Overview of End States:

Groundwater Remediation, Management and the Use of Alternative Endpoints at Highly Complex Sites

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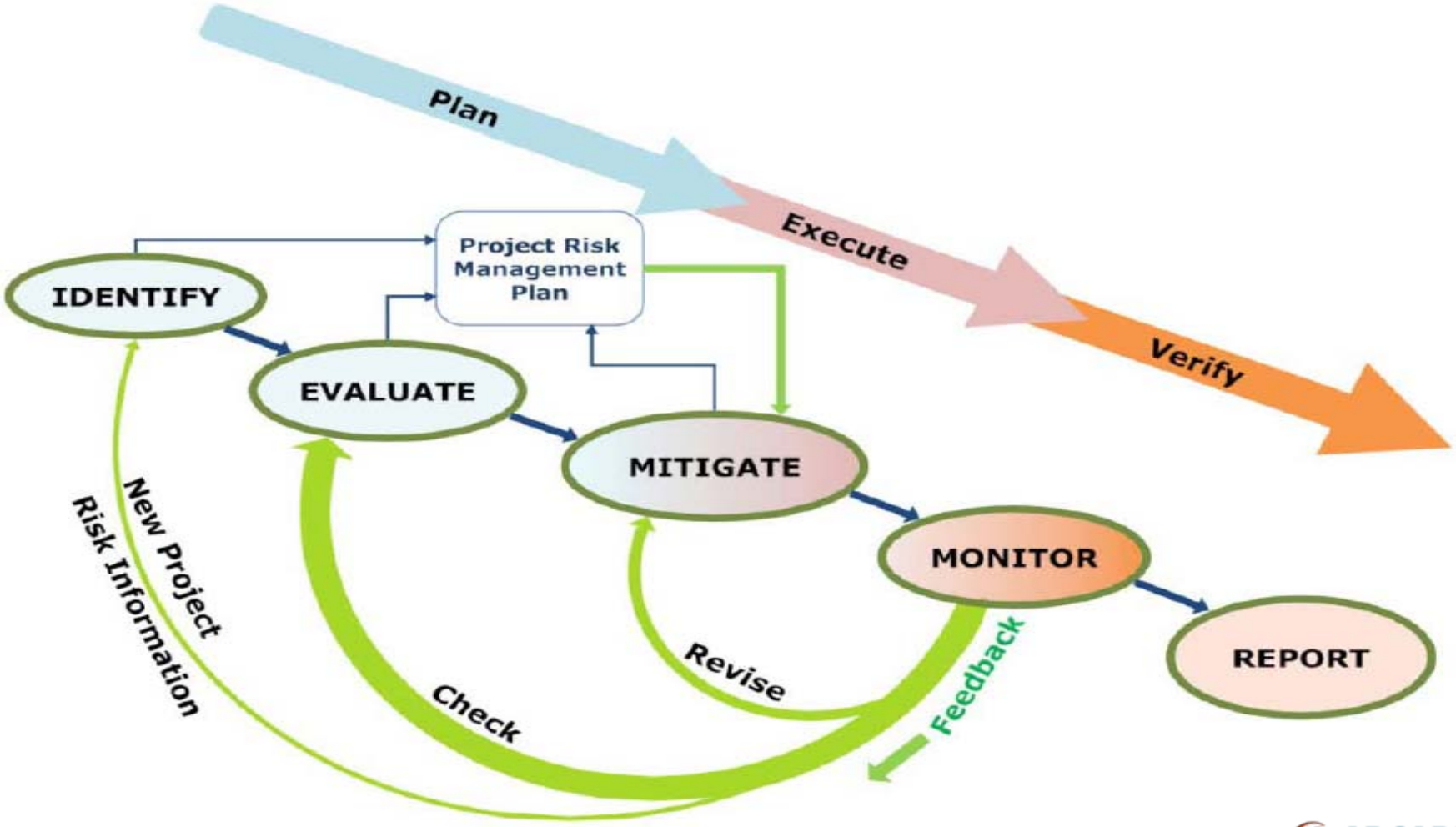
Presentation Outline

- Technical challenges at highly complex sites
- Remediation risk management at highly complex sites
- Alternative endpoints and other approaches
  - Overview
  - Case studies

Project Risk Management Process



***Source**: www.itrcweb.org/Documents/RRM-1.pdf*

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Project Risk Identification at Complex Sites

Complex site setting

- Highly heterogeneous geology
- Contaminants in fractured rock, sequestered in low permeability units
- Widespread regional contamination
- Long-lived inorganic contaminants

Potential project risks

- Lack of exit strategy/ pathway to site closure
- High cost of iteratively implementing, optimizing technologies
- Long cleanup timeframe

Project Risk Evaluation at Complex Sites

- Conceptual assessments
  - Mass estimates, remedial timeframe estimates, DNAPL dissolution rates, cost estimates
- Technology performance assessments
- Integration into the conceptual site model

Likelihood of Occurrence	Impact or Consequence of Occurrence				
	Negligible	Marginal	Significant	Critical	Crisis
Very unlikely	Low risk	Low risk	Low risk	Low risk	High risk
Unlikely	Low risk	Low risk	Moderate risk	Moderate risk	High risk
Likely	Low risk	Moderate risk	High risk	High risk	High risk
Very likely	Low risk	Moderate risk	High risk	High risk	High risk

***Source**: Section 2.3 of RRM-2 document; Table 2-3 of RRM-1 document*

Project Risk Mitigation at Complex Sites

- Remedial goals
  - MCLs, risk-based cleanup goals
  - Modified RAOs
  - Alternate Concentration Limits (ACLs)
  - Groundwater reclassification (can be site-specific)
- Remediation
  - Active remediation (adaptive approach)
  - Monitored natural attenuation (MNA)
- Institutional controls

***Source**: Section 3 of RRM-2 document*

Project Risk Mitigation at Complex Sites (*Cont'd*)

- Containment/long-term management designations

Designation	Reference
Containment zone	**California** State Water Resources Control Board Resolution No. 92-49
Technical impracticability zone	**Georgia** VRP Act (Article 3, Chapter 8, Title 12 of the Official Code of Georgia); **New Jersey** DEP Administrative Code 7:26E-6.1(d); **Wyoming** DEQ VRP Statutes § 35-11-1605(d)
Groundwater management zone	**Delaware** Remediation Standards Guidance under the Delaware Hazardous Substance Cleanup Act; **Illinois** RCRA Facilities under 35 Illinois Administrative Code Part 620.250; **New Hampshire** Department of Environmental Services Code of Administrative Rules, Chapter Env-Or 600
Risk-based tiered objectives	**Illinois** Environmental Protection Agency under 35 Illinois Administrative Code Part 742
Plume management zone	**Texas** Commission on Environmental Quality, 30 Texas Administrative Code § 350.33(f)(3)(A)-(E); § 350.37(1)(4)

Definitions

- Traditional endpoints
  - Risk-based cleanup objectives
  - ARARs
- Alternative endpoints
  - Formally waive or substitute for final cleanup standards (e.g., ARAR waivers)
  - Alternative goals can be used to guide intermediate milestones, remedy transition points (adaptive site management)
- Other approaches which informally acknowledge the complexity of meeting final cleanup standards
  - MNA over long timeframes

Context for Alternative Endpoints

- Considered at highly complex sites with technical cleanup challenges and limitations to cleanup
  - Meet regulatory requirements despite technical limitations
  - Establish common expectations for remedial performance
  - Provide a pathway towards remedy-in-place, long-term management strategies, regulatory closure
  - Manage remedial project risks
  - Use resources more efficiently and sustainably
- Protection of human health and environment remains the primary goal
- Alternative endpoints are no quick or easy fix. Long-term management needed to address residual contamination

Types of Alternative Endpoints

Alternative Endpoints	CERCLA	RCRA	State(s)*
ARAR waivers	X		
Technical impracticability (TI) waivers	X	X	
Greater risk waivers	X		
Other waivers (Interim remedy, inconsistent application of state standards, fund balancing, equivalent performance)	X		
Alternate Concentration Limits (ACLs)	X	X	
Groundwater management/containment	X	X	X
Groundwater reclassification	X	X	X

** Various terminology is used under different state cleanup programs*

Types of Other Approaches

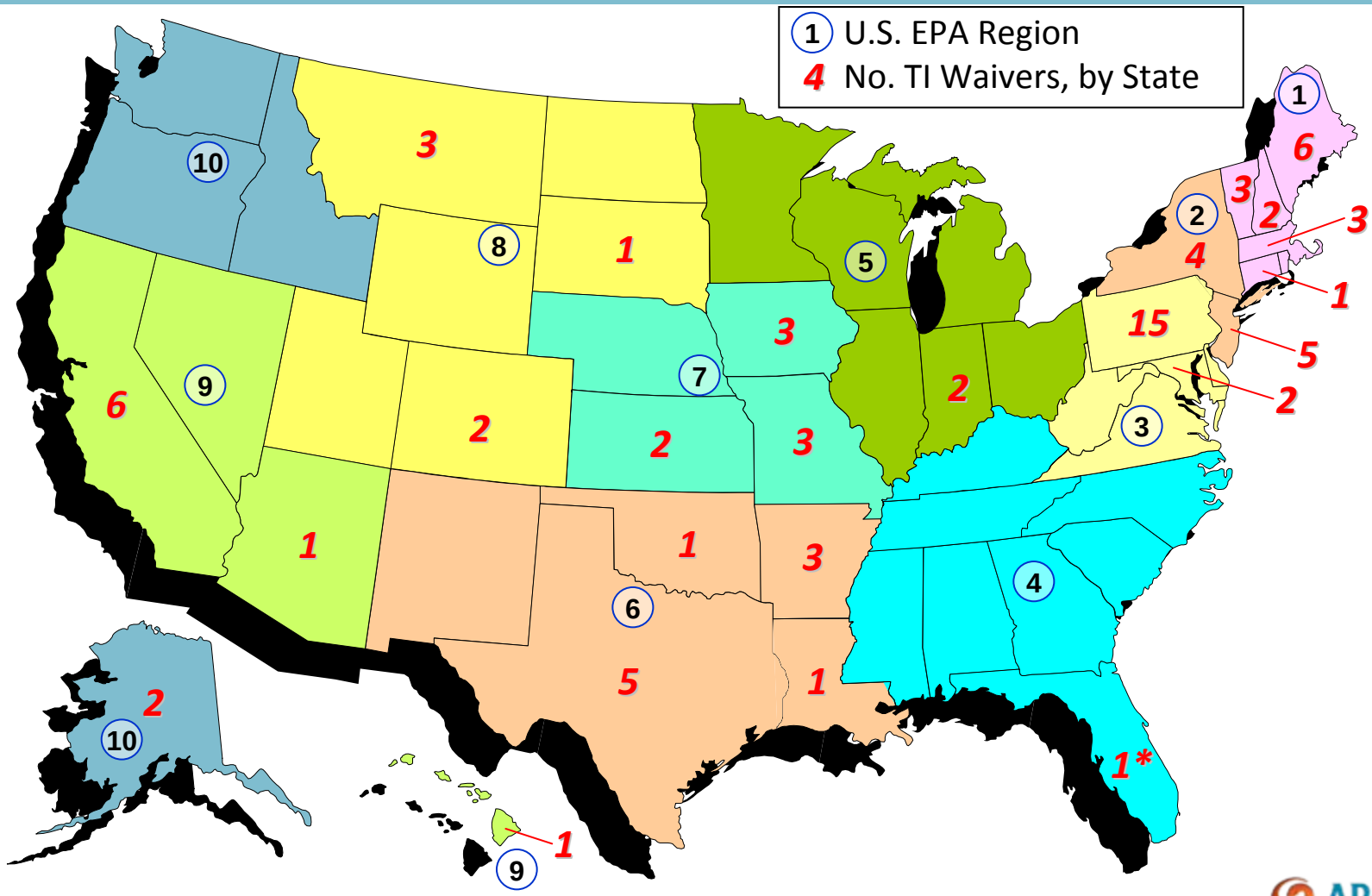
Other Approaches	CERCLA	RCRA	State(s)
MNA over long timeframes	X	X	X
Adaptive site management	X	X	X
Low-threat closure			X

TI Waivers: Process

- Applies at sites where it is “technically impracticable to meet cleanup requirements within a reasonable timeframe”
  - Applies to specific contaminants, ARARs
  - Applies within a defined area and vertical extent (TI zone)
- Site-specific TI evaluation is required (EPA, 1993)
  - Description of the location (area and depth) and ARARs for which TI waiver applies; conceptual site model (CSM); evaluation of restoration potential; proposed remedial strategy
- Stakeholder consensus is critical
- Documented in ROD, ROD amendment or Explanation of Significant Difference (ESD)

TI Waivers

Used for Groundwater at 77* CERCLA Sites



*One additional TI waiver was used and later revoked

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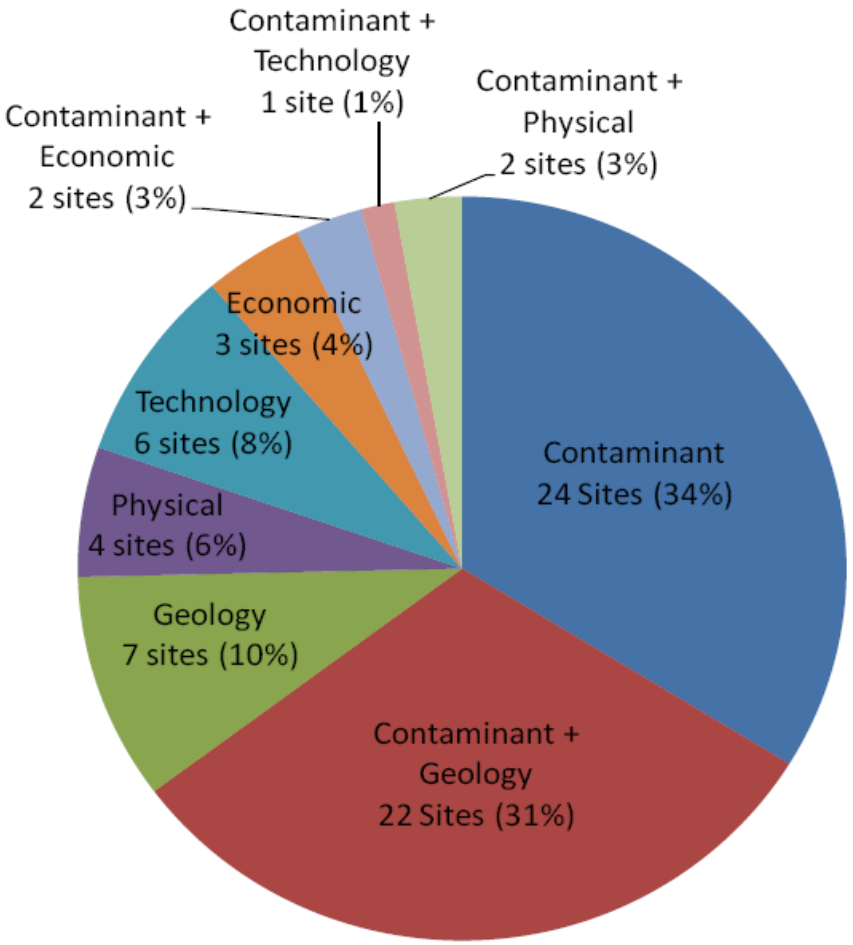
TI Waivers: Primary Reasons

- 75% of all TI waivers are based on contaminant and/or geologic setting
  - DNAPL
  - Extensive regional contamination (e.g., mining sites)
  - Immobile, low risk
  - Fractured rock, karst environments



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TI Waivers: Hydrogeology

Hydrogeologic Setting	# Sites	# Sites where hydrogeology led to TI	Percent of Total
Fractured rock/karst/mining voids	36	21	47%
High heterogeneity	10	2	13%
High heterogeneity overlying bedrock	4	-	5%
Layered high- and low-permeability	9	2	12%
High-permeability sands and gravels	7	-	9%
High-permeability sands and gravels overlying bedrock	2	-	3%
Low-permeability silts and clays	6	6	8%
Low-permeability silts and clays overlying bedrock	3	-	4%
TOTAL	77	31	100%

TI Waivers: Contaminant Characteristics

- NAPL is present at 56% of all sites
- Mix of various contaminants typically included
  - Chlorinated solvents
  - Creosote/PAHs
  - Metals/mine drainage

Compounds	# Sites
Chlorinated solvents, VOCs	16
Coal tar, PAHs, creosote	11
Metals	14
BTEX	1
PCBs	2
Pesticides	2
Mixture (2 or more types)	20
Mixture (3 or more types)	11
TOTAL	**77**

TI Waivers: Case Study # 1

J.H. Baxter Site (Weed, California)

- Wood treatment facility (PCP, PAHs, arsenic, dioxins, metals, creosote)
- DNAPLs present in source zone; timeframe estimates > 400 years, assuming 95% mass removal

- Remedy included TI waiver, slurry wall, pump-and-treat system for containment, long-term monitoring, and institutional controls

TI Waivers: Case Study # 2

RCRA site in Connecticut

- Former factory for aircraft engines
- 133 areas of concern over 40 acres
- 1,1,1-TCA DNAPL in a multi-layer overburden aquifer
  - Sands and silty sands with silty-clay confining layer
- Project risks of reaching site closure goal
  - Feasibility study shows clean closure is not feasible
  - Remedial efforts may be ineffective and costly
  - Long-term stewardship requires stakeholder support

TI Waivers: Case Study # 2 (*Cont'd*)

RCRA site in Connecticut

- Investigation
  - Delineate limits of VOC contamination
  - Demonstrate stable or diminishing plume (hydraulic control)
  - Mass flux and natural attenuation calculations
- Remediation to extent practicable
  - Excavation, in-situ heating, persulfate ISCO, high-vacuum extraction for mobile NAPL
- Long-term stewardship
  - Modeling to define boundary restricting groundwater use
  - Technical impracticability assessment and approval

Connecticut Department of
ENERGY & ENVIRONMENTAL PROTECTION

APPROVAL

September 29, 2011

Quadrelle Realty Services, LLC.
One West Avenue
Larchmont, NY 10538

ATTN: Robert Hassler

RE: Southington Business Park, 75 Aircraft Road, Southington Rem ID No.7364

The Remediation Division of the Bureau of Water Protection and Land Reuse ("Department") has reviewed the report titled "Proposed Technical Impracticability Variance, Southington Business Park, Former Pratt & Whitney Manufacturing Facility, 75 Aircraft Road, Southington, Connecticut dated March 3, 2011, in combination with supplemental submissions compiled in the document titled "Final Compendium of Documents in Support of Technical Impracticability Variance, Southington Business Park, 75 Aircraft Road, Southington, CT" dated September 28, 2011 (collectively referred to herein as the "TI Request"). The TI Request was submitted by Arcadis U.S., Inc., Inc. on your behalf, and in conjunction with the filing of a Form III certification pursuant to 22a-134a(c) of the Connecticut General Statutes.

The TI Request proposes use of a variance under subsection 22a-133k-3(e)(2) of the Connecticut Remediation Standard Regulations. It describes how remedial measures at 75 Aircraft Road in Southington ("site") have reduced chlorinated solvent contamination at the site to the maximum extent prudent, and depicts the limits of areas in which groundwater protection criteria and/or volatilization criteria are unable to be achieved in a reasonable time frame. Actions required under the TI Request include the filing of Environmental Land Use Restrictions, the performance of a program for operation of a groundwater containment system, the performance of a program for long-term indoor air monitoring, and the implementation of limitations on future groundwater use.

The above referenced TI Request is hereby approved.

Nothing in this concurrence shall affect the Commissioner's authority to institute any proceeding, or take any action to prevent or abate pollution, to recover costs and natural resource damages, and to impose penalties for violations of law. If at any time the Commissioner determines that the approved actions have not fully characterized the extent and degree of pollution or have not successfully abated or prevented pollution, the Commissioner may institute any proceeding, or take any action to require further investigation or further action to prevent or abate pollution. This conditional approval relates only to pollution or contamination identified in the above referenced TI Request.

In addition, nothing in this concurrence shall relieve any person of his or her obligations under applicable federal, state and local law.

Patrick Bowe, Director
Remediation Division
Bureau of Water Protection and Land Reuse

PFB:MSH

c: Ira Star, IRAMCo
David Seliger, Arcadis

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Greater Risk Waiver: Overview

- Waives ARAR at sites where greater harm would result by conducting activities to meet ARAR
- Examples of potential “greater risk” scenarios
  - Potential DNAPL mobilization, spreading
  - Damage to sensitive ecosystems, species
  - Technology-related health and safety risks
- Waiver is not often used
  - Few examples of process, tools used to justify greater risk
- Long-term monitoring, five-year reviews needed

Greater Risk Waiver

Onondaga Lake LCP Bridge Street Site, New York

- DNAPL mercury contamination
- Managed in place because of the greater risk of exposure during excavation and off-site transport

- Remedy included greater risk waiver, slurry wall, pump-and-treat system, excavation of shallow soils, temporary cap, and long-term monitoring

***Source**: U.S. EPA Superfund Record of Decision: Onondaga Lake, NY*

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Alternate Concentration Limits (ACLs)

- Replaces or modifies groundwater cleanup requirements
- Only applies at sites where contaminated groundwater discharges to surface water
  - Accounts for dilution that occurs prior to point of exposure
- Basis for ACL value in groundwater
  - Can be calculated from surface water quality criteria (assuming dilution, perhaps using mixing zone model)
  - Can be risk-based value
- Formal process under CERCLA (EPA, 2005) and RCRA

ACLs: Case Study

Former Naval Station, Long Beach, CA

- VOCs in groundwater, established ACLs based on CA Ocean Plan
  - ACL point of compliance at land's edge
  - Post-air sparge/vapor extraction system operation
- Response complete in 2007. Currently, long-term management
  - No longer performing groundwater monitoring at IR Sites 1, 2
  - Maintaining LUCs, five-year reviews

Groundwater Management

- Used to define areas that exceed water quality standards and manage contaminants in place
- Terminology and meaning varies from state to state
  - Sometimes indicates cleanup is technically infeasible
  - Can be used for tracking land use controls
- Formal designations in federal and state cleanup programs
  - Plume management zone (Texas)
  - Technical impracticability (Wyoming, Georgia)
  - Waste Management Areas (RCRA, CERCLA)

Groundwater Management

Three Examples

Description	Georgia	Texas	Illinois
Designation	Technical impracticability (TI) zone	Plume management zone (PMZ)	Groundwater management zone (GMZ)
Regulation	Part 3 of the Georgia Voluntary Remediation Program Act (2009)	30 Texas Admin. Code 350.33(f)	35 Ill. Adm. Code Part 620.250
Jurisdiction	Georgia Voluntary Remediation Program	Texas Risk Reduction Program	Illinois EPA and Site Remediation Program
Purpose	• Site delineation or remediation not required beyond the point of TI, if the site does not pose imminent or substantial danger	• Modifies groundwater cleanup objectives by controlling and preventing the use of and exposure to groundwater	• For areas that do not yet meet cleanup standards • Used to delineate and track institutional controls
Example site	May include DNAPLs in fractured bedrock settings	Naval Weapons Industrial Reserve Plant (NWIRP) Dallas, Texas	Joliet Army Ammunition Plant, Illinois

Groundwater Management

Case Study: LNAPL site in Texas

- Fuel oil releases in several areas at power station
- LNAPL fuel oil present in groundwater over 0.5 acres in active power station
  - LNAPL delineation and recovery as interim remedy
  - Source area inaccessible; residual NAPL likely
- Risk driver 1-methylnaphthalene in soils to 38 feet
- Project risks
  - Schedule delays would affect fixed-price contract
  - Cost, safety issues with large deep excavation

Groundwater Management

Case Study: LNAPL site in Texas (*Cont'd*)

- Used Texas risk-based NAPL management guidance
  - Robust data set for soil and groundwater end points
  - Designed LNAPL characterization program and demonstrated LNAPL was immobile
  - Used TRRP-32 framework for requesting in-place closure
- Risk-based soil cleanup
  - Careful assessed risk pathway leaching to groundwater
  - Lines of evidence approach: soil source area delineation, time since release occurred, leachate test results, concentration trends in soil and groundwater

Other Approaches

- MNA over long timeframes
- Adaptive site management
- Low-threat closure

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MNA Over Long Timeframes

- Monitoring and/or limited action, approved over long timeframe (e.g., ~100 years)
- Applied at sites where circumstances warrant and stakeholders accept long timeframe
  - Timeframe for all other remedial options may be similar
- No separate formal process
- Avoids controversy of ARAR waivers
- MNA is fairly well-accepted, low cost, may be greener

MNA Over Long Timeframes

Case Study: Orlando, FL

- Site setting (vehicle maintenance, waste oil/fuel drums, wash racks, TCE likely present as DNAPL)
- Past remedial activities
  - ISCO (Fenton's) as an interim remedy to reduce total chlorinated VOCs below 500 µg/L (lack of hydraulic connection, preferential flow path, rebound due to back-diffusion)
  - Enhanced bioremediation
- MNA multiple lines of evidence (stable plume, favorable geochemical conditions, functional genes present for dehalogenation, reductive dechlorination products)
- Approach supported by Partnering Team despite remedial timeframe of 60-70 years with source removal and VOC concentrations 10-100 times greater than MCLs

Summary

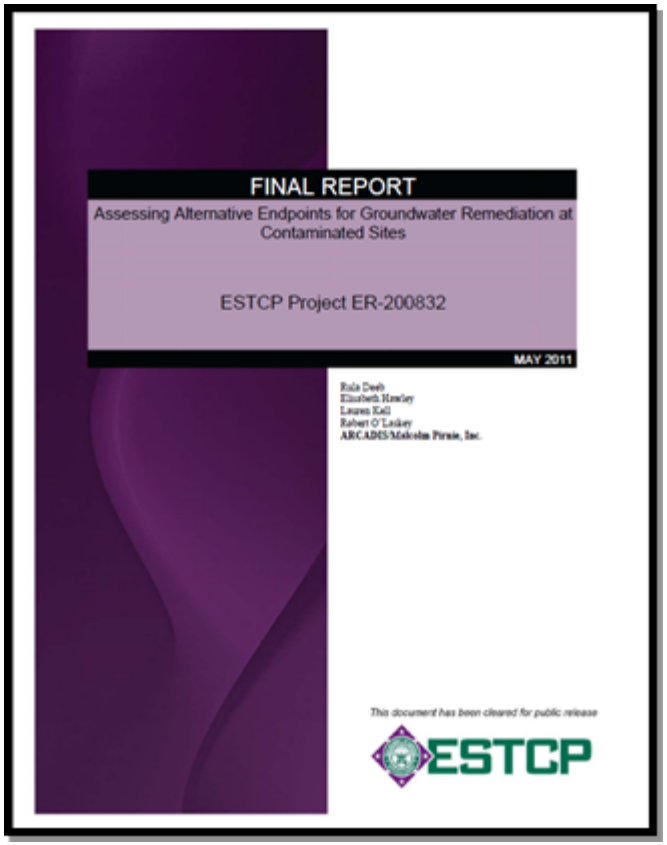
- Several options for alternative endpoints and other approaches for groundwater at complex sites
- Applicable under CERCLA, RCRA, and/or several state cleanup programs
- Long-term management of residual contamination likely needed
- RRM principles can be used to identify, evaluate, mitigate, monitor and document project risks

Summary (*Cont'd*)

- Factors that increase likelihood of implementing an alternative endpoint
  - Broad stakeholder agreement on conceptual site model
  - Controlled risks/threats (incomplete pathways)
  - Contingency measures to protect human health and environment
  - Durable and reliable ways to manage long-term residual contamination
  - Receptiveness of regulatory agency and stakeholder
  - Collaboration between stakeholders
  - Communication strategies to reduce barriers

Resources

- EPA policy and guidance
- ESTCP report www.serdp.org/content/download/10619/130969/file/ER-200832-FR.pdf



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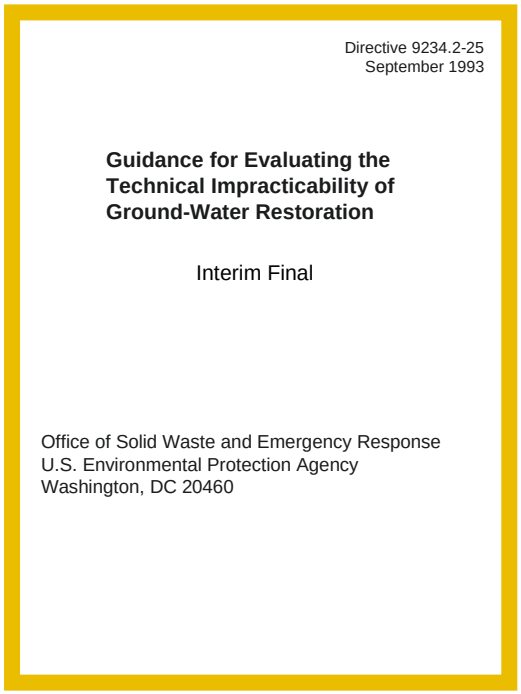
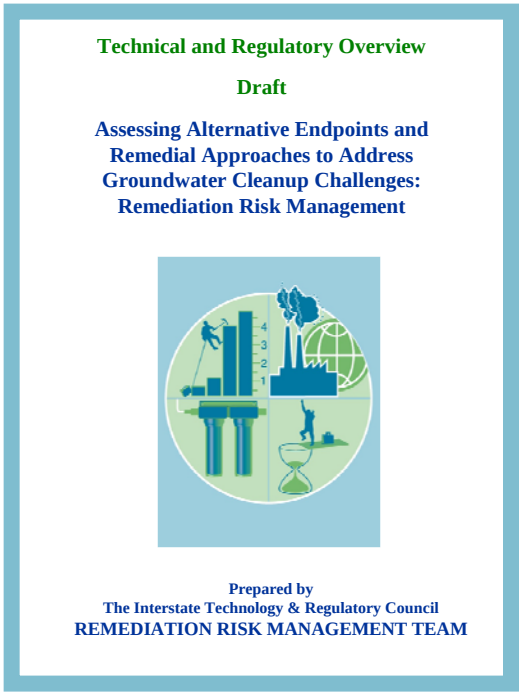
Resources (*Cont'd*)

- ITRC overview document
  - Developed in response to state survey
  - Identify and manage project risks before they occur





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