting uncertainty this way oversimplifies the mathematics involved to compress the individual sources of uncertainty into only 2 major components, this legitimately illustrates the basic concept.)

Uncertainties (when expressed as statistical standard deviations) add as orthogonal vectors, that is, the sum of 2 uncertainty components (represented by the sides of a right triangle) is represented by the hypotenuse. The heterogeneity of environmental materials, especially solids (waste materials, soils, the subsurface) is very high. The vast majority of result uncertainty in environmental samples is due to sampling considerations. Attempts to quantify the relative contributions of sampling and analytical variabilities to the environmental measurement process have "estimated that up to 90 percent of all environmental measurement variability can be attributed to the sampling process." (Reference: Homsher et al, 1991, see Environmental Lab articles in Resources/Links section). It is reasonable to expect that the actual value would vary greatly from project to project and analyte to analyte, depending upon the environmental matrix and the concentrations of the contaminants, the mechanism by which contaminants were introduced into the environment, the fate and transport of the contaminants, as well as how the partitioning of variability was derived and calculated.

The Example 1 figure illustrates a ratio of sampling uncertainty to analytical uncertainty in soil of about 9 to 1 ratio. As illustrated in Example 2, decreasing the analytical uncertainty to 1/3rd of the original without addressing sampling uncertainty will no doubt add to the analytical costs, but will not meaningfully decrease the overall uncertainty in the data. Alternatively, allowing the analytical uncertainty to increase to 3 times the original without changing the sampling uncertainty does not significantly increase the overall uncertainty in the data (Example 3).

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The overall uncertainty is what impacts the decision-making process (i.e., the overall data quality impacts the decision quality). Therefore, both analytical and sampling uncertainties must be managed. Minimizing one without addressing the other is

How Do We Control Data Uncertainty?

- For analytical errors:
  - » Modify existing technique
  - » Switch to a better analytical technique
  - » Improve QC on existing techniques
- For sample preparation and handling errors:
  - » Improve sample preparation
- For sampling errors (heterogeneity):
  - » Collect samples from more locations
  - » Use composite or multi increment techniques

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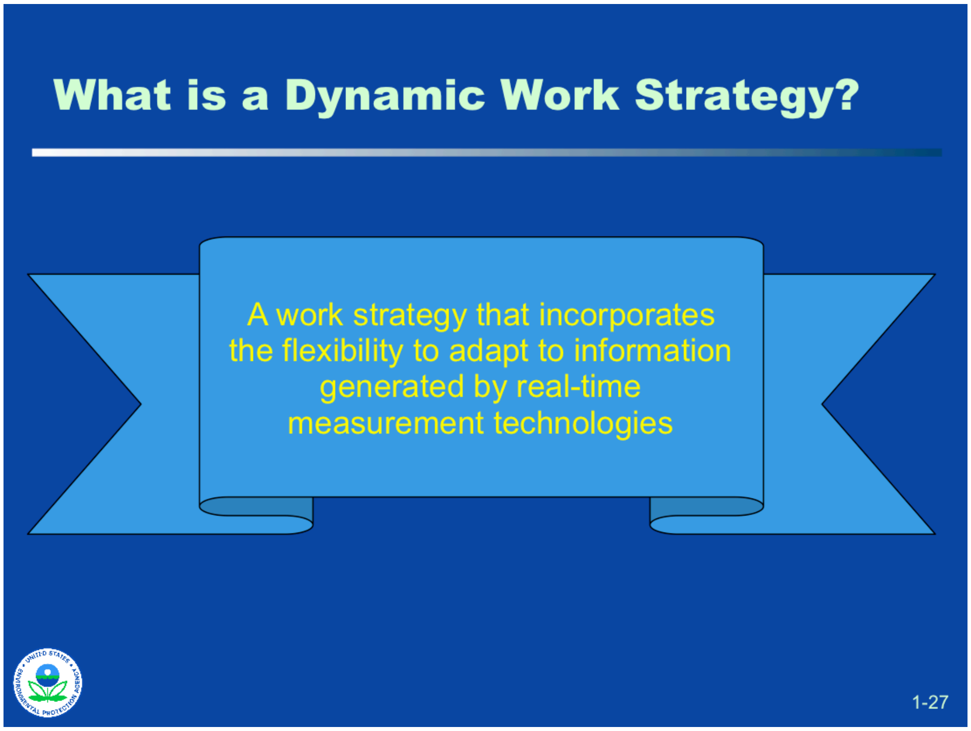
What is a Dynamic Work Strategy?
A work strategy that incorporates the flexibility to adapt to information generated by real-time measurement technologies
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Components of Dynamic: Learn-as-you-go Work Strategies

- Identify critical data gaps in the CSM
- Identify critical decision criteria for the planned reuse (and alternatives)
- Sequence activities to improve efficiency and fill data gaps
- Develop decision logic diagrams to guide field activities
- Real-time data management and communication strategies

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Essential Elements of a Dynamic Work Strategy

- Sequencing
- Scheduling
- Segmenting or staggering
- Tracking

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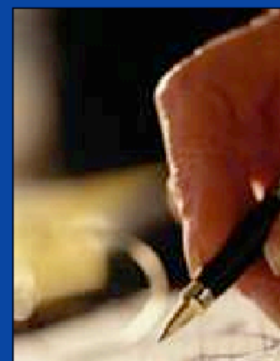
Important Considerations

- Logistics
- Lines of authority
- Documentation requirements
- Vendor involvement



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Common Pitfalls When Developing Dynamic Work Strategies

- Not involving stakeholders
- Use of untested field-based methods and SOPs
- Prescribed sample locations
- Not planning for proper data collection and management
- Not addressing logistics

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Sequencing

- Project
  - » Site characterization to support remedy selection
  - » Detailed design support
  - » Verification of treatment efficiency
  - » Performance optimization
- Site characterization effort
  - » Non-intrusive methods
  - » Slightly intrusive methods
  - » Wide spread or exposure point reconnaissance
  - » Localized source delineation

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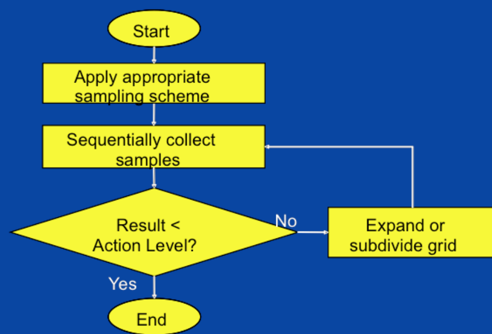
Developing Streamlined Work Plans

- Traditional versus streamlined
- Components of a streamlined work plan
- Decision logic diagrams
- Benefits



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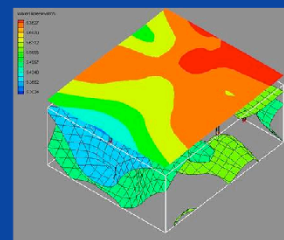
Data Management, Assessment, Communication and Visualization

- Sampling
- Electronic deliverables
  - » Chemical data
  - » Geology and hydrogeology
  - » Probe data
- Database considerations
- Data output formats
- Data visualizations



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Matching Data Quality and Documentation to a Decision

- Field-based and fixed laboratory methods
- Decision support tools
- Real-time measurement technologies

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Collecting, Storing, Managing, and Using Data

- Decision support tools matrix
- Scribe and Scriblets
- The Rapid Assessment Tools software
- The FIELDS Tools for ArcView
- Visual Sampling Plan
- Spatial Analysis and Decision Assistance

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Communicating Results

- Importance
- Options

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What is Real Time Measurement Technologies?

Any data generation activity that supports real-time decision-making

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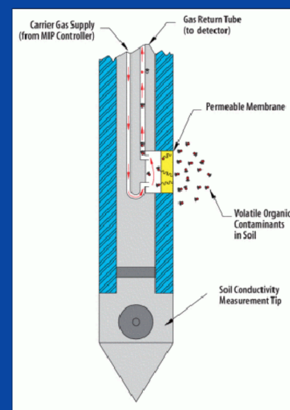
Examples of Real-time Measurement Technologies

- Field test kits
- Field portable instruments
- Mobile laboratories
- Fixed laboratories with rapid turnaround times
- Downhole sensors
- Other tools



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What is a Demonstration of Methods Applicability?

- A preliminary evaluation of the adequacy of sampling and analytical method performance relative to:
  - » Decision criteria
  - » Sample support
  - » Practical constraints
  - » Throughput
  - » Potential remedies

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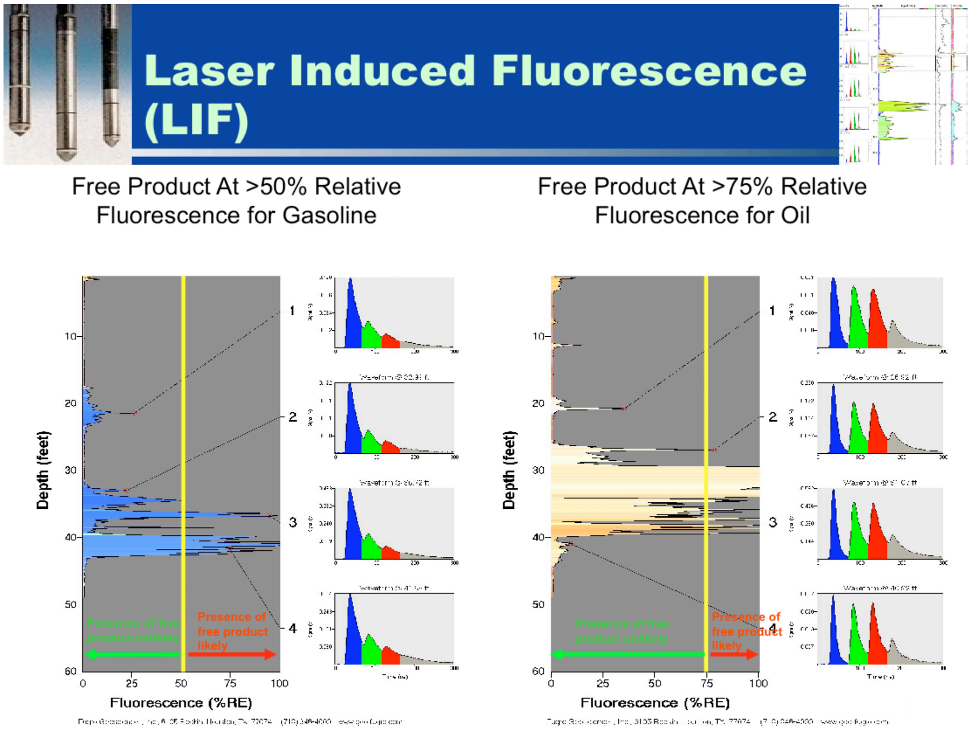


Fuels (PAHs) in the vadose and saturated zones (>50-100 ppm, free product)

Excitation sources- lasers (single wavelength, tunable), Hg lamp (FFD or ex-situ)

Stacked (CPT), high density, ID fuel class

Define areas of concern, refine CSM, locate source areas, optimize sample collection (location, depth), NFA, remedy design, DNAPLs, LNAPLs, free product, lithology

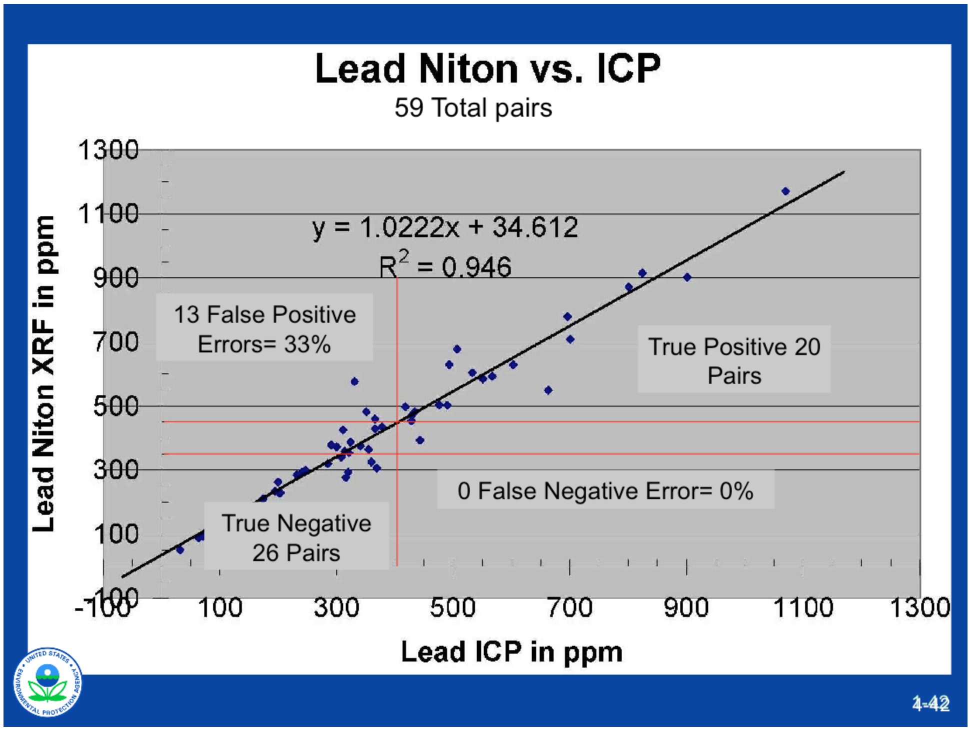
MGPs, refineries, wood treaters, fuel depots, waste recyclers, bulk terminals

Decisions include: clean, dirty, collaborative data required, revise site boundaries, update CSM, FA/NFA required, well placement, pathway determinations, product mapping/thickness, remedy optimization

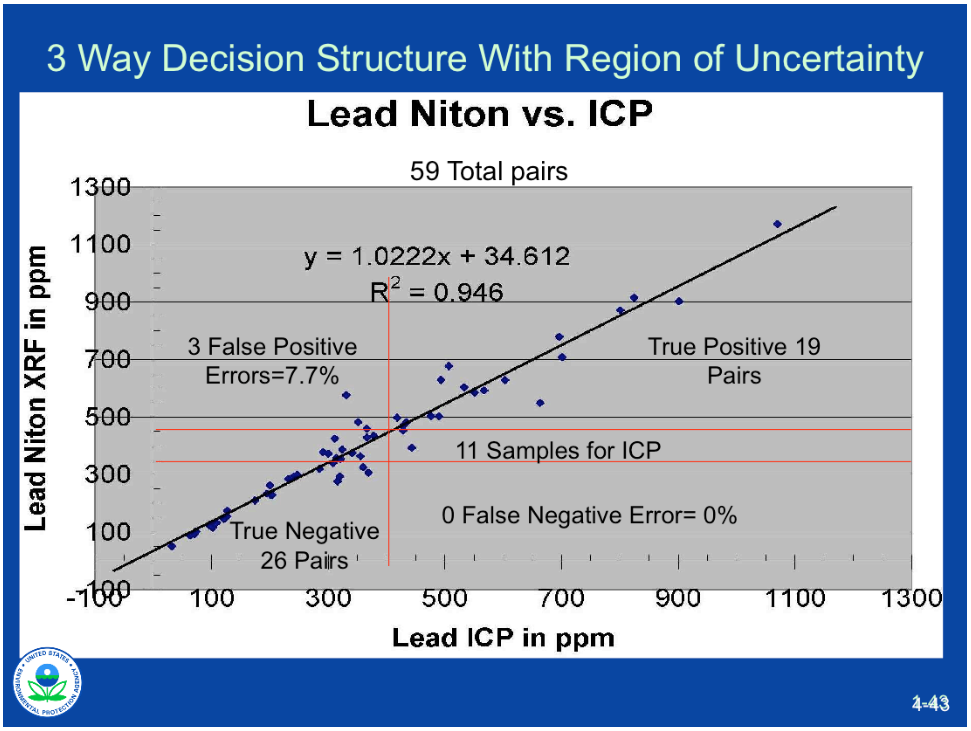
Direct push platforms limiting factor.

Provides a detector response, not a concentration or identification of specific compounds. Wavelength signature can be used to ID fuel classes, differentiate sources.

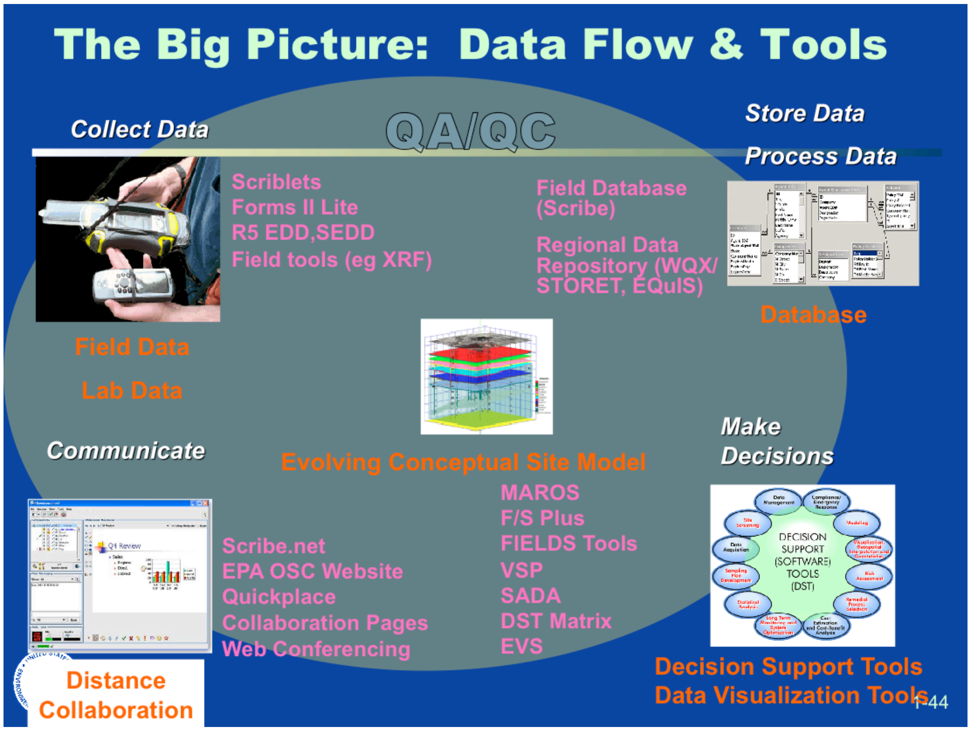
Consider a service- experienced vendors, visualization, interpolation



This is a well correlated data set. If you are more concerned about a Type I or false negative error you could also reduce the XRF field based action level to 350 ppm and decrease the false negative or "false clean" to 0. This would however result in a higher false positive or "false dirty" rate of 13 false positive errors or 22%. You have to weigh the consequences of a false negative vs. the costs associated with excavation or clean up at a rate of 22% false dirty. Many sites default to 5% error for false negative and 10% for false positive.



Structure of a 3 way decision. 19 true positives, 26 true negatives, 3 false positives, and 11 samples for ICP. Region of uncertainty is 350-450 ppm. Below 350 is definitely clean, above 450 is definitely dirty (with 5% false positives)



Contact Joann Eskelson? Info on NARAC/IMAC

Last Year

Date and Time: Tuesday, February 13, 9:00 am to 12:30 pm Tuesday, February 13, 1:30 pm to 5:30 pm**Instructors:**John Bing-Canar, EPA Region 5 Abbey Brake, EPA Region 5 Brian Cooper, EPA Region 5 Patrick Hamblin, EPA Region 5 James Mitchell, EPA Region 5 Charles Roth, EPA Region 5**The Rapid Assessment Tools (RAT)** are developed to aid OSCs, Remedial Project Managers (RPM), and other support personnel in real-time continuous field data collection and assessment. The tools have integrated data retrieval, global positioning system (GPS), geographic information systems (GIS), mapping, and analysis through an elementary but powerful and robust interface that requires no post-processing of GPS and GIS data. All data produced from the system can be exported and used in most other GIS mapping applications and database packages. All screen outputs can be printed or saved to a standard output file type. This system is unique because it has been developed in-house by EPA, is stand-alone, and requires no software licensing or purchasing. RAT also allows for mapping and recording of continuous streams of external data merged with GPS locations. The data streams are processed internally and saved directly to a database-compatible format such as SCRIBE, and can be used in many other modeling applications.

RAT was developed for Superfund-contaminated site assessment using spatial data analysis and 2D visualization. RAT focuses on tools needed for rapid assessment and mapping in the field. More complex modeling can be achieved and easily exported to another GIS software tool. RAT includes

How is Site Characterization Under a Triad Framework Different?

- Sequence activities is decision driven and based on a CSM
- Use of collaborative data sets
- Streamlined work plans
- Real-time data management and communication
- Uncertainty and cost management
- Considers potential remedies and reuse

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Successful Characterization Using the Triad Approach

- Site characterization using the Triad approach addresses:
  - » Specific decision criteria with sufficient detail and flexibility
  - » Sequencing
  - » Load balancing
  - » Cost benefit analysis
  - » Collaborative data and DMAs
  - » Quality assurance and quality control
  - » Contingencies
  - » Real-time data management and assessment
  - » Communication strategies

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How is Site Remediation and Reuse Under a Triad Framework Different?

- Remedial action plans are more complete
- Potential for reduced insurance rates
- More realistic performance goals for inclusion in procurement documents
- Decision documents include multiple exit strategies that assure site closure
- Optimization during implementation reduces short and long range costs

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Successful Remedies Using the Triad Approach

- Remedy design and implementation using the Triad approach addresses:
  - Choosing a remediation plan based on an updated CSM
  - Procuring insurance
  - Collecting optimization information
  - Identifying clear performance goals, performance metrics, and decision points
  - Selecting a proven remedy
  - Identifying alternative exit strategies
  - Optimizing remedy after implementation

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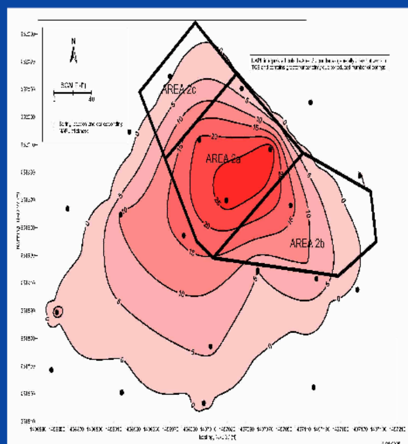
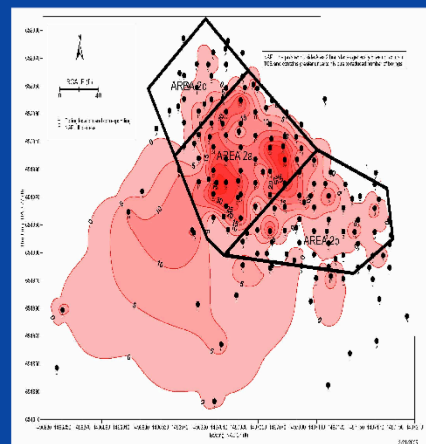
Site Remedy Example: Focused Remediation Efforts





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Measures of Success

Saves Time and Money

- Fewer mobilizations
- Reduces debate
- Insurance less costly
- Get to closure and reuse faster
- Remedy optimization
- Avoids “overdesign”

End Goals Meet Expectations

- Intended reuse achieved

Minimizes Workload, Maximizes Control

- Constant oversight not required
- Easy to check whether decision logic is followed

(continued)

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Measures of Success

No Surprises, Ensures Information Quality

- Better site characterization, fewer unknowns

Profitability

- Performance-driven contracts allow innovation to save costs

Maximum Protectiveness and Reuse Potential

- Quality decisions ensure protection of environment, human health
- Property brought back into use quickly, helping economy

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Projects Best Suited for the Triad Approach

- Past investigations with limited success
- High levels of uncertainty
- Heterogeneity is high
- Time frame to reach goals is limited
- Site where the selected remedy is not working as planned

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Projects Not Well Suited for the Triad Approach
◆ Sites where scheduling does not allow for sufficient upfront planning
◆ Simple sites with proven remedies or standard approaches
◆ Sites where stakeholders are not interested in cooperating or using innovative methods
◆ Sites where dynamic decision making is not advantageous
◆ Sites where contaminants or site constraints do not permit the use of innovative methods
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Opportunities for Using the Triad Approach

- Optimum benefits when used starting in the site characterization phase
- Can be beneficial at any phase of an environmental remediation project
- Consistent with the requirements of most regulatory programs
  - CERCLA
  - RCRA corrective action
  - Brownfields
  - State voluntary cleanups
  - UST

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Items to Verify Before Starting a Triad Project

- A statement of work is not in place or can be revised
- Candidate subject matter experts are experienced
- Time to modify the plan
- Stakeholders cooperate and all are involved
- Procurement staff are involved
- Regulatory and political barriers are overcome

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Getting Started: Writing a Request for Proposal

- Provide a preliminary CSM when possible
- Qualifications based on experience, availability, and key personnel
- Cost instructions
- Evaluation factors
- Schedule of events

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Writing a Statement of Work

- Specific goals and objectives for the project
- Tasks should be broken down by related activities for costing
- Reference real-time measurement technologies
- Require real-time data management and assessment
- Communication strategy
- Required documentation

Evaluation of Written Responses

- Should stress importance of systematic planning
- Technical expertise and approach
- Data collection, management, communication, and assessment
- Examples of past performance, references, costs, and insurance

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Selecting a Qualified Contractor

- Firm and staff with education and experience that matches the work
  - » Good communication skills
  - » Data management and assessment skills
  - » Web-based communication services
  - » Geographic location
  - » Vendors
- Relationships with regulators
- Proven ability to adapt to changing circumstances

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Pitfalls that can Impact Triad Projects

- Poorly structured RFPs and review processes
- Inflexible contractors with limited Triad experience
- Contractors with no real-time data collection, management, communication, and assessment capabilities

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Where to Go for Help
◆ Understanding Procurement for Innovative Sampling and Analytical Services for Waste Site Clean-up
» www.epa.gov/tio/download/char/procurement.pdf
◆ Assessing Contractor Capabilities for Streamlined Site Investigations
» www.brownfieldstsc.org/pdfs/ContractorCap.pdf
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Case Studies: Success Stories in Site Characterization

Site	On Time, On Budget	End Goals Met Expectations	Minimized Workload, Maximized Control	No surprises, ensures information quality	Profitability	Maximized Protectiveness and Reuse Potential
Poudre River Site, Fort Collins, CO	✓	✓	✓	✓	✓	✓
Cos Cob, Greenwich, CT	✓	✓	✓	✓	✓	✓
Hartford Hydrocarbon Plume Site, Hartford, IL	✓	✓	✓	✓	✓	✓
Ellsworth Industrial Park, Downers Grove, IL	✓		✓	✓		

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Case Studies: Success Stories in Site Remediation and Reuse

Site	On Time, On Budget	End Goals Met Expectations	Minimized Workload, Maximized Control	No Surprises, Ensures Information Quality	Profitability	Maximized Protectiveness and Reuse Potential
Tree Fruit, Wenatchee, WA	✓	✓	✓	✓	✓	✓
Fort Lewis Small Arms Firing Range, Tillicum, WA	✓	✓	✓	✓	✓	✓
Fort Lewis East Gate Disposal Yard, Tillicum, WA		✓	✓	✓	✓	✓

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Triad Myth #1

The Triad approach is nothing new!

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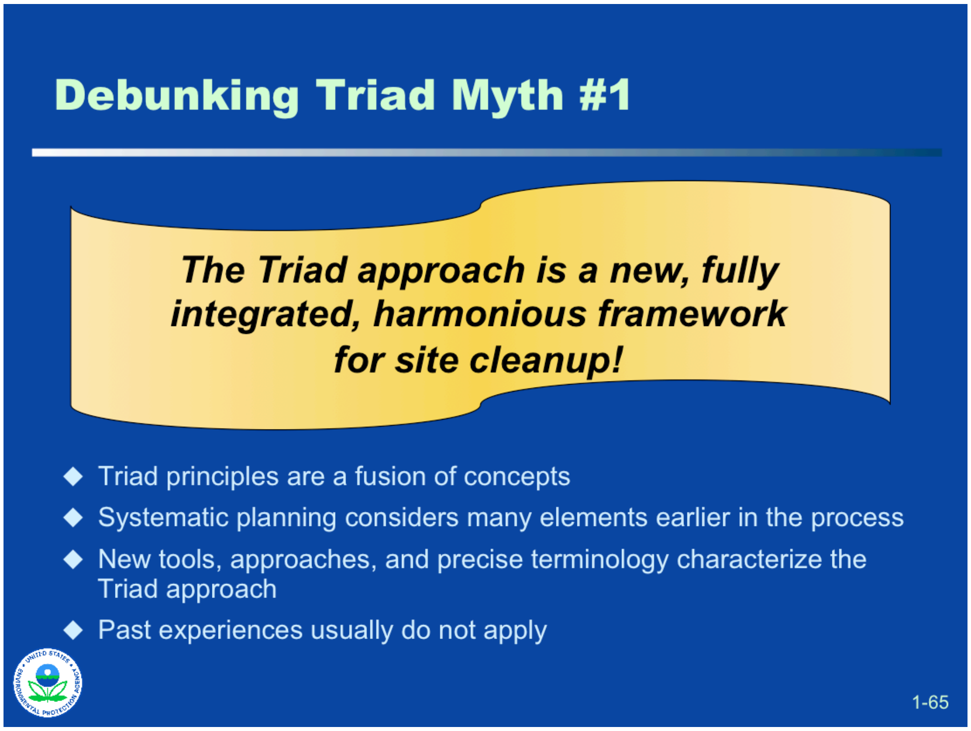


•**Triad principles are a fusion of concepts:** The fusion of existing concepts, ideas, strategies, and tools into a fully integrated, internally harmonious framework for site cleanup is clearly different and new. The ways that Triad practitioners weave these together over the life of the project to achieve project efficiency and defensibility is markedly innovative compared to routine practices. But Triad strategies are not experimental; they have been field tested and refined since the 1980s. Several features are so fundamental to a Triad project that a claim for Triad cannot be made unless they are present. These include:

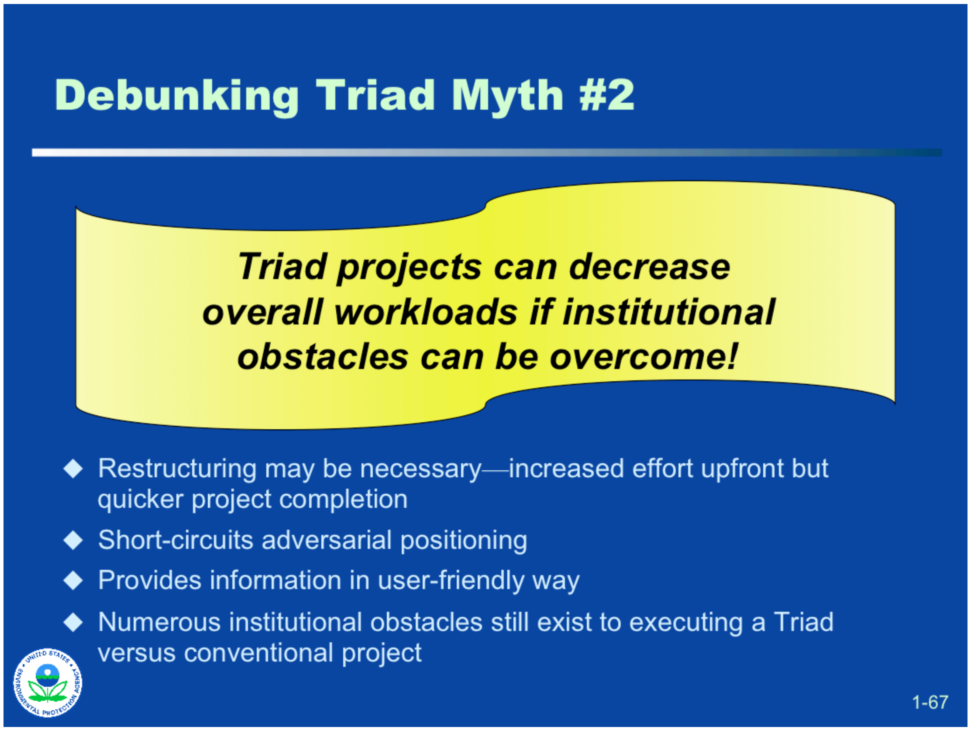
> •developing clearly articulated goals (for the project), clear statements about what decisions must be made in order to reach those goals, and expressions of how much uncertainty can be tolerated in those decisions;
>
> •establishing metrics by which decision uncertainty can be managed to accepted levels;
>
> •using collaborative data sets to manage all significant contributions to data uncertainty (both sampling and analytical); and
>
> •a dynamic work strategy (which usually requires that real-time pollutant data be generated) that implements a pre-negotiated decision logic that refines the CSM to manage decision uncertainty while the field effort is still active.

•**Systematic planning considers many activities earlier in the process:** Among other things that differentiate Triad from more traditional approaches, Triad's systematic planning shifts several activities to much earlier in the project lifecycle than typical. Those activities include achieving agreement on the exit strategy between regulators and problem holders, and developing a robust process for managing, analyzing, and effectively communicating project data. These are the methods, when employed properly, that provide higher success rates then the traditional 'status quo' project.

•**New tools, approaches, and precise terminology characterize the Triad approach:** The Triad approach not only uses new tool and approaches. Another way Triad is different is that it uses language more precisely than commonly observed in the cleanup community. The multi-agency Triad workgroup found that seemingly familiar phrases needed to be carefully defined. Terms such as "DQOs," "confirmation," "false positive/false negative," "source area", "definitive," even the word "sample," sometimes cause confusion because they mean different things to different people in different contexts. In line with the key principle of managing uncertainty, the Triad workgroup needed to manage ambiguity in its own communications. It needed a common language before it could articulate Triad concepts within its own multidisciplinary teams. So they developed a glossary for potentially misunderstood terms and defined how they would be used within the context of the Triad approach. They drew from precedent and standard definitions whenever possible. They agreed to strive for clarity in their own usage. It is important that other Triad practitioners make the same effort as Triad disseminates throughout the cleanup community. The glossary is readily accessible on the TRC website (www.triadcentral.org). Anyone preparing any Triad-related documents, guidance, or case studies intended for public dissemination should consult this glossary or confer with workgroup members (who can be contacted through the TRC website) to ensure that terminology usage is consistent with workgroup consensus. As with all Triad-related efforts, this glossary is not fixed in stone, but is open to feedback and refinement as cleanup science and Triad practice evolves. Additional discussion of how Triad is new is available on the Triad Resource Center (TRC) website in the Overview and Key Concepts subsection of Triad Management (http://www.triadcentral.org/mgmt/over/index.cfm) and in the Regulatory Information section (http://www.triadcentral.org/reg/index.cfm). Also see pages 1-4 in the ITRC Triad guidance (http://www.itrcweb.org/SCM-1.pdf).

•**Past experiences usually don't apply:** Experience with the method of traditional project planning doesn't always apply. During initial systematic planning efforts are often quite revealing as participants exclaim, "But this isn't the way we do things! Why are you asking us to think about that now? We don't address that until later." They are quite certain "this will never work" because it is so foreign to what they traditionally do. But if they stick with it through their discomfort and cooperate with the Triad practitioner, toward the end of the project they see how all the pieces fall into place. Then the overall strategy—why it has to be done that way and why it works so much better than the conventional approach—finally makes sense to them. Only after completion of their first project can they see both the "forest" and the "trees." If they give up partway through, they never see the big picture—Triad will remain a mystery.


Triad Myth #2
The Triad approach increases workloads!
1-66



•**Restructuring may be necessary – increased management up-front but tailing off more quickly than traditional project:** From a total-project perspective, this fear is overblown. It is true that Triad projects do require higher levels of regulatory participation, especially during the planning and fieldwork phases of a project. Restructuring of a regulator's workload would be necessary to handle Triad projects. However, investment of regulator time "up-front" pays greater dividends later by reducing the time necessary to evaluate the resulting project documentation and reporting because of the early project planning and on-going involvement with data evaluation during the fieldwork. In addition, since a Triad project will be better focused on the decisions important to all team members, including the regulator, the project will be brought to resolution faster (fewer investigation iterations) than a conventional project. This has the associated benefits of reducing the number of cycles for document production and review. Projects are taken "off the books" much faster, so that attention can be devoted to other projects. Although a higher level of regulator involvement is needed for specific parts of the project timeline, there is an overall reduction in effort, greater continuity, and a higher level of satisfaction by the end of the project. An added bonus is that the rapid pace and real-time feedback of Triad projects allows lessons about what works and what doesn't to quickly develop practitioner expertise and regulator proficiency.

•**Short-circuits adversarial positioning:** There is another way that Triad projects make life easier for regulators. An unfortunate result of non-Triad projects is that relationships among the principal stakeholders (client, project team, regulators, and community groups) sometimes begin with wariness and may quickly become adversarial. A goal of the Triad approach is to "short-circuit" this phenomenon by building social capital: that is, by engaging the principal stakeholders (from the planning process through project completion) in the information and decision-making stream comprising the effort. This is a subtle but important point: the stakeholders do not move from their traditional roles per se; rather, they are provided the opportunity to be aware and contribute at critical junctures of a project as their expertise and insight lead them. Thus, successful systematic planning for a Triad project may involve several iterations of information transfer and discussion through various means (for example, planning team meetings) where initial CSMs, possible contingencies, field tools and approaches, etc. are presented to principal stakeholders for discussion and input.

•**Provides information in user-friendly way:** Additionally, during field execution, real-time data and preliminary data interpretations are made available in a user-friendly way (for example, through secure internet sites dedicated to a project) to principal stakeholders for consideration at their convenience. This free-exchange of information empowers all stakeholders and minimizes the development of the "us versus them" mentality that often characterizes stakeholder relationships and allows for a more streamlined decision making process.

•**Numerous institutional obstacles still exist to executing a Triad versus conventional project:** Site owners and others with financial incentives for faster and more efficient projects can use their purchasing power to create a market draw by shopping for proficient Triad practitioners. Regulatory agencies desiring more confidence in their decisions might suggest that the Triad approach be used, but this runs counter to the usual regulatory stance. Most regulatory agencies see their role as only accepting or rejecting what is proposed, not proactively suggesting alternatives. Many consultants propose only what they know regulators have accepted in the past. Consultants are often reluctant to propose innovative strategies if the regulator might respond negatively. At this time, New Jersey is the only state with a formal policy statement encouraging site owners to propose Triad projects (http://www.state.nj.us/dep/srp/triad/policy.htm). As New Jersey program managers "cut their teeth" on a small number of Triad projects, they are exploring how to address the assorted regulatory and institutional hurdles that inevitably arise. Other states have signaled their willingness to participate in Triad projects, but on a project-specific basis that is less formal than the New Jersey initiative. Although Triad is applicable across the full range of project complexity and site size, Triad projects are run so differently from conventional projects that we do not recommend combining an inexperienced team with a complex project. Unless supported by an experienced Triad practitioner who can steer the team through the pitfalls, we strongly advise that the learning curve be navigated on simple projects. For more information, see the TRC website in these locations: FAQs (Regulatory Acceptance section), Glossary, and the Regulatory Information/Business Process Changes and Regulatory Impacts page (http://www.triadcentral.org/reg/process/index.cfm). Also see sections 5.0 (representative state concerns) and 6.0 (New Jersey's Triad efforts) in the ITRC Triad guidance. The result of this

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Triad Myth #3
Analytical costs for Triad projects are less than conventional projects!
1-68

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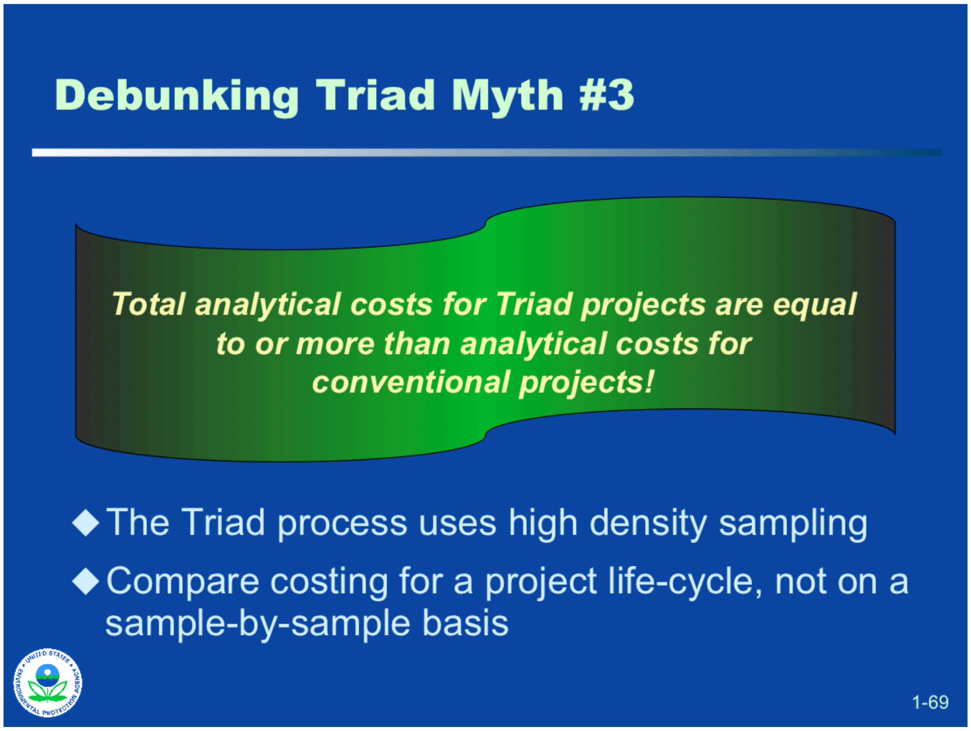

•**The Triad process uses high density sampling:** It is true that field measurement technologies are generally less expensive than off-site analyses on a “per analysis” basis for most contaminants of concern. However, most Triad projects use high density sampling and analysis to manage the uncertainty associated with sample heterogeneity. This means that even though per-analysis cost may be less when field measurement technologies are used, the total analytical costs associated with a Triad mobilization will often be equivalent to, and occasionally more than, the analytical costs for a single mobilization of a conventional project. This investment, however, gives a much clearer and more certain picture of the nature and extent of contamination at the site, which in turn improves the quality of decision-making.

•**Compare costing for a project life-cycle, not on a sample-by-sample basis:** Another aspect of the incomparable nature of the costing comparison between a Triad project and a traditional project is the difficulty with trying to compare costs on a per-sample basis is that field analytical service providers usually charge in terms of daily rates, not per-sample rates. In general, the better the project is planned, the more efficiently field crews will collect and analyze samples. Analyzing more samples per day translates into lower per-sample costs. A better comparison is to look at costs from a life-cycle perspective. The total analytical costs to get the site to completion will nearly always be significantly reduced using Triad. Life-cycle costs are less because the Triad approach completes projects in fewer field investigation phases; Triad systematic planning minimizes the collection of non-informative data; and dynamic work strategies keep characterization and remediation work focused on project objectives. Because Triad field work is much more efficient, its life-cycle costs are less than the costs of a conventional investigation and remediation program (that produces an equivalent degree of decision confidence). Greater efficiency comes from real-time adaptive work strategies that generate more accurate CSMs from higher densities of field samples taken where there was decision uncertainty that needed to be managed. For more information, see the TRC website in these locations: FAQs (Implementation section), Glossary, and the Scheduling and Load Balancing pages (http://www.triadcentral.org/mgmt/log/schedule/index.cfm).

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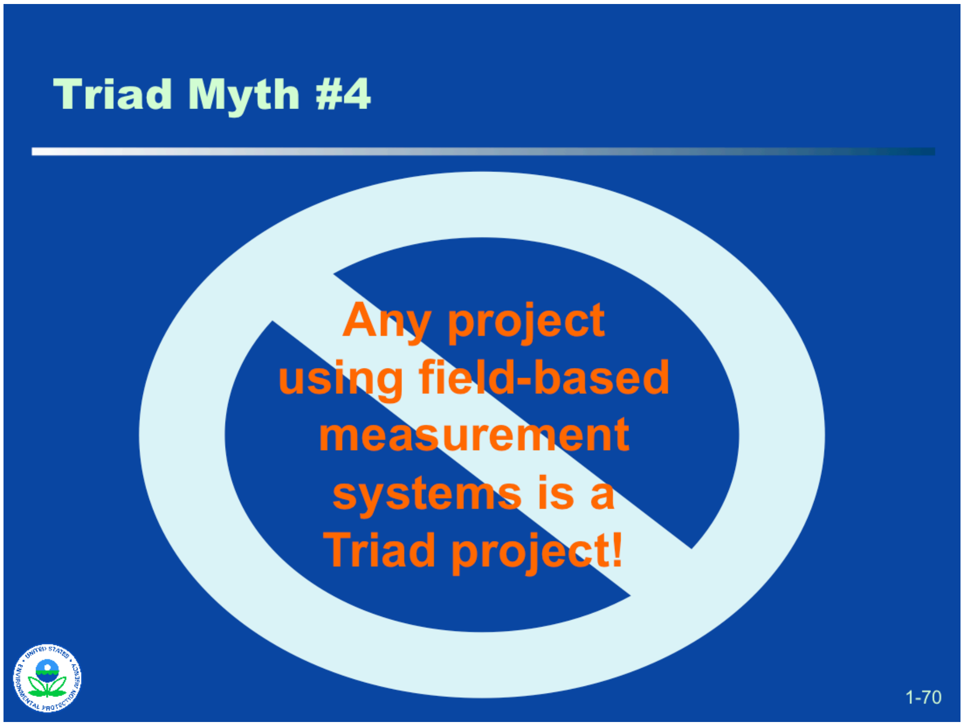
Triad Myth #4
Any project
using field-based
measurement
systems is a
Triad project!
1-70

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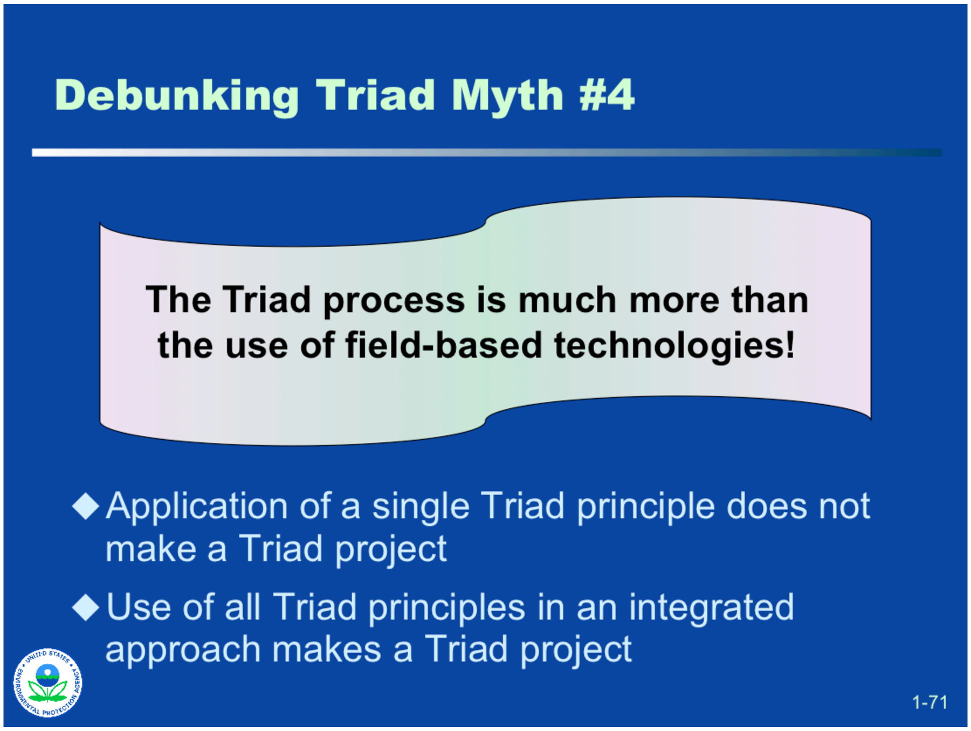


•**Application of a single Triad principle does not make a Triad project:** The keystone feature of a Triad project is demonstrating that decision uncertainties were identified and managed to the satisfaction of project participants. Dynamic strategies and field analytics are important mechanisms by which this is done efficiently. But both mechanisms are often implemented without any attempt to control for uncertainties. If decision uncertainty is not explicitly addressed, the project cannot be considered to be a Triad project, even though it may share some features of a Triad project.

•**Use of all Triad principles in an integrated approach makes a Triad project:** Projects that are incomplete from a Triad standpoint may still be fully acceptable to decision-makers and offer many benefits over more traditional project designs. Such projects may also serve as a stepping stone to Triad projects by providing staff and field crews with valuable experience. But the Triad workgroup has deliberately set a high bar (i.e. uncertainty management) for what qualifies as a Triad project. Setting the bar in this way specifies "what" a Triad project will accomplish (i.e., a high quality project outcome), but allows the "how" to have maximum flexibility and responsiveness to advancing science, experience, and new technologies. Creativity is strongly encouraged, yet accountability is always required. Making uncertainty management the hallmark feature of a Triad project ensures that Triad projects have the greatest likelihood of achieving a satisfactory outcome in the most efficient way possible. Extensive experience has shown that chances for an equally favorable outcome are reduced if isolated Triad elements are deployed independent of an overarching strategy to manage uncertainty. Implementing a dynamic field activity when project goals are unclear may move field work along faster, but the information produced may not meet the regulator's needs. Most likely, important data gaps will be discovered afterwards at the same rate as conventional work plans. Similarly, deploying field methods without multidisciplinary input during planning or using poorly trained analysts is a recipe for generating unreliable, unusable data. Only when all essential Triad features are employed is a favorable outcome highly probable. At a minimum, Triad projects will display the following characteristics:

•A concerted effort to build social capital, achieving clarity and consensus about the desired project outcomes (end goals or exit strategies) so that intended project decisions are clearly articulated (with expressions of what decision errors are tolerable and which are not) before expensive investment in field work begins.

•A CSM that relates site conditions to the decision process, while anticipating site-specific heterogeneities in contaminant distributions at both macro and micro scales.

•Strategies that test and refine the CSM over the course of the project until there is sufficient confidence in the model to support decision-making while avoiding intolerable decision errors.

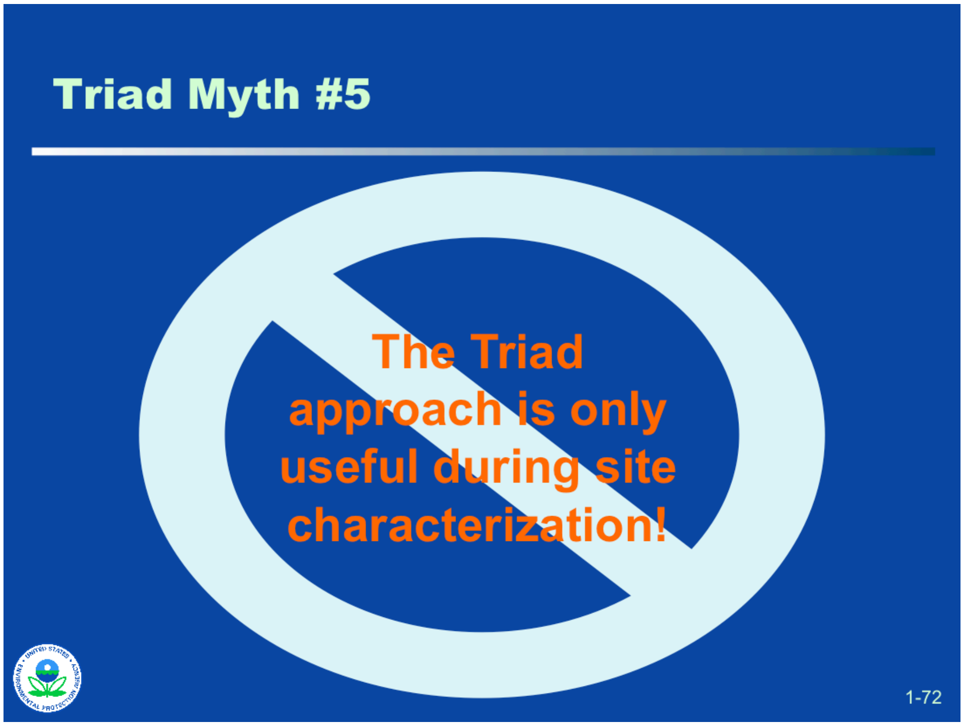
•Strategies (such as demonstrations of method applicability) to identify and control significant sampling and analytical uncertainties in data collection and interpretation.

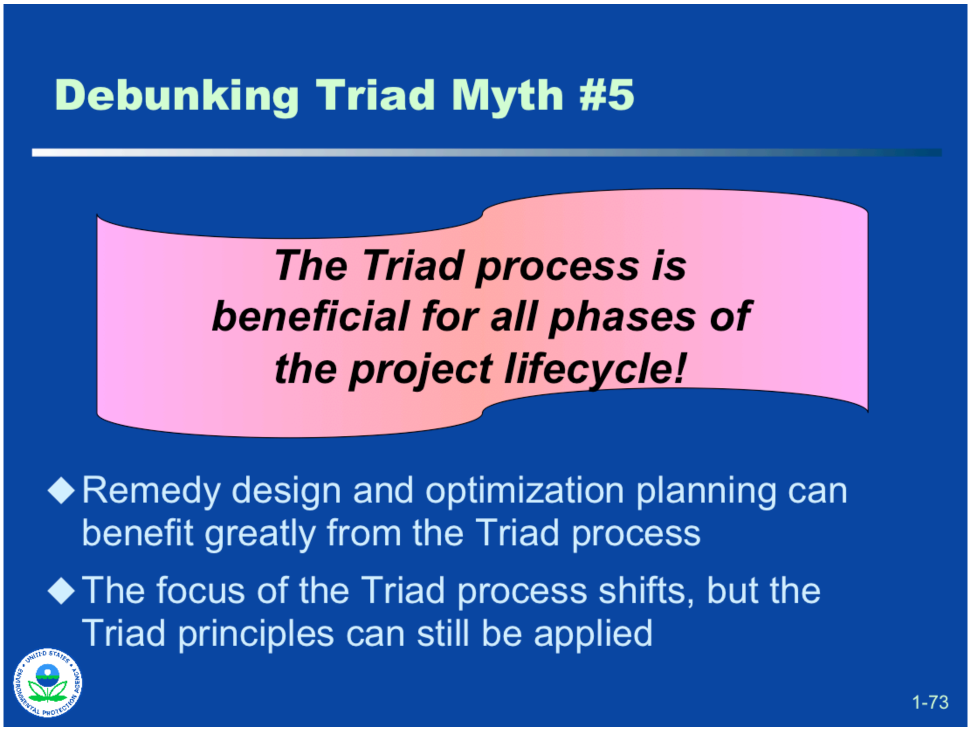
•As much real-time data generation and in-field decision-making as possible to make field work is as efficient as possible.

•A multidisciplinary team with the skills and knowledge needed to accomplish the above.

Management of decision uncertainty begins by figuring out exactly what the project decisions are. Documentation (i.e., work plans or reports) that is unclear about the project's objectives is a red flag that Triad's systematic planning process is not being followed. On the other hand, there is no bright-line criterion for how extensive a dynamic strategy needs to be to qualify for a Triad project. Different Triad projects will employ real-time tools and decision-making to varying degrees depending on the needs of the project, the availability of relevant technology tools, and logistical factors such as regulatory, budgetary, contracting and legal constraints and the expertise of the project team.

See additional detail on this topic in Triad Overview section of the TRC website (http://www.triadcentral.org/over/index.cfm).


Triad Myth #5
The Triad approach is only useful during site characterization!
1-72



•**Remedy design and optimization can benefit greatly from the Triad process:** A Triad approach can specifically support remedial design and implementation in a number of ways. Triad-based data collection programs can be used to "fill" data gaps in the CSM that adversely impact design. Remedial investigations (RI) may not provide adequate information for proper remedy design. This should not be surprising, and does not necessarily reflect an inadequate RI effort. The ultimate remedy is usually not known when the RI is being conducted. The list of contaminants of concern is often incomplete, and final cleanup goals have not been defined. The CSM will still be relatively immature at the outset of an investigation. Even if a Triad approach is used to support an investigation, there may still be a need to resolve design data needs once the preferred remedial alternative has been selected. Triad concepts can be used to optimize another dimension to data collection: timing. As discussed earlier, spatially sparse data sets often contribute the bulk of uncertainty to decision-making. The problem of insufficient sample numbers to support confident decision-making is compounded for monitoring programs over time. One of the key benefits of the Triad approach is the ability to bring a mix of measurement technologies to bear on sampling problems, allowing a higher-density data collection program for the same sampling and analysis budget, leading to better decisions. As a simple example, a large number of monitoring wells might be screened with real-time measurement techniques for potential problems, and a subset of those selected for more definitive fixed-laboratory analyses where screening results are not conclusive, or point to unexpected conditions. Another example is the use of dedicated in situ depth-to-groundwater probes to monitor potentiometric surfaces for groundwater systems. These are capable of logging data every few minutes or hours (as compared to months or quarters for more traditional measurement approaches), and so can be used to flag situations where groundwater gradient changes might compromise the effectiveness of a passive system such as a subsurface reactive barrier.

•**The focus of the Triad process shifts, but the Triad principles can still be applied:** Applying the Triad process to remedy design and optimization is different than applying it to site characterization, because the focus of the efforts is different. However, the same Triad principles of systematic planning, dynamic work strategies, and real-time measurement technologies are followed when using the Triad approach during design and optimization. During later stages of a project, the CSM becomes more of a site model with real data making conditions sufficiently well understood such that a cleanup strategy can be evaluated. Fine-tuning the site conditions and monitoring of process efficiency become the focus of the data collection efforts performed in support of process optimization. Stakeholders can remain the same or even change as the focus in a project leans towards system design optimization, but communication of results, and learning from these results to optimize the project design is where environmental professional have experienced their largest wake-up calls that something wasn't quite right.

Triad Myth #6

Triad-generated data will be unsuitable for risk assessment!

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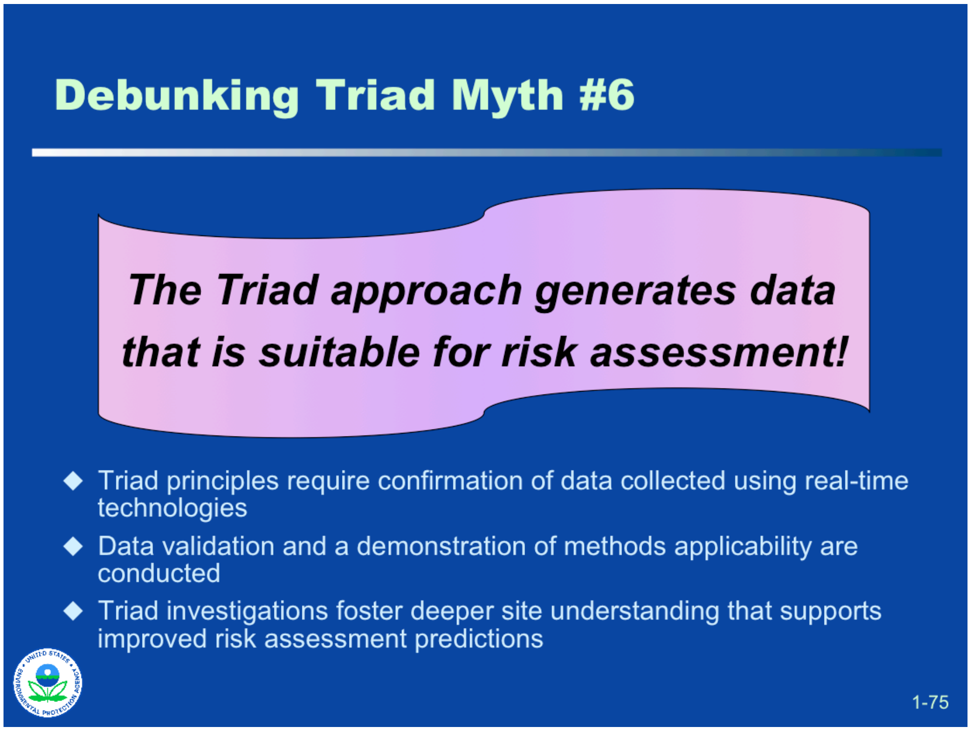


•**Triad principles require confirmation of data collected using real-time technologies:** Triad investigations gather chemistry data using multiple techniques to address issues like determining the confirmatory nature of field-based sampling, sample representativeness, defining analytical uncertainty, and ensuring desired detection limits. Much of this data can be used for the risk assessment. In addition, the resulting collaborative data set allows creation of an accurate CSM. The CSM then supports the selection of samples that are analyzed using methods appropriate for the generation of risk data. An accurate CSM is essential to establish the representativeness of the data used to make risk predictions. Risk assessment calculations depend not just on data of known analytical quality, but also on having data of known sampling quality, addressing the questions: What contaminant population does the data point represent? Is it legitimate to extrapolate a single analytical result on a 1-gram subsample to a volume of 100 cubic yards of soil as part of the risk calculation? Confidence that that data give an accurate picture of site contamination is possible only when sampling variables are controlled and knowledge of contamination variability and extent is captured in the CSM.

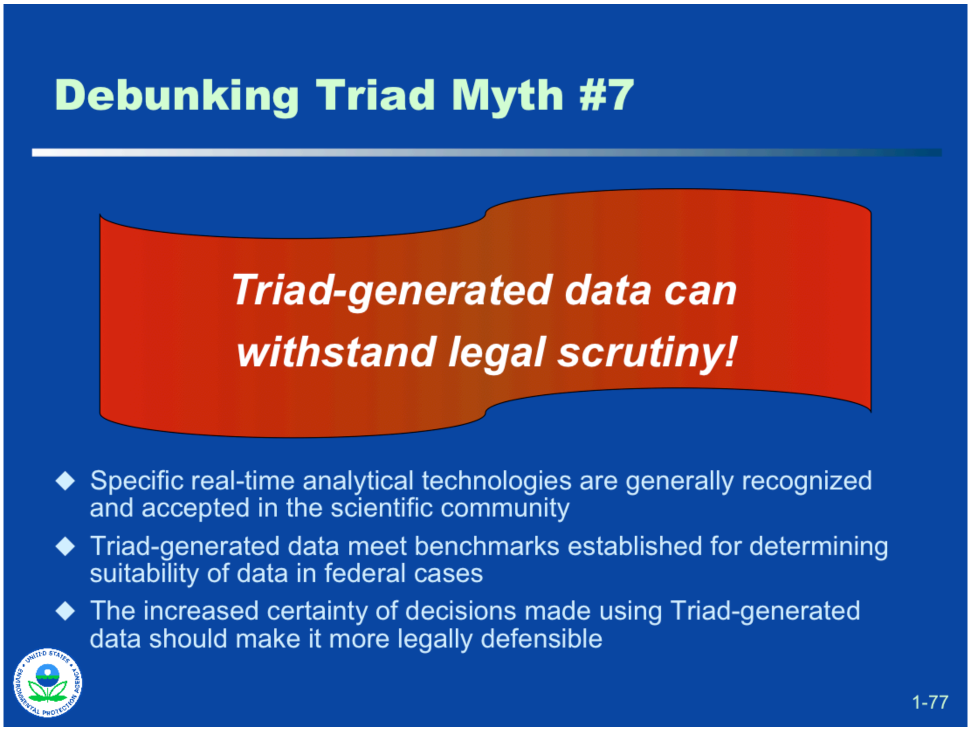
•**Data validation and demonstration of methods applicability are conducted:** The Triad approach pays detailed attention to the issues affecting quality control and data validation for all data collected. Field-based technologies undergo a demonstration of methods applicability to ensure they are suitable for their intended purposes. All data, whether generated in the field in real-time or using a fixed laboratory in near real-time, are validated before being used. The Triad approach addresses many issues of uncertainty not addressed by the traditional approach.

•**Triad investigations foster deeper site understanding that supports improved risk assessment predictions:** Triad investigations therefore not only generate acceptable data sets, but they also foster deeper site understanding that supports improved risk assessment predictions and greater decision confidence by all team members, including risk assessors. For more details, see the TRC website in these locations: FAQs (Dynamic Work Strategies section), and Dynamic Work Strategies/Adaptation/ Adaptive Data Collection Strategies (http://www.triadcentral.org/mgmt/dwstrat/adapt/index.cfm). See also sections 2.4, 2.6, and 2.7 in the ITRC Triad guidance.

Triad Myth #7

A Triad project will not withstand legal scrutiny!

1-76



- **Specific real-time analytical technologies are generally recognized and accepted in the scientific community:** An often expressed concern is that data generated with real-time measurement techniques are not adequate for legal purposes. Interpretation of this issue in state courts varies, but principles established in California (The People v. Kelly, 17Cal.3d 14, 1976) are instructive in providing three tests for legal defensibility of data:
    - the analytical technology is generally recognized in the scientific community;
    - it can be shown that the test method was performed correctly; and
    - the applicability of the method can be substantiated by an expert witness.

- **Triad-generated data meet benchmarks established for determining suitability of data in Federal cases:** Federal law (William Daubert v. Merrell Dow Pharmaceuticals, Inc. United States Supreme Court, 509 U.S. 579, 1993) also has established benchmarks to establish the suitability of such data. These tests include
    - the technique is valid and tested;
    - the scientific basis of the technology has been subjected to peer review in the professional publications;
    - the rates of potential error associated with the method are known; and
    - the technique has gained general acceptance in the relevant scientific community.

- **The increased certainty of decisions made using Triad-generated data should make it more legally defensible:** Triad projects place great emphasis on demonstrations of method applicability and QC, on using multiple complementary analytical techniques and converging lines of evidence to support decisions, and on having a work plan that systematically fills data gaps and manages the impacts of heterogeneity through high data densities which test and verify the CSM. All these efforts to explicitly manage all contributions to data uncertainty allow the Triad approach to generate a comprehensive, interlocking appraisal of data quality and defensible project decisions. Although we are not aware of any Triad project that has "gone to court," Triad-generated data and project conclusions should be more legally defensible than projects forced to rely on sparse data points of questionable representativeness (no matter how accurately the 1-gram samples were analyzed). For more details, see the TRC website in these locations: FAQs (Regulatory Acceptance section), and the Regulatory Information/Triad Compatibility with State and Federal Guidelines page (http://www.triadcentral.org/reg/compat/index.cfm). See also section 5.2.3 in the ITRC Triad guidance.

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Resources

- Key Information Resources
  - Brownfield Technology Support Center, *www.brownfieldstsc.org*
  - Triad Resource Center, *www.triadcentral.org*
  - Cleanup Information Clu-in Site, *http://cluin.org*
  - Federal Remediation Technologies Roundtable, *www.frtr.org*

1-78

Opportunities for Using the Triad Approach

- Optimum benefits when used starting in the site characterization phase
- Can be beneficial at any phase of an environmental remediation project
- Consistent with the requirements of most regulatory programs
  - CERCLA
  - RCRA corrective action
  - Brownfields
  - State voluntary cleanups
  - UST

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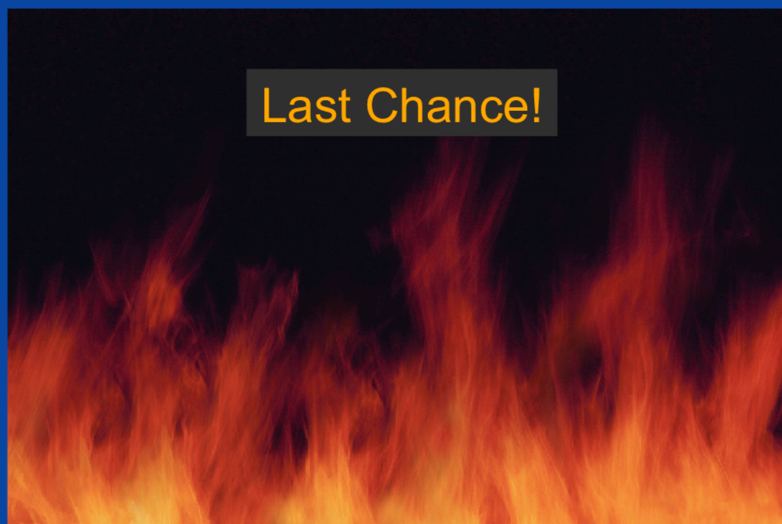
Burning Questions?



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Thank You

After viewing the links to additional resources, please complete our online feedback form.

Thank You

[Links to Additional Resources](#)

[Feedback Form](#)

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