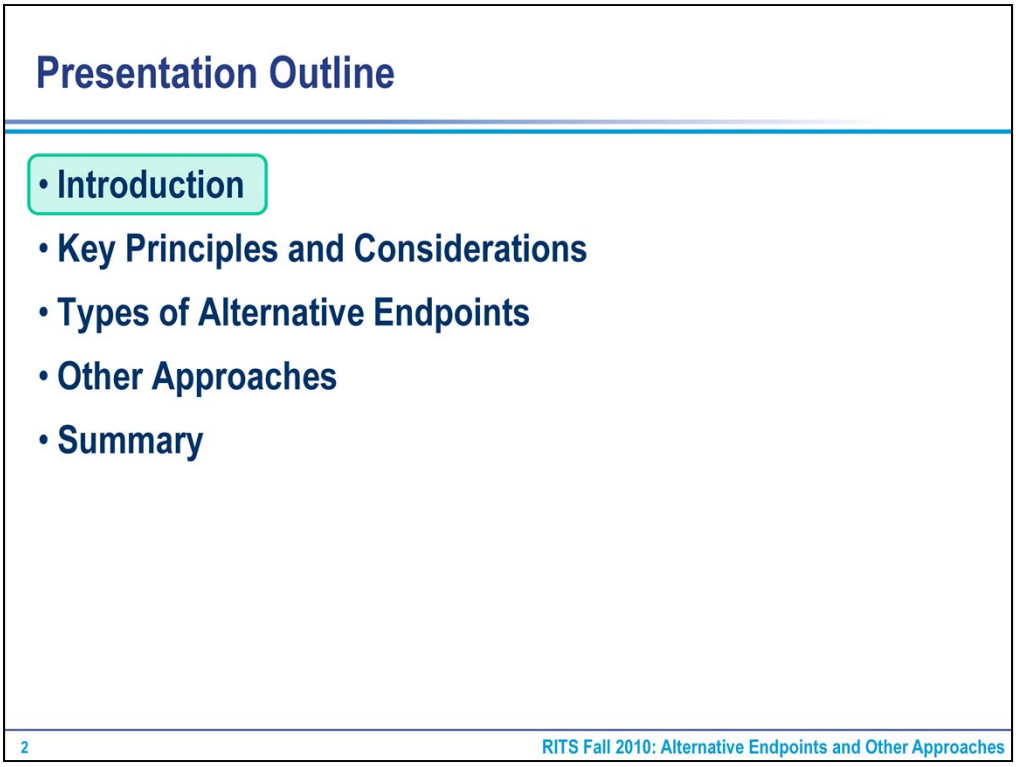
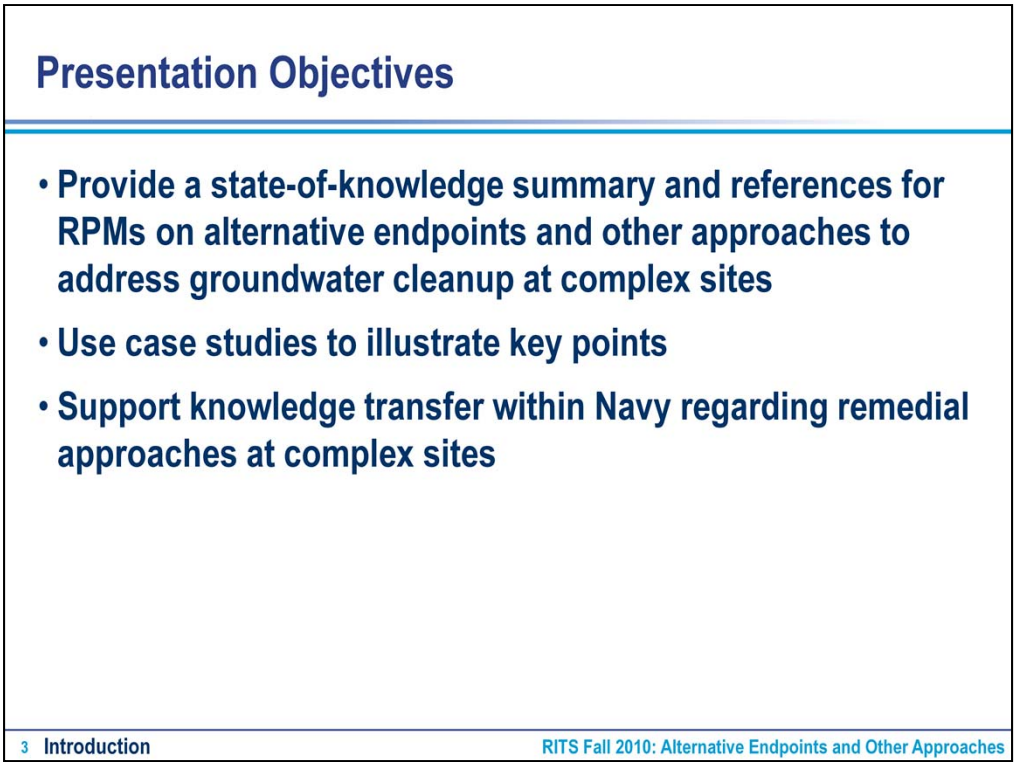

NAVFAC
Naval Facilities Engineering Command
Alternative Endpoints and Other Approaches for Groundwater Cleanup at Complex Sites
RITS Fall 2010



Outline

Case studies will be included throughout the presentation to illustrate key points



What is the presentation about? Why should you listen over the next hour?

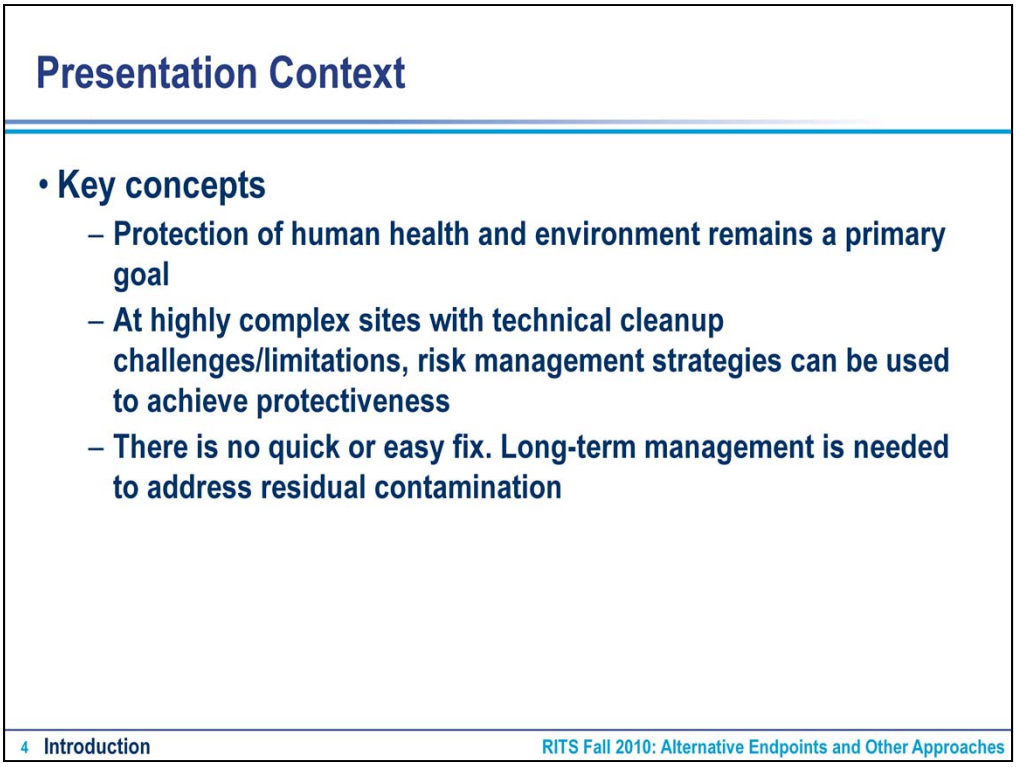
How can RPMs benefit from this information?

Answers: The goal is to provide Navy RPMs with information about alternative endpoints and other approaches, including when to consider them and why.

We are talking about a small subset of sites where the conditions are highly complex and there are significant challenges or limitations to meeting groundwater cleanup requirements. State of knowledge summary and case studies.

This information may not be new to some people – Navy RPMs are already doing this.

Primary goal is knowledge transfer, technology transfer.



Some key concepts to provide some context for this topic.

The protection of human health and environment remains a primary goal. Protection is never waived.

Focus is on achieving protectiveness at complex sites using risk management strategies and doing so appropriately while making cleanup progress.

There is no quick or easy fix at these sites.

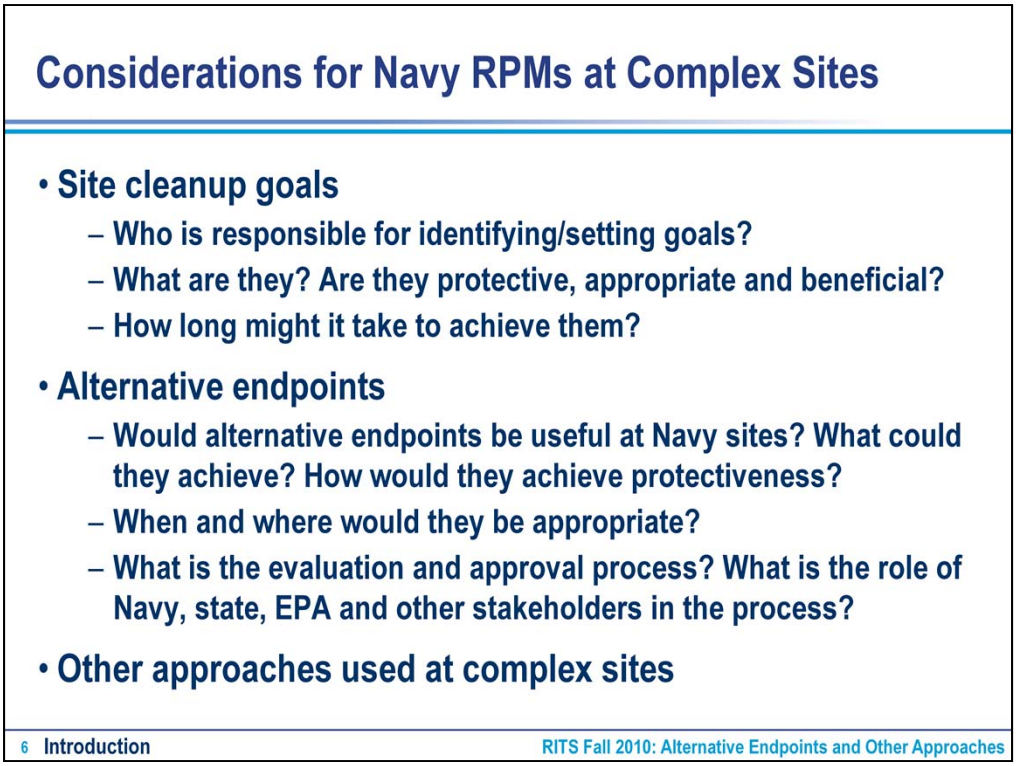
Presentation Context (cont.)

- **Background on the topic of alternative endpoints and approaches**
  - **Work presented here evolved from a DoD project funded by the Environmental Security Technology Certification Program (ESTCP Project ER-0832)**
  - **Project's initial focus was on technical impracticability (TI) waivers**
  - **Topic was later expanded to include alternative endpoints and other approaches for groundwater at complex sites**

Some background on this topic and how it has evolved.

Can mention 2004 report for US AEC.

More details about these reports later in the presentation.



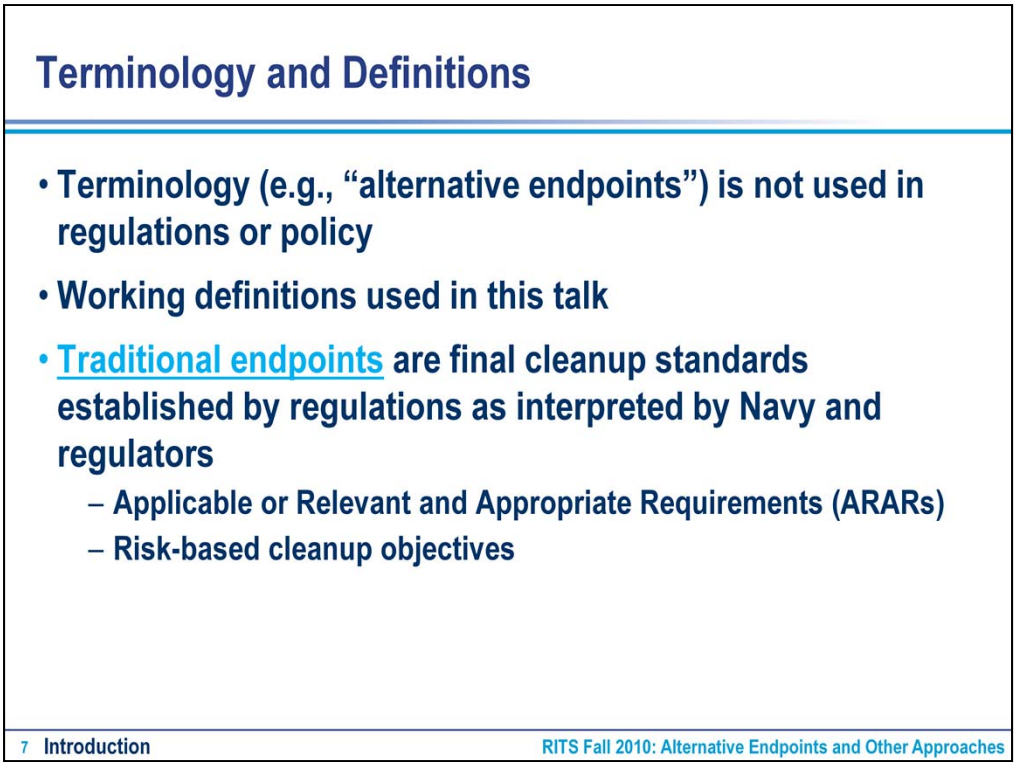
Some of the hardest questions at complex sites relate to site cleanup goals, and this is where alternative endpoints come in. Key questions include the following (read list).

Regarding alternative endpoints, think about whether they would be useful, what they could achieve, etc.

These same questions apply to other alternative endpoints.

Ask RPMs to keep in mind as we go through the talk whether they are using these approaches at their sites and whether this sounds familiar

(terminology may differ). If so, speak up to help discussion and/or fill out a form suggesting a case study/contact name.

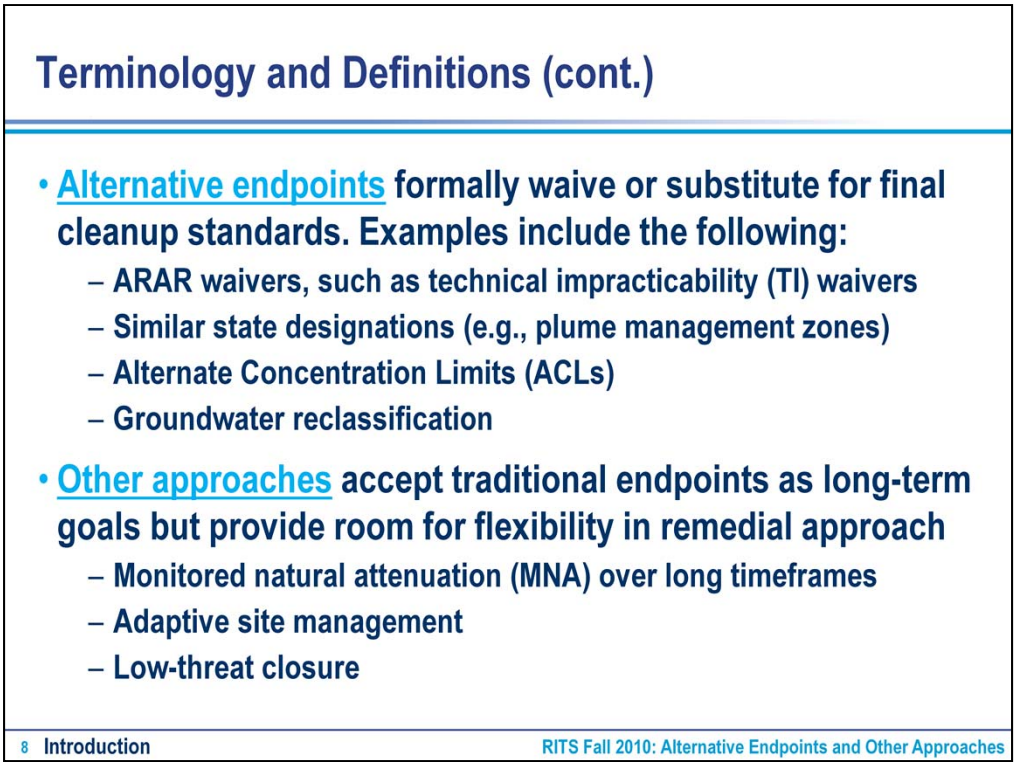


The terminology used in this presentation includes our own descriptive terms. Navy may be familiar with other terms.

Working definitions used in this talk:

- Traditional endpoints refer to ARARs at CERCLA sites and to Risk-based cleanup objectives at RCRA sites and other numerical criteria for groundwater (chemical-specific ARARs) and other RAOs.

[Clearly define ARARs so people will remember when it is used later.]

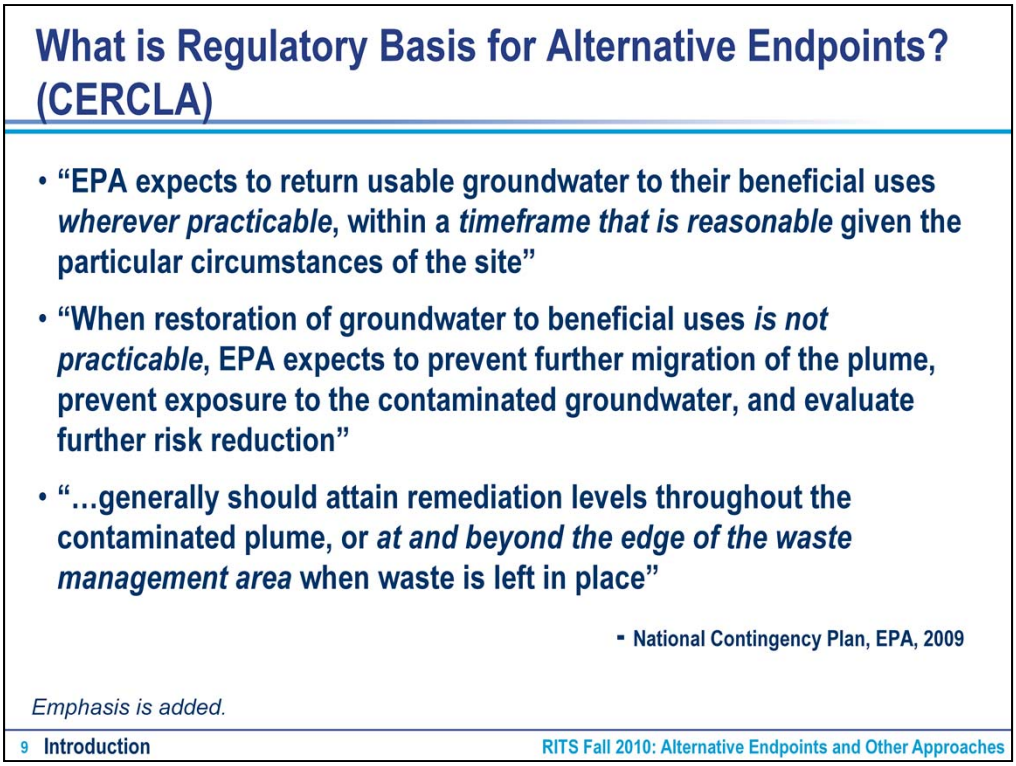


Alternative endpoints are formal waivers or substitutions for groundwater cleanup standards.

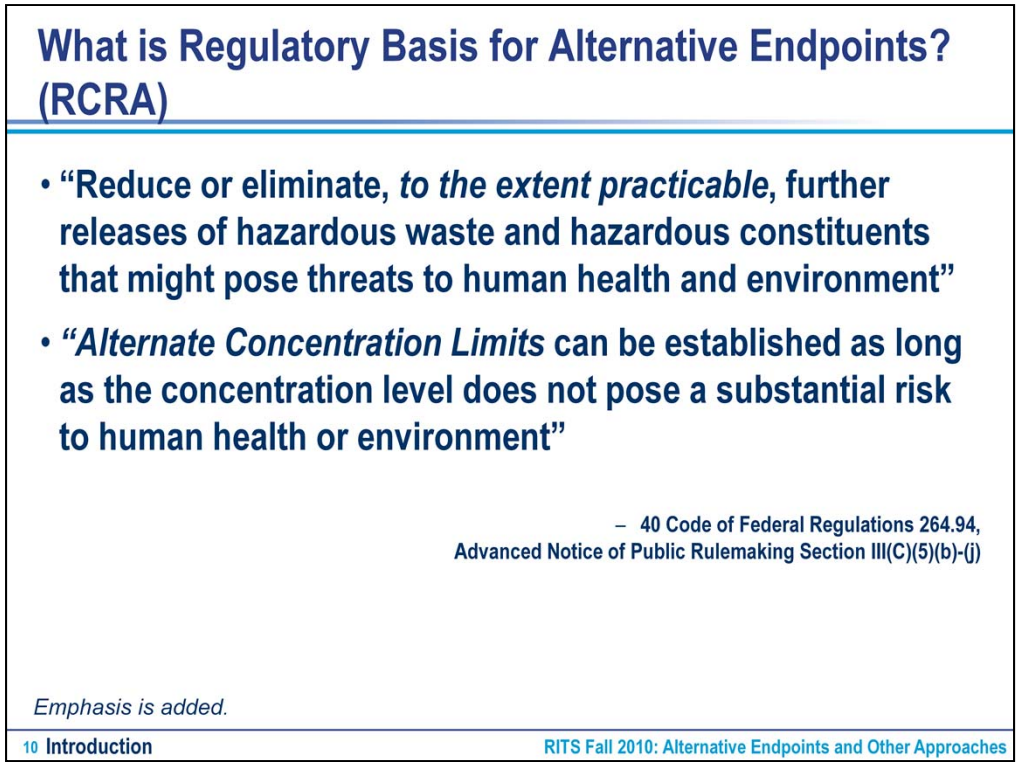
When researching sites that would considering alternative endpoints, we found that not every complex site ends up adopting an alternative endpoint.

Sites may use other approaches, such as MNA over long timeframes, where the traditional endpoint is still the long-term goal but there is flexibility in the remedial approach, in this case, in the duration of the remedial timeframe.

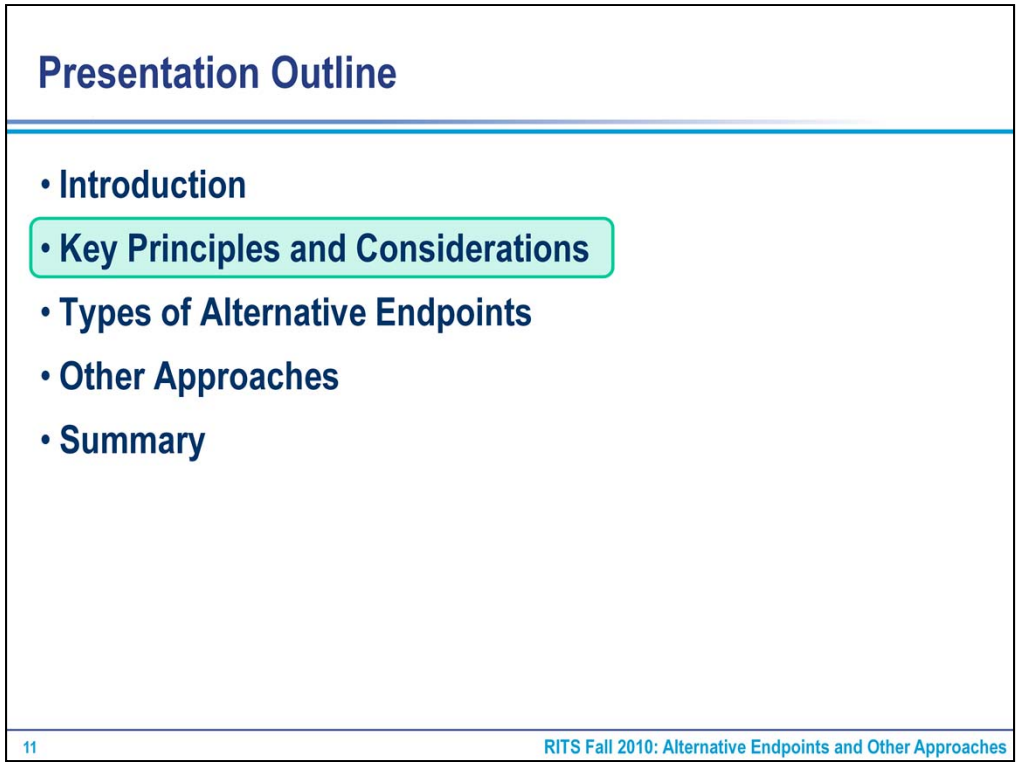
[Clearly define terms like technical impracticability (TI) and other ARAR waivers, ACLs and MNA.]



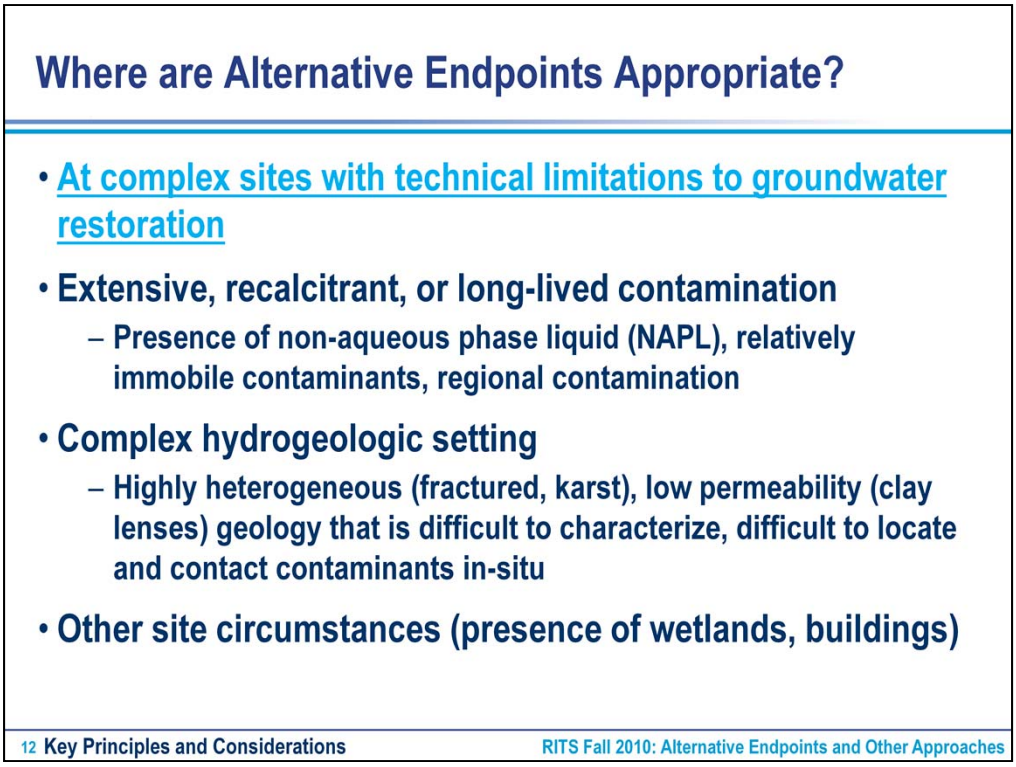
Alternative endpoints have their basis in the underlying statutes and regulations. At CERCLA sites, this is described generally in the National Contingency Plan text. EPA has interpreted these regulations and published policy and guidance clarifying the intent of the regulations.



Key point: Similar to CERCLA, there is a place for alternative endpoints in the language used in RCRA regulations. For example, there is text regarding practicability in the RCRA Advanced Notice of Public Rulemaking. There is also language that applies to both RCRA and CERCLA sites regarding Alternate concentration limits.

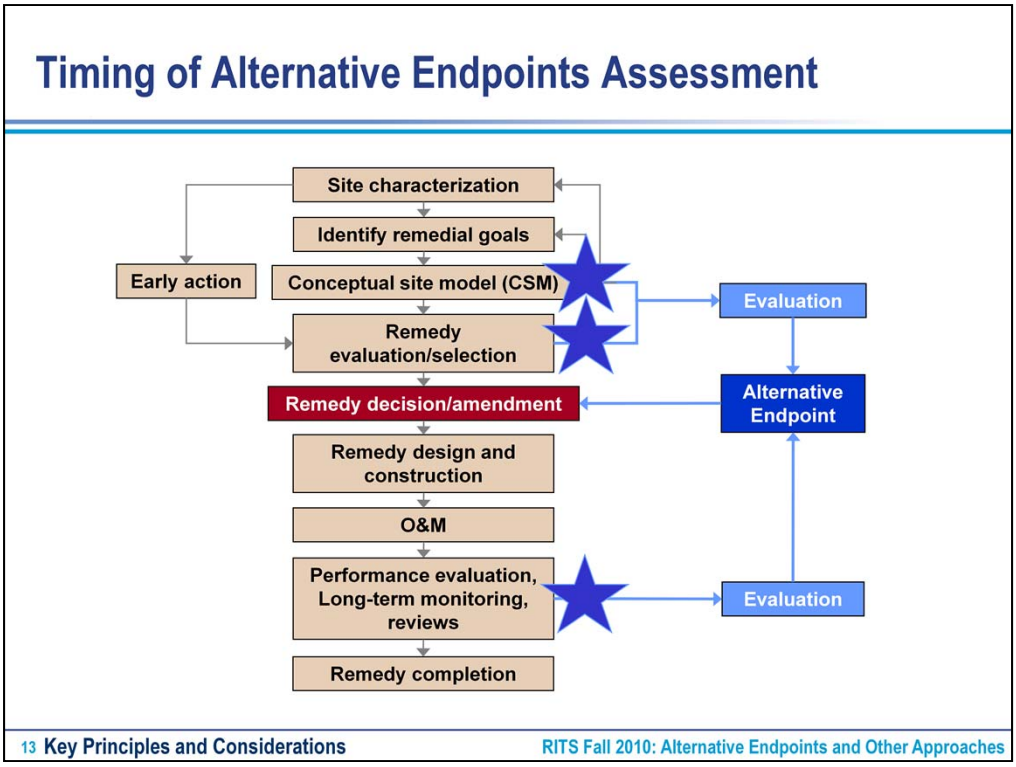


Let's move into some key principles and considerations before diving into the details on several types of alternative endpoints.



Rest of these pertain to complex sites. The only exception to this is at low-threat sites that are granted site closure early.

Examples of complex site settings are provided in the case studies



Speak to alternative endpoints in general, not TI.

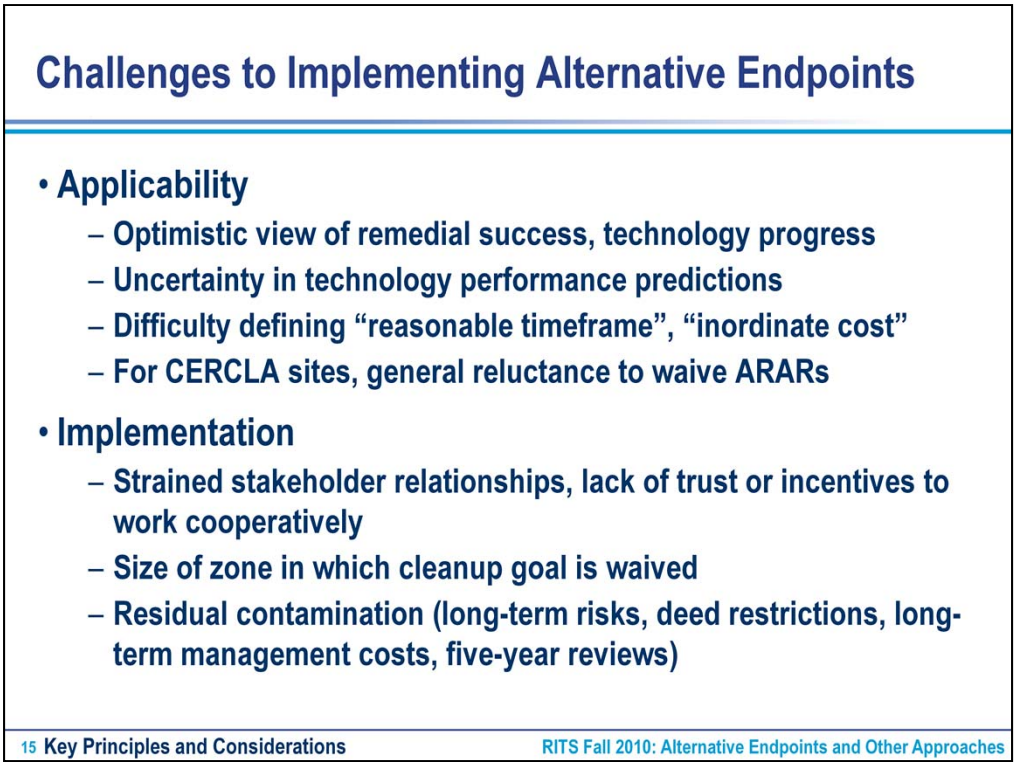
Key points:

- Can identify the need for alternative endpoint early on, before selecting a final remedy, based on CSM and/or FS analysis
- Careful identification of appropriate remedial goals can help incorporate other approaches into the final remedy
- The need for an alt endpt/other approach can also come out of performance evaluation/five-year review of a remedy that is already in place but not making sufficient progress to meeting cleanup goals.

Benefits of Considering Alternative Endpoints

- Meet regulatory requirements despite technical limitations
- Establish common expectations for remedial performance
  - Differentiate between technology performance objectives and long-term remedial goals
- Provide a pathway towards remedy-in-place, long-term management strategies, regulatory closure
- Manage remedial project risks
  - Maintain protectiveness of human health and environment
  - Avoid remedy failure, re-opening final remedy
  - May simplify long-term property restrictions
- Use resources more efficiently and sustainably

This slide covers the question: what will the RPM get out of using an alternative endpoint/other approach?



Size of the zone was key issue at Anniston Army Depot, multiple meetings to discuss waiving ARARs off-site in deeper bedrock aquifer.

Site Closure Considerations

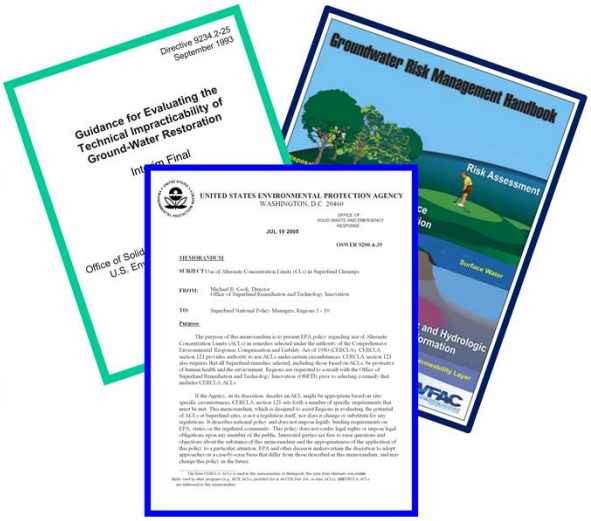
- Long-term management may be the only option at complex sites
  - Navy expectations regarding property use, time to closure
  - Land use controls (LUCs), deed restrictions, other institutional controls may be required in conjunction with alternative endpoint
- Construction complete, regulatory closure ≠ clean closure
  - Alternative endpoints and other approaches may lead to regulatory closure (regulator oversight no longer needed)
  - At other sites, five-year reviews, LUCs may still be required
  - Not likely to meet Navy's definition of closure (finished at the site, no ongoing long-term management or monitoring)

Cost Analysis

- Savings difficult to quantify relative to other remedial options
- Potential savings:
  - Partial source treatment not needed
  - Additional pilot-scale studies, feasibility studies not needed
  - Shut down treatment system earlier
  - Avoid rework (final remedy not revisited)
- Added cost of assessing/documenting alternative approach
  - Minimize by integrating process into existing work (stakeholder meetings, CSM, reports)
- Net cost/saving is highly site-specific and difficult to quantify

Resources for RPMs on Alternative Endpoints and Other Approaches

- Several summary reports published by ESTCP, US Army Environmental Center, ITRC
- Training by ITRC
- Policy and guidance published by NAVFAC and EPA



Define acronyms when you talk about these

USAEC Report on Technical Impracticability

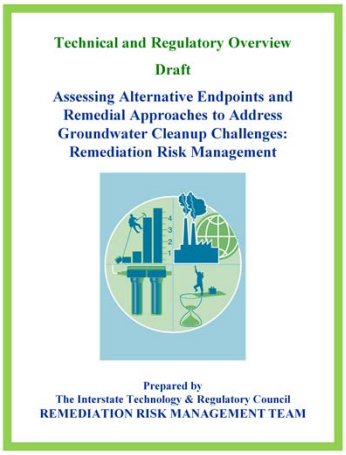
- "Technical Impracticability Assessments: Guidelines for Site Applicability and Implementation", Phase II Report (USAEC), March 2004
  - Researched CERCLA sites with technical impracticability waivers for groundwater
  - Prepared site summaries
  - Interviewed state and EPA regional contacts
  - Key findings and recommendations

ESTCP Report on Alternative Endpoints

- "Alternative Endpoints and Approaches Selected for the Remediation of Contaminated Groundwater" (ESTCP Project ER-200832), DRAFT
  - Focus on state of knowledge and technology transfer, not guidance or policy
  - Not meant to clarify viewpoints of regulators and other stakeholders, or reasons for decision-making
  - Illustrate examples of approaches used at complex sites through case studies
- Report available online 2011

ITRC Remediation Risk Management Team Documents and Training

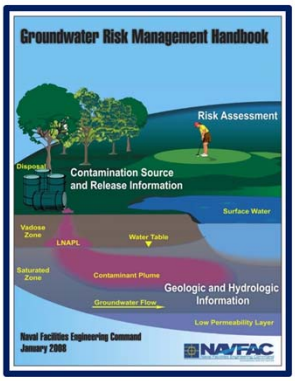
- "Assessing Alternative Endpoints and Remedial Approaches to Address Groundwater Cleanup Challenges: Remediation Risk Management (RRM)", ITRC team, 2010
  - Overview document on alternative endpoints developed in response to member state survey
  - RRM process: Identify and manage project risks before they occur



- Training available through ITRC in Spring 2011

Navy Guidance and Policy

- "Groundwater Risk Management Handbook", January 2008
  - Consider the use of risk management strategies to guide decision-making
  - Factors affecting groundwater restoration
  - Risk management, remediation strategies
  - Case studies
- "Guidance for Optimizing Remedy Evaluation, Selections, and Design", March 2010



Navy Guidance and Policy (cont.)

- "Alternative Endpoints for Groundwater Remediation" Navy's Alternative Restoration Technology Team (ARTT) workgroup white paper (in progress)
  - Complements Groundwater Risk Management Handbook (NAVFAC, 2008)
  - Focuses on allowances and considerations regarding alternative endpoints in key states of interest to the Navy
    - CA, HI, VA, NC, WA, FL, NY, MD, TX, SC
  - Includes discussion of LUCs to maintain protectiveness with alternative endpoints
- Contact ARTT workgroup members for more information

EPA Guidance and Policy

- "Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration", EPA OSWER 9234.2-25, 1993
- "Use of Alternate Concentration Limits in Superfund Cleanups", EPA OSWER 9200.4-39, 2005
- "Summary of Key Existing EPA CERCLA Policies for Groundwater Restoration", EPA OSWER 9283.1-33, 2009
- "Updated EPA fact sheets describing CERCLA sites that have received TI waivers in the past" (EPA HQ, in press)

Presentation Outline

- Introduction
- Key Principles and Considerations
- Types of Alternative Endpoints
- Other Approaches
- Summary

1. ARAR Waivers
2. ACLs
3. Groundwater Management/Containment
4. Groundwater Reclassification

Types of Alternative Endpoints

Alternative Endpoints	CERCLA	RCRA	State(s)*
1. ARAR waivers	X		
1a. TI waivers	X	X	
1b. Greater Risk Waivers	X		
1c-f. Other Waivers (Interim remedy, inconsistent application of state standards, fund balancing, equivalent performance)	X		
2. ACLs	X	X	
3. Groundwater Management/Containment	X	X	X
4. Groundwater Reclassification	X	X	X

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

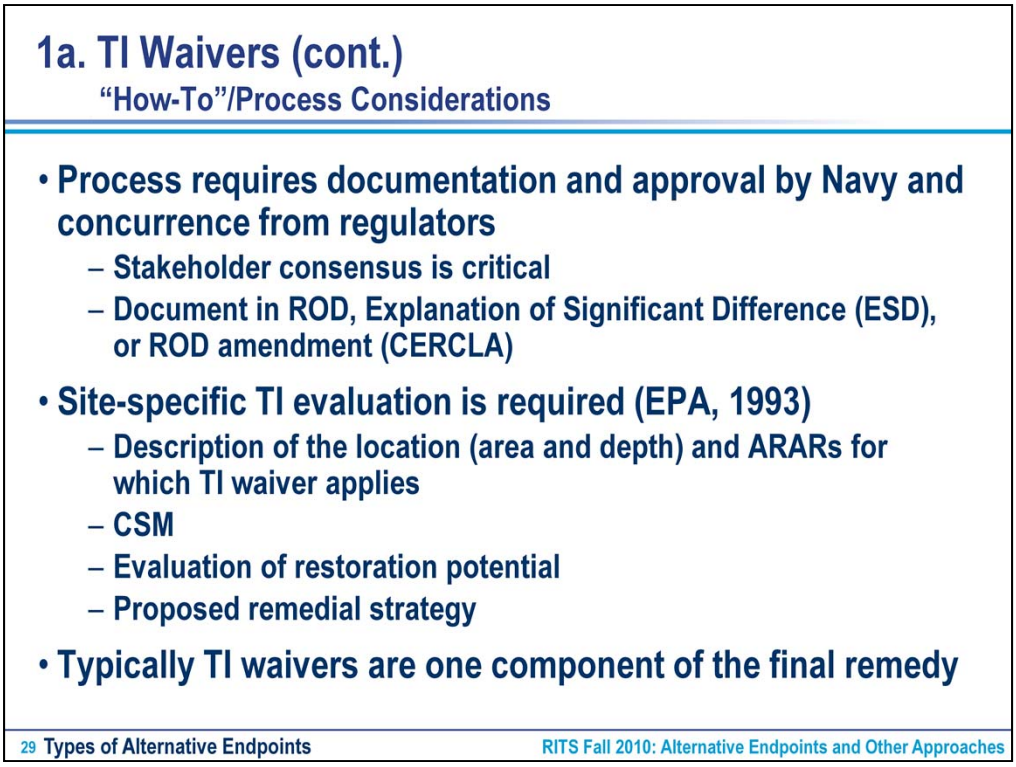
1a. Technical Impracticability (TI) Waivers

- **Waives cleanup requirements for specific contaminants within a defined area and depth**
- **Does not waive requirement to protect human health and environment**
- **Applies at sites where it is "technically impracticable to meet cleanup requirements within a reasonable timeframe"**
  - **Most TI waiver sites have complex hydrogeology, DNAPL source zones or extensive contaminant sources**
    - DNAPL deep in rock fractures
    - Elevated metals/mining contaminants over widespread area

"Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration", EPA OSWER 9234.2-25, 1993

1a. TI Waivers (cont.)

- Formal process under CERCLA and RCRA
  - TI waiver used at one Navy site and over 70 other CERCLA sites
  - Rarely used at RCRA sites; Technical and Economic Feasibility (TEF) analyses frequently used at RCRA sites to waive background cleanup requirements
- State cleanup programs may have similar terminology
  - See Slides 46-48, Groundwater Management/Containment
- Not a "walk away" solution
  - Ongoing monitoring, five-year reviews
  - Site closeout not likely attainable at TI waiver sites
  - Regulatory closure has been achieved (delisting from NPL)



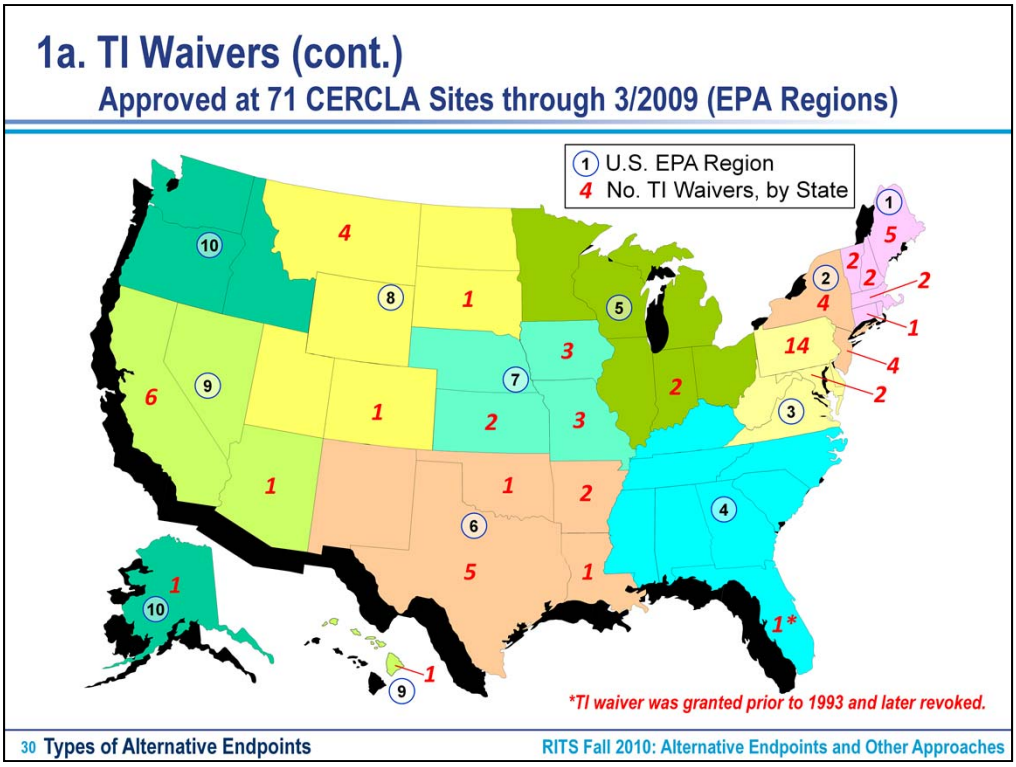
EPA Headquarters may be involved to support the region. May be a TI waiver specialist from the region rather than the EPA site project manager. Partnering meetings, not just submitting an application and getting it approved.

Can implement TI waiver as part of the initial remedy

Limited use of TI waivers at complex Navy sites relative to other CERCLA sites

Use of technical impracticability (TI) waivers by the Navy is limited

In a study of 71 CERCLA sites with TI waivers, the only Navy site was Naval Air Development Center, Warminster, PA

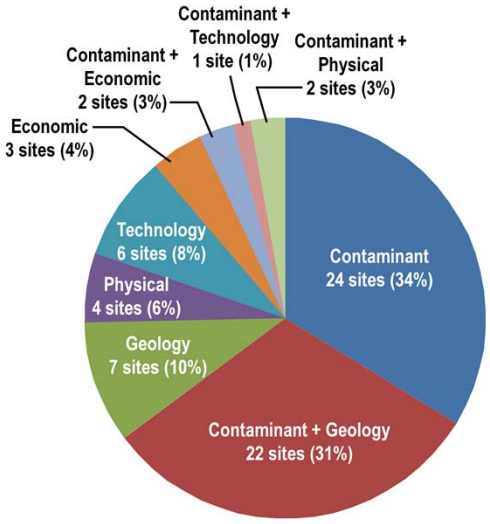


With the exception of Region 4, have been granted in all regions and nearly half the states. Region 4 is very much against TI waivers.

1a. TI Waivers (cont.)

Site Characteristics

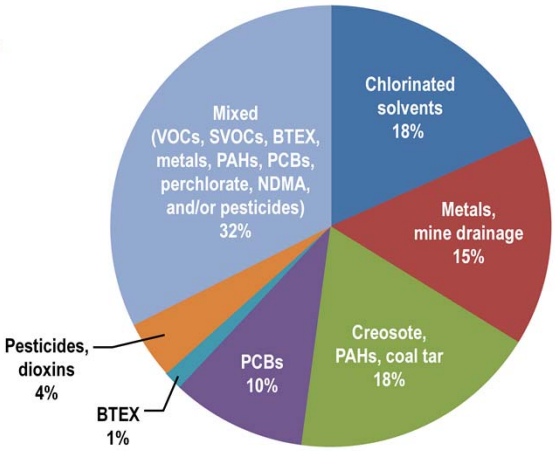
- 75% of all TI waivers are based on contaminant and/or geologic setting
  - DNAPL
  - Extensive regional contamination (e.g., mining sites)
  - Immobile, low risk
  - Fractured rock, karst environments



1a. TI Waivers (cont.)

Contaminant Characteristics

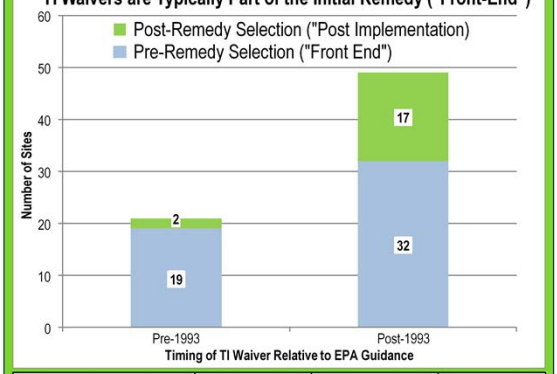
- Mix of various contaminants typically included
  - Chlorinated solvents
  - Creosote/PAHs
  - Metals/mine drainage
- NAPL is present at ~50% of all sites



1a. TI Waivers (cont.)

Timing Considerations

- Most TI waivers (75%) are "front-end" (pre-ROD), based on RI/FS evaluations
- No change in usage rate over time (~2% of decision documents)
  - Number of sites considering TI waivers is unknown



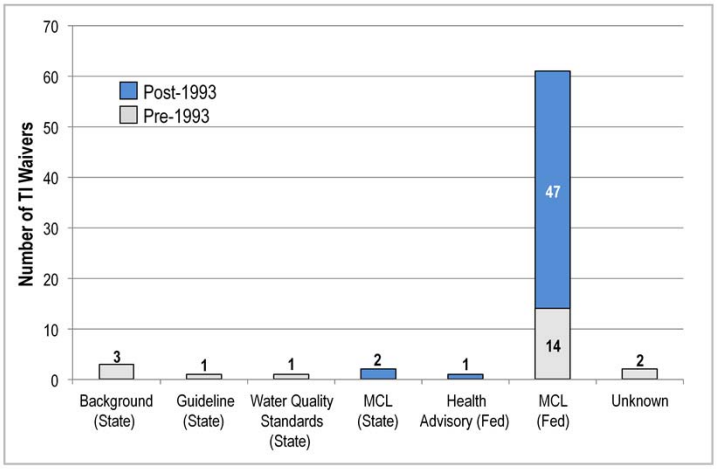
Timeframe of Decision Document	# Sites with TI Waivers	# Decision Documents	Percent Total
1989-1993	21	923	2.3%
1994-1998	19	966	2.0%
1999-2003	17	743	2.3%
2004-2008	13	519	2.5%

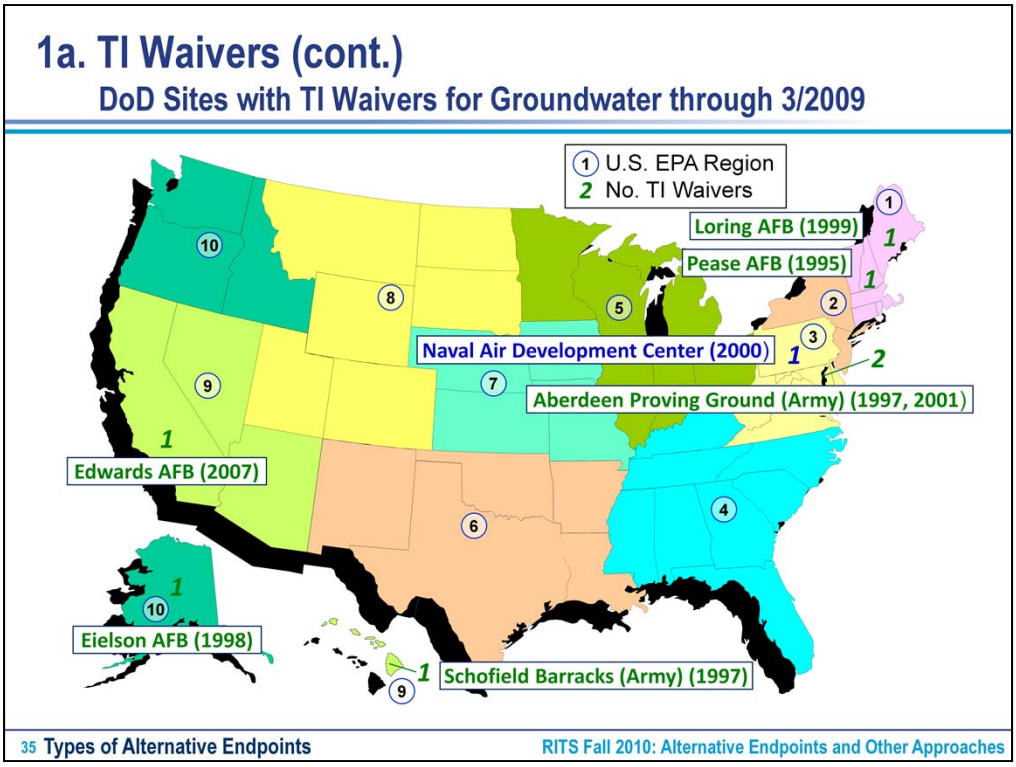
Frequently used upfront in the initial selected remedy. Do not need to demonstrate failure. This is a key finding!!

1a. TI Waivers (cont.)

Types of ARARs Waived due to TI

- **Majority of sites waived Federal MCLs**





DoD has used TI waivers, most recently at Edwards

1a. TI Waivers (cont.)

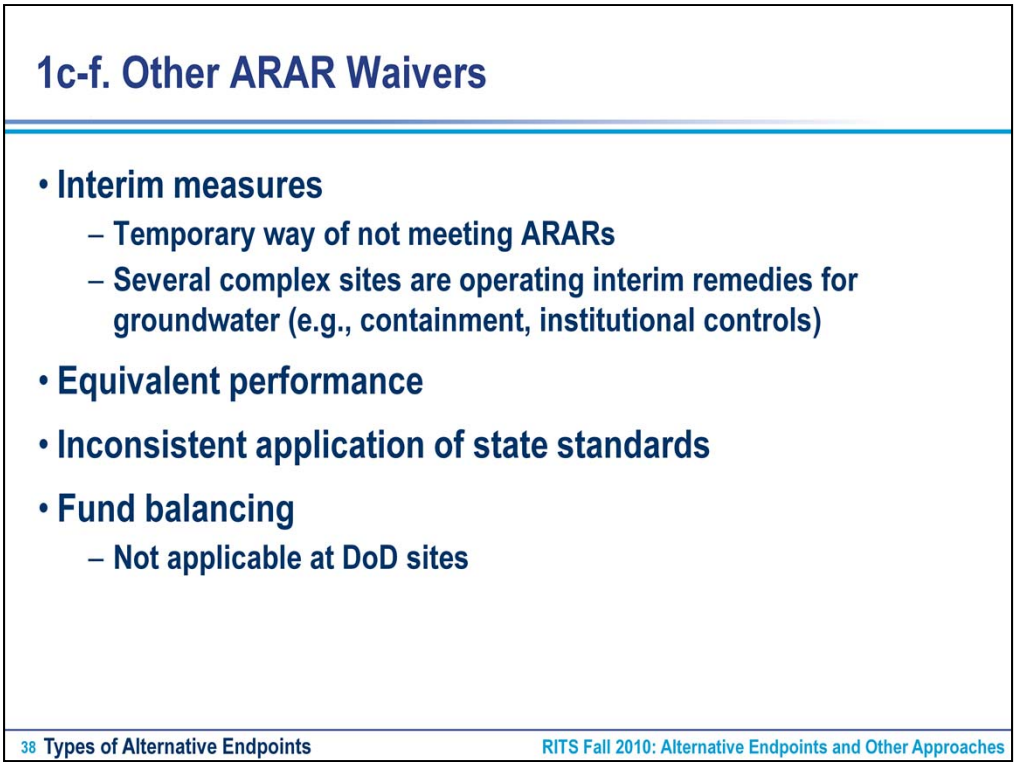
Navy Site: Naval Air Development Center, Warminster, PA

- TCE, PCE, carbon tetrachloride at DNAPL concentrations (~100 mg/L) confirmed by dye testing; present in fractured rock
- TI zone = source area; ~ 80 ft diameter area, extends from water table to 70 ft bgs
- Front-end TI waiver, final remedy (approved in 2000)
  - Pump-and-treat system (continue interim remedy)
  - Institutional controls
    - e.g., Deed restrictions, groundwater use restrictions
  - Monitoring, five-year reviews

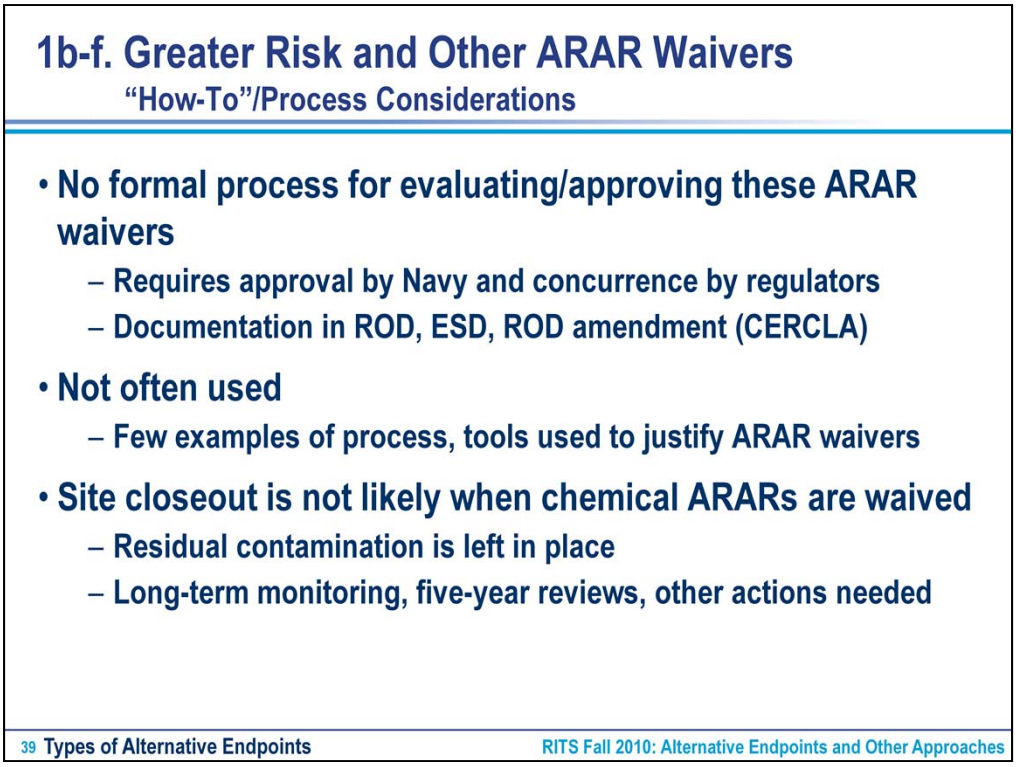
1b. Greater Risk ARAR Waiver

- 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
- Used at CERCLA sites rarely
  - Onondaga Lake Street site, New York (Region 2)
  - Managed mercury contamination in place because of the greater risk of exposure during excavation and off-site transport

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

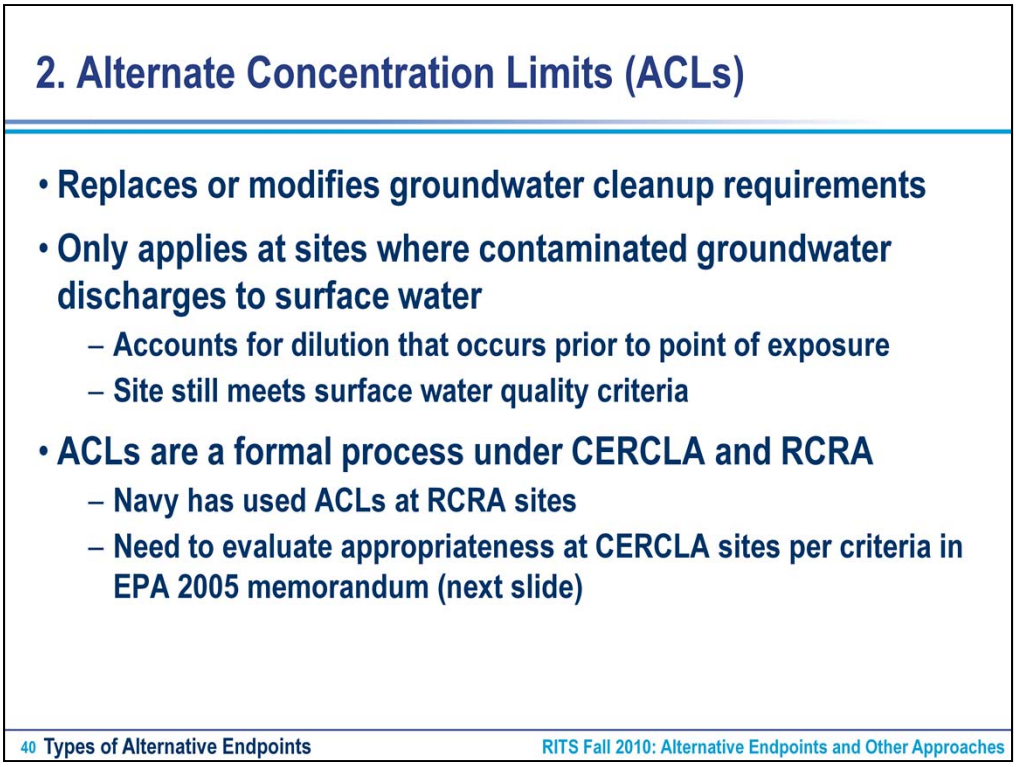


No examples found for the last three types of ARAR waivers



Navy is not using these ARAR waivers and there are few precedents at other CERCLA sites

Might not identify the ARAR if Navy knows that it's difficult to meet.



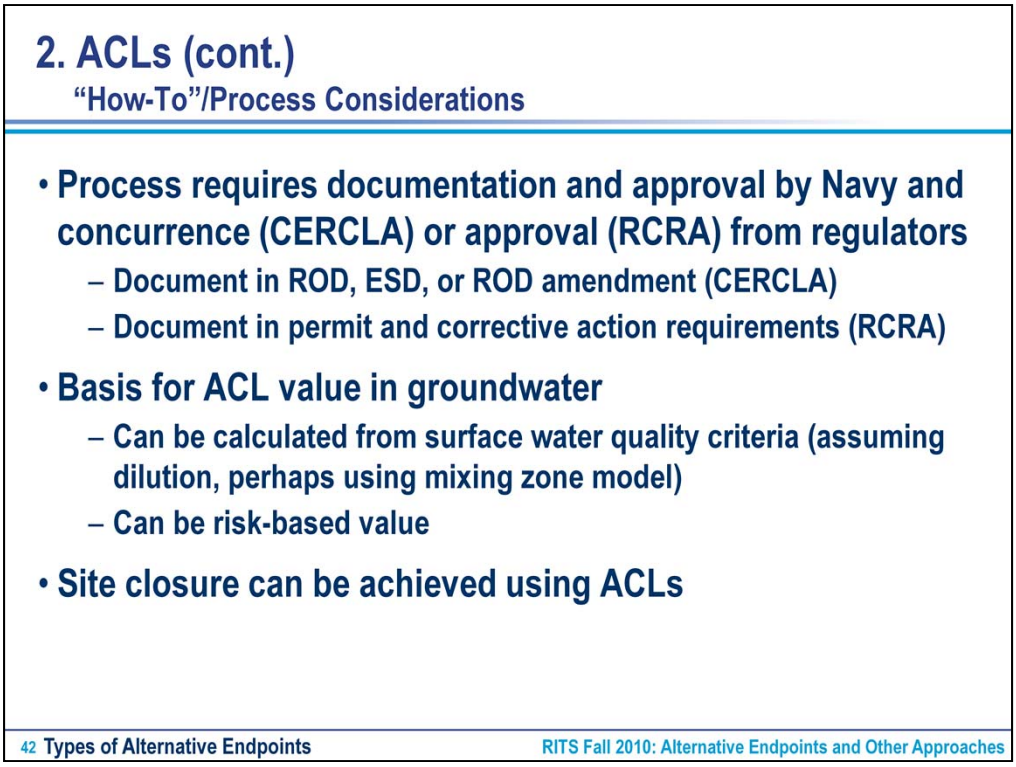
(We have started with ACLs because the Navy may be using it on a regular basis, particularly at RCRA sites.)

2. ACLs (cont.)

Considerations at CERCLA Sites (EPA, 2005)

- Memorandum clarifies ACL policy at CERCLA sites
- Lists 10 considerations including the following
  - Do all plumes discharge to surface water?
  - Any increase in concentration at points of entry, downstream, or any accumulation points?
  - Any degradation products between source and points of entry, particularly with higher health risks?
  - Can human exposure routes between source and points of entry be precluded?
  - Is there a Total Maximum Daily Load (TMDL) for surface water?

U.S. EPA Guidance: ACLs



There will most likely be back-and-forth negotiating ACLs with agencies.

Define ROD, ESD

Navy has successfully implemented Alternate Concentration Limits (ACLs), particularly at RCRA sites

Naval Surface Warfare Center, Crane, IN

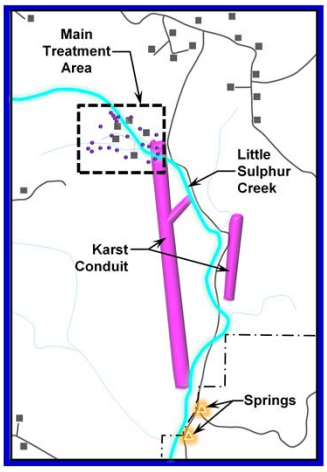
Sites 1 and 2, Former Naval Station, Long Beach, CA

OU3, Naval Air Station Jacksonville, FL

2. ACLs (cont.)

Case Study: Naval Surface Warfare Center, Crane, IN

- **Ammunition Burning Grounds (RCRA site)**
  - Royal Demolition eXplosive (RDX) in groundwater
  - Karst conduit environment
- **Approved ACLs, LUCs**
  - Tracer testing used to confirm flow through karst conduit towards springs
  - Demonstrated that natural attenuation was occurring over time (dilution/mixing)
  - 140 µg/L RDX at spring, 3 µg/L at public water supply intake based on dilution calculation



Navy has successfully utilized ACLs, particularly at RCRA sites with demonstrated mixing, natural attenuation

Define karst environment

The Naval Surface Warfare Center in Crane Indiana is a RCRA site where TCE, RDX and metals are present in groundwater as a result of historical waste management practices including burning waste ammunition. The geology is karst – limestone and sandstone. Through tracer studies, the Navy has figured out that groundwater from the Ammunition Burning Grounds flows south through a karst conduit to springs and into Little Sulphur Creek. Because of significant dilution downstream of the springs and the fact that the Navy demonstrated that natural attenuation was occurring, the State approved a risk management approach as a final remedy, using ACLs and land-use controls. The final cleanup limits for RDX are 140 µg/L at the springs, 240 µg/L in surface water downgradient, and 3 µg/L in the public water supply intake about 11 miles downgradient of the site.

Q: what about TCE? What is RDX MCL or action level – is it 3 µg/L?

2. ACLs (cont.)

Case Study 2: 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 and 2
  - Maintaining LUCs (fencing, property use restrictions)
  - Five-year reviews

Achieved RAO of preventing contaminants from reaching surface water at concentrations exceeding California Ocean Plan criteria

2. ACLs (cont.)

Case Study 3: ACL plans at OU3 Naval Air Station, Jacksonville, FL

- CERCLA site
  - Residual DNAPL VOCs, industrial land use
  - Groundwater flows to St. Johns River
- Remedy optimized in 2008
  - Air sparge, soil vapor extraction, pump-and-treat not meeting source removal goals
  - Supplemental investigation (direct push/membrane interface probe)
  - Used fate and transport model for mixing zone analysis, basis for proposed ACLs
- ROD amendment will be required

3. Groundwater Management/Containment

- 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 LUCs
- Formal designations in federal and state cleanup programs
  - Plume management zone (Texas Commission on Environmental Quality)
  - Technical impracticability (Wyoming and Georgia Voluntary Remediation Programs)
  - Waste Management Areas (RCRA and CERCLA)

3. Groundwater Management/Containment (cont.)

Three Examples

Description	Texas	Illinois	Federal
Designation	Plume management zone (PMZ)	Groundwater management zone (GMZ)	Waste Management Area (WMA) under RCRA Groundwater Protection Standards
Regulation	30 Texas Admin. Code 350.33(f)	35 Ill. Adm. Code Part 620.250	Federal ARARs under CERCLA
Jurisdiction	Texas Risk Reduction Program	Illinois EPA and Site Remediation Program	CERCLA
Purpose	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	• Establish Waste Management Area (WMA) with Point of Compliance (POC) monitoring under RCRA Groundwater Protection Standards
Example site	Naval Weapons Industrial Reserve Plant (NWIRP) Dallas, Texas	Joliet Army Ammunition Plant, Illinois	Barstow Marine Corps Logistics Base, California

Point out that the white paper is going to be state-specific and will include California.

NAVFAC SW does not accept CZs as a potential option because of the onerous procedural requirements are not compatible with CERCLA ARAR concept.

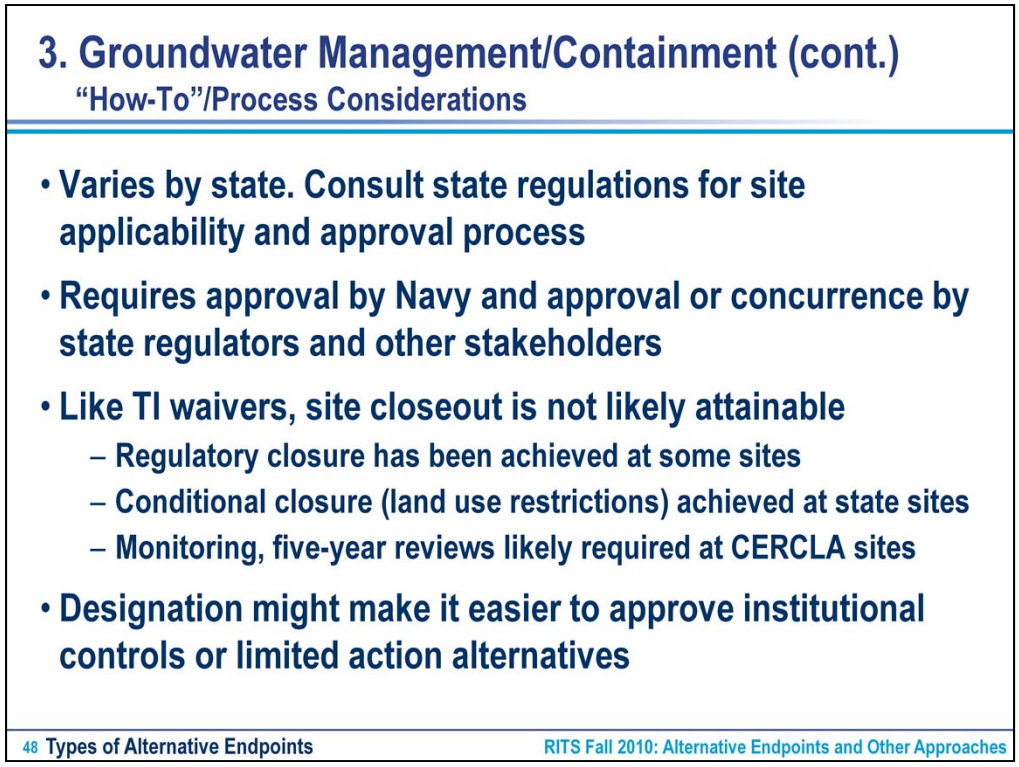
I have three examples of groundwater management zones or similar designations, in Illinois, Texas and California. This table summarizes the state designation, the regulatory citation, the cleanup agency in charge, and the purpose of the designation.

In the Texas Voluntary Cleanup Program, a “plume management zone” can be established. A PMZ modifies cleanup objectives and is very similar to a TI zone. However, it can be established for reasons other than technical impracticability.

In California, “containment zone” also modifies cleanup objectives and is intended for areas where it is technically and/or economically infeasible to fully remediate groundwater.

IN CONTRAST, Illinois EPA has a “groundwater management zone” or GMZ designation. A GMZ can be used for any areas that do not yet meet cleanup standards. The designation provides a way to delineate and track institutional controls. It is not used to modify cleanup criteria within the zone. Several other

states have similar designations, including Delaware and New Hampshire.



Considered containment zone at China Lake Naval Weapons Center. Problem was basin plan was promulgated applied MCLs to the aquifer, RWQCB couldn't waive MCLs within containment zone without de-designating the aquifer.

3. Groundwater Management/Containment (cont.)

Case Study: Naval Weapons Industrial Reserve Plant, Dallas, Texas

- **NWIRP Dallas (RCRA facility)**
  - Currently used for aircraft production
  - Chlorinated solvents in soil and groundwater
- **Approved plume management zone (PMZ), monitoring**
  - Limited natural degradation potential (low carbon)
  - Operated 3 pump-and-treat systems for 11 years with no reduction in plume footprint
  - Failed to identify viable technologies to meet goals, despite pilot studies

Department of the Navy, ER Program 2008 Progress Report

Other approaches can be used to achieve protectiveness that are similar to TI waivers

NWIRP Dallas, Texas (Plume management zone (PMZ))

Former NTC Orlando, Florida (MNA over long timeframes)

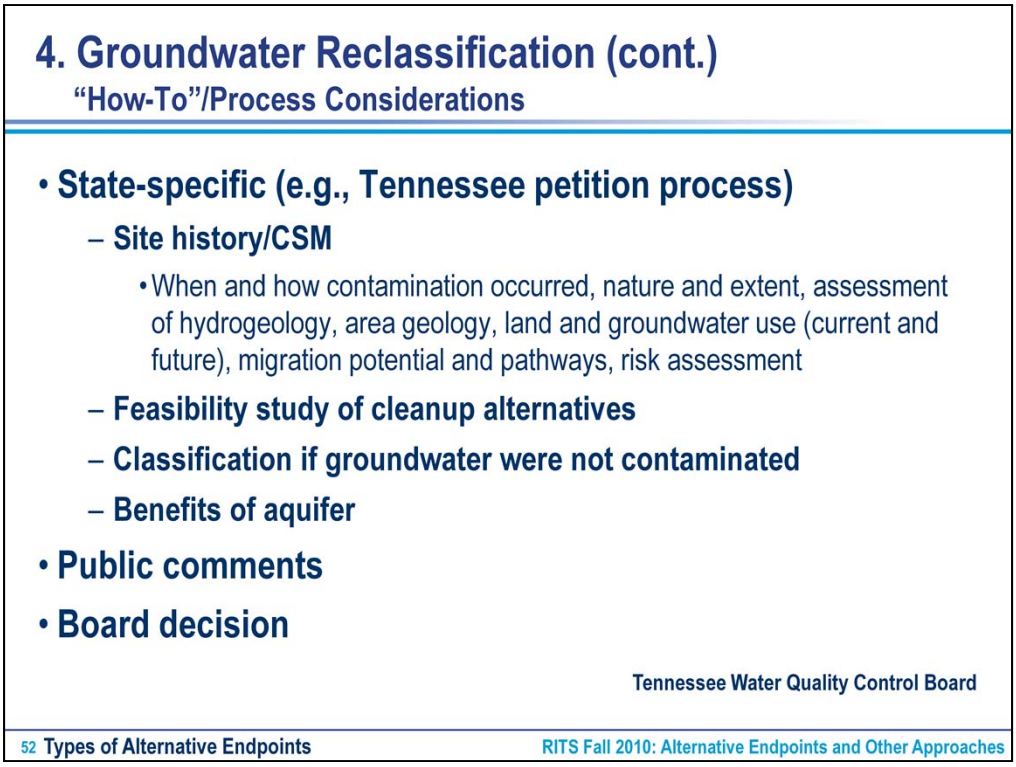
3. Groundwater Management/Containment (cont.)

Case Study: NWIRP, Dallas, Texas

- **PMZ preparation**
  - Described PMZ as part of Remedial Action Plan, submitted it to state and EPA for approval
  - Stakeholders worked within Restoration Advisory Board (RAB) to reach agreement
- **PMZ content**
  - Involves deed restrictions, land use covenant
  - Installation of two permeable reactive barriers
  - Long-term monitoring (30 years) to verify that the plume is not expanding or migrating beyond PMZ boundaries

4. Groundwater Reclassification

- **Changes state regulations so that groundwater is no longer classified as drinking water. Drinking water standards no longer apply**
- **Reasons for groundwater reclassification varies by state**
  - **Site-specific reclassification**
    - Site-specific impaired groundwater (Tennessee Department of Environmental Conservation Water Quality Control Board)
    - Classification exemption area (New Jersey EPA)
    - Urban setting designation (Ohio EPA's Voluntary Cleanup Program)
  - **Aquifer reclassification**
    - Impaired aquifer classification (Illinois, California, Nebraska)
- **Can apply to CERCLA, RCRA and state sites**



Sites that are eligible in Tennessee: "Groundwater that has been contaminated by human activity and the board finds that either it is not technologically feasible to remediate the ground water to the criteria required for other classifications or it is not reasonable to remediate to that criteria"

4. Groundwater Reclassification (cont.)

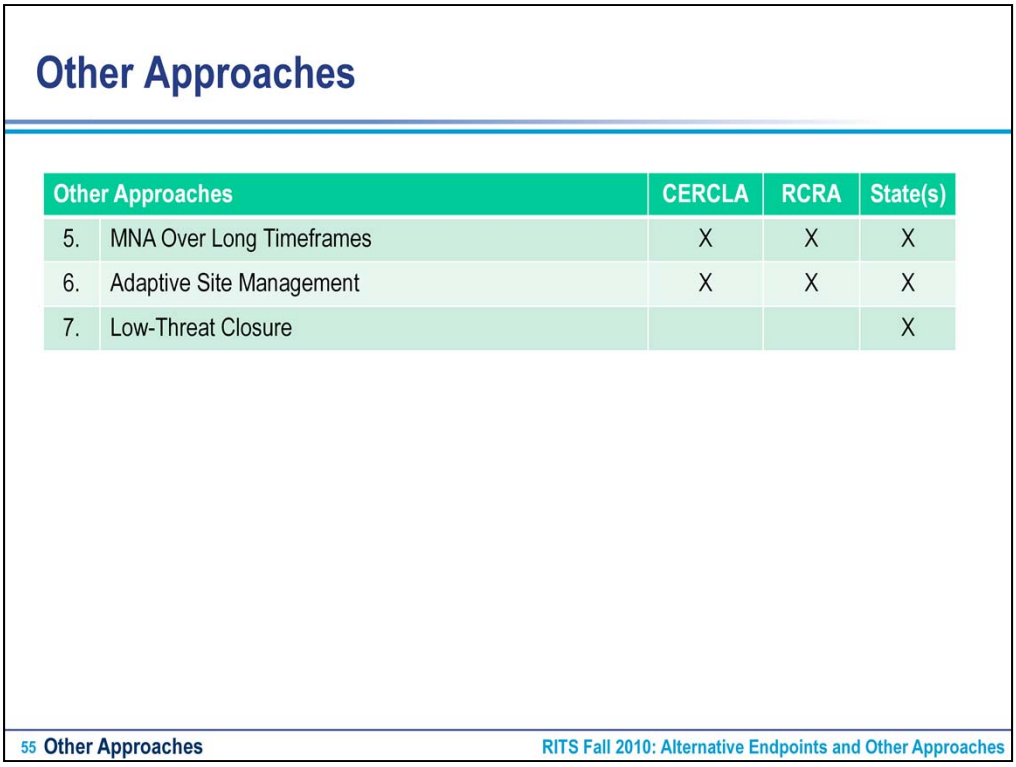
"How-To"/Process Considerations

- **Decision-making process varies by state**
  - **For example, submit request for Ohio Urban Setting Designation to Ohio EPA Voluntary Action Program**
    - Site name, location
    - How site meets threshold criteria
    - Whether local government favors designation
- **Documentation**
  - **ROD (CERCLA), permit (RCRA) or letter (state sites)**
  - **Aquifer classification documented in state law, basin plan**
- **Groundwater reclassification changes groundwater cleanup requirements but can be a lengthy process**

Presentation Outline

- Introduction
- Key Principles and Considerations
- Types of Alternative Endpoints
- Other Approaches
- Summary

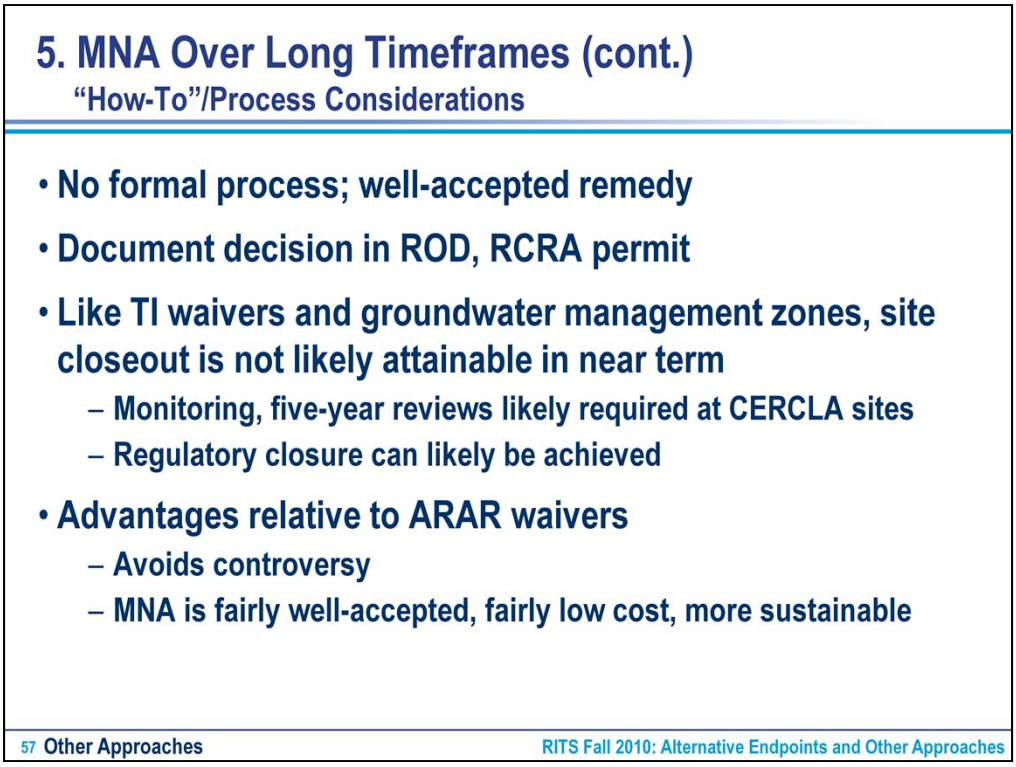
5. MNA Over Long Timeframes
6. Adaptive Site Management
7. Low-Threat Closure



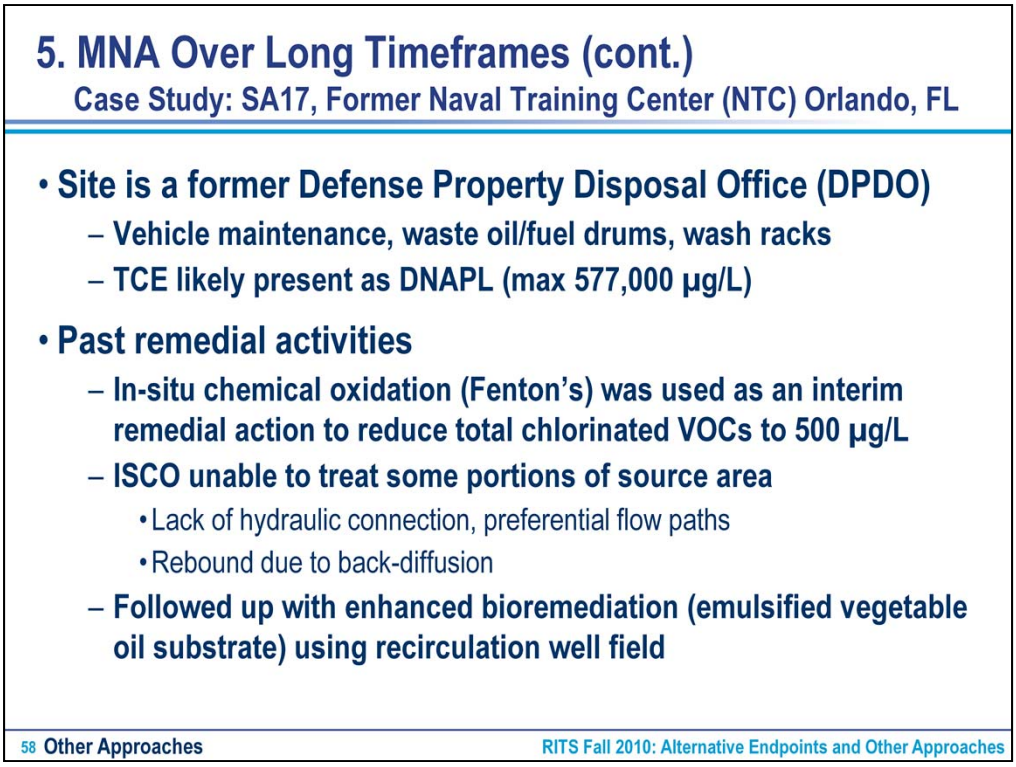
Other approaches such as MNA over long timeframes, groundwater containment, and/or institutional controls are used as an alternative to TI waivers

5. Monitored Natural Attenuation (MNA) Over Long Timeframes

- Traditional remedy that involves 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
- Applied at CERCLA, RCRA or state sites
  - Several examples have been identified (see case study slides)



What are key considerations compared with other options?



- Soil and groundwater contaminated with TCE
- Flat groundwater gradient – velocity ~ 10-20 ft/yr
- Depth to groundwater ~5 ft bgs

5. MNA Over Long Timeframes (cont.)

Case Study: MNA Evaluation at NTC, Orlando, FL

- Natural Attenuation Software (NAS) predictions
  - Plume is stable
  - Remediation timeframe ~60 to 70 years in downgradient plume
  - Additional source removal would have an insignificant impact on remediation timeframe

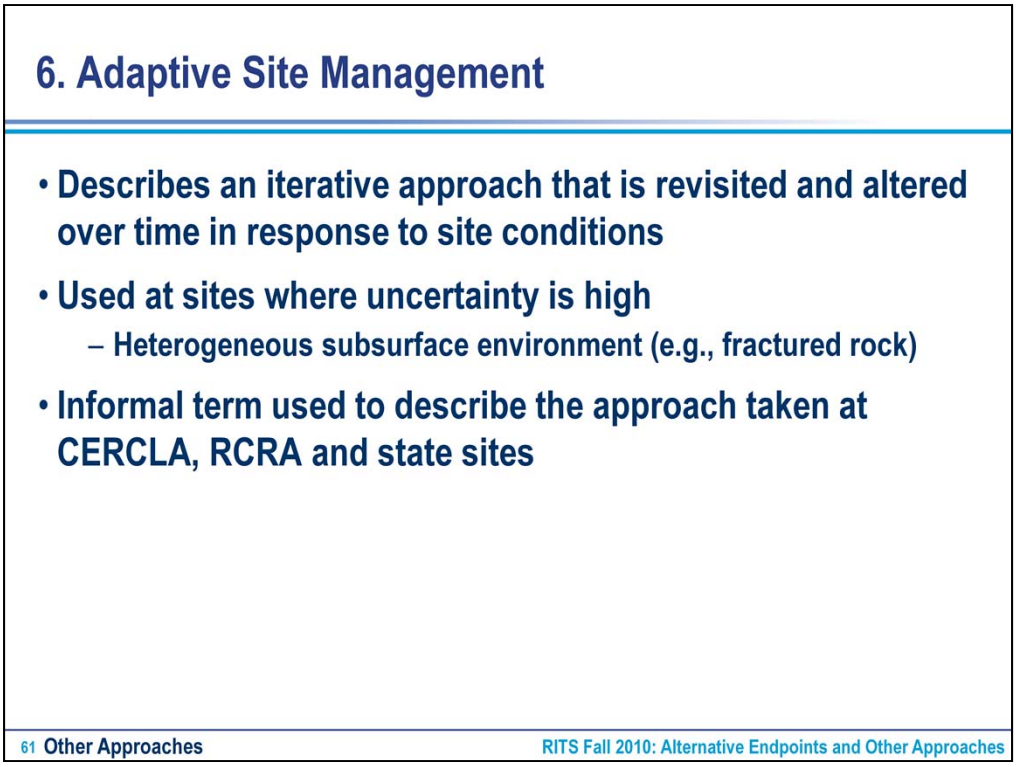
RITS Spring 2008: Estimating MNA Remedial Timeframes with Natural Attenuation Software (NAS)

- Favorable geochemical conditions
  - Iron, sulfate reducing conditions
  - Depleted oxygen
- Functional genes present
  - Used microbiological tools to assess phylogenetic and functional gene biomarkers for dehalogenation

5. MNA Over Long Timeframes (cont.)

Case Study: MNA Evaluation at NTC, Orlando, FL

- Reductive dechlorination products present
  - cis-1,2-DCE and VC in downgradient plume
- VOC concentrations approaching FDEP Natural Attenuation Default Criteria (NADC)
  - Typically 10 to 100 times higher than MCLs (e.g., 300 µg/L TCE)
- MNA evaluation showed conditions support sustained natural attenuation
- MNA approved by Orlando Partnering Team: Navy, EPA, FDEP, Community Representative, contractors

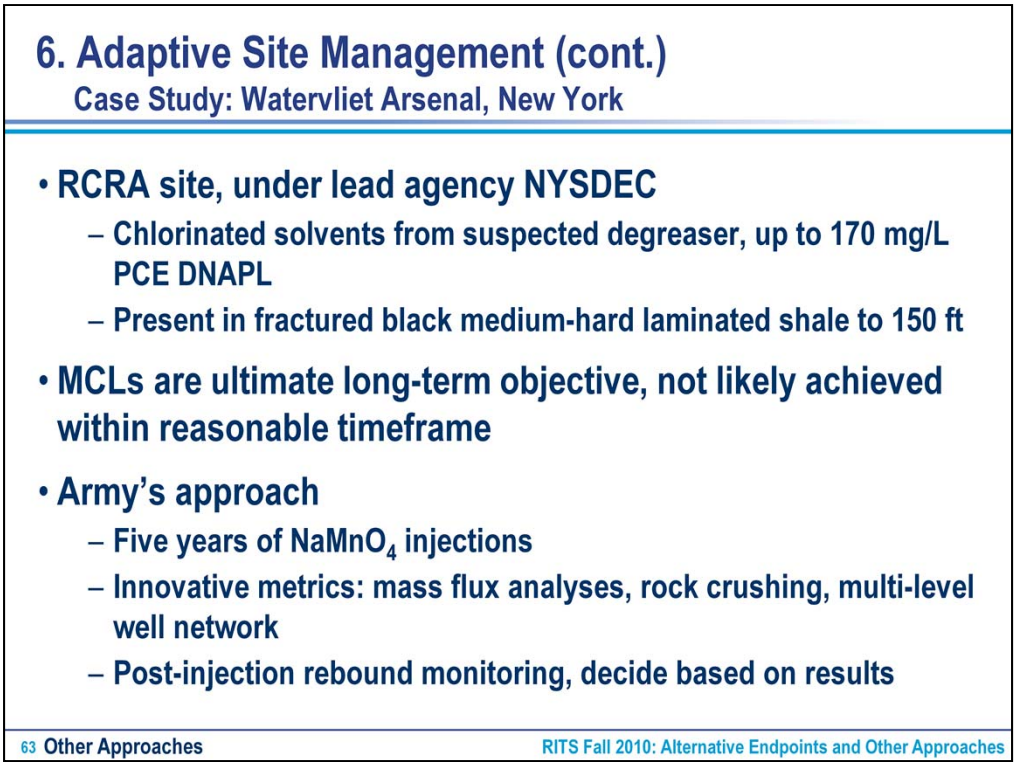


Clarify definition – NRC 'Adaptive site management' focused on site characterization.

6. Adaptive Site Management (cont.)

"How-To"/Process Considerations

- No formal process – approach is to revisit and verify or refine assumptions, CSM, over time
  - Establish short-term goals, metrics, and decision points
  - Verify/refine remedial design assumptions through technology testing and pilot studies before full-scale design
- Document long-term goals, approach in decision document
  - Can use contingency language to minimize revisiting remedy (i.e., if mass removal rate falls below threshold, transition to MNA)
- Navy, regulators and other stakeholders must agree on metrics, decision points up front
- Long-term management, monitoring likely needed



Extensive ISCO application in fractured rock demonstrates the technical basis for an alternative endpoint

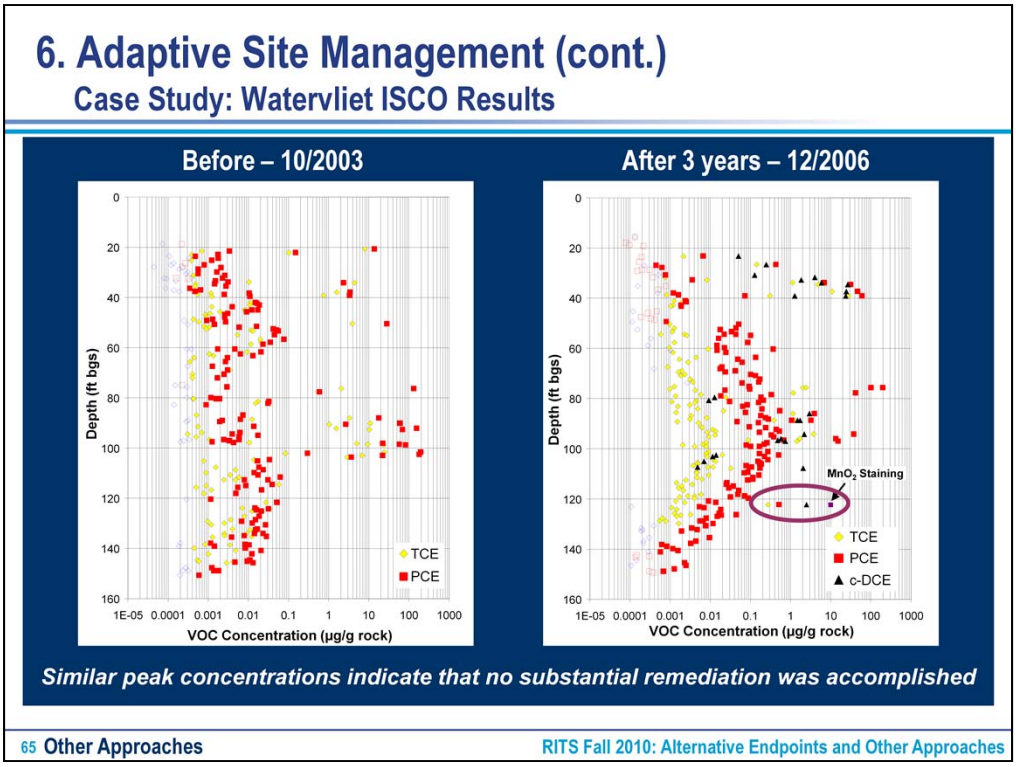
Adaptive site management, extensive testing can provide technical basis for an alternative endpoint

Watervliet Arsenal, Watervliet, New York (ISCO, ACLs)

6. Adaptive Site Management (cont.)

Case Study: Watervliet ISCO Pilot Test and Full-Scale Operation

- **Extensive characterization**
  - Define fracture network and system hydraulics through borehole geophysical and hydrophysical logging, inter-borehole flow testing
- **Measured MnO_4 distribution and effectiveness**
  - Estimated 50 years for MnO_4 to diffuse into matrix
  - Limited effectiveness of treatment based on comparative results of rock coring
- **Measured mass discharge across property boundary**
  - Integrated mass flux testing using short-term constant rate pumping test over entire affected area



Semi log scale
Core that was collected during monitoring well installation
UW took the core, took subsamples (few inches from every foot), crushed them, extracted them with methanol and looked at VOC concentrations in rock samples
Concentrations in rock core approaching solubility which is indicating presence of DNAPL in rock matrix
Very high concentrations in rock matrix

Advantages
- Confirm diffusion of contaminants into rock matrix
- Identify active flow paths that are too small for detection using hydrogeophysical techniques
- Identify contaminant transport pathways
- Evaluate potential for post-treatment contaminant rebound

Disadvantages
- Highly location-specific and not commercially available

Collected rock core sub-samples (0.1 to 0.4 ft spacing)
VOC samples: crushed and preserved in field
Physical property samples: intact sections analyzed for f_{oc}, ρ_{bulk}, η, carbonate minerals
Matrix diffusion samples: intact sections for laboratory diffusion tests

Not much treatment (reduction in concentrations) of VOCs
80 and 100 foot zone DNAPL transported in fracture (mass not destroyed in matrix)
3 years later, MNO2 staining in fractures (only one place)
Similar peak concentrations in samples taken before/ after permanganate injection indicate no substantial remediation accomplished; MnO4 was not observed in fractures at depths where most

mass occurs

6. Adaptive Site Management (cont.)

Case Study: Watervliet Mass Discharge Results

Mass Discharge Increased at Boundary Over Time*

** Increase attributed to calculation method, which assumed baseline hydraulic conductivity values. MnO_4 injections likely changed the aquifer hydraulics*

# of total hydraulic zones sampled is 16
Have not adjusted mass flux measurement to changes in transmissivities (did we create mass?) – loss in transmissivity due to clogging – the number will go down if transmissivity goes down
8 zones with permanganate
Were able to get some reduction early on but it tailed off; could not reduce long-term mass discharge
We may have made it worse due to changing pressures in rock due to injections (stagnant high concentration zones were initially not connected to high flow zone – mobilized DNAPL??)

6. Adaptive Site Management (cont.)

Case Study: Watervliet Key Findings

- Attempted mass removal "to the extent practicable"
  - Concluded that MCLs are not achievable within "reasonable timeframe" in matrix-dominant fractured rock
- Limited change in VOC mass discharge at site boundary (increase due to change in hydraulic conductivity)
- Technology testing provided a technical basis for alternative endpoint
  - Army, NYSDEC and other stakeholders are considering ACLs based on post-injection monitoring data and analyses

7. Low-Threat Closure

- Approves site closure (end of monitoring, reporting, regulatory interaction)
- Applies at sites that will reach cleanup standard soon under natural conditions and pose little threat to human and ecological health
- Applicable to chlorinated solvent sites under San Francisco Bay Regional Board
  - Analogous designations for Underground Storage Tank sites in various states
  - Analogous practices at other state sites?

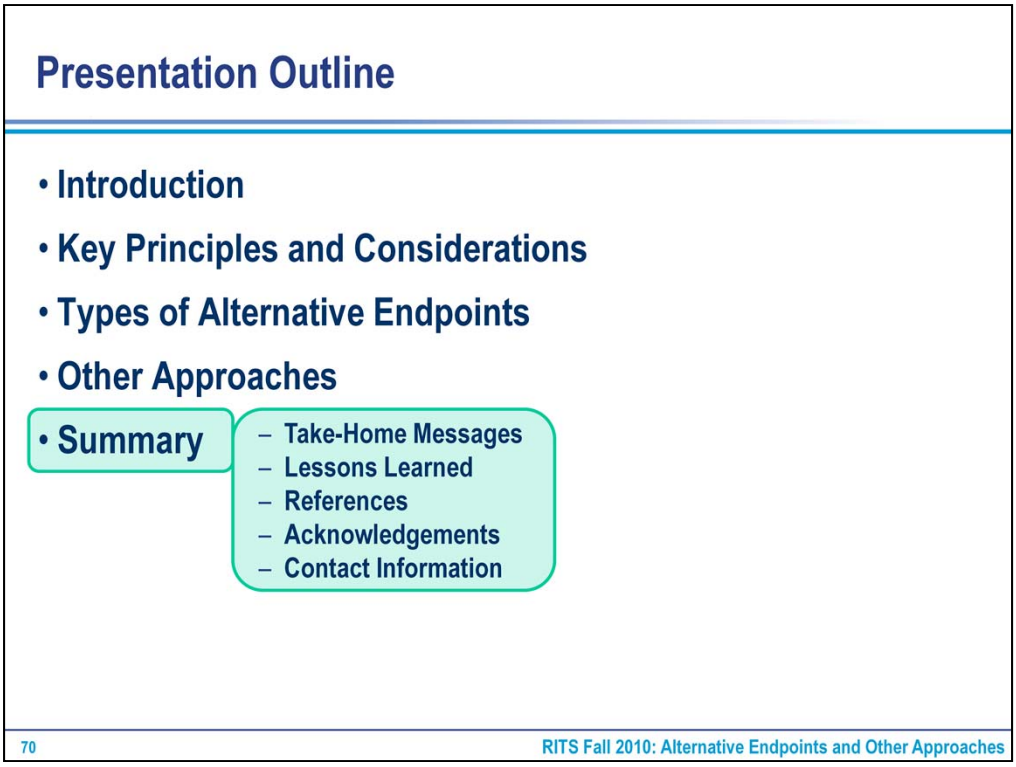
7. Low-Threat Closure (cont.)

"How-To"/Process Considerations

- **Process described in SF Bay RWQCB document**
  - Outlines nine criteria for issuing low-threat closure, consistent with existing policy
- **Documented in a letter from a state regulator**
- **Allows Navy to close sites sooner, saving money while being protective of human health and the environment**
  - Groundwater use restrictions, LUCs may still be necessary

Assessment Tool for Closure of Low-Threat Chlorinated Solvent Sites, SF Bay RWQCB

Different from Containment Zones (CZs), where no one expects groundwater to meet MCLs within a reasonable timeframe.



Lot of material covered so far, wanted to illustrate process at some of these sites to drive home some key points

Complex material, broad topic, typically covered in 4 hrs in workshop so we are going through it very quickly

Take-Home Messages

- Variety of alternative endpoints and other approaches for groundwater at complex sites
  - Option that's available
  - Not applicable at every site
  - Not a quick and easy fix
  - Approach must be protective of human health and environment
- Applicable under CERCLA, RCRA, and/or several state cleanup programs
  - Regulatory language is flexible rather than prescriptive, allowing for site-specific approaches

Take-Home Messages (cont.)

- Typically, alternative endpoints supplement (don't replace) active remediation; not a "do-nothing" solution
  - Source treatment/mass removal to the extent practicable
  - Containment, MNA, monitoring, institutional controls
  - Long-term management of residual contamination likely needed
- Case studies provide examples of site-specific ways to meet cleanup expectations, including
  - Tools and metrics
  - What worked and what didn't

Lessons Learned

- Alternative endpoints should be considered at all complex sites as part of remedy selection and implementation
  - Incorporate at the earliest possible stage of remedial process
- Assess factors related to aquifer restoration potential during site characterization and remedial design
- Consider recent research findings on the potential benefits of partial source depletion
  - Will partial source depletion affect the need for an alternative endpoint/remedial strategy?
- At sites where remediation system is in place, optimize system prior to assessing alternative endpoints

Lessons Learned (cont.)

- Where appropriate, use quantitative tools (e.g., mass removal trends, modeling) to support the assessment
- Recognize and mitigate barriers to incorporating some alternative endpoints into site remedial strategy
  - Use communication strategies to reduce barriers
  - Consider other approaches
- Utilize existing Navy resources, collective knowledge of legal framework and guidance on alternative endpoints

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