Solidification/Stabilization

ITRC Technical And Regulatory Guidance Document: Development of Performance Specifications for Solidification/Stabilization (S/S-1, 2011)

Remediation Technologies Symposium 2011
Charles M. Wilk, CETCO

ITRC (www.itrcweb.org) – Shaping the Future of Regulatory Acceptance

- Host organization
- Network
  - State regulators
    - All 50 states, PR, DC
  - Federal partners

DOE DOD EPA

  - ITRC Industry Affiliates Program
  - Academia
  - Community stakeholders

- Wide variety of topics
  - Technologies
  - Approaches
  - Contaminants
  - Sites
- Products
  - Technical and regulatory guidance documents
  - Internet-based and classroom training

What is S/S Treatment?

Involves mixing binding agent(s) into contaminated media such as soil, sediment, sludge or industrial waste.

S/S treatment protects human health and the environment by immobilizing hazardous constituents within treated material.

S/S Treatment does not remove contaminants.

Immobilizes by physical (solidification) and chemical (stabilization) changes to the treated material.

S/S Transformation of Waste Material

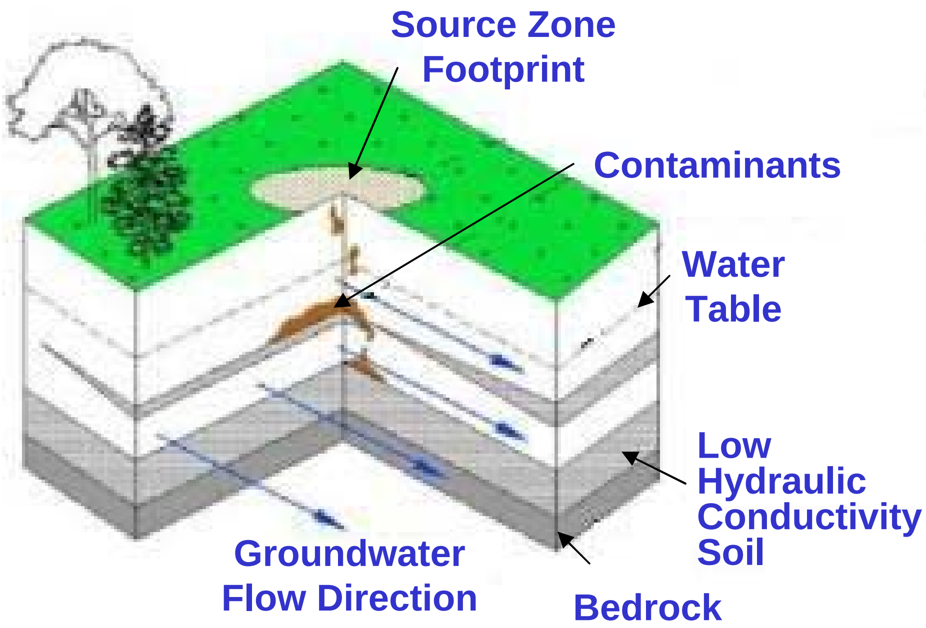
Oily Soil Before S/S

S/S Treated Soil

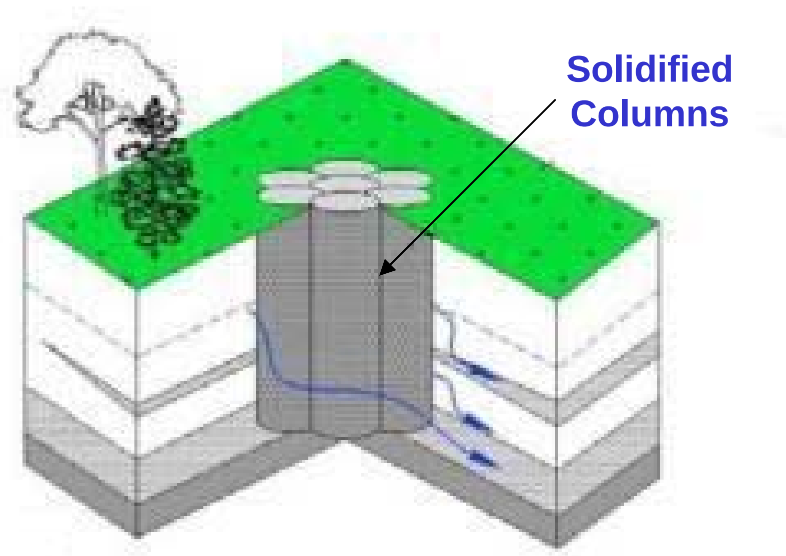
S/S Treatment

- ↑ Strength
- ↓ Hydraulic Conductivity
- ↓ Leachability

S/S Technology Process



Before S/S



After S/S

Site Examples

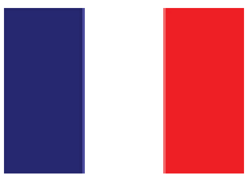
Auger-mixed in situ S/S treatment of a former manufactured gas plant (MGP) site with coal tar contaminants at Kendall Square, Cambridge, MA, United States.

Excavator bucket mixing of contaminated sediment of a former steel mill operation, Sydney Tar Ponds, Sydney, NS, Canada.

Acceptance

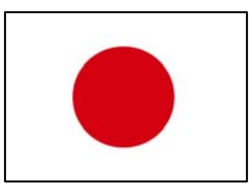
Belgium

Canada

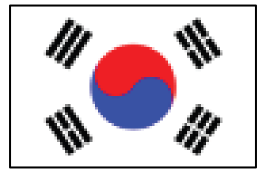


France

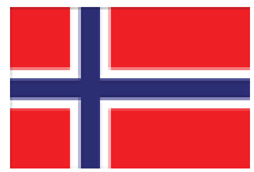
Italy



Japan

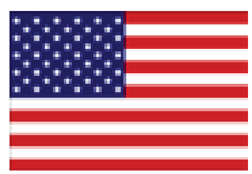


Korea



Norway

United Kingdom

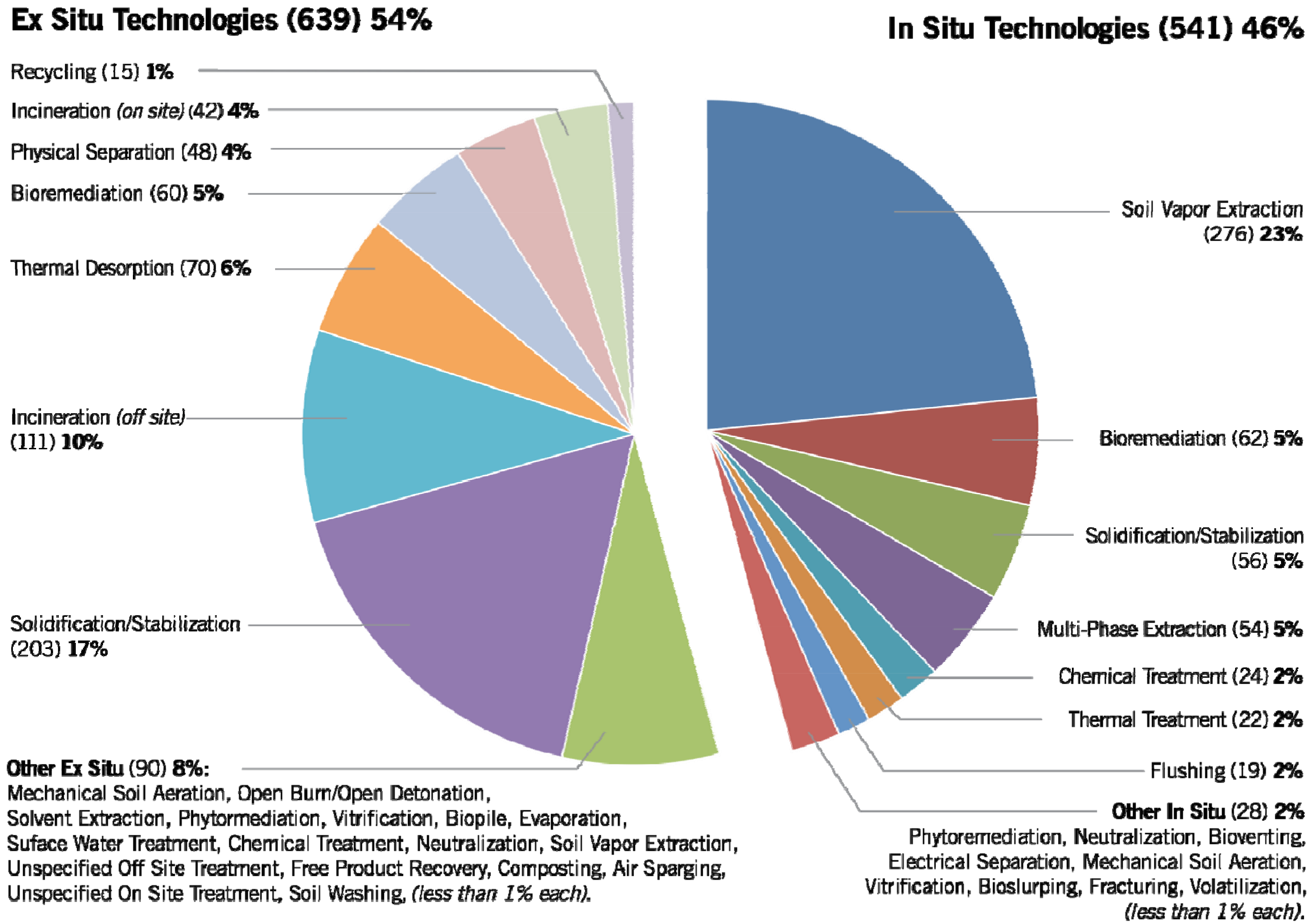


United States

Technology Selections for Source Control Remedies Superfund Projects and Decision Documents

FY 1982-2008

Total Number of Projects and Decision Documents = 1180



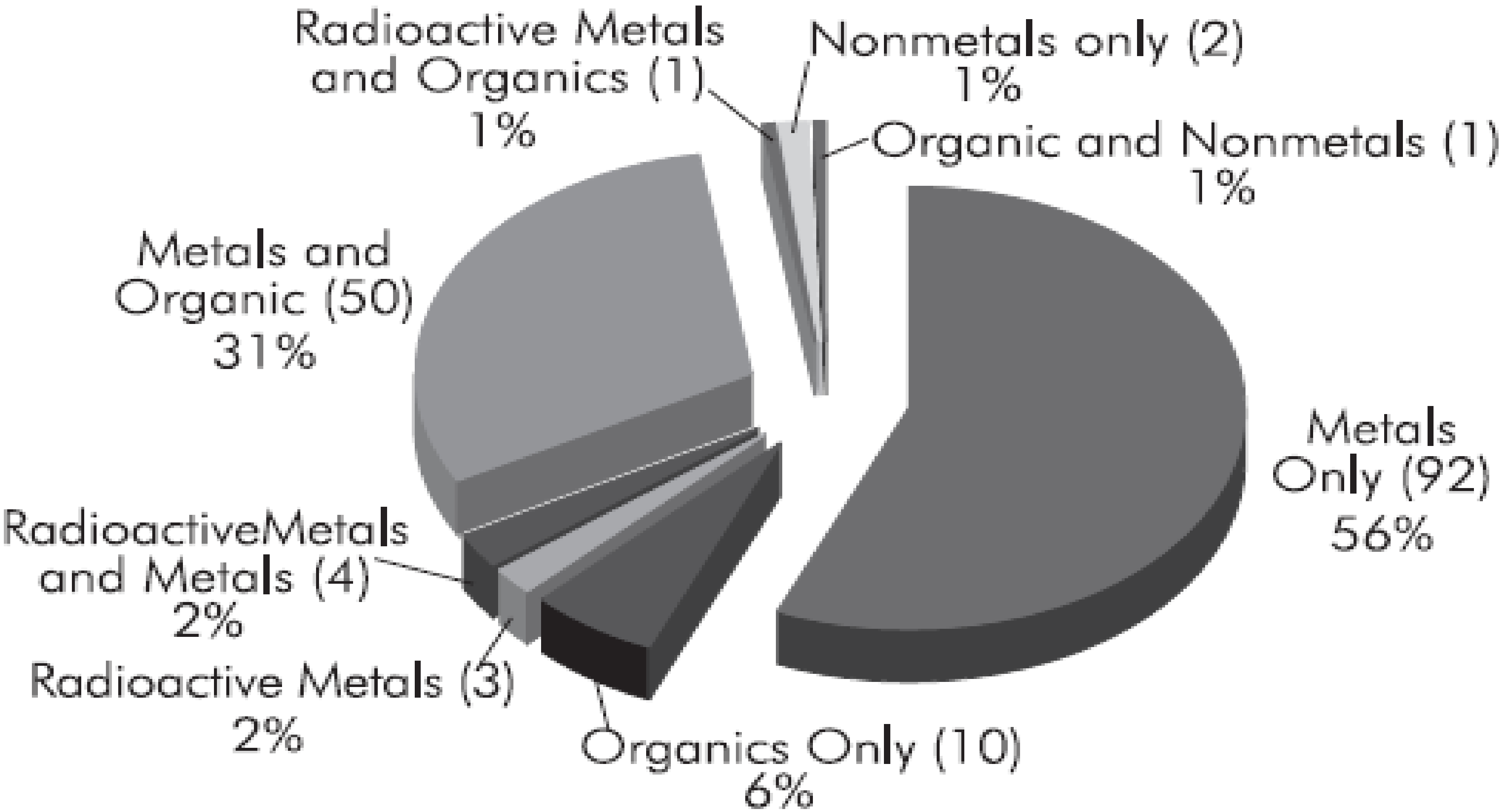
Source of Data for Pie Chart: Table 2 *Superfund Remedy Report*, Sept. 2010, EPA-542-R-10-004

EPA-542-R-07-012

Technology	Total number of projects[a]	Polycyclic aromatic hydrocarbons (PAHs)	Other nonhalogenated semivolatile organic compounds[b]	Benzene-toluene-ethylbenzene-xylene (BTEX)	Other nonhalogenated volatile organic compounds[c]	Organic pesticides and herbicides	Other halogenated semivolatile organic compounds[d]	Halogenated volatile organic compounds	Polychlorinated biphenyls	Metals and metalloids
Bioremediation	113	37	51	33	33	24	17	22	2	5
Chemical Treatment	29	1	2	3	4	1	4	12	4	13
Multi-Phase Extraction	46	9	3	11	6	4	8	18	1	1
Electrical Separation	1	0	0	0	0	0	0	1	0	0
Flushing	17	3	5	5	5	1	3	11	0	5
Incineration	147	27	41	33	23	36	34	52	36	6
Mechanical Soil Aeration	7	0	0	3	1	0	1	7	0	0
Neutralization	15	2	0	0	0	0	0	0	0	6
Open Burn/ Open Detonation	4	0	1	0	0	0	0	0	0	0
Physical Separation	21	4	2	1	0	3	0	0	4	5
Phytoremediation	7	1	2	2	2	1	1	4	0	4
Soil Vapor Extraction	255	15	31	107	51	3	33	217	1	0
Soil Washing	6	1	1	0	0	2	0	0	1	2
Solidification/ Stabilization	**217**	**17**	**18**	**13**	**13**	**16**	**7**	**20**	**35**	**180**
Solvent Extraction	4	2	1	0	1	1	0	2	2	1
Thermal Desorption	71	21	17	24	15	8	12	33	16	0
In Situ Thermal Treatment	14	5	0	2	0	3	3	8	0	0
Vitrification	3	0	0	1	1	0	1	3	2	1
Total Projects	**977**	**145**	**175**	**238**	**155**	**103**	**124**	**410**	**104**	**229**

Exhibit 10: Contaminant Types Treated by S/S

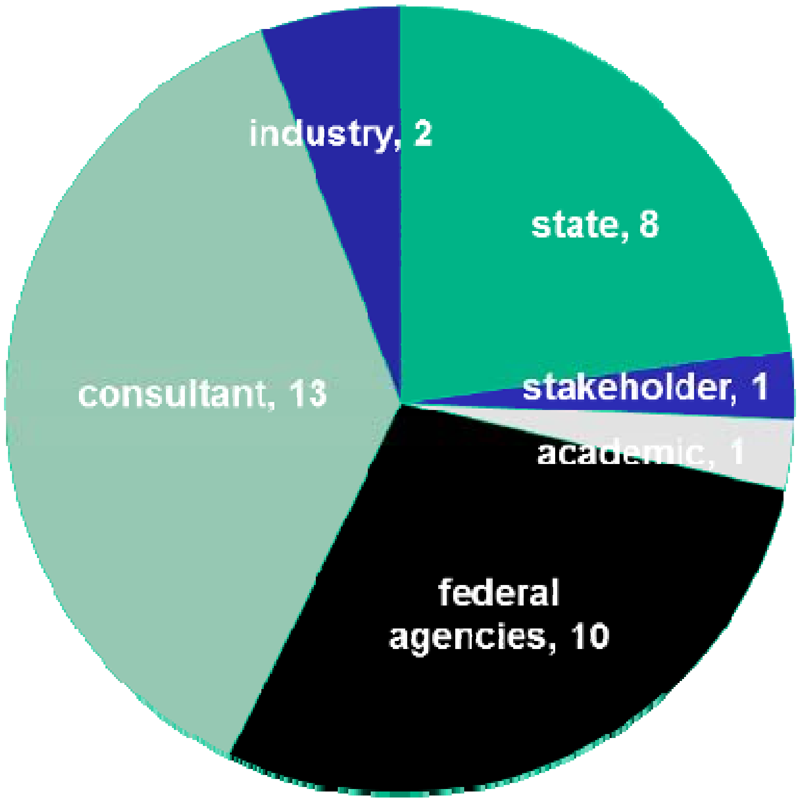
Total Number of Projects = 163



EPA-542-R-00-010

ITRC S/S Guidance Addresses Technical and Regulatory Barriers

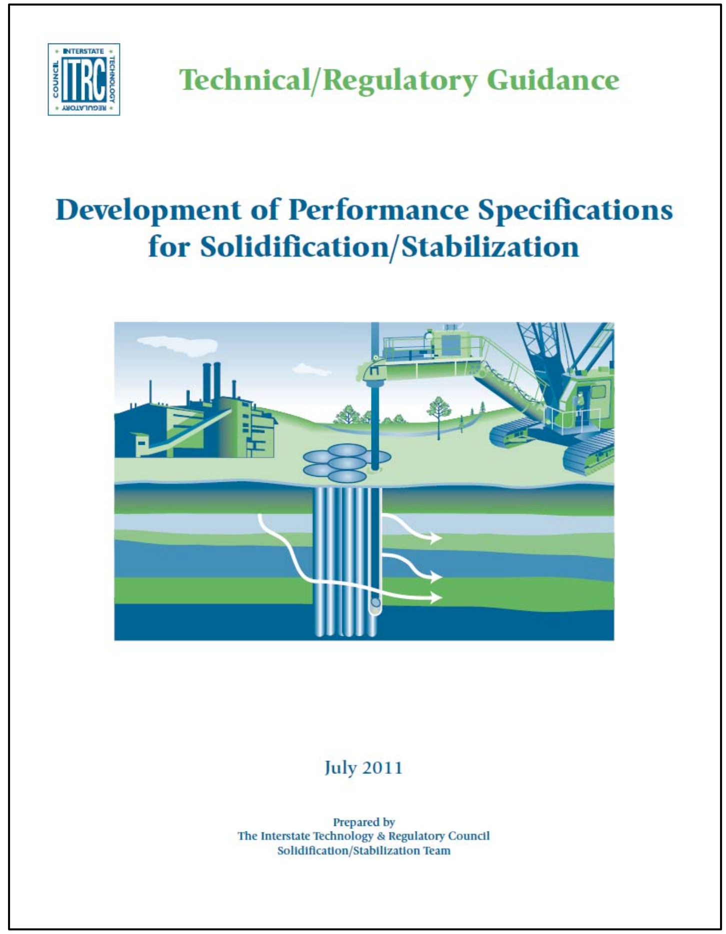
- Inconsistent criteria for development of performance specifications
- Uncertainties associated with prediction of long-term performance
- Lack of methodologies for measure of long-term compliance
- ITRC S/S Team members collective experience addressed barriers in guidance



ITRC S/S Team members collective experience addressed barriers in guidance

ITRC Guidance and Training

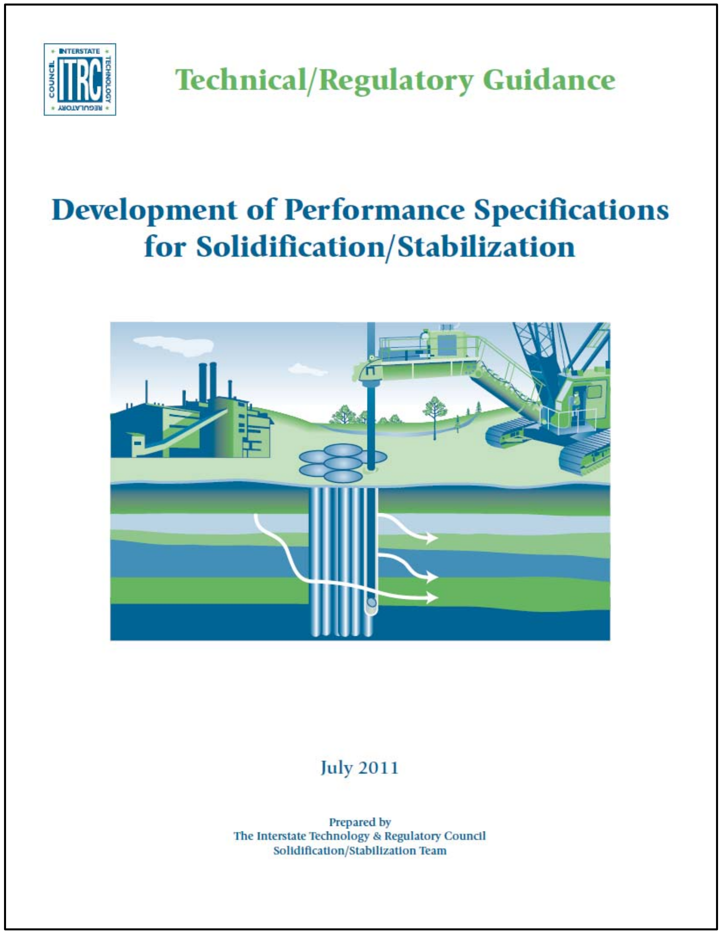
- Publication dated July 2011
  - PDF on-line www.itrcweb.org
  - Bound copies (limited)
- Internet-based Training
  - 2 1/4-Hour
  - Next Scheduled Nov. 15th
  - More in 2012
  - Register at http://clu-in.org/studio/seminar.cfm
- Free
- Slide repeats at end



ITRC Development of Performance Specifications for Solidification / Stabilization (S/S-1, July 2011)

What is Included in the ITRC Guidance and Training

- ▶ Performance specifications
  - Concepts
  - Identification and selection
  - Assessment methodology
- ▶ Technology performance
  - Treatability studies
  - Implementation
- ▶ Long-term stewardship
  - Considerations
  - Criteria for compliance



Technical/Regulatory Guidance

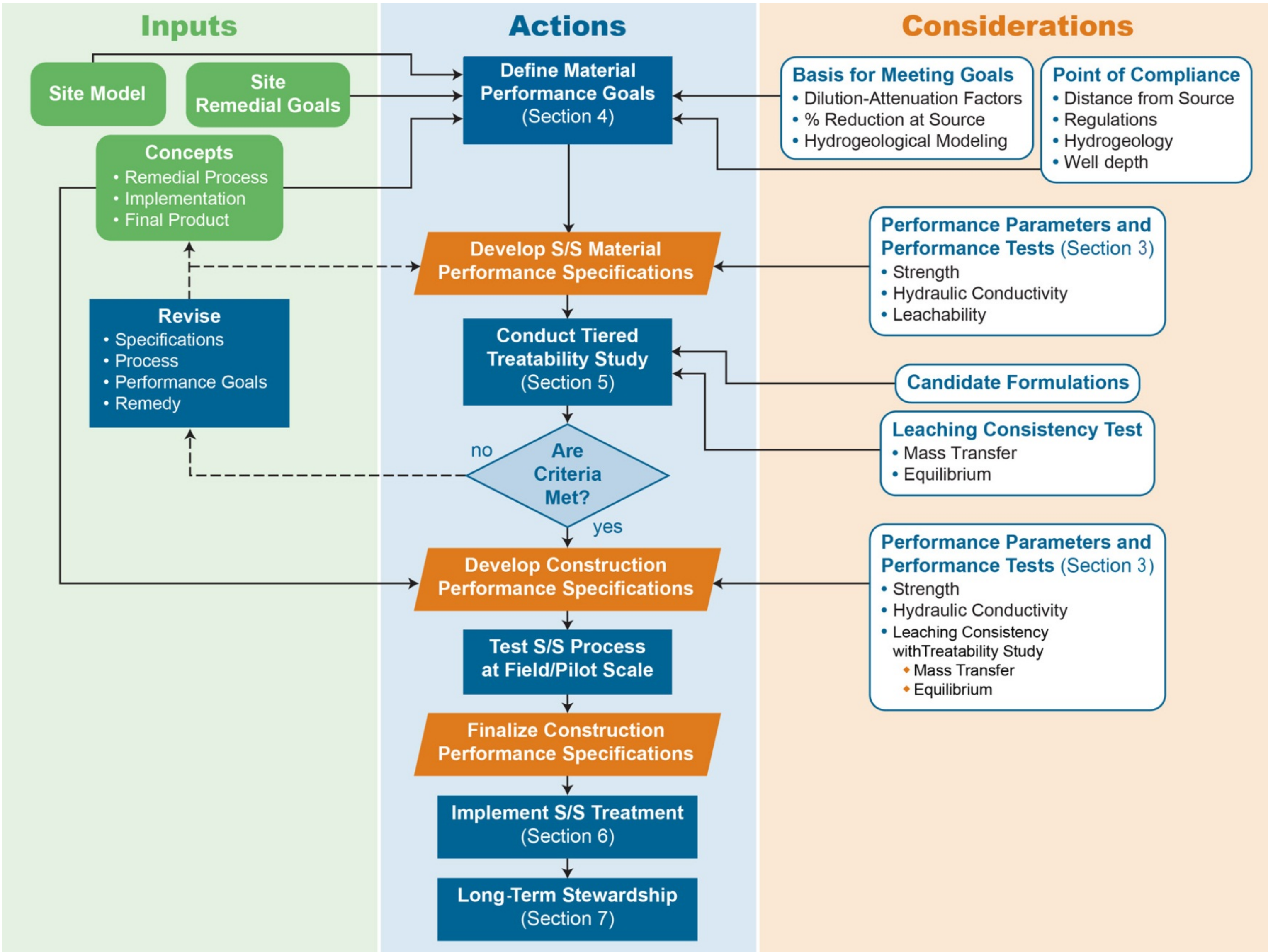
Development of Performance Specifications for Solidification/Stabilization

July 2011

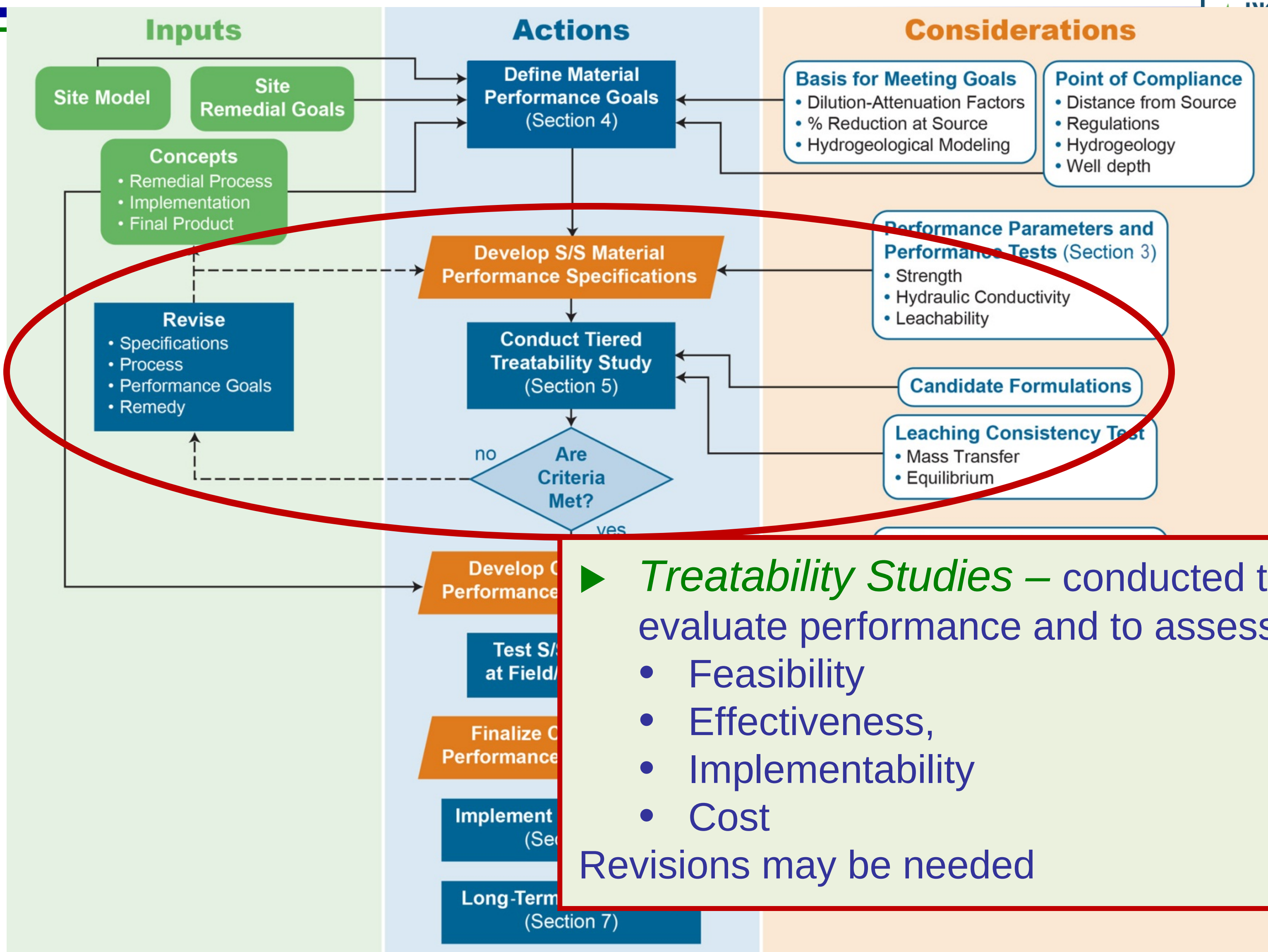
Prepared by
The Interstate Technology & Regulatory Council
Solidification/Stabilization Team

ITRC Development of Performance Specifications for Solidification / Stabilization (S/S-1, July 2011)

S/S Process Flow Chart
(ITRC S/S-1, Figure 4-1)



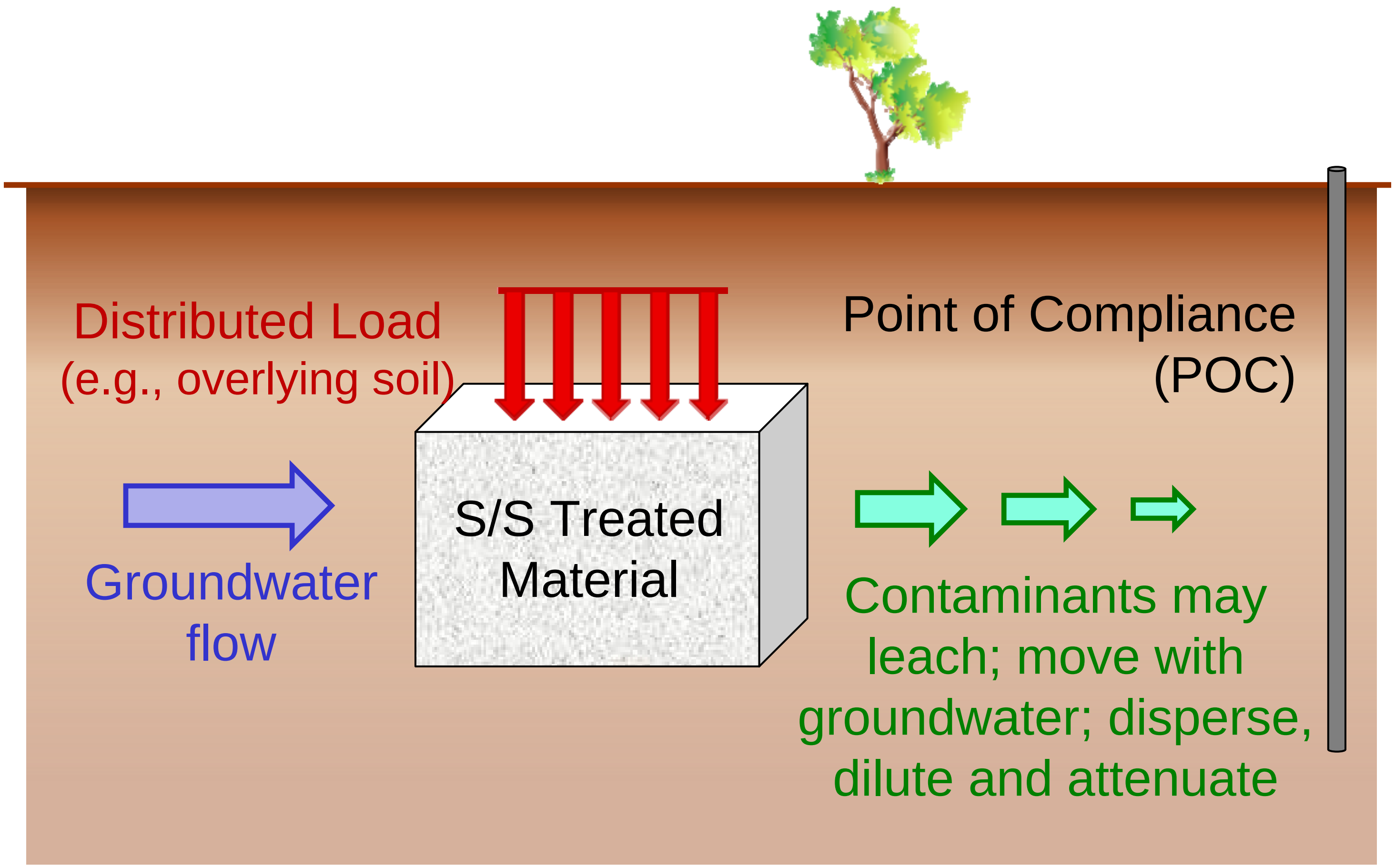
S/S Process Flow Chart



- *Treatability Studies* – conducted to evaluate performance and to assess:
  - Feasibility
  - Effectiveness,
  - Implementability
  - Cost

Revisions may be needed

S/S Materials in the Environment



Three Key Performance Parameters

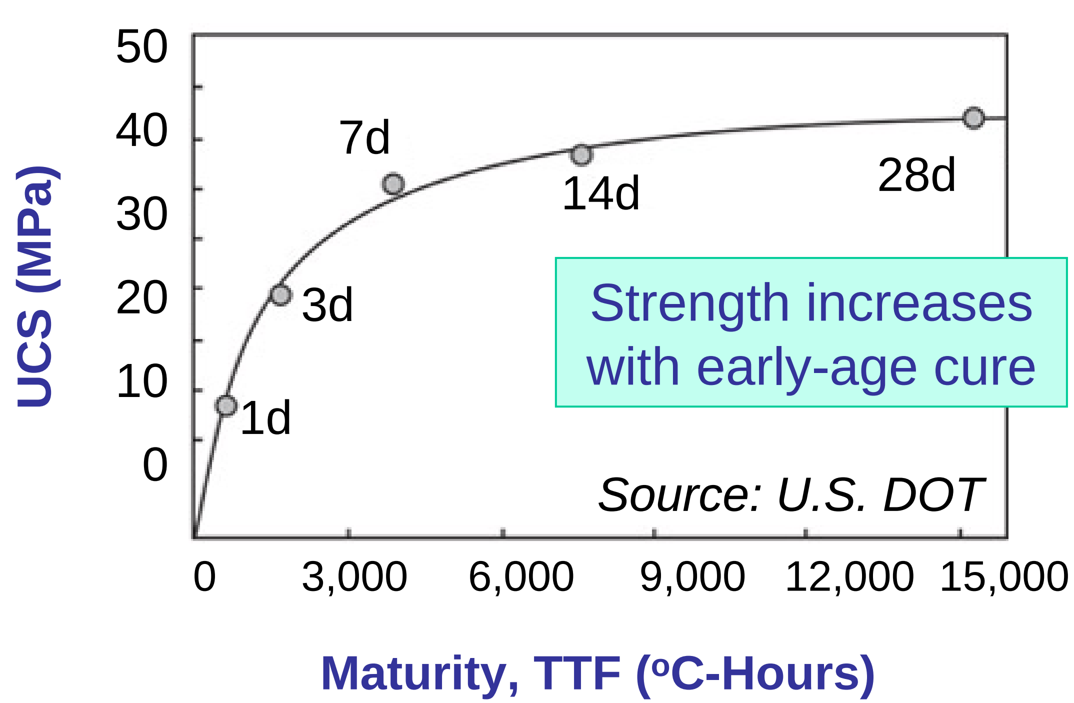
- Strength
  - Withstand overlying loads
- Hydraulic Conductivity
  - Manage water exposure
- Leachability
  - Retain contaminants

Laboratory Analysis – Treated Samples

- Chemical testing
  - Total chemical analysis
  - Leaching Test
  - Documenting pH of extract
- Other testing
  - Strength
  - Hydraulic conductivity

Strength: Ability to Withstand Loads

- Unconfined Compressive Strength (UCS)
  - Most commonly-used parameter for S/S
    - Indicator of *chemical reaction* or binding
    - Indirect indication of *durability*



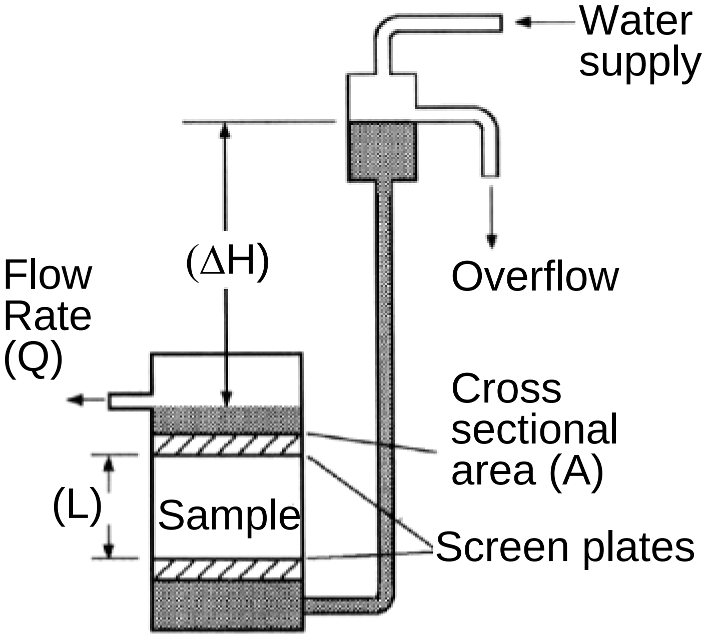
ASTM D1633:
UCS for soil-cement cylinders

Hydraulic Conductivity: Water Movement Through a Porous Material

- Hydraulic conductivity (K)
  - K relates groundwater flow (Q) to hydraulic head (ΔH/L)
- Relative hydraulic conductivity
  - Difference in K between adjacent materials
  - Determines
    - water contact mode
    - primary leaching mechanism

D'Arcy's Law

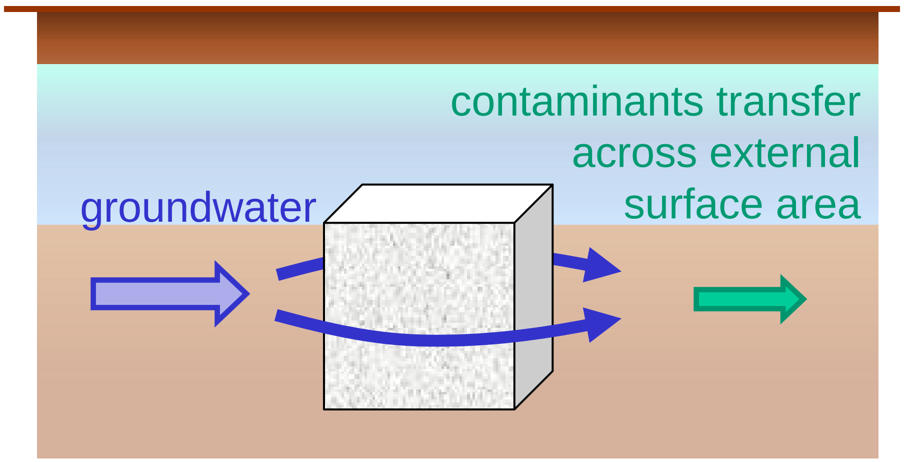
$$Q = A \cdot K\left(\frac{\Delta H}{L}\right)$$



ASTM D5084:

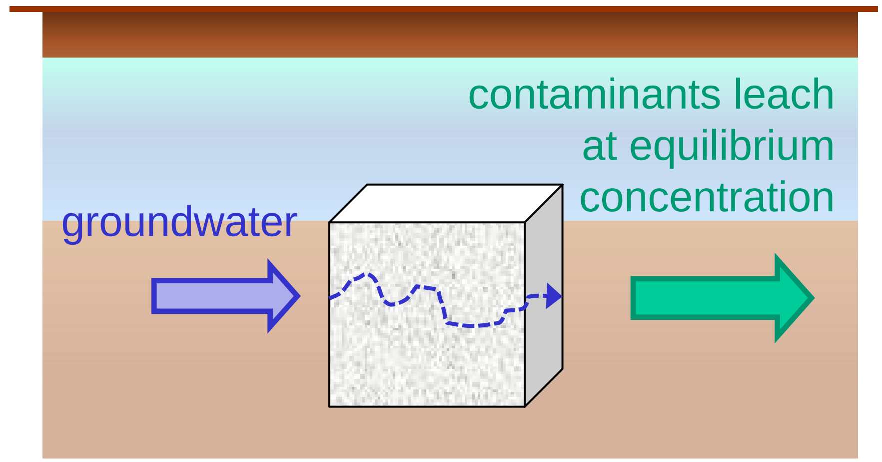
Why is Relative Hydraulic Conductivity Important?

$K_{S/S} << K_{soil}$



- Water is diverted around material
- Exposed surface area limited to external surface
- Contaminant release rate controlled by *Rate of Mass Transfer*

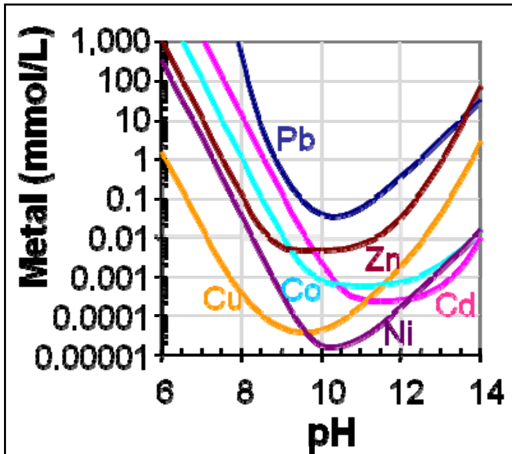
$K_{S/S} \sim K_{soil}$



- Water percolates through material
- Continuous pore area exposed
- Release concentrations based on *Liquid-Solid Partitioning* (local equilibrium)

Contaminant release under equilibrium conditions will always be greater than under mass transfer conditions.

Factors Influencing S/S Material Leaching Performance



Moisture Transport

Leachant Composition

Water, Acids, Chelants, DOC

Leaching Factors

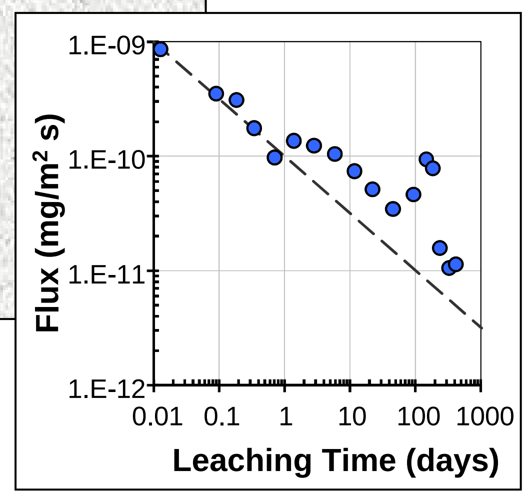
- Equilibrium or Mass Transport
- pH
- Liquid-to-solid ratio
- Rates of mass transport (flux)

Physical Factors

- Strength (durability)
- Hydraulic conductivity (water contact)

Chemical Degradation
(Sulfate, Carbonation)

Physical Degradation
(Erosion, Cracking)

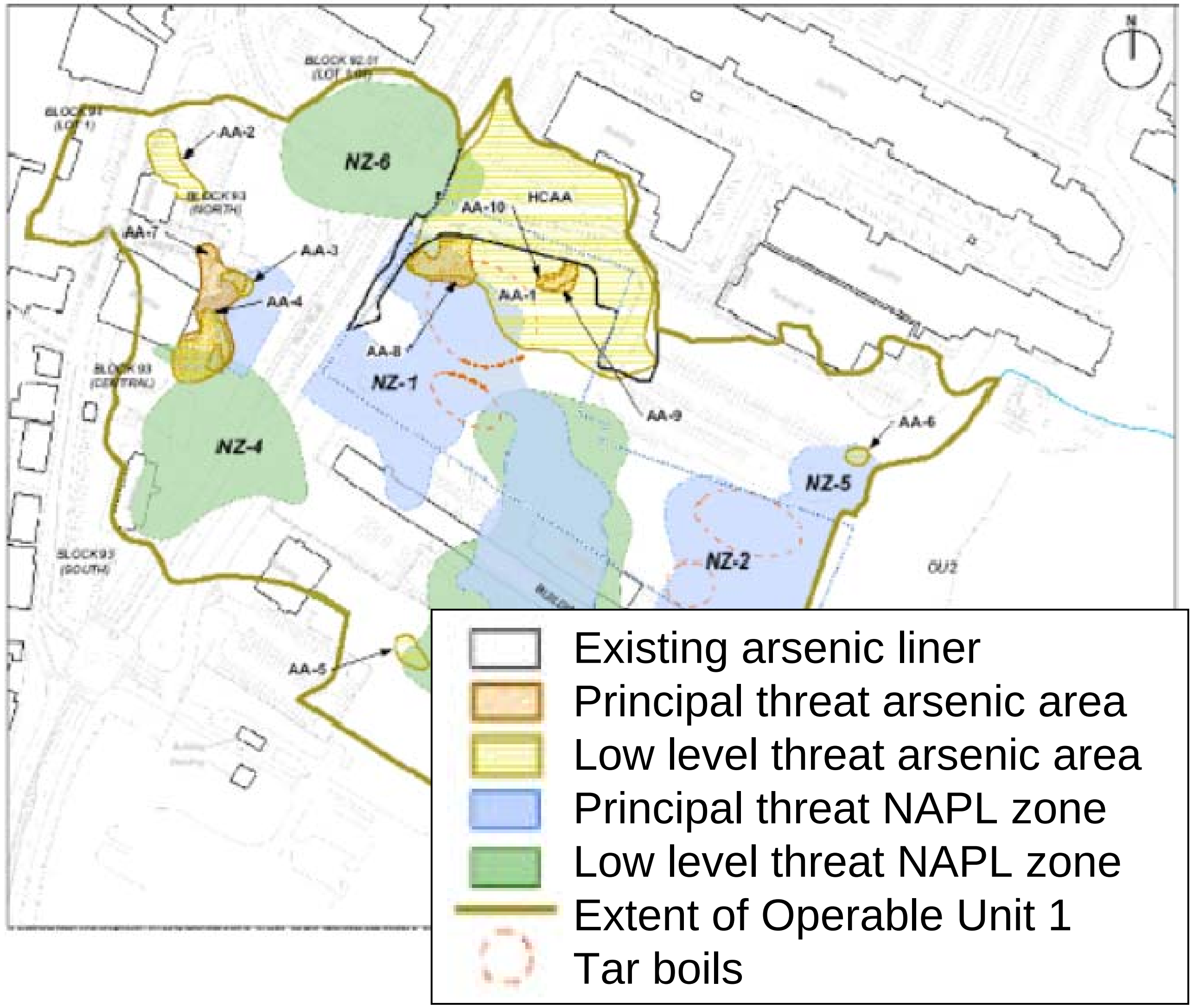


Chemical (Leaching) Testing

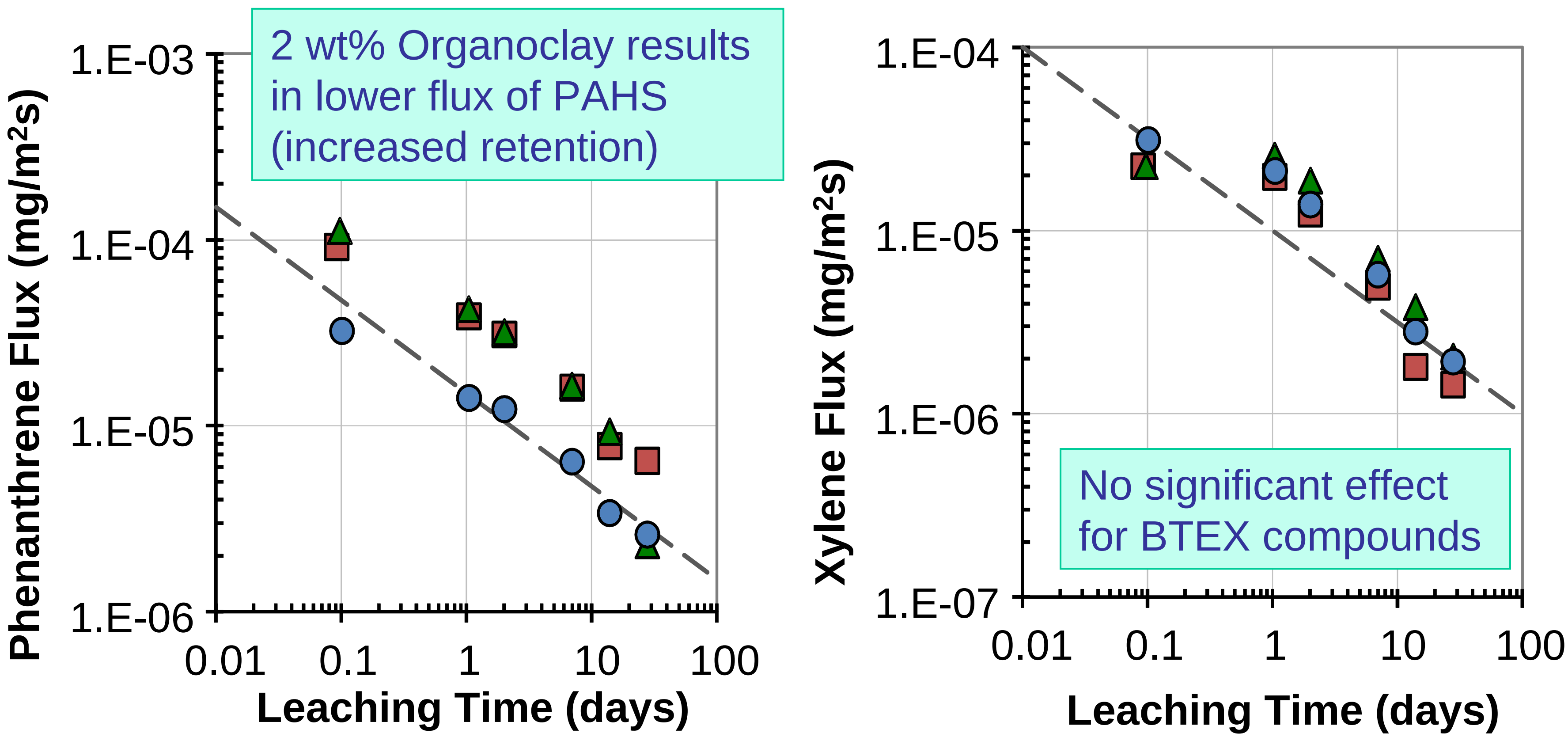
- Synthetic Precipitation Leaching Procedure (SPLP)
- Toxicity Characteristic Leaching Procedure (TCLP)
- Multiple Extraction Procedure
- Equilibrium Leach
- ANS/ANSI 16.1
- Dynamic Leach
- Leaching Environmental Assessment Framework (LEAF)
  - Under review for inclusion into EPA's SW-846

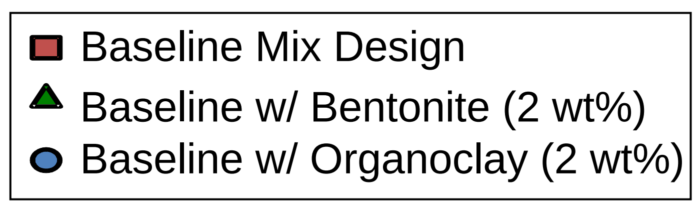
Sample Collection Critical and Requires Careful Planning

- Appropriate locations
- Sample compositing
- Method for collecting representative samples
- Full-scale implementation approach



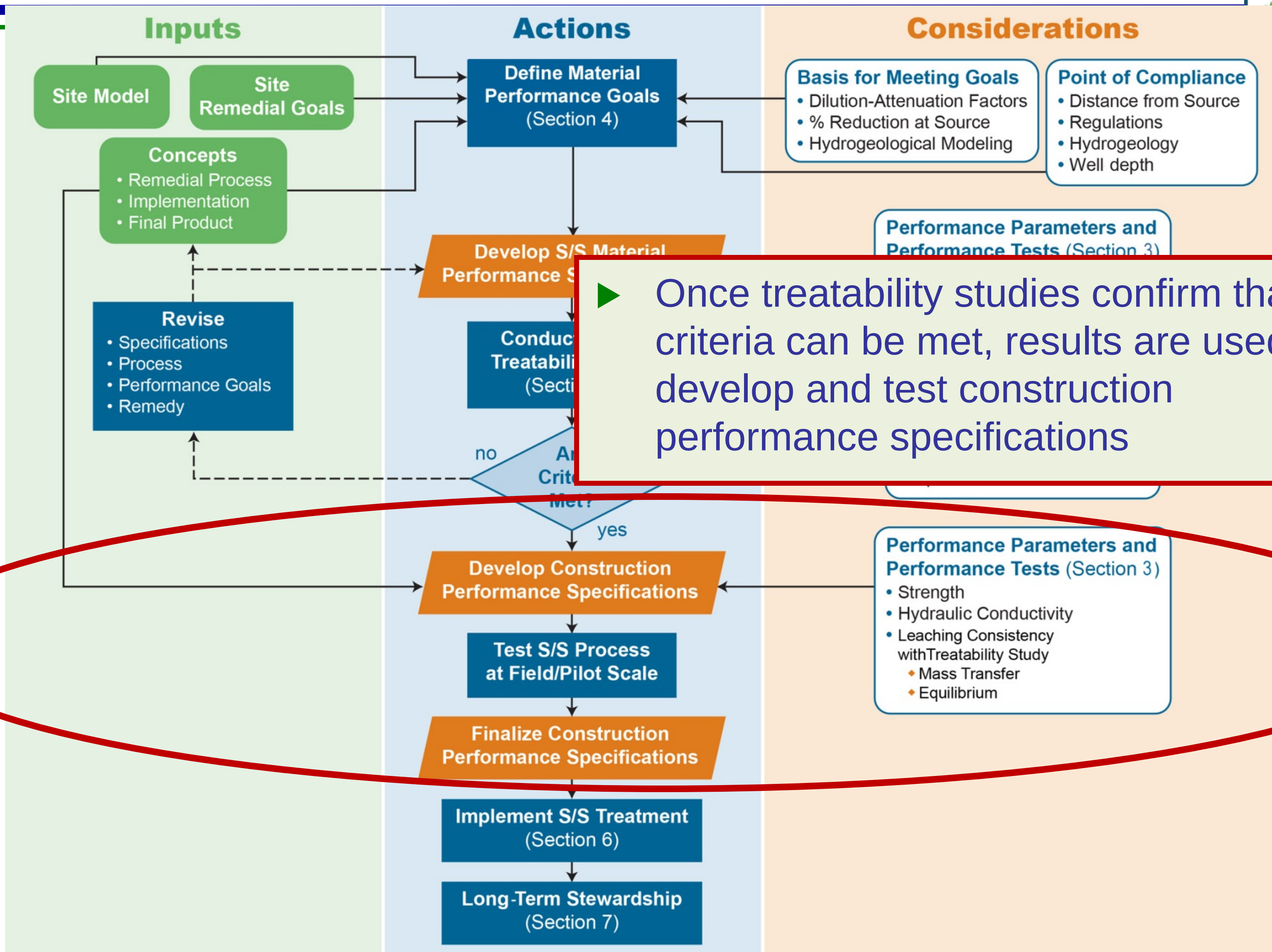
Mix Design Selection Using Flux from S/S Treated MGP* Soil





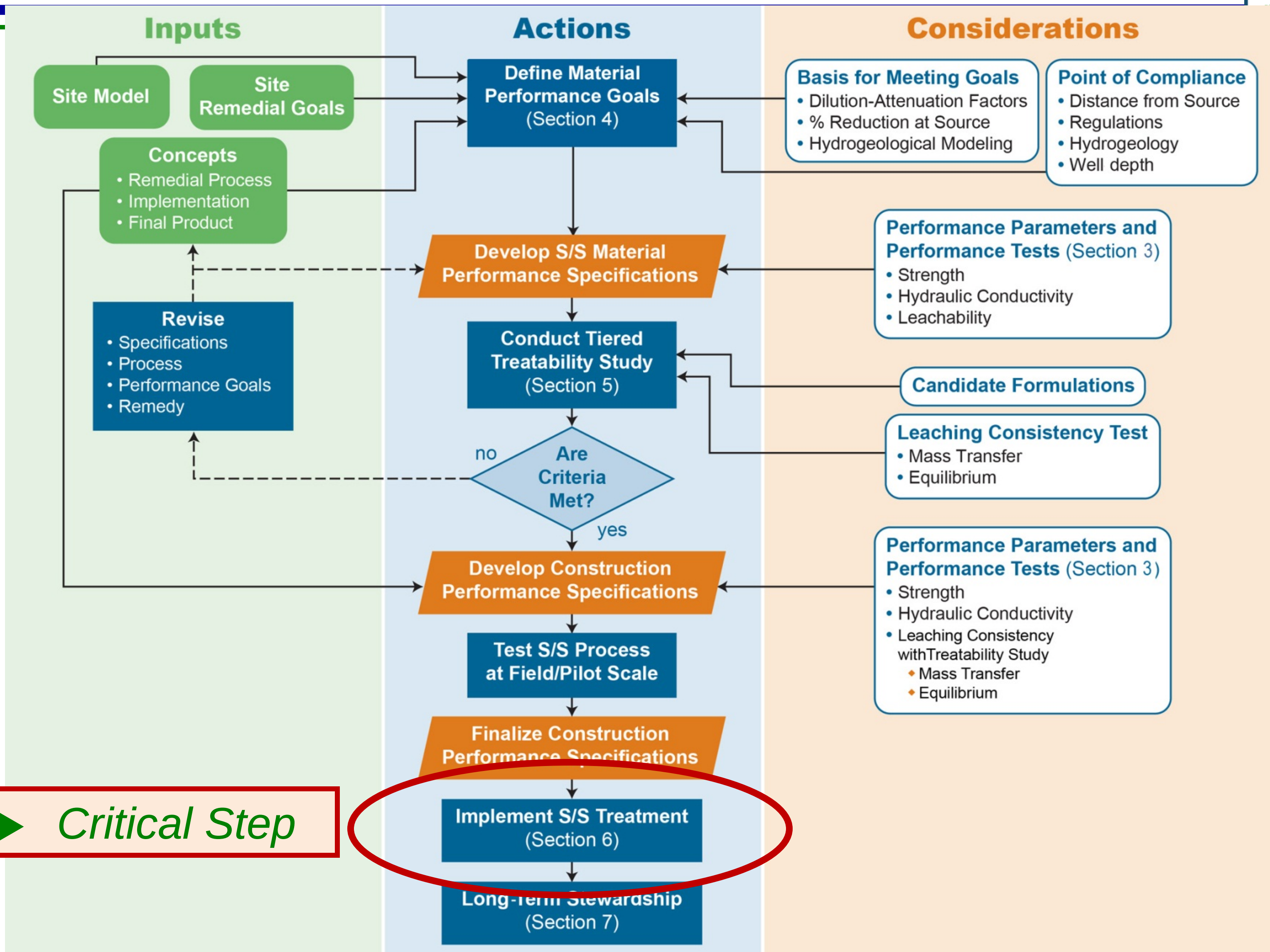
*MGP – Manufactured Gas Plant

S/S Process Flow Chart



- Once treatability studies confirm that criteria can be met, results are used to develop and test construction performance specifications

Performance Verification During Implementation



▶ *Critical Step*

Implementation

- Performance verification during implementation
- Sampling and testing considerations
- Test data evaluation
- Long-term performance considerations

Sampling and Testing During Implementation

- Observations, sampling, testing
  - Demonstrate that the treated material achieves the project's performance specifications
  - Documents that the proper reagents were mixed in accordance with the approved mix design
  - Allows for adjustments to be made as needed to respond to variations in material and/or site conditions
  - Getting it right the first time

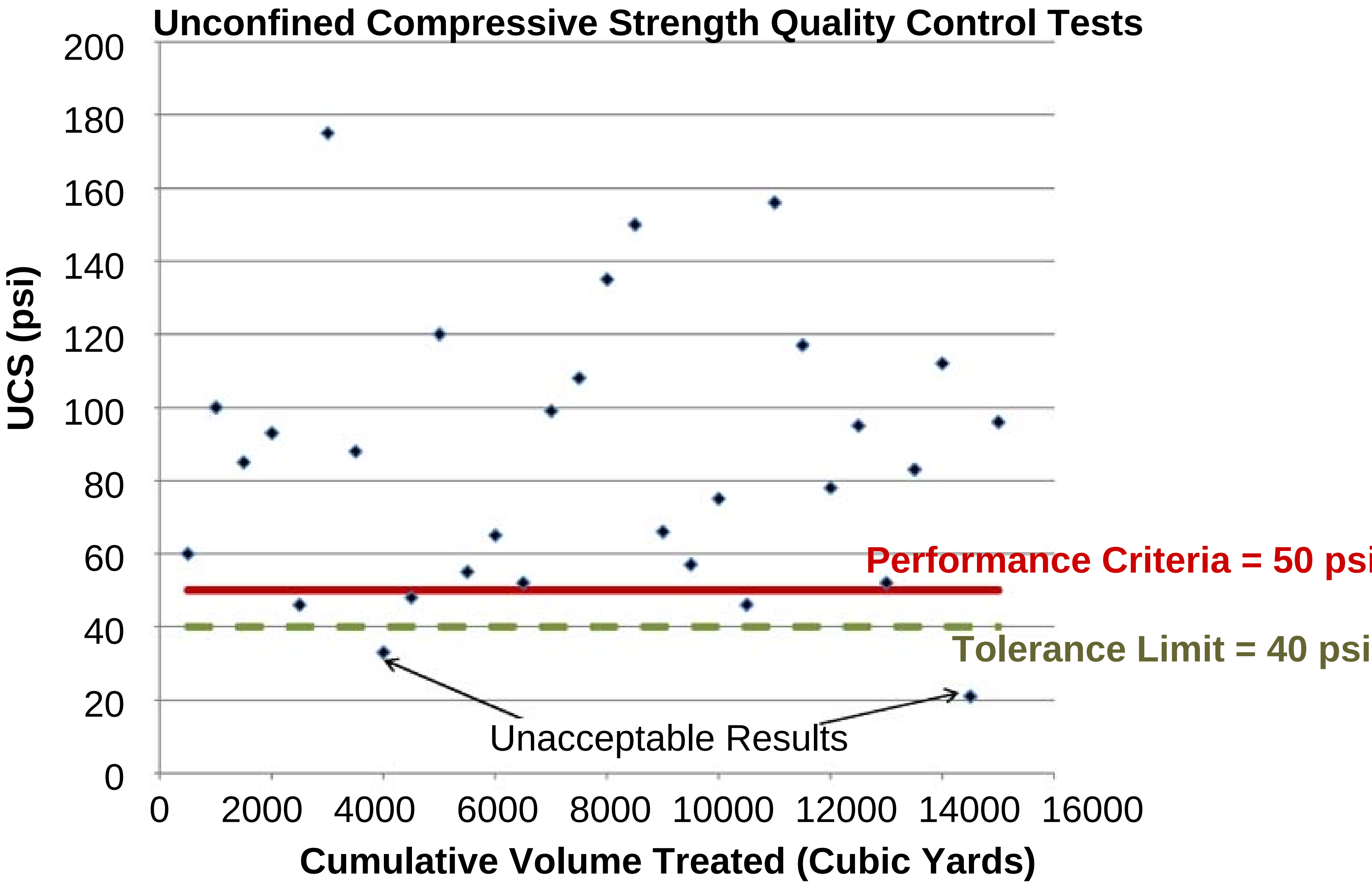
Types of Performance Verification Testing

- Consistency testing
  - Real-time or short-term evaluation of treated material through observation and testing
  - Does treated material exhibit characteristics consistent with bench and pilot baseline observations?
- Compliance testing
  - Evaluate cured material properties using performance tests for direct comparison to project performance criteria

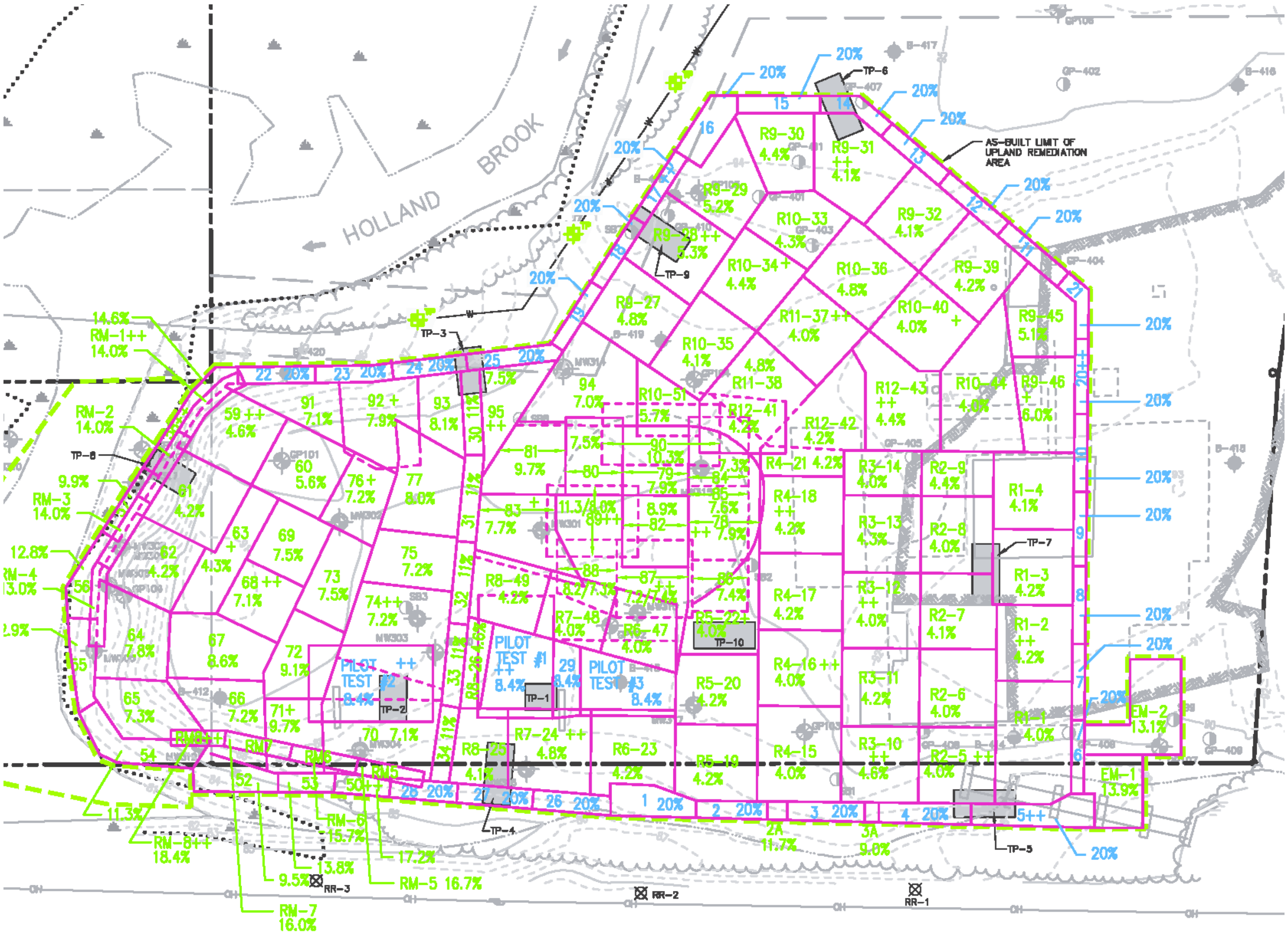
Evaluating Field Performance Data

- Performance criteria statements
  - Require all results to pass **OR**
  - Accept some limited variability without compromising the overall success of the remedy (i.e., tolerance intervals)
  - Extra samples for testing is useful
- Consider remedial objectives and reality check
  - Bulk performance of the treated mass
  - Material to be treated **will** vary in both physical and chemical properties

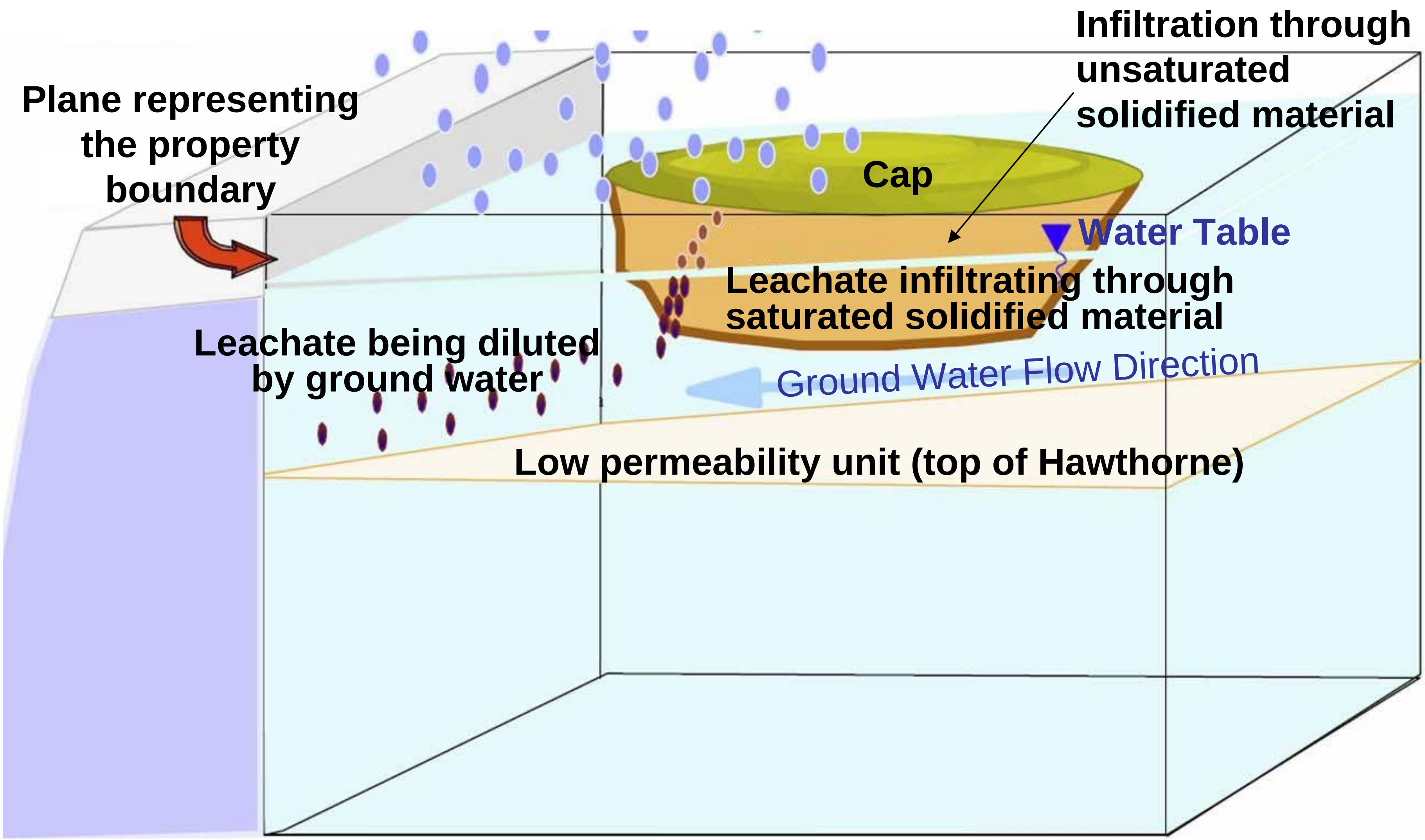
Sample Performance Data Tracking



Documenting Mix Cells and Test Data



Post Remediation Peak Oil Site Model



Long-Term Stewardship Objectives

- Confirm the S/S monolith is performing as designed
- Assure that groundwater meets targets

Before S/S Treatment

After S/S Treatment

Long-Term S/S Performance

- Properly designed S/S remedies can be expected to last on the order of decades to centuries. Success tied to remedial goals!
- Research studies have been conducted to evaluate the long-term performance of S/S remedies.
  - EPRI studies
  - PASSiFy project
  - Other literature
- EPA has used S/S effectively on many sites.

Groundwater Monitoring Design

- Monitoring points
  - Compliance may be at one or more specific points or everywhere onsite within an impacted aquifer
- Monitoring parameters…usually the key COCs
- Monitoring locations
  - Site conditions
  - Potential changes in the groundwater flow regime induced by the treated material
  - Time of travel to compliance points
  - Contamination in groundwater prior to treating

Frequency and Duration of Monitoring

- Superfund (CERCLA) requirements
  - Often quarterly to start, changing to annual
  - As needed for Five-Year Reviews
- State Programs
  - Usually follow CERCLA frequency for quarterly and annual monitoring
  - May vary in requirement for Five-Year Review periods
- Predictive modeling can be used to further identify appropriate monitoring frequency and duration

Interpreting Monitoring Data

- Evaluation of concentration trends over time should confirm
  - Decreasing or acceptable low concentration of COCs near the monolith
  - Decreasing concentrations at points of compliance
  - Achievement of GW goals over time at POCs
- Achievement of other criteria such as % reduction

Institutional and Engineering Controls

- Institutional controls
  - Environmental covenants to the property deed
- Engineering controls
  - Impervious caps
  - Vertical walls

Installing Vertical Wall With A Panel Cutter

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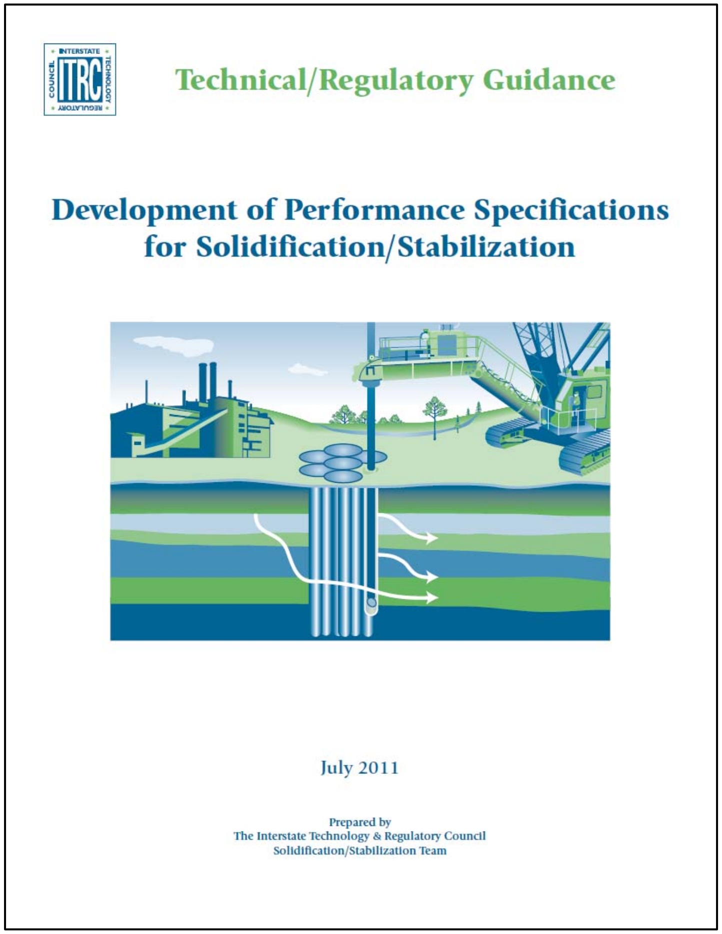
- charles.wilk@cetco.com
  - 1 (630) 902-0232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