

Module 5

# Triad Toolbox



***“All truths are easy to understand once they are discovered; the point is to discover them.”***

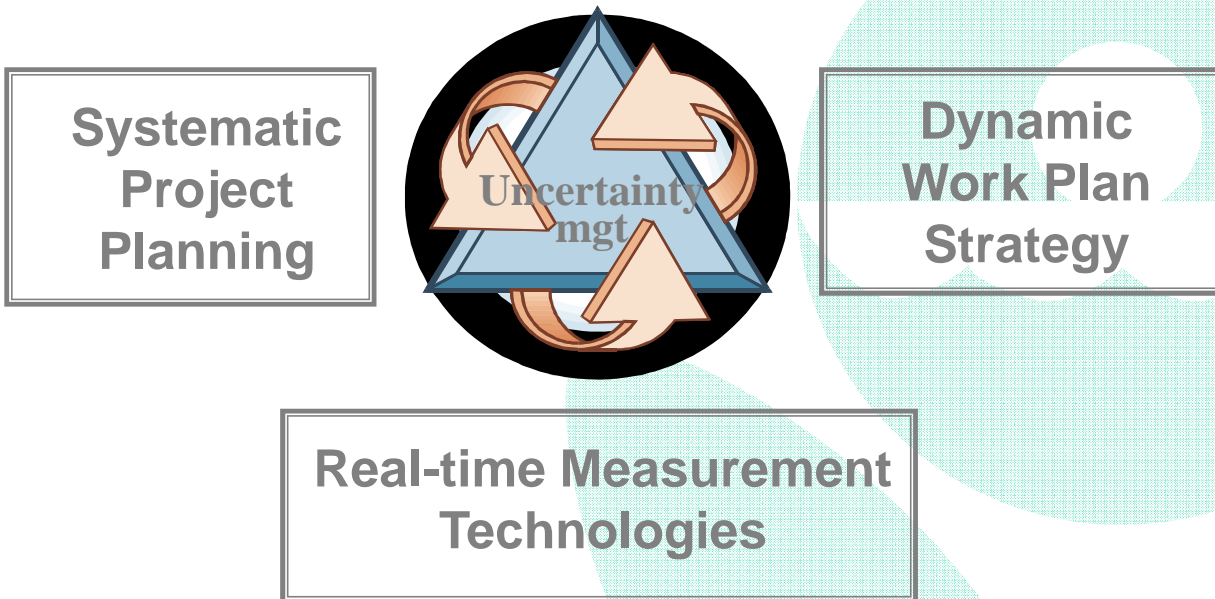
**Galileo**

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# The Triad Approach



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## Triad Data Collection Design and Analysis Built On:

- **Planning systematically** (CSM)
- **Improving representativeness**
- **Increasing information** available for decision-making via field methods
- **Addressing the unknown** with dynamic work strategies and real-time data

## Systematic Planning and Data Collection Design

### Planning Systematically

- Systematic planning defines decisions, decision units, and sample support requirements
- Systematic planning identifies sources of decision uncertainty and strategies for uncertainty management
- Clearly defined cleanup standards are critical to the systematic planning process
- Conceptual Site Models (CSMs) play a foundational role

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## The Conceptual Site Model (CSM) is Key to Successful Projects

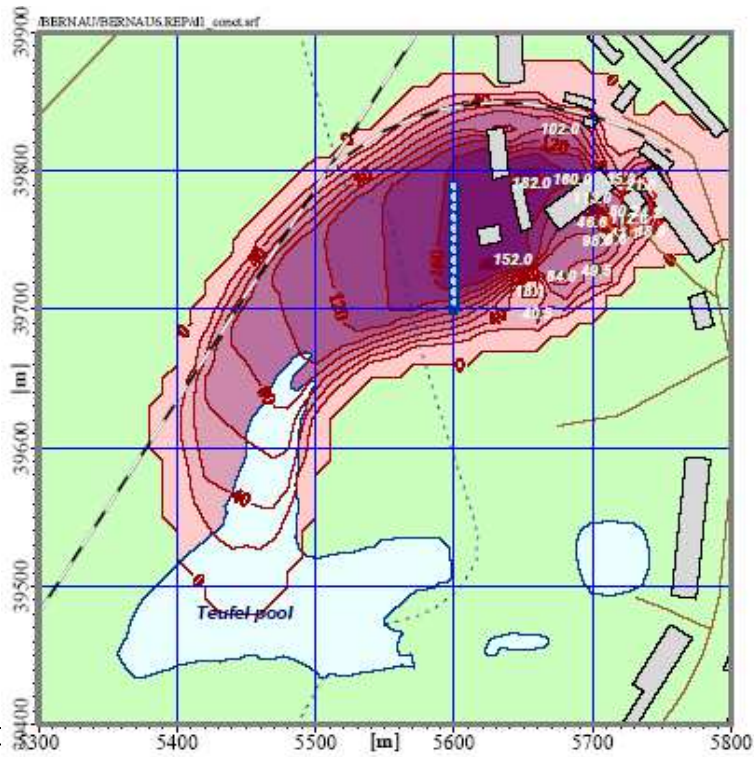
***Not to be confused*** with a fate/transport or exposure scenario model (although these may be components).

THE basis for cost-effective, confident decisions

- **Decision-maker's mental picture** of site characteristics pertinent to risk & cleanup
- A **CSM** can include any component that represents contaminant populations to make predictions about
  - Nature, extent, and fate of contamination,
  - Exposure to contamination, and
  - Strategies to reduce risks from contamination

Planning Systematically

How well does the idealized mental model match reality?



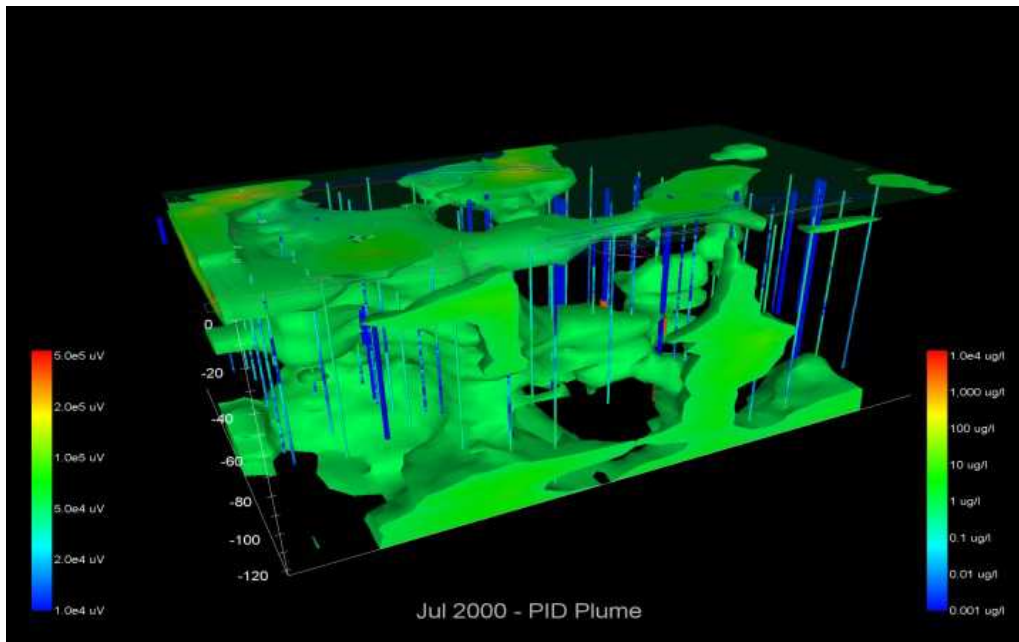
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# The real world is usually a lot messier than models portray

(Subsurface CSM from high density data using DP-MIP sensing)

Planning Systematically



Slide adapted from Columbia Technologies, Inc., 2003

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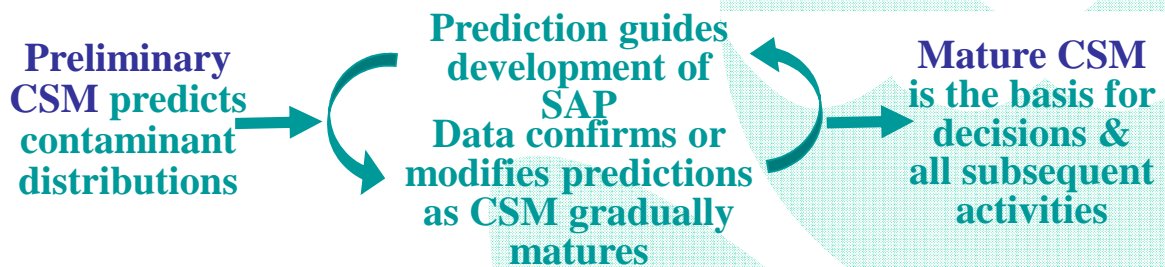
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## CSMs Are Critical!!

### Planning Systematically

- Whether or not openly articulated, the CSM is the basis of all site decisions about risk, remediation, & reuse. Unarticulated CSMs create conflict, are often based on untested assumptions, & lead to faulty projects designs.



- The CSM is the working hypothesis about the site's physical reality, so working without a CSM is like working blind-folded!

**Planning Systematically**

## CSMs Articulate Decision Uncertainty

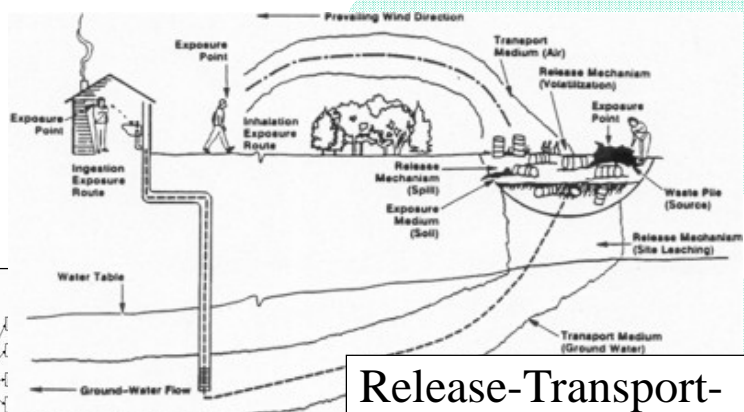
- CSM captures understanding about site conditions.
- CSM identifies uncertainty that prevents confident decision-making.
- A well-articulated CSM serves as the point of consensus about uncertainty sources.
- Data collection needs and design flow from the CSM:
  - Data collection to reduce CSM uncertainties
  - Data collection to test CSM assumptions
- The CSM is living...as new data become available, it is incorporated & the CSM matures.

Planning Systematically

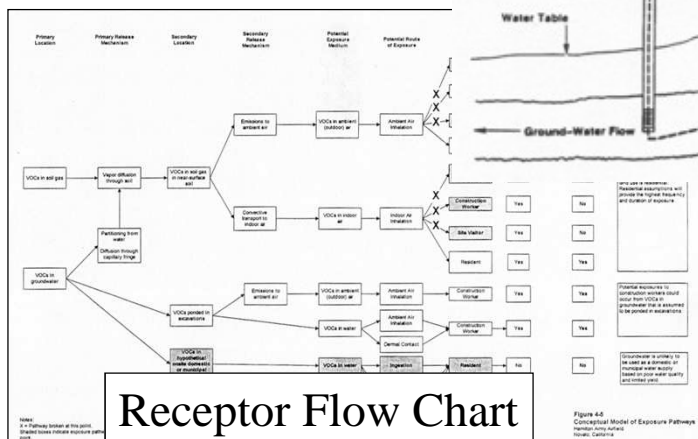
# A CSM Organizes Information

Text  
(simple scenarios)

Computer Model



Release-Transport-Exposure Cartoon



Receptor Flow Chart

2-D Cross Section

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## Improving Data Representativeness

- Sample support
  - matching sample support with decision needs
  - field of view for in situ analyses
- Controlling within-sample heterogeneity
  - Appropriate sample preparation important (see EPA EPA/600/R-03/027 for additional detail)
  - Uncertainty effects quantified by appropriate sub-sample replicate analyses
- **Controlling short-scale heterogeneity**
  - multi-increment sampling
  - aggregating in situ measurements

# Multi-Increment Sampling? Incremental Sampling Compositing?

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**"I'm the consultant they brought in to  
create some new statistical buzzwords."**

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## Compositing Strategies to Improve Representativeness

- Samples are assumed “representative” of the location from which they are taken
- Past experience has demonstrated that discrete grab samples are not necessarily “representative” of their decision unit or even their immediate vicinity
- Compositing strategies, if done correctly, can greatly improve representativeness without significantly increasing costs for surface soils

## Increasing Information via Field-Deployable Methods

### Increasing Information

- Field-based methods are usually cheaper and faster
  - Allow increased data densities
  - Allow real-time decision-making and optimization of the sampling approach
  - Typically higher detection limits, or greater analytical error, or less specificity, or more limited range of analytes
- Typically produce “collaborative data sets”
  - Collaborative data sets are powerful!!
  - Multiple lines of evidence = “weight of evidence”
  - Control multiple error sources
  - Result: increased confidence in the CSM, better decisions

## Examples of Common Field-Based Methods

Increasing Information

Technology	Matrix	Data Provided
X-ray fluorescence (XRF)	Soil	Metals
Immunoassay test kits	Water, Soil	SVOCs (PAH, pest., PCB)
UV methods (UVF, UV lamp)	Water, Soil	TPH, PAH, DNAPL
Misc. colorimetric kits	Water, Air	Water Quality, Toxic Gas
Direct push sensors (MIP, DSITMS, LIF)	Water, Soil	VOCs, TPH, DNAPL
Geophysical tools	Soil	Sources, Pathways
Gamma scans	Soil	Radionuclides
In situ HPGe	Soil	Radionuclides
Field GC and GC/MS	Water, Soil	VOCs

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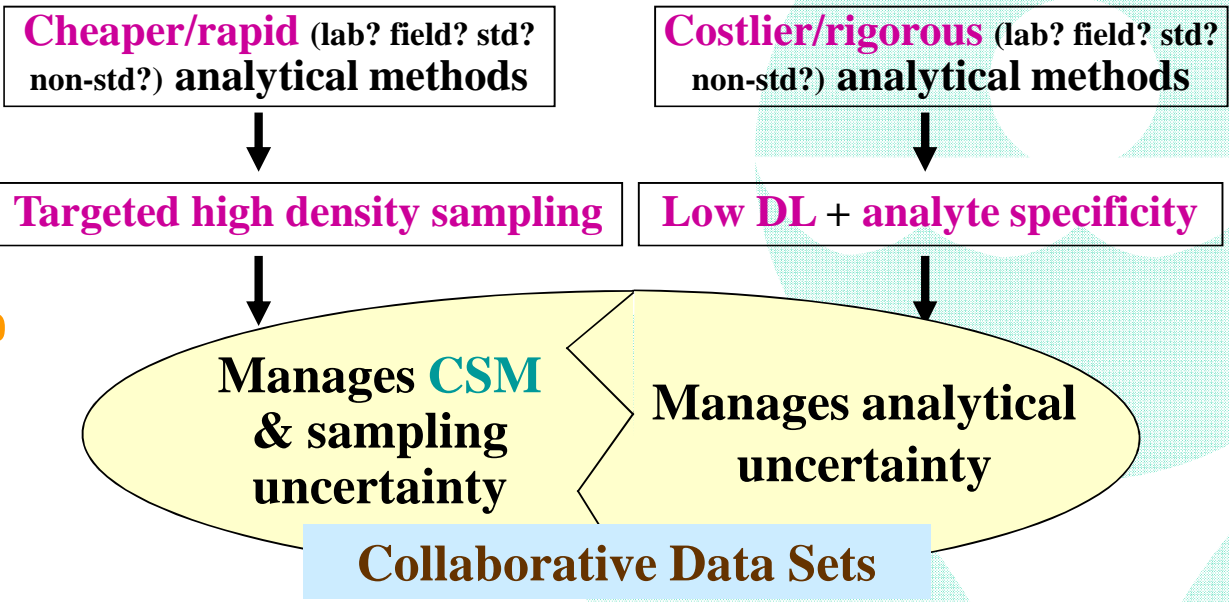
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# Collaborative Data Sets Address Analytical and Sampling Uncertainties

Increasing Information



## Regression Analysis is Not Always Appropriate for Collaborative Data Sets

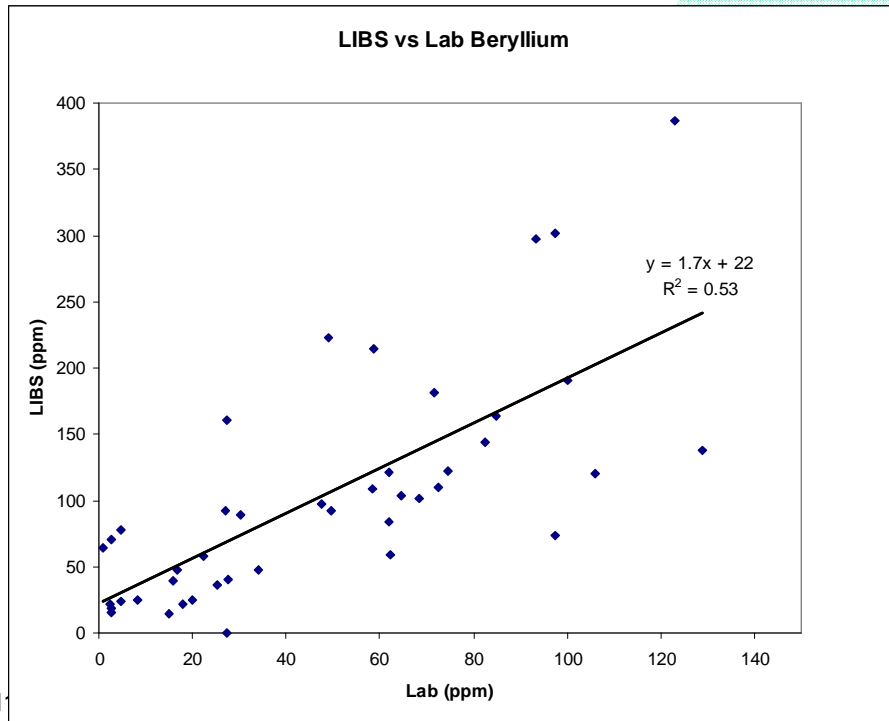
### Increasing Information

Beryllium/LIBS (laser-induced breakdown spectroscopy) example illustrates:

- Site with surficial beryllium contamination
- Experimental backpack LIBS system used to generate a lot of characterization data
- Much smaller set of laboratory analysis for a subset of LIBS locations also available
- Question: Where's the contamination?

# At First Glance, LIBS Data Appear of Little Value...

Increasing Information

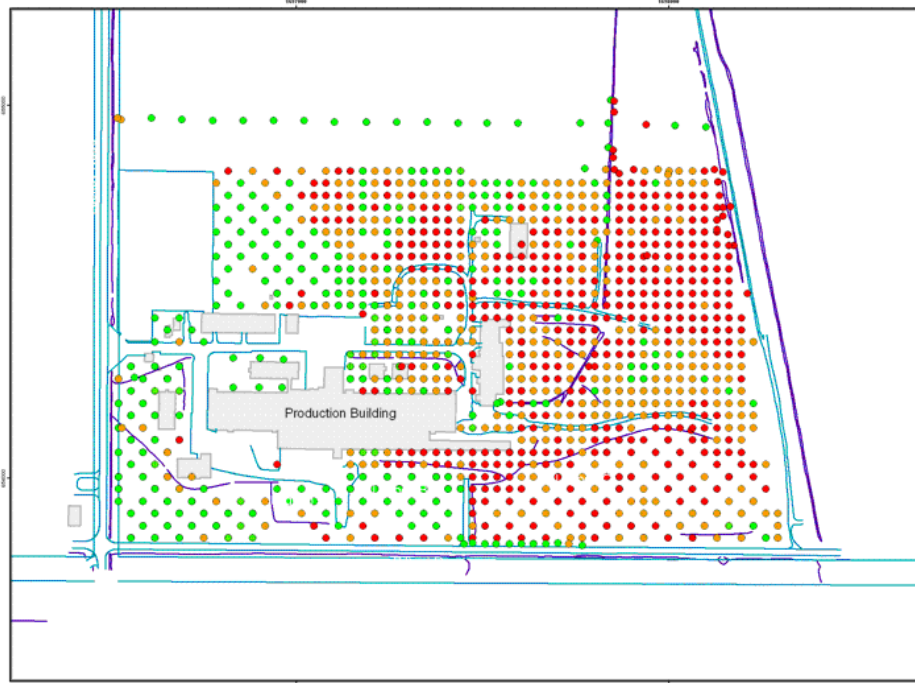


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# But Mapping Suggests a Different Conclusion...

Increasing Information

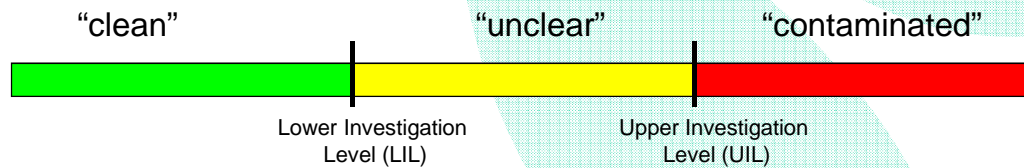


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## Non-Parametric Analysis Can Be a Useful Alternative to Regressions

- Decision focus is often yes/no
  - Is contamination present at levels of concern?
  - Should a sample be sent off-site for more definitive analysis?
- Goal is to identify investigation levels for a real-time method that will guide decision-making
  - Lower investigation level (LIL) for real-time result below which we are confident contamination is not present
  - Upper investigation level (UIL) above which we are confident contamination is present



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"Real-time" analytical result  
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## Dynamic Work Strategies: a Product of Systematic Planning

- Cost effective means for addressing unacceptable decision uncertainty
- Recognize that we don't know enough to support "fixed" work strategies at the outset
- Require a clear articulation of
  - Project goals/decisions
  - Sources of uncertainty
  - Acceptable levels of uncertainty
- Grounded in Conceptual Site Model

## DWS Cut Across Cleanup Activities

**Addressing the Unknown**

Increasing DWS Sophistication



- Selecting analytical options
- Determining sampling strategies, numbers, and locations
- Form and intensity of QC
- Course of remediation activities
- Overall characterization and remediation strategies

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# Successful DWS Affect Field-Work Planning and Implementation

## Addressing the Unknown

- Strategies employed
- Regulatory approval
- Cost estimation
- Contracting
- Logistics
- Collaborative data usage
- Decision-making framework
- Data management



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## DWS, Data Collection, and Real-Time Measurements

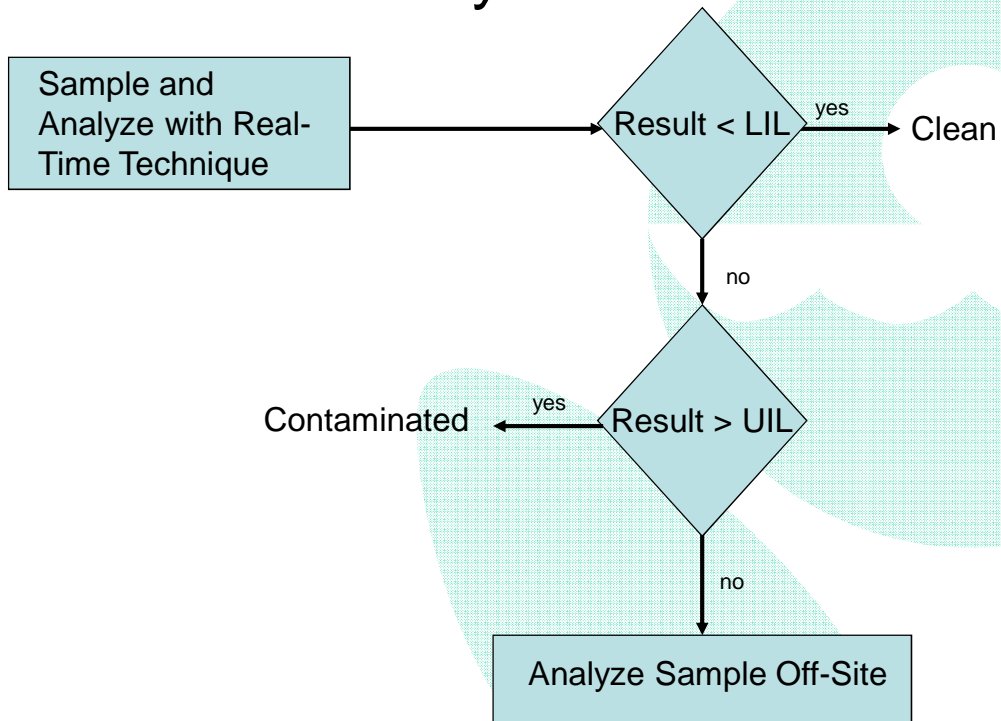
- **Optimizing data collection design**
  - Strategies for testing CSM assumptions and obtaining data collection design parameters on-the-fly
- **Adaptive analytics**
  - Strategies for producing effective collaborative data sets
- **Adaptive compositing strategies**
  - Efficient strategies for searching for contamination
- **Dynamic stratification strategies**
  - Strategies for estimating mean concentrations
- **Adaptive sampling strategies**
  - Strategies for estimating mean concentrations
  - Strategies for delineating contamination

## Adaptive Analytics

- Goal is to identify elevated areas or delineate contamination
- Assumptions:
  - Two methods, one cheap/less accurate, one expensive/“definitive”
  - Investigation levels (i.e., LIL and UIL) can be derived for cheaper, real-time data
- High density real-time data used to screen out areas that are obviously contaminated, or obviously clean
- Fixed laboratory analyses target locations where real-time results were ambiguous
- Design requires determining appropriate real-time investigation levels (e.g., LIL and UIL)

**Addressing the Unknown**

# Typical Decision Logic Adaptive Analytics



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## The Biggest **Bang** Comes from Combining...

- CSM knowledge, with...
- Incremental sampling, with...
- Collaborative data sets, with...
- Adaptive analytics, with...
- Adaptive QC & data uncertainty reduction, with...
- Adaptive compositing, with...
- Adaptive sample location selection.



# Any Questions?



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