Naval Facilities Engineering Systems Command

EXWC Engineering and Expeditionary Warfare Center

Optimizing the Journey to Long-Term Management and Site Closure

Paul Favara, P.E., and Kim-Lee Yarberry, P.G.
Jacobs

RITS 2026

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Information in this presentation is current as of April 22, 2026.

EXWC: Engineering and Expeditionary Warfare Center
NAVFAC: Naval Facilities Engineering Systems Command

Speaker Introduction

Paul Favara, P.E.
Sr. Principal Technologist

- M.S., Environmental Engineering, Illinois Institute of Technology, 1987
- B.S., Business Oriented Chemistry, Western Michigan University, 1983
- P.E., Florida, 1990
- LEED Green Associate, 2013
- 41 years (26 years with Jacobs)
- Working on Navy projects since 2000 (GFFP, CLEAN, RAC, SB-RAC)

CLEAN: Comprehensive Long-term Environmental Action—Navy
GFFP: guaranteed firm fixed price
LEED: Leadership in Energy and Environmental Design
Navy: Department of the Navy
RAC: Remedial Action Contract
SB-RAC: Small Business Remedial Action Contract

Speaker Introduction

Kim-Lee Yarberry, P.G.
Senior Technologist

- M.S., Environmental Engineering and Science, Clemson University, 1999
  - Fate and Transport Focus
- B.S., Environmental Geoscience, University of Connecticut, 1997
- P.G., Georgia and Mississippi
- Joined CH2M HILL, Inc. (now Jacobs) in 1999
  - Program Technology Manager for Navy CLEAN contract
  - Leader of Jacobs' Field Characterization Method Community of Practice

Presentation Overview

- Introduction
- Overview of Exit Strategy Options
- Decision Frameworks
- Transition Assessments
- Case Studies
- Overcoming Challenges
- Wrap Up

Objectives

1. **Overview of Exit Strategy Options:** Create awareness of endpoints, core components, approaches, and best management practices
2. **Decision Frameworks:** Plan future decisions points and potential outcomes
3. **Transition Assessments:** Identify points where active remedies can transition to passive strategies
4. **Case Studies:** Provide examples of how above topics have been implemented in Navy projects
5. **Overcoming Challenges:** Identify common challenges and approaches to overcoming those challenges

Key Definitions

- **Exit Strategy:** Detailed, dynamic, and succinct plan for accomplishing specific performance goals within a defined time period to assure protection of human health and the environment (ITRC 2006 as cited in NAVFAC 2022a)
- **Decision Framework:** A structured process that uses site data, performance metrics, and decision criteria to guide exit strategies and transition decisions toward LTMgt or site closure (consistent with regulatory and NAVFAC guidance)
- **Transition Assessment:** A process to determine when a transition from an active treatment to a long-term passive treatment such as MNA (NRC 2013 as cited by SERDP 2024)

LTMgt: long-term management
MNA: monitored natural attenuation

Past Related RITS Offerings

- **2025:** Optimization Tools and Strategies Implemented at Sites with Long-Term Remediation Systems
- **2023:** Best Practices and Risk Management Options for Metal-Impacted Sites
- **2019:** How Much Risk Does LNAPL Pose at Legacy Petroleum Impacted Sites?

LNAPL: light nonaqueous phase liquid

Navy Optimization Policy

- Policy for Optimizing Remedial and Removal Action at Navy ER Program Sites (NAVFAC 2012)
  - Re-emphasizes that "opportunities to improve performance…shall be considered and implemented throughout all phases of remediation…"
  - SiteWise should continue to be used to assess life cycle considerations when evaluating remedial alternatives within the Feasibility Study
    - Solely considering energy usage, water usage, criteria pollutants, and safety – primary metrics that impact our efficiency and cost-effectiveness in remediating our cleanup sites
- Policy for Optimizing Remedial and Removal Actions under the ER Programs (Navy 2004)
  - Establishes procedures for optimizing the screening, evaluation, selection, design, and implementation for long-term operation and management of response actions

ER: environmental restoration

NORM Optimization Module

- Optimization actions shall be entered and tracked in the NORM Optimization Module
  - Supports adherence to Navy Optimization Policy
  - Provides visibility to Headquarters/Assistant Secretary of the Navy on potential future cost avoidances
  - Demonstrates continued fiscal responsibility within the program
- NORM Optimization Module required data include:
  - CERCLA phase
  - Goal and success indicators
  - Implementation date and cost
  - Cost avoidance and final potential cost avoidance
  - Acceleration dates
  - Description of the optimization review
  - Reduced impacts of energy consumption, criteria air pollutants, water usage, and worker safety

(NAVFAC n.d.)

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
NORM: Normalization of Environmental Data Systems

New OPTI Award!

- Advancing an optimized approach or technology that:
  - Improves ROI or reduces costs
  - Accelerates reaching remedial goal
  - Is innovative
  - Requires extra/unique stakeholder negotiations
- Action MUST be entered into the NORM Optimization Module for consideration
- Annual award for accomplishments over past 2 years
- Two awardees—one from Atlantic AOR and one from Pacific AOR
- OTI Workgroup Members review NORM entries and recommend awardees to Headquarters and ER Managers

(Stanley London n.d.)

AOR: area of responsibility
OTI: Optimization and Technology Innovations
ROI: return on investment

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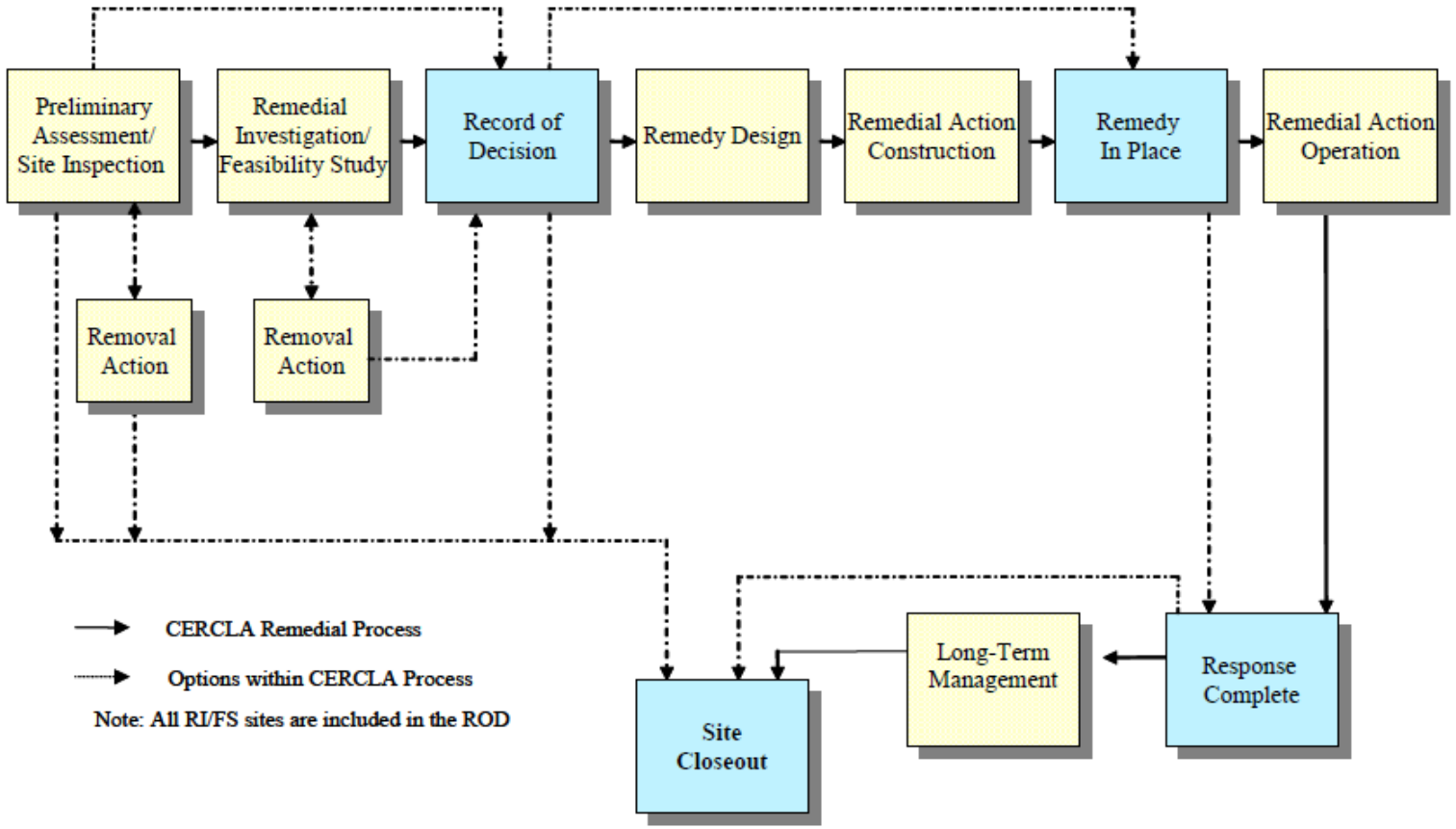
Navy ER Process: Key Exit Strategy Terms

- Milestone metrics used to measure ER Program progress
- SC is the ultimate endpoint objective in an exit strategy
- LTMgt may be an acceptable endpoint at complex or perpetual care (e.g., landfill sites)

Navy Environmental Restoration Process – Phases and Milestones



(NFESC 2006)

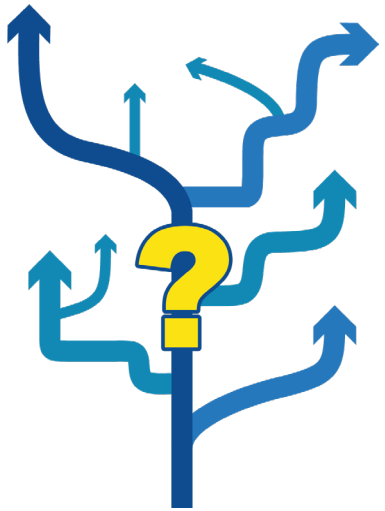
FS: Feasibility Study
RI: Remedial Investigation
ROD: Record of Decision
SC: site closeout

Factors that Favor Exit Strategy with LTMgt Endpoint

- Lack of regulatory pathway to SC
- Persistence of NAPL
- Persistent groundwater contamination
- Very low numeric ARARs
- Engineered and/or administrative institutional controls can be enforced to maintain protectiveness of HH and environment with in-place residual contaminants
- Natural processes or engineered remedy demonstrated to mitigate migration of NAPL and dissolved plume
- Heterogeneous fine-grained and/or bedrock lithology
- Sites with significant resiliency concerns
- Alternate, lower costs to achieve ARARs
- Ineffective prior source removal remedial activities

KEY POINT

Groundwater impacts typically drive both SC and LTMgt decisions.



ARARs: applicable or relevant and appropriate requirements
HH: human health
NAPL: nonaqueous phase liquid

Examples of SC and LTMgt Endpoints

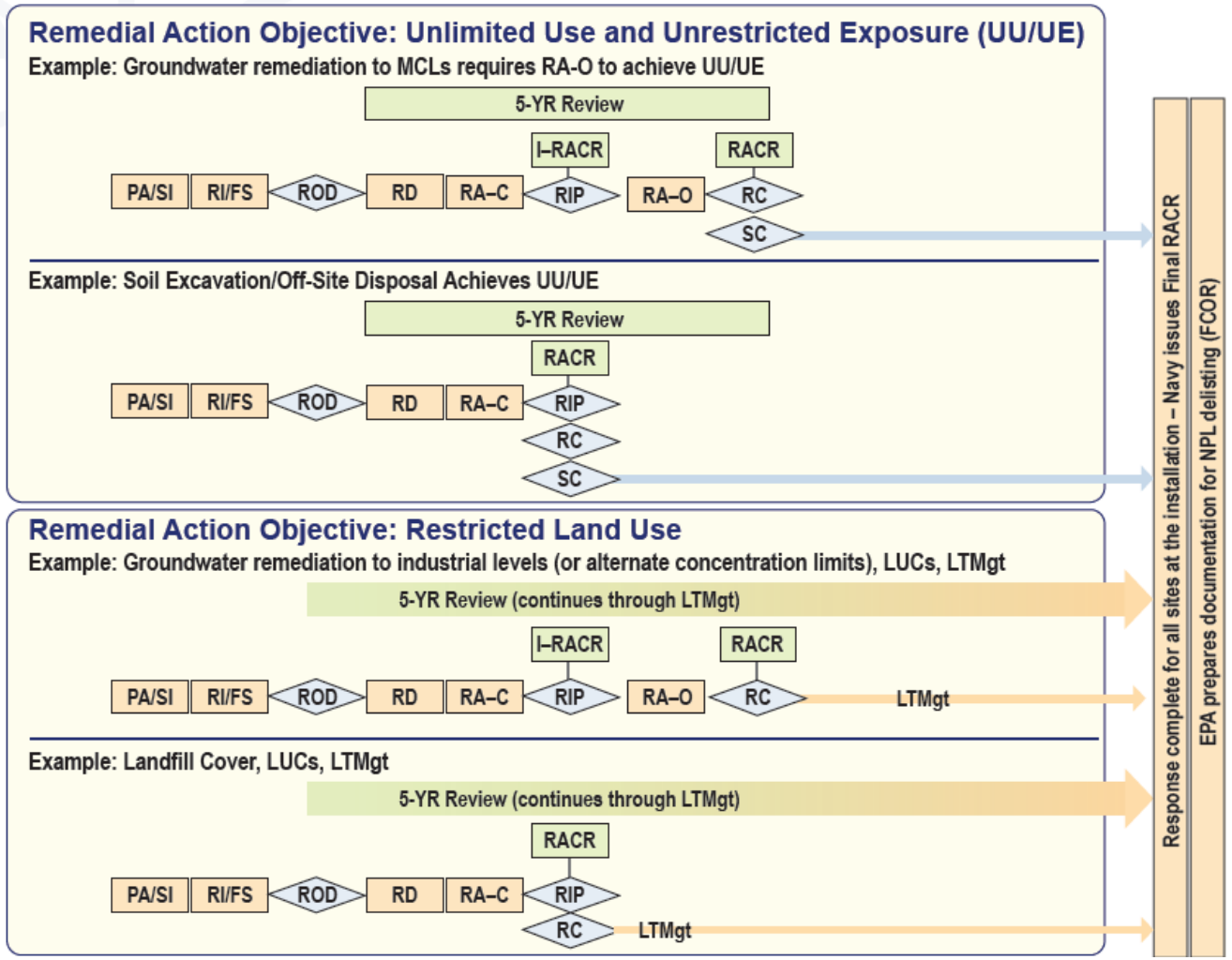
KEY POINT

Note difference between soil and groundwater is RA-O.

I-RACR: Interim Remedial Action Completion Report
LUC: land use control
MCL: maximum contaminant level
PA: preliminary assessment
RA-C: remedial action-construction
RA-O: remedial action-optimization
RACR: Remedial Action Completion Report
RC: response complete
RD: remedial design
RIP: remedy in place
SI: site inspection

SC endpoint

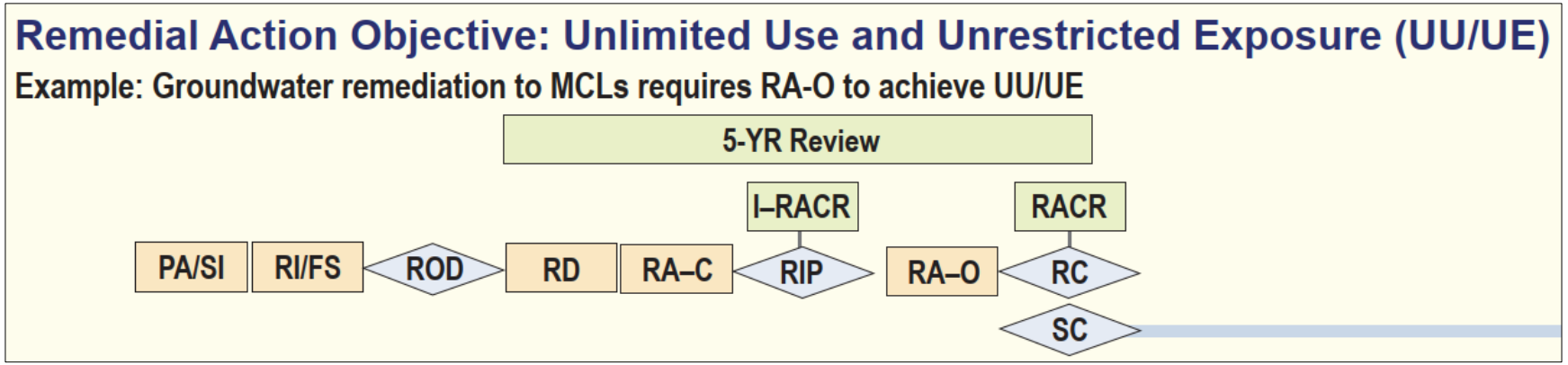
LTMgt endpoint



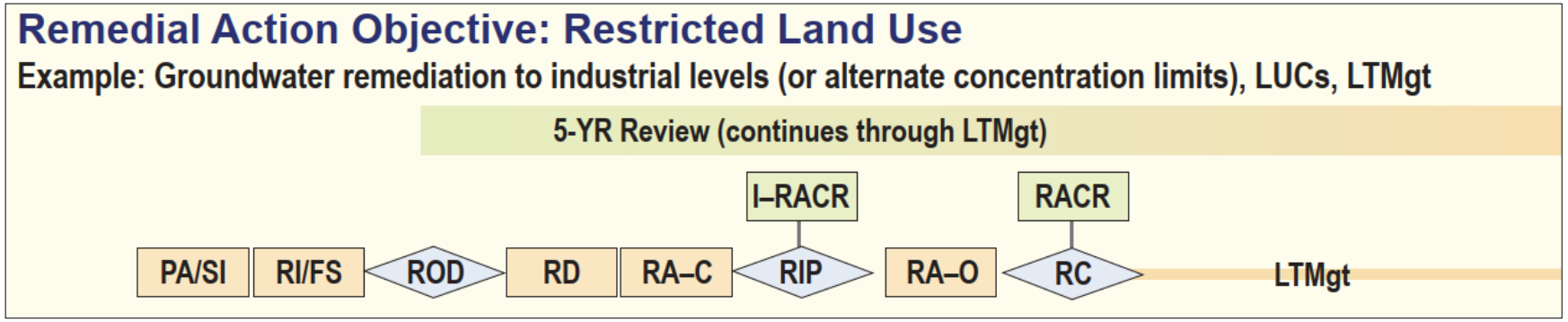
(NAVFAC n.d.)

Groundwater, SC, and LTMgt Examples

SC



LTMgt



Adapted from (NAVFAC n.d.)

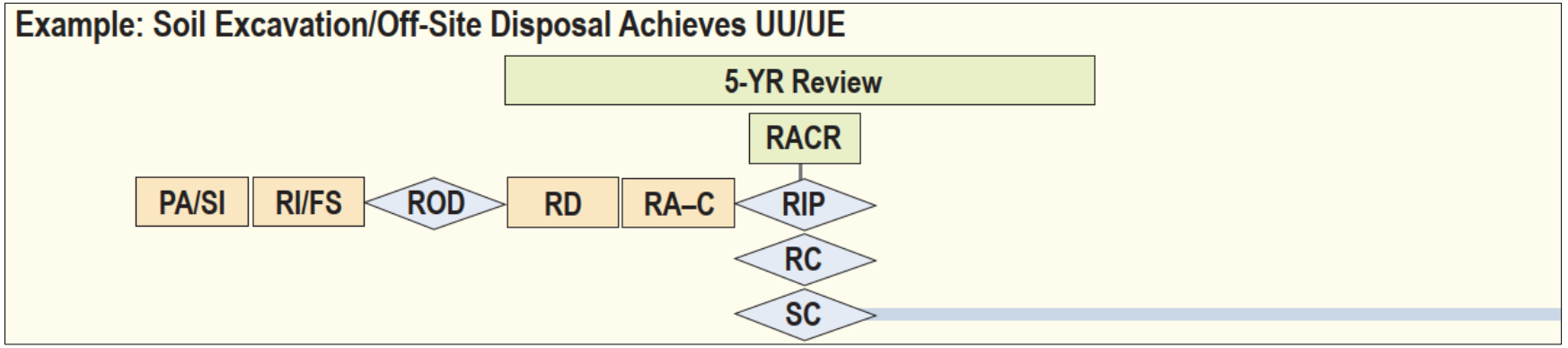
KEY POINT

Both require RC. For SC, RC achieves UU/UE.

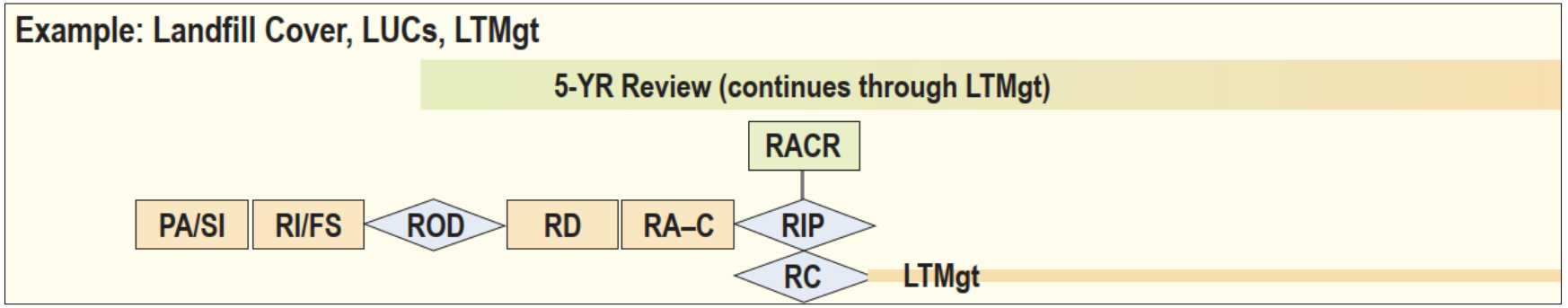
UU/UE: unlimited use and unrestricted exposure

Soil, SC, and LTMgt Examples

SC



LTMgt



Adapted from (NAVFAC n.d.)

KEY POINT

Both require RC. For SC, RC achieves UU/UE.

Exit Strategies: Core Components

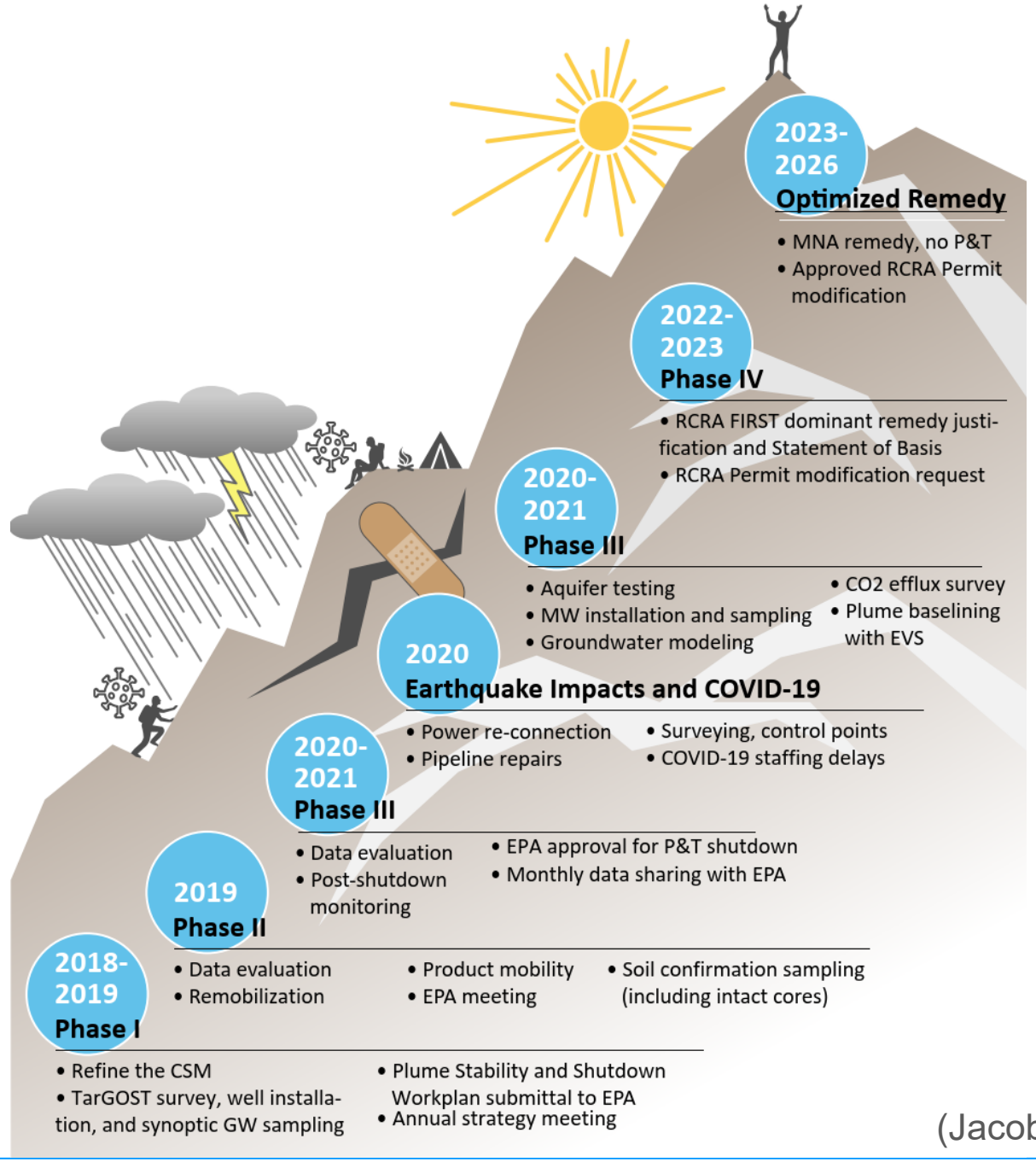
- Document and routinely assess exit strategy
  - Include updated milestones and metrics for success
- Apply optimization principles to track progress and transition remedies
  - Metrics for transition
  - Routine performance evaluations
  - Revisit original assumptions, cost estimates, and remedial time frames
- Update the CSM as site conditions change
  - Data gaps needed to facilitate site understanding
- Select effective remedial technologies
  - Consider contingency actions
- Flexible decision documents
  - ESD can document changes

CSM: conceptual site model
ESD: Explanation of Significant Differences

KEY POINT

Document and then routinely assess and adapt your exit strategy.

Example engaging graphical exit strategy presentation

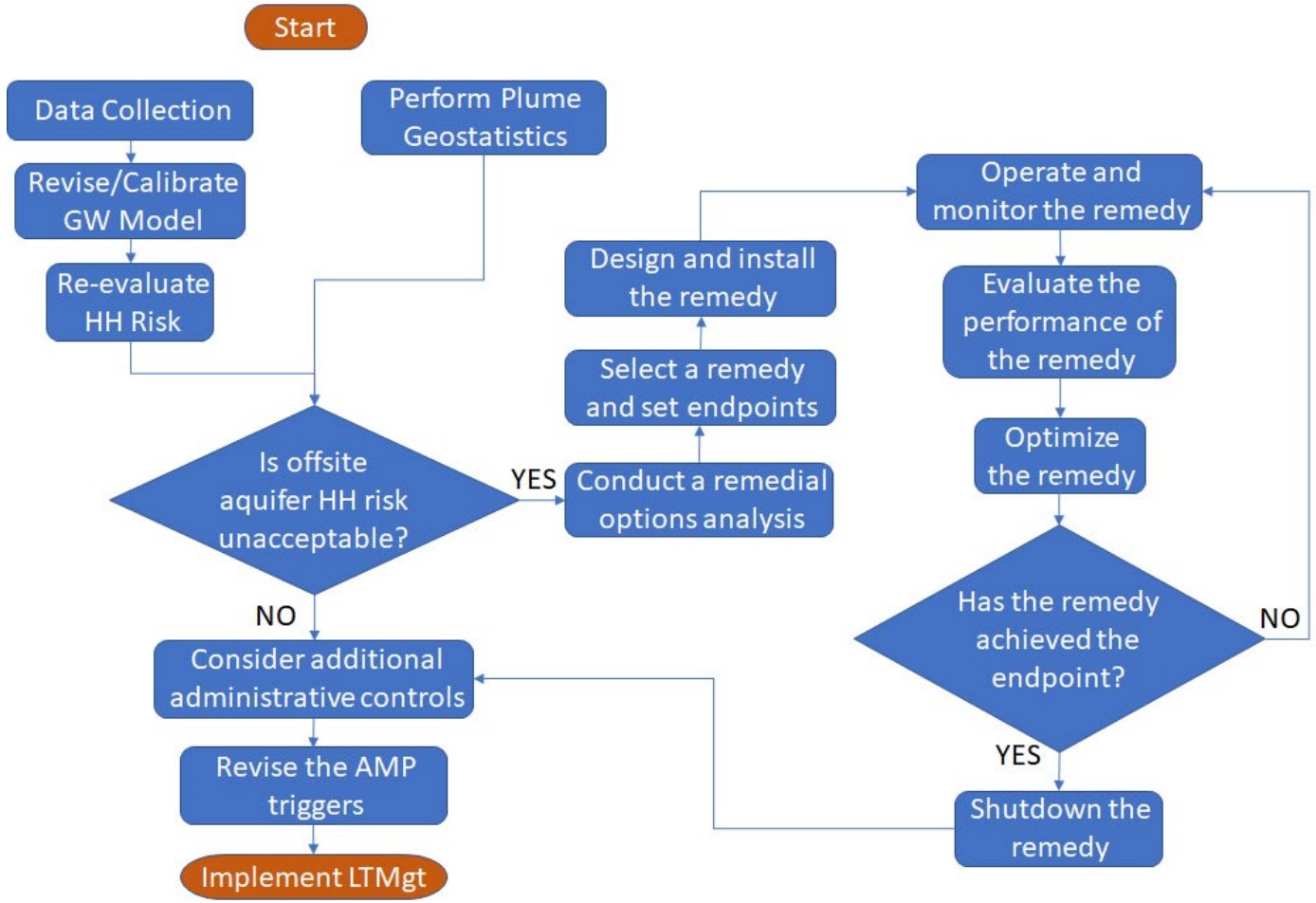


(Jacobs 2025)

EPA: United States Environmental Protection Agency
EVS: Earth Volumetric Studio
GW: groundwater
MNA: monitored natural attenuation
MW: monitoring well
P&T: pump and treat
RCRA: Resource Conservation and Recovery Act
TarGOST: Tar-specific Green Optical Screening Tool

Example Path to LTMgt for Risk Management

- Risk-based assessment of site conditions
- Exit strategy depends on the outcome of the HHRA
- Proposed approach to ultimately achieve LTMgt
- SC not viable
- Cost increment to SC should always be a consideration



AMP: adaptive management plan
HHRA: human health risk assessment

Exit Strategy Approach Options

Regulatory and Administrative

- Groundwater use reclassification
- ACLs
- Points of compliance
- LUCs, including institutional and engineering controls
- TI waivers

ACL: alternate concentration limit
TI: technical impracticability

Exit Strategy Approach Options (continued)

Technical and Remedy-Based

- Risk-based or low-threat closure
- Source control or partial removal
- Transition from active to passive technologies
- MNA: NSZD
- California Low Threat Closure Criteria for UST Sites (CSWRCB 2025)

NSZD: natural source zone depletion
UST: underground storage tank

Exit Strategy Best Management Practices

- Engage stakeholders early, socialize approach
- Follow a clear regulatory pathway for SC or LTMgt
- Document all decisions and rationale
- Use multiple lines of evidence to demonstrate plume stability and risk mitigation
- Apply lessons learned from similar sites or installations
- Adapt exit strategies and update CSM based on new data
- Incorporate optimization throughout (policy link below) and document to support team changeover

DON Optimization Policy (NAVFAC 2012)

KEY POINT

An effective exit strategy is a critical success factor.

Knowledge Check: Exit Strategy Options

Question: What are important components of an exit strategy?

Answers:

a. Review historical documents, summarize remedial objectives, evaluate remedial progress, and create a new exit strategy to fit the intentions
b. Conduct a remedy performance evaluation to assess its ability to achieve the existing remedial objectives
c. Revisit the CSM and past remedial technology selection assumptions, verify their validity, and close data gaps necessary to refine site understanding
d. Evaluate and discuss remedial options to achieve SC (or LTMgt if SC not achievable) with stakeholders including the regulatory agency
e. All of the above

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e. All of the above

KEY POINT

Hop in the driver's seat and chart your course to closure. It's not a regulatory required document but could be one of the most important to write.

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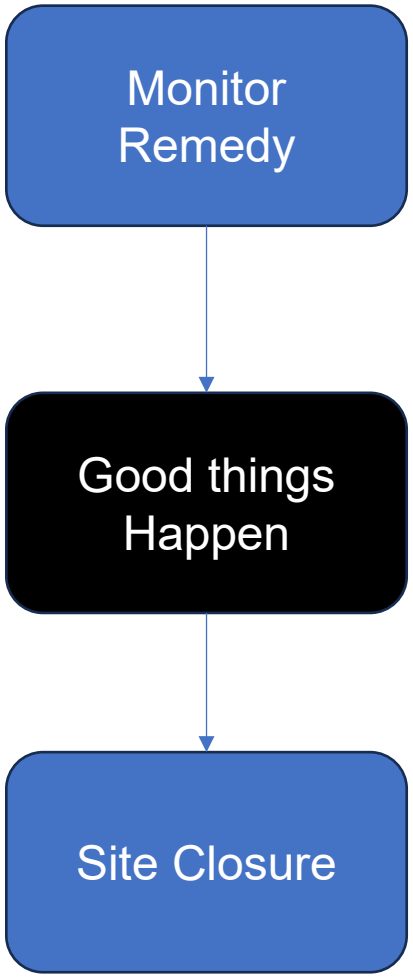
Importance of Decision Frameworks

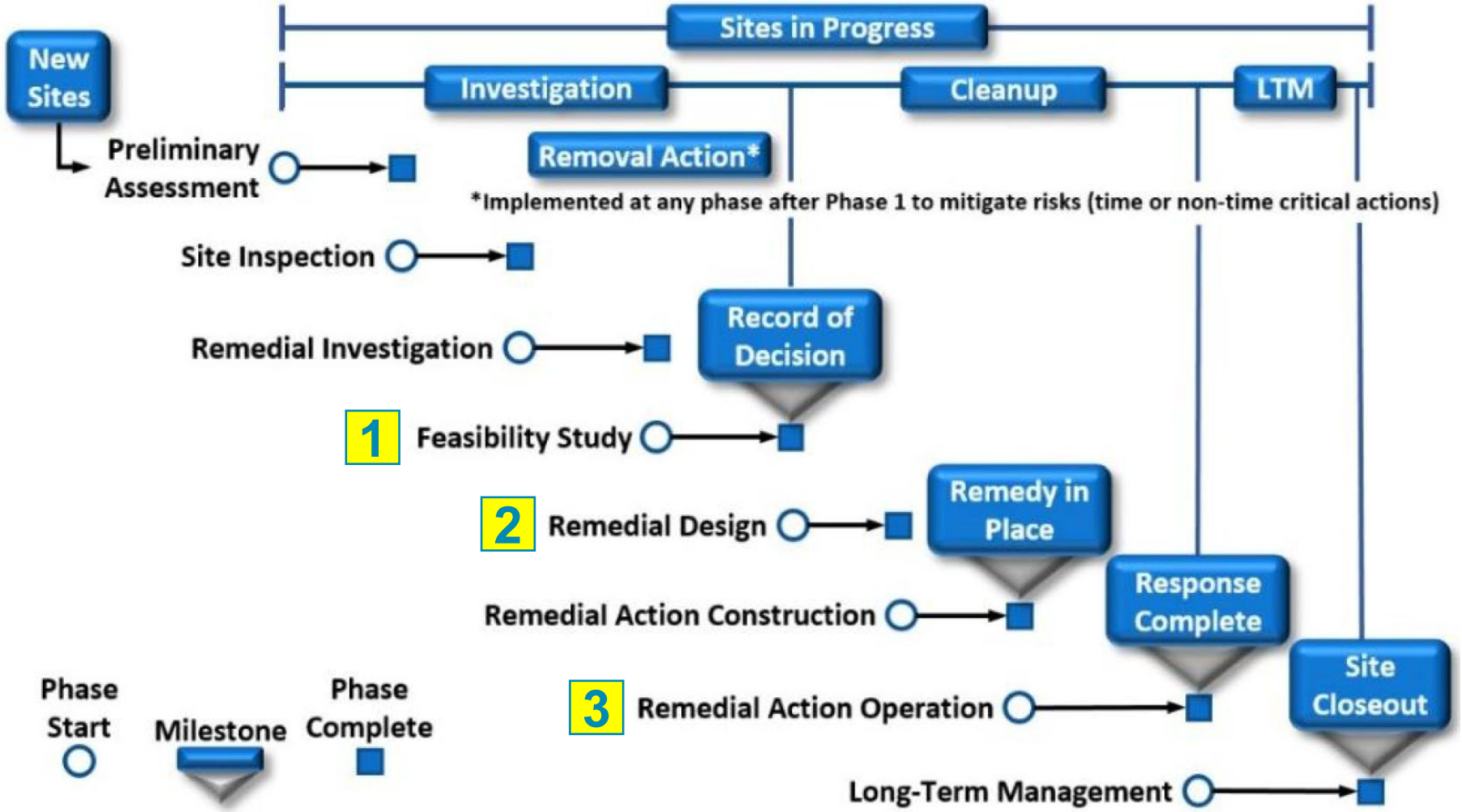


"Everything is going to be fine."

- Monitoring alone does not equal closure progress
- Performance data are collected, but not translated into decisions
- Assumptions made during remedy selection may persist long after site conditions change
- Without decision points, monitoring becomes end state instead of pathway

Define Decision Points and Potential Outcomes

1. What are metrics for the successful selected remedy?
2. What metrics will be used to measure progress?
3. What happens if performance objectives are not achieved?



LTM: long-term monitoring

(NAVFAC 2022)

Decision Points and Potential Outcomes

- Every selected remedy has multiple possible futures, including:
  - Performing as expected
  - Plateauing due to site complexity
  - Requiring optimization or augmentation, or transitioning to passive management or long-term stewardship
- Decision flowcharts help RPMs ask critical questions before issues arise:
  - What indicators suggest remedy is plateauing?
  - At what point does optimization make sense?
  - When should transition to MNA or LTMgt be evaluated?

RPM: Remedial Project Manager

Decision Points and Potential Outcomes

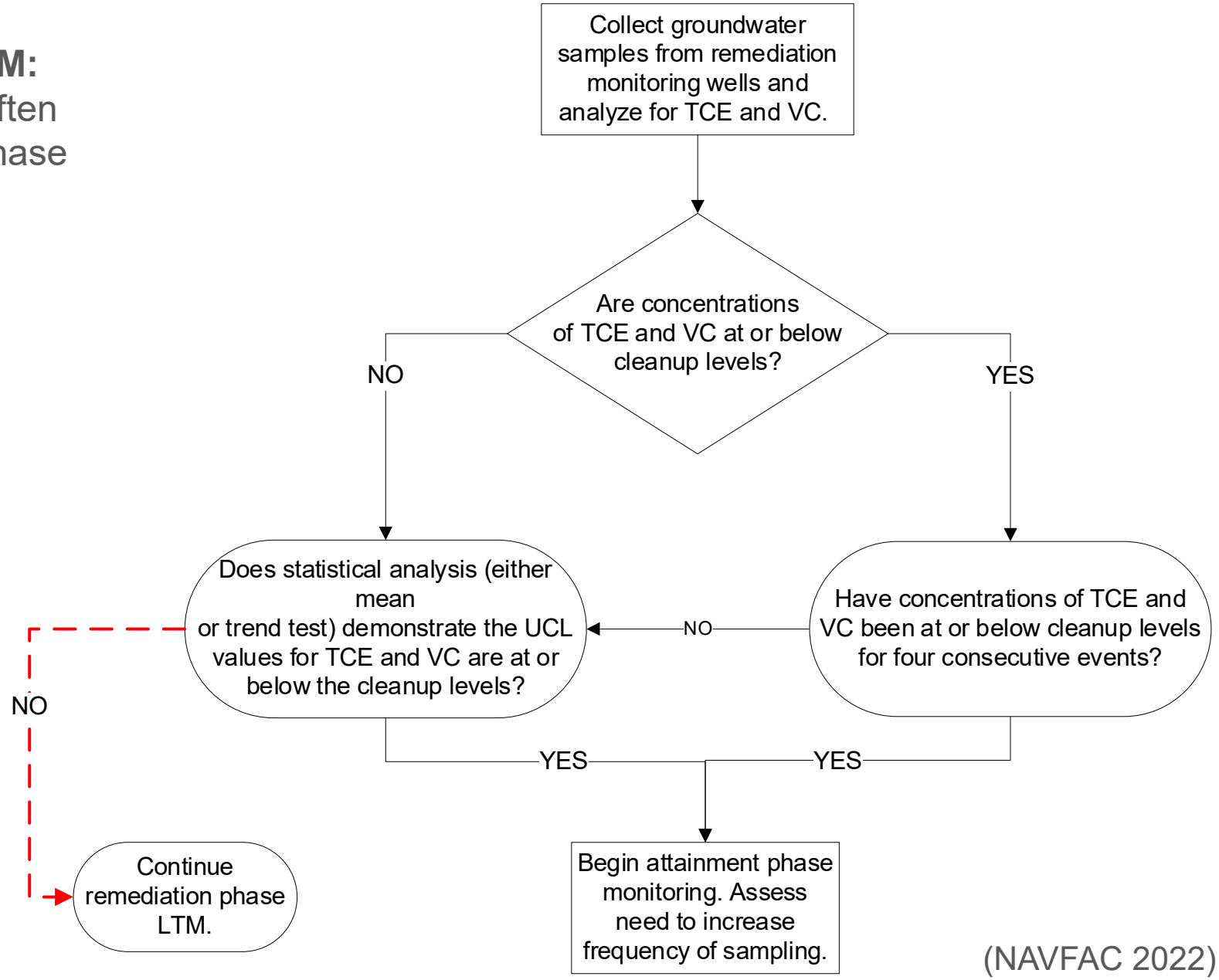
- Department of War and Navy guidance explicitly recognize that:
  - Active remedies may not achieve closure at complex sites
  - Transitioning remedies can still be protective and cost effective
  - LTMgt can be a planned outcome and not a failure
- Formal decision frameworks:
  - Reduce uncertainty for regulators and stakeholders
  - Support defensible transitions (e.g., active to passive)
  - Reduce life cycle costs and long-term liabilities
- To the extent possible, bake in flexibility

Decision Logic for JEB Little Creek Site 12

- **Remediation Monitoring** evaluates performance to assess if goals are achieved
- Predetermined number of samples are assessed to transition to attainment monitoring
- Flowchart is based on individual wells
- Does not address site as a whole

JEB: Joint Expeditionary Base

Remediation Phase LTM:
Groundwater sites are often challenged to exit this phase when goals are UU/UE.



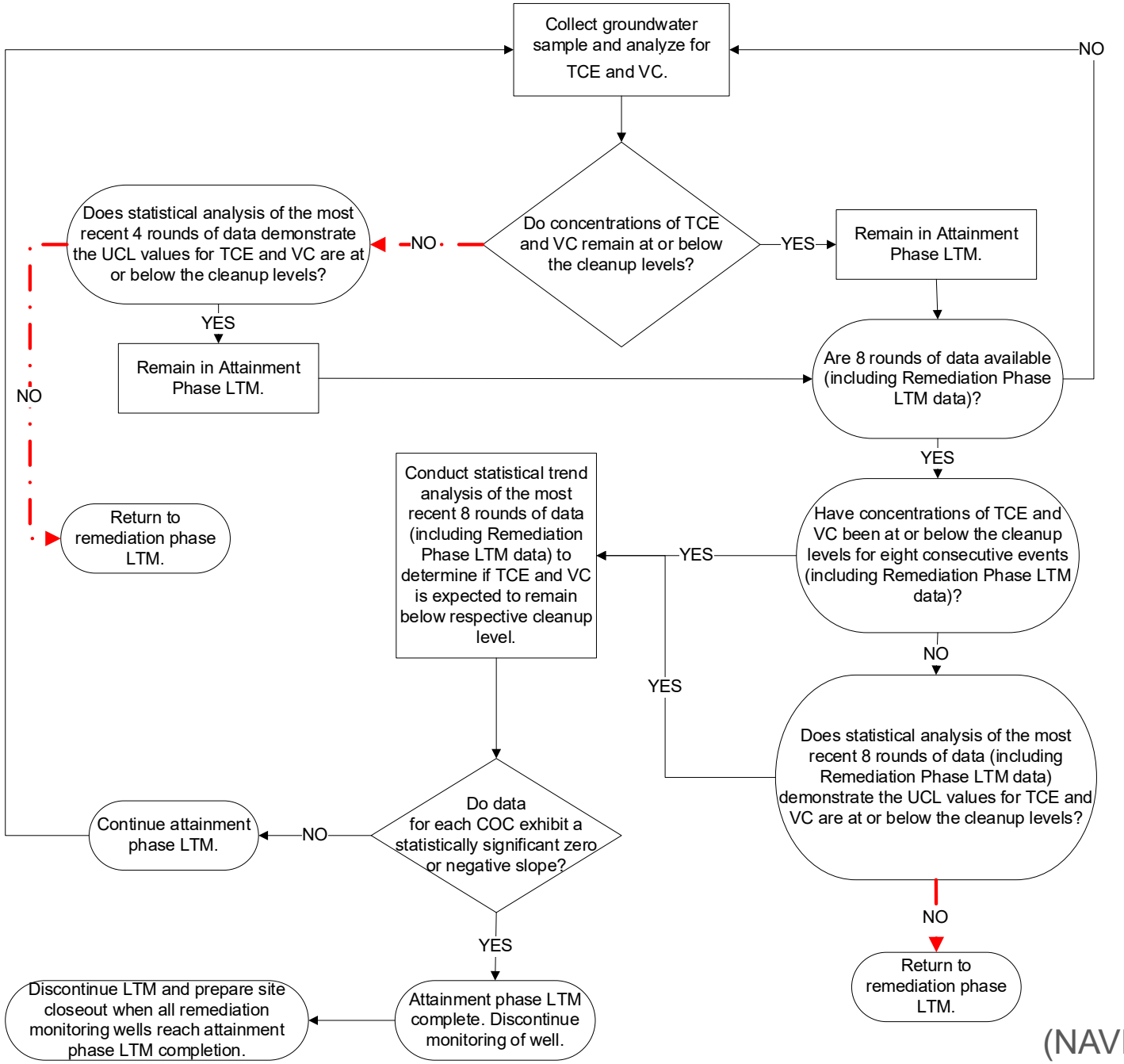
TCE: trichloroethene
UCL: upper confidence level
VC: vinyl chloride

(NAVFAC 2022)

Decision Logic for JEB Little Creek Site 12

- **Attainment Monitoring** is conducted after remediation monitoring to confirm that groundwater cleanup levels have been achieved and will continue to be met in the future
- Predetermined number of samples are assessed to transition to attainment monitoring (frequency independent, but needs to be reasonable)
- Flowchart is based on individual wells
- Does not address site as a whole

Attainment Phase LTM

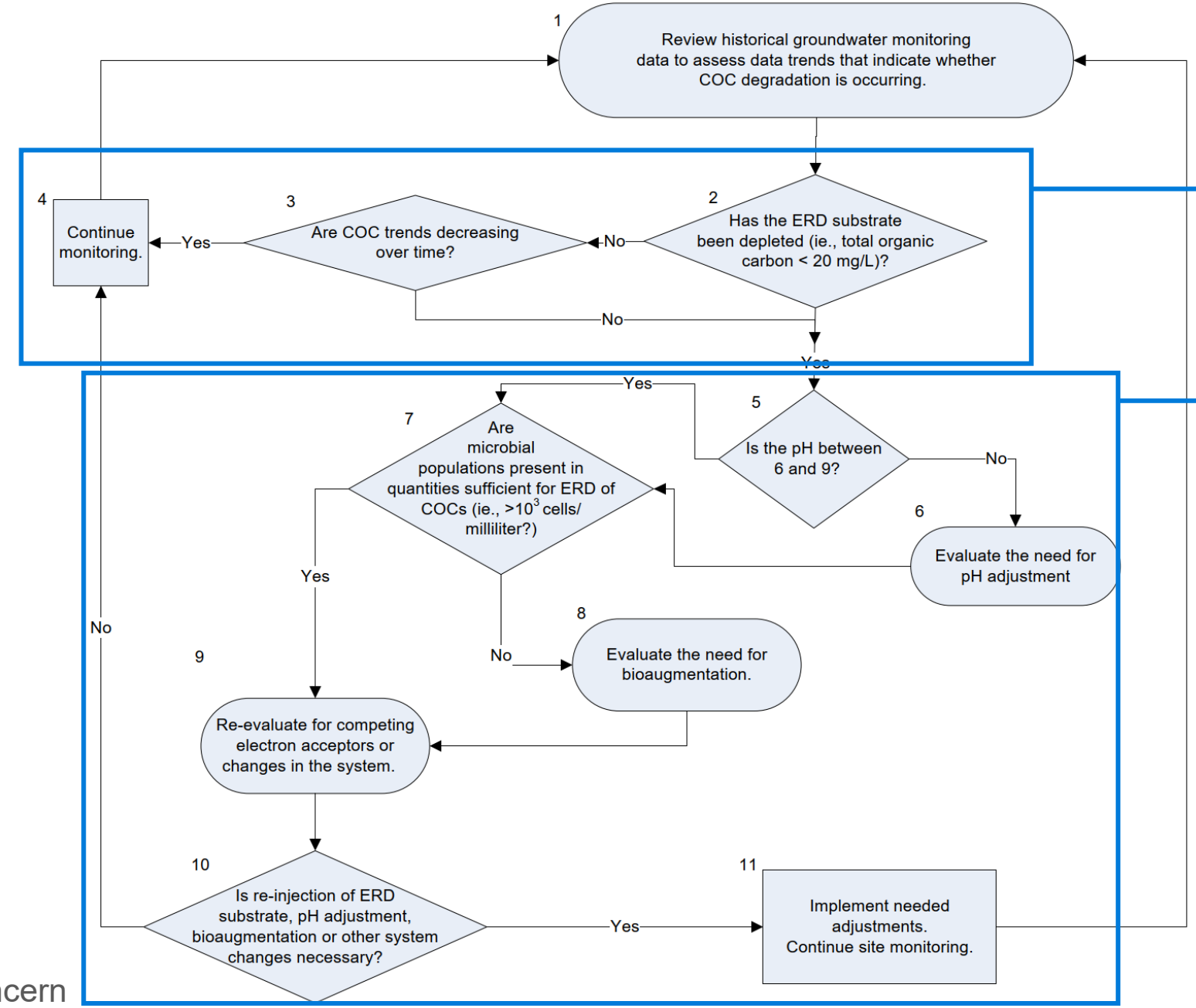


(NAVFAC 2022)

ERD Flow Chart for JEB Little Creek Site 12

- Example of how in situ remedy metrics assess field conditions
- Decision point to determine when reinjection is necessary

ERD: enhanced reductive dechlorination



This box is ideal, supports progress towards exiting Remediation LTM

This box indicates more evaluation is needed to progress toward exiting Remediation LTM (evaluate pH, microbial population, fermentable carbon, competing electron acceptors)

COC: chemical of concern
mg/L: milligram(s) per liter

(NAVFAC 2022b)

Knowledge Check: Decision Frameworks

Question: Why are decision frameworks (e.g., flowcharts) critical for managing remediation projects on path to SC or LTMgt?

Answers:

a. They ensure remedies are operated consistently without need for periodic re-evaluation
b. They help translate monitoring data into clear decision points for optimization, transition, or continued operation
c. They replace regulatory requirements by defining when remedies can be shut down
d. They eliminate uncertainty by predicting future site conditions with certainty

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KEY POINT

Decision frameworks ensure monitoring results lead to deliberate actions. They define, in advance, what success looks like and what to do when performance falls short.

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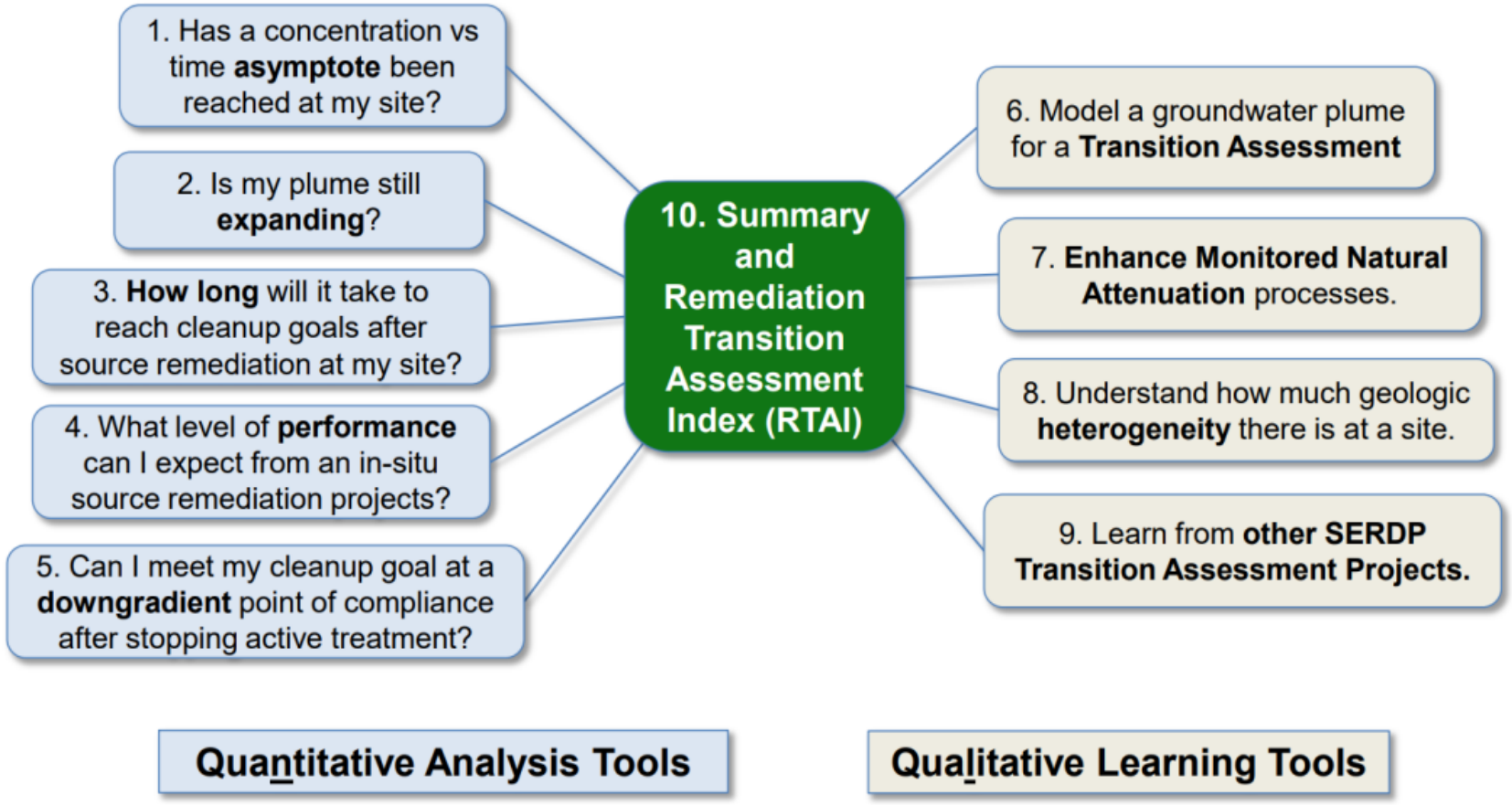
Transition Assessments inform SC and LTMgt

- Identifying defensible points where active remedies can transition to passive strategies or MNA
- Demonstrating protectiveness and long-term risk stability through clear lines of evidence
- Reducing life cycle costs in cases where SC is not attainable

NAVFAC 2024 Fact Sheet – Transitioning from Active Remedies to MNA

- Provided a technical framework for if/when site should transition from active remediation to MNA
- Helps identify sites where active remedies plateau due to matrix diffusion or diminishing returns
- Addresses common challenges
- More details in SERDP Project ER20-1429 (Transitioning from Active Remedies to Monitored Natural Attenuation, Principal Investigator GSI Environmental)

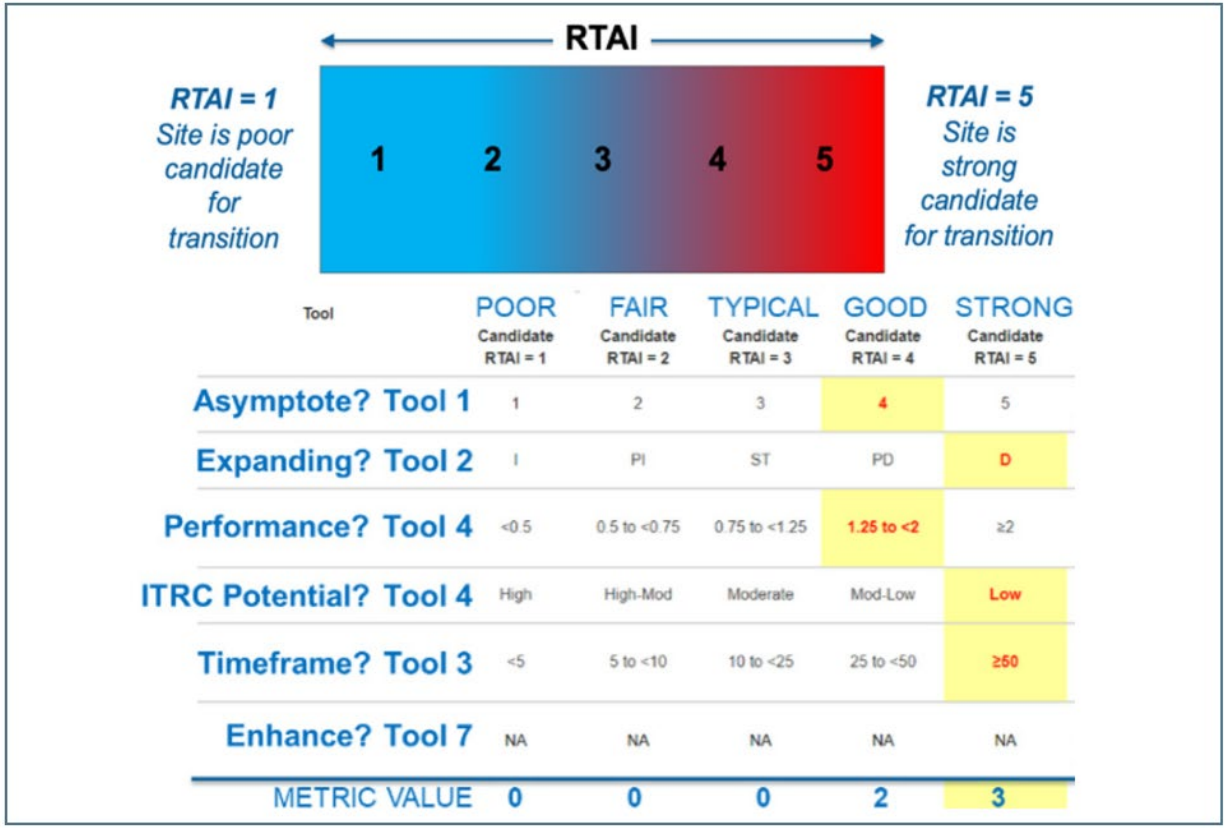


(NAVFAC 2024)

SERDP: Strategic Environmental Research and Development Program

How NAVFAC 2024 Fact Sheet Helps RPMs Transition to MNA

- Provides structured, defensible lines of evidence for deciding whether transitioning to MNA is appropriate
- Ensures protectiveness while informing opportunities to reduce long-term operation and maintenance costs
- Supports use in FS, optimization evaluations, and remedy transition decisions



Tool	POOR Candidate RTAI = 1	FAIR Candidate RTAI = 2	TYPICAL Candidate RTAI = 3	GOOD Candidate RTAI = 4	STRONG Candidate RTAI = 5
Asymptote? Tool 1	1	2	3	4	5
Expanding? Tool 2	I	PI	ST	PD	D
Performance? Tool 4	<0.5	0.5 to <0.75	0.75 to <1.25	1.25 to <2	≥2
ITRC Potential? Tool 4	High	High-Mod	Moderate	Mod-Low	Low
Timeframe? Tool 3	<5	5 to <10	10 to <25	25 to <50	≥50
Enhance? Tool 7	NA	NA	NA	NA	NA
METRIC VALUE	0	0	0	2	3

Top: RTAI scale definition. Bottom: Example of RTAI result with 2 metrics with a score of "4" and 3 metrics with a score of "5". Based on an unweighted average of these values, the final RTAI = 4.6.

(NAVFAC 2024)

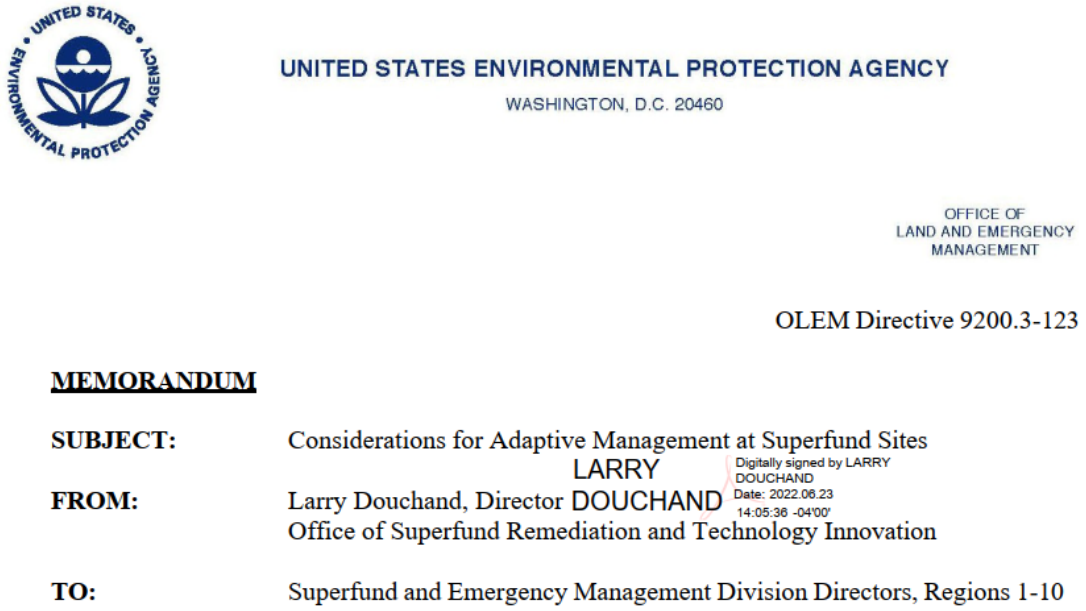
ITRC: Interstate Technology and Regulatory Council
RTAI: Remediation Transition Assessment Index

2023 ITRC P&T Optimization: Transition and Termination

- Provides structured framework for determining when to optimize, transition, or maintain remedies as part of LTM
- Introduced LTM-specific tools for monitoring reduction and system right-sizing
- 3-step process
  - Step 1: Identify trigger conditions and affirm need for P&T transition
  - Step 2: Identify transition approach and develop lines of evidence for P&T transition
  - Step 3: Implement P&T transition

Plan for Transition Example: NWS Yorktown Site 1 – Dudley Road Landfill

- Site was used for sand mining
- Two borrow pits were filled with waste materials
- HHRA showed unacceptable risks for TCE, cis-1,2-DCE, VC, and 1,1,2-TCA
- Excavation, in situ groundwater treatment with reductive dechlorination was chosen as recommended remedy, with MNA contingency
- AM principles were incorporated into project management plan as part of EPA pilot project



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
LAND AND EMERGENCY
MANAGEMENT

OLEM Directive 9200.3-123

MEMORANDUM

SUBJECT: Considerations for Adaptive Management at Superfund Sites

FROM: Larry Douchand, Director
Office of Superfund Remediation and Technology Innovation

LARRY DOUCHAND Digitally signed by LARRY DOUCHAND Date: 2022.06.23 14:05:36 -04'00'

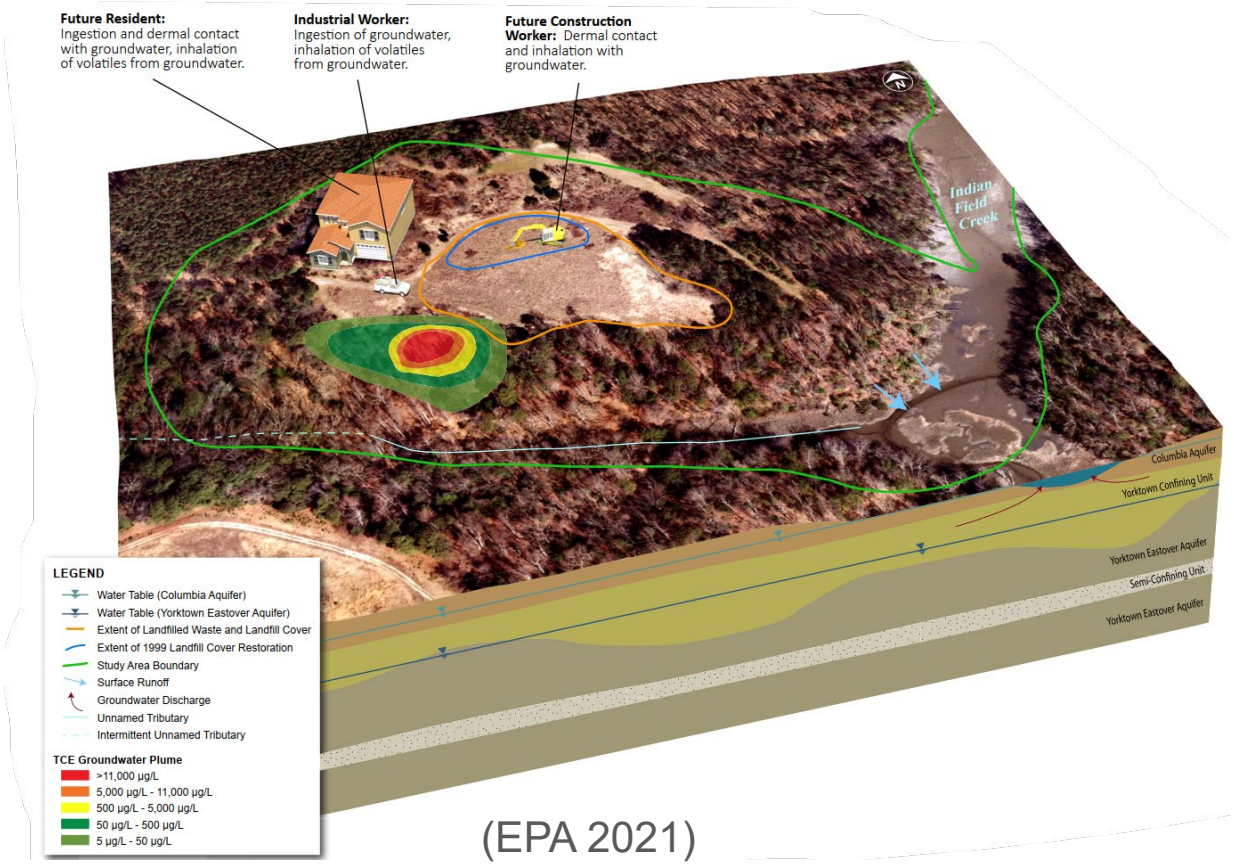
TO: Superfund and Emergency Management Division Directors, Regions 1-10

1,1,2-TCA: 1,1,2-trichloroethane
AM: Adaptive Management
cis-1,2-DCE: cis-1,2-dichloroethene
NWS: Naval Weapons Station

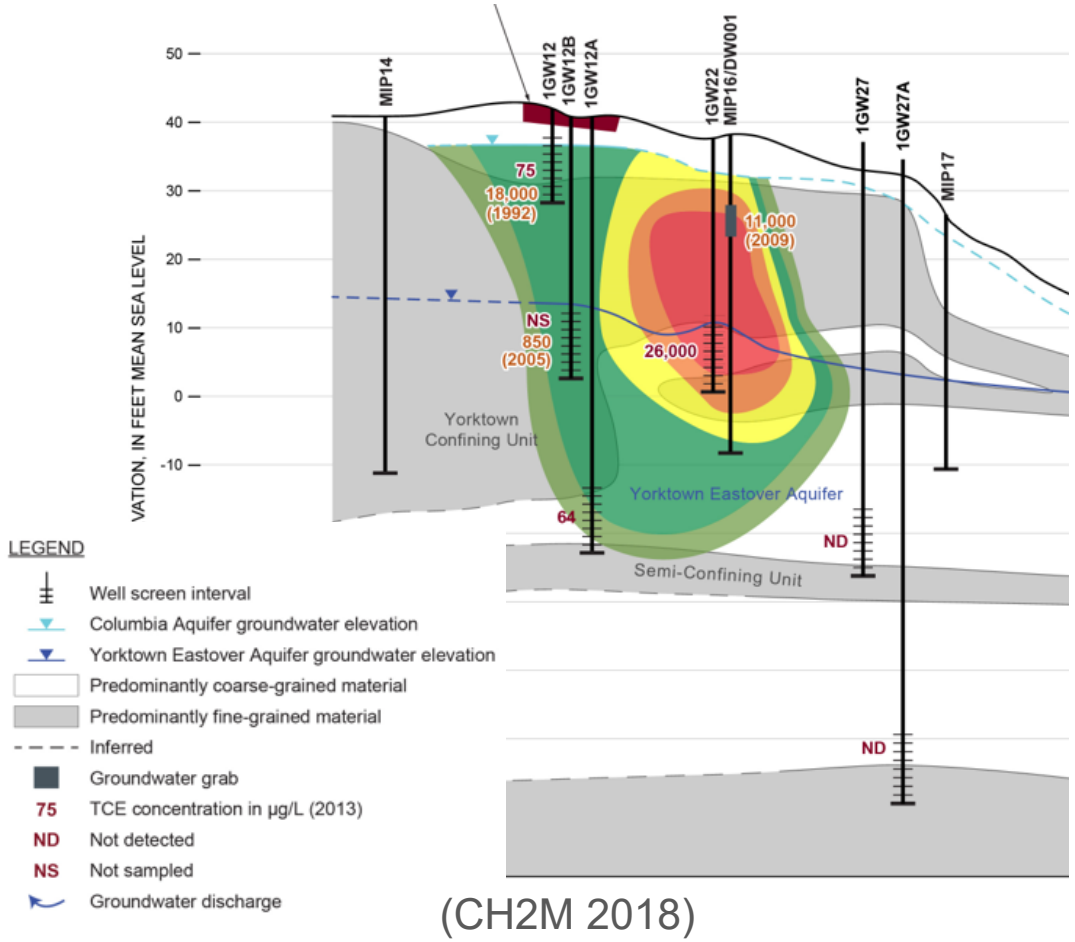
KEY POINT

Modeled after plan-do-check-act process for considering future decisions and metrics. Underscores CERCLA process is not always linear.

Conceptual Site Model



(EPA 2021)

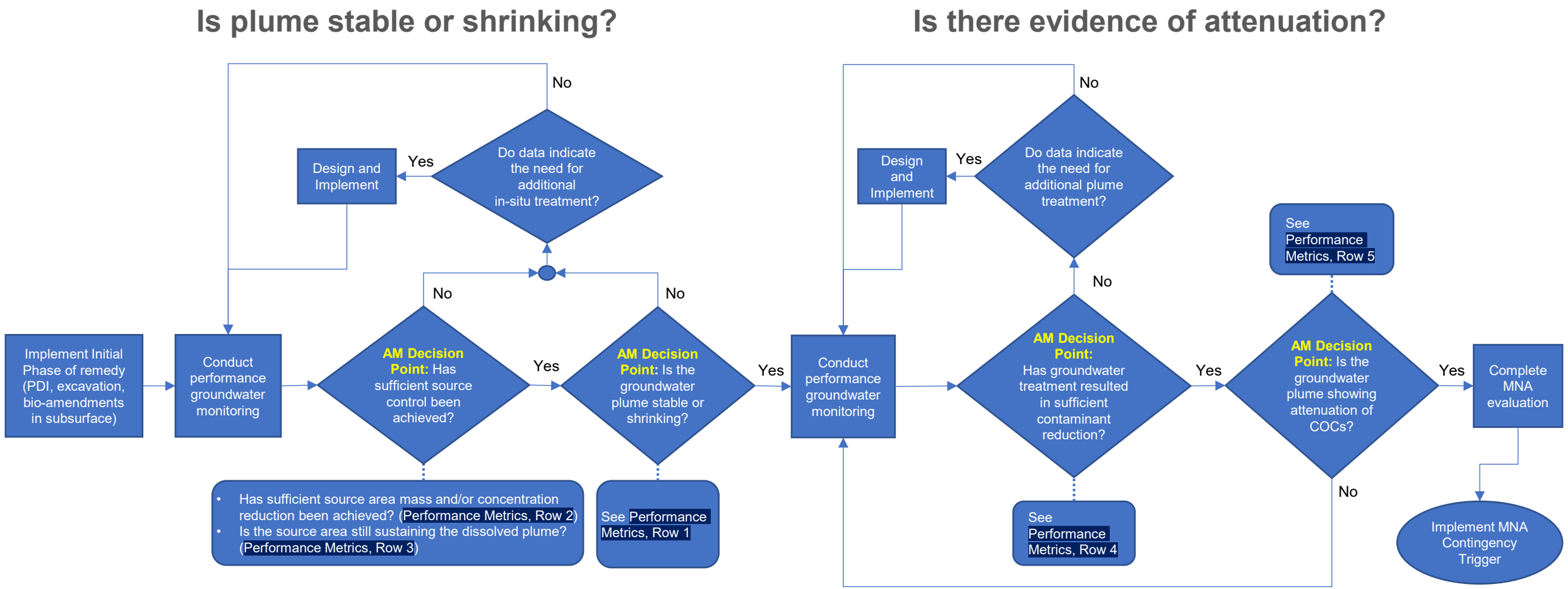


(CH2M 2018)

KEY POINT

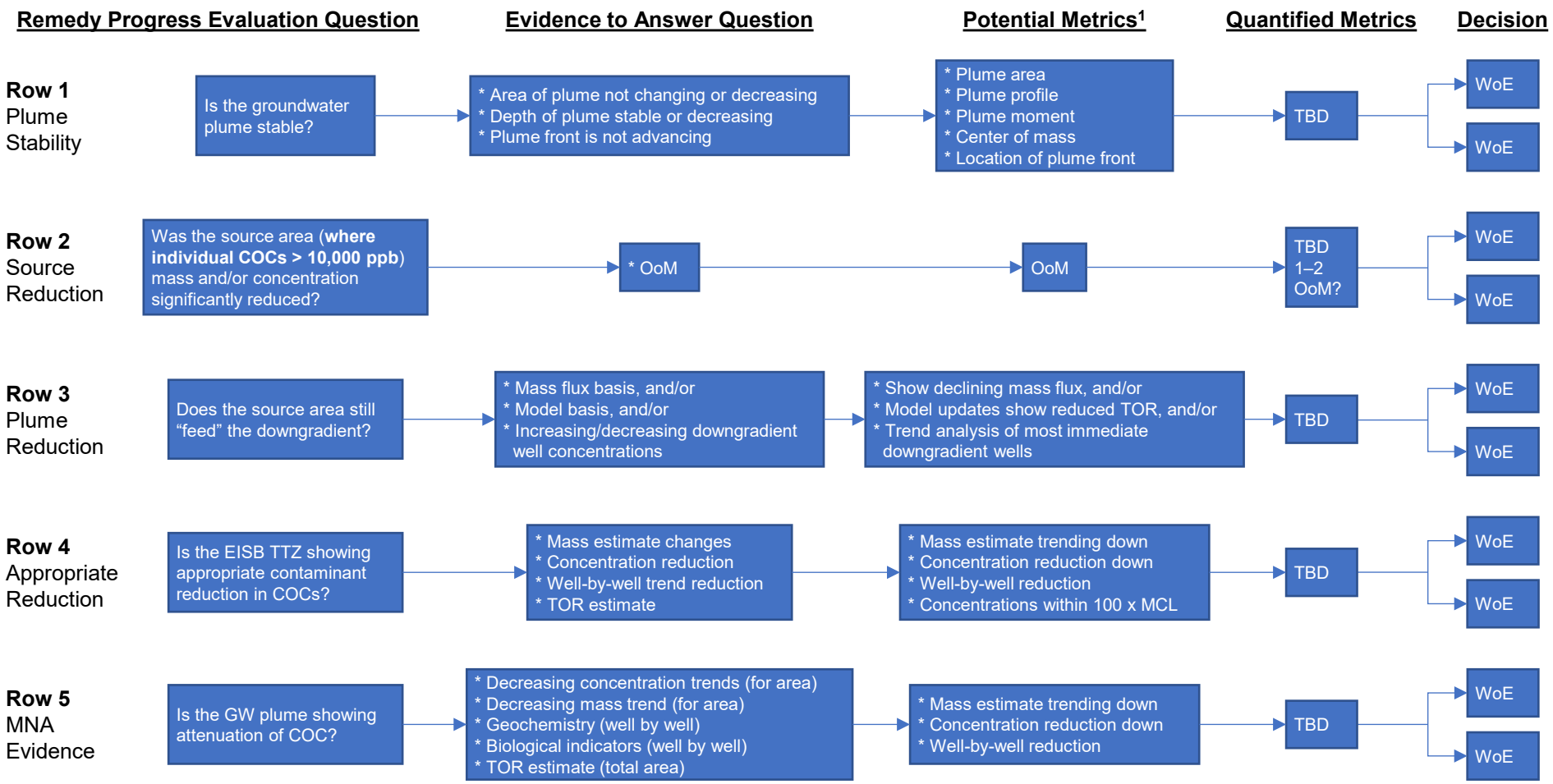
Challenging site conditions; contamination in fine-grained material unit. Expect contaminant rebound after initial injections.

Decision Flow Chart for Adaptive Management



(Jacobs 2025)

Performance Monitoring and Metrics



[1] These metrics can be used to answer the remedy progress evaluation questions. They will be considered as part of the AM process and finalized based on the results of the PDI. These metrics are only example considerations at this time. Metrics will be finalized in SAP and may change based on results of the PDI future work at the site, as agreed upon by the partnering team.

Columns

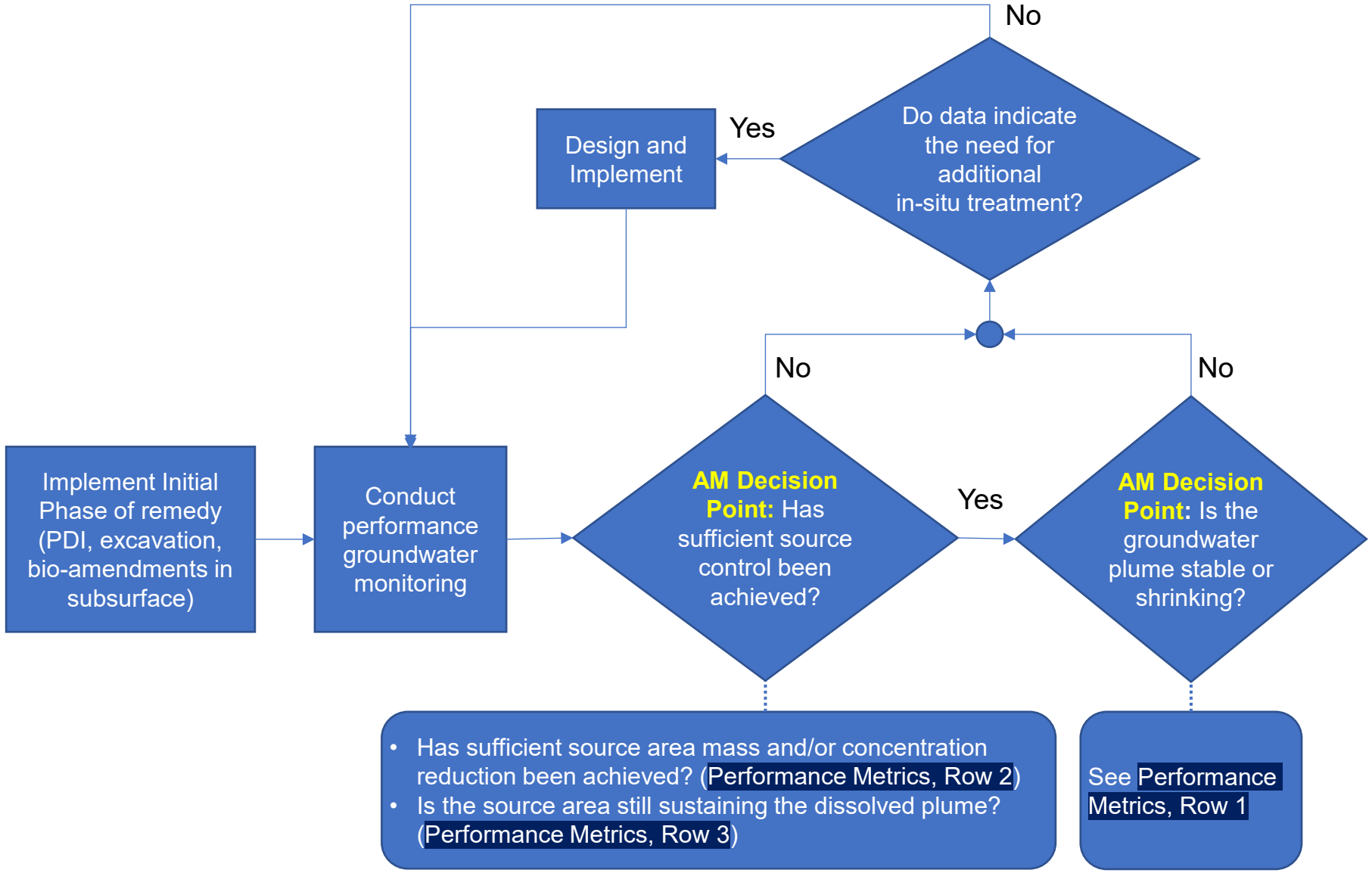
- Remedy Progress Evaluation Question
- Evidence to Answer Question
- Potential Metrics
- Quantified Metrics
- Decision Based on Metrics

Rows

- Plume Stability
- Source Reduction
- Plume Reduction
- Appropriate Reduction
- MNA Evidence

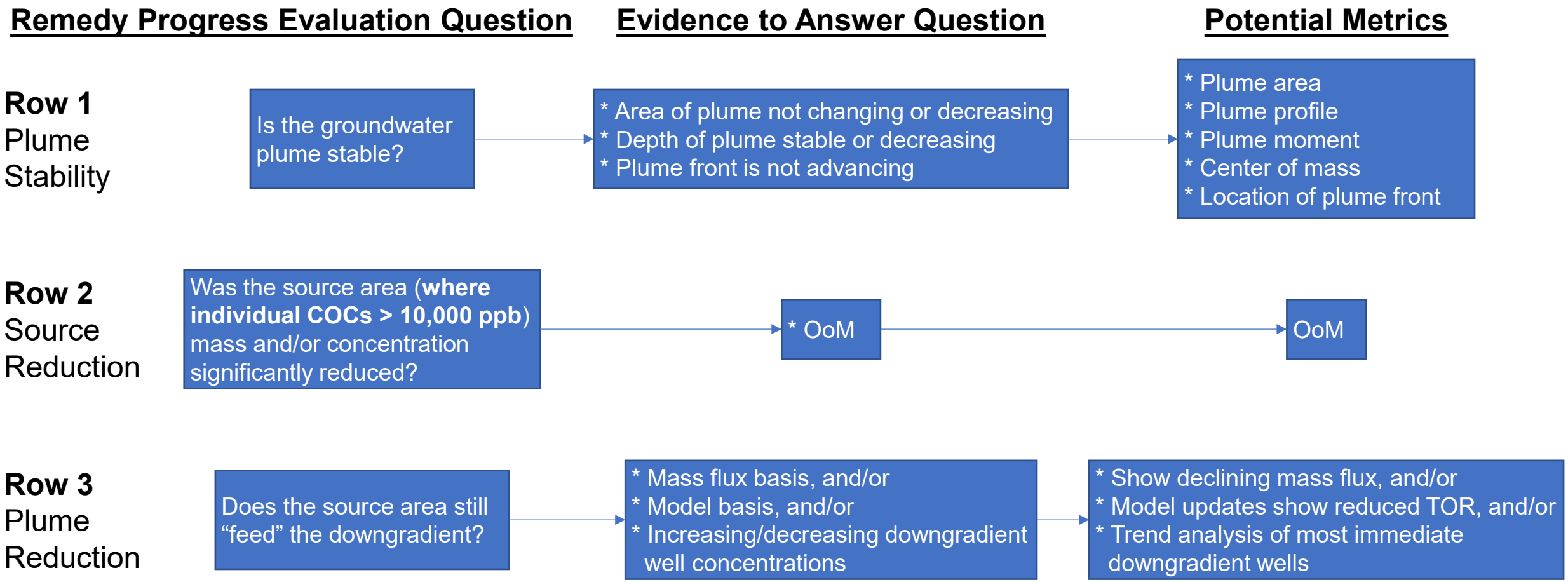
(Adapted from Jacobs n.d.)

Is plume stable or shrinking?



PDI: predesign investigation

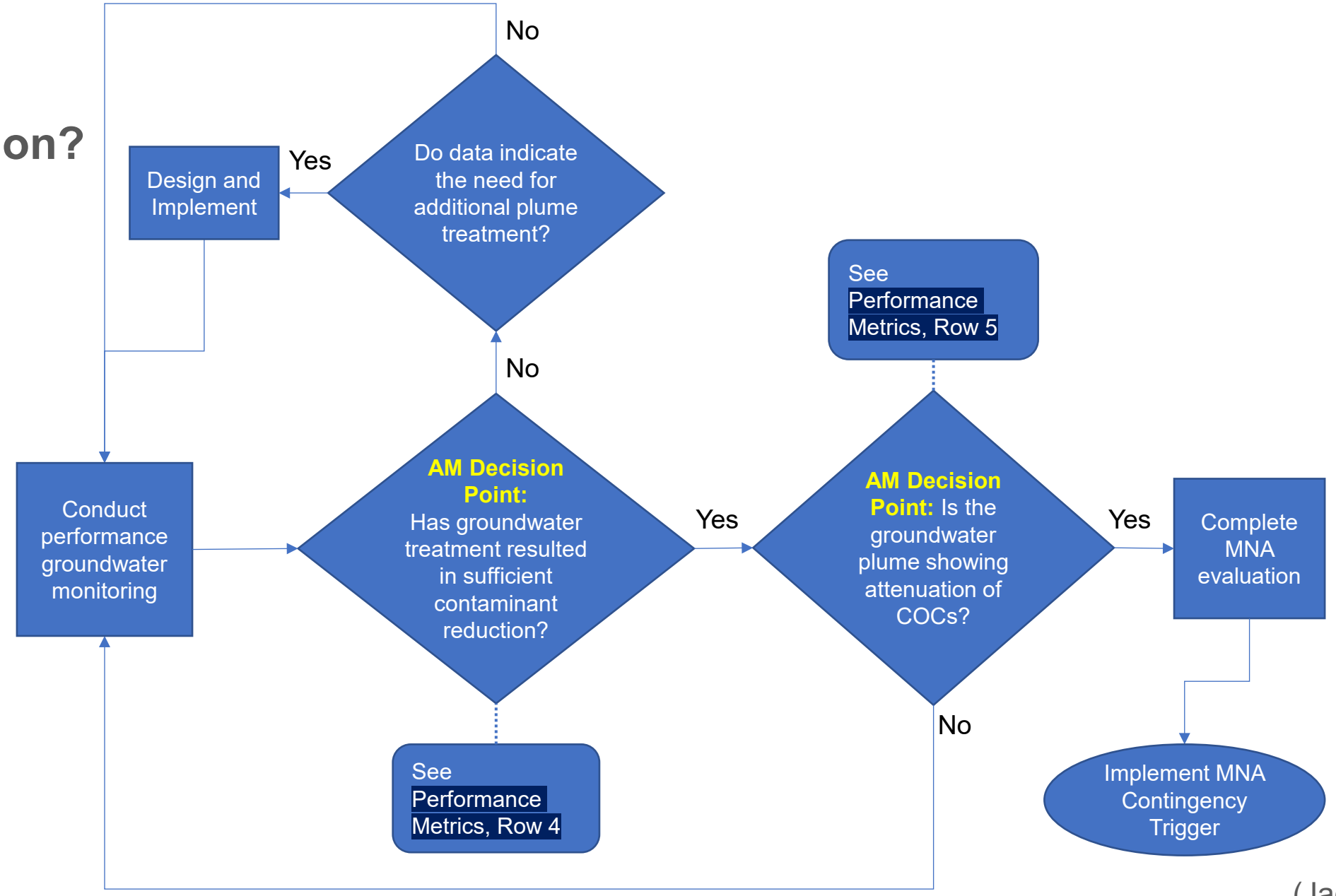
(Jacobs 2025)



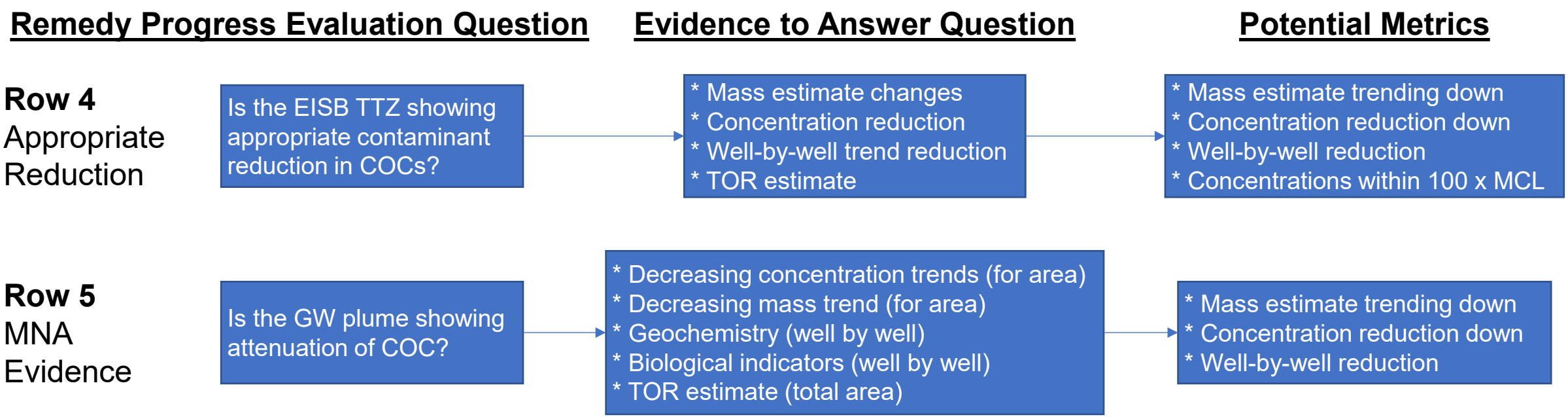
OoM: Order-of-Magnitude
ppb: part(s) per billion
TOR: Time of Remediation

(EPA 2021)

Is there evidence of attenuation?



(Jacobs 2025)



EISB: enhanced in situ bioremediation
TTZ: target treatment zone

(EPA 2021)

Adaptive Management Pilot Lessons Learned

- Recommendations: OLEM Directive 9200.3-123 (June 2022)
  - Early engagement by stakeholders
  - Technical, legal, and management staff
- AM process may be too early for pre-decisional document phase
- There is greater project resolution in the design and RA-O phase

KEY POINT

Requires a high level of coordination with regulators. AM is not a common process, so there is still learning curve. If you have the right team chemistry, could result in expanding scope definition in later project phases.

OLEM: Office of Land and Emergency Management

Knowledge Check: Transition Assessment

Question: What is primary purpose of transition assessment?

Answers:

a. To document remedy has been operating for sufficient period of time
b. To determine whether MNA should replace all active remedies
c. To evaluate whether active remedy can transition to passive approach or optimized LTMgt while remaining protective
d. To satisfy regulatory requirement before site closure

Knowledge Check: Transition Assessment

Question: What is primary purpose of transition assessment?

Answers:

a. To document remedy has been operating for sufficient period of time

b. To determine whether MNA should replace all active remedies

c. To evaluate whether active remedy can transition to passive approach or optimized LTMgt while remaining protective

d. To satisfy regulatory requirement before site closure

KEY POINT

Transition assessments turn monitoring data into defensible decisions about when and how to change remedy, rather than letting remedies operate indefinitely without evaluation.

Presentation Overview

- Introduction
- Overview of Exit Strategy Options
- Decision Frameworks
- Transition Assessments
- Case Studies
- Overcoming Challenges
- Wrap Up

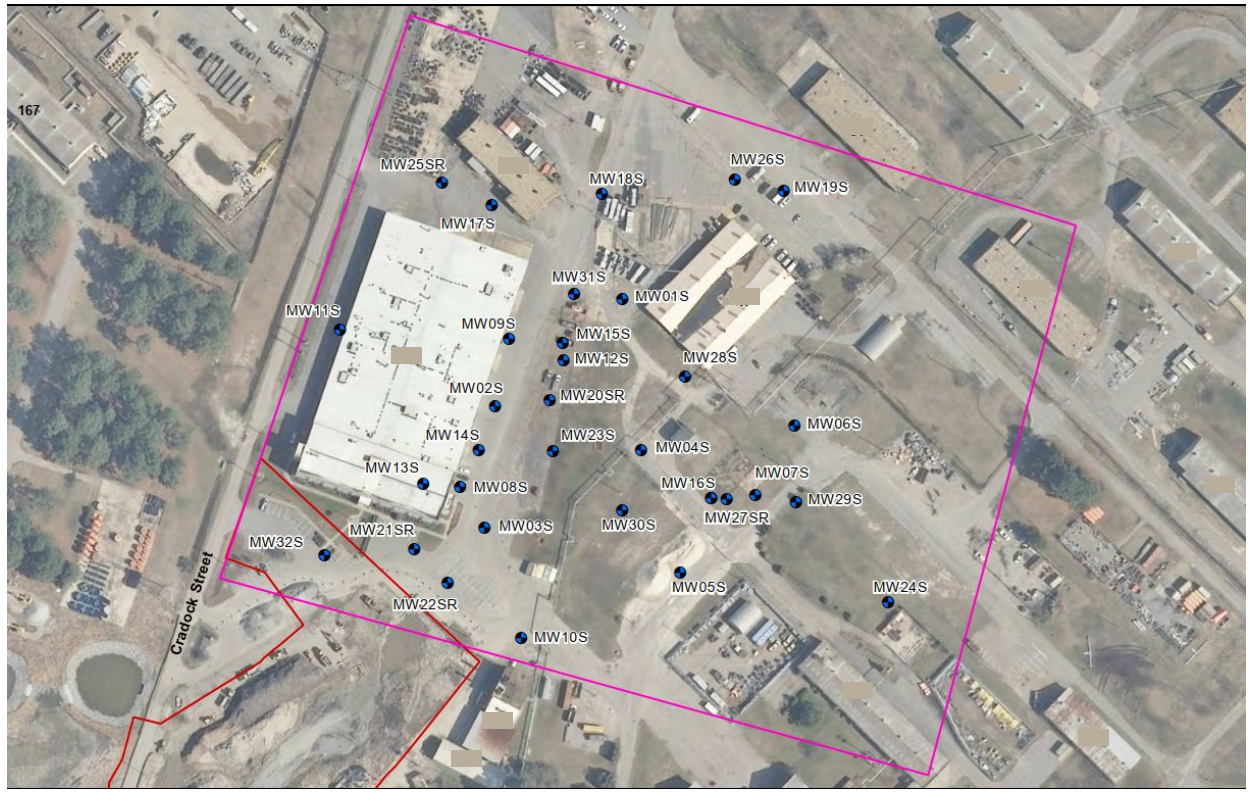
Case Study 1: St. Juliens Creek Site 21

Decision framework supports reduced LTM sampling

Chesapeake, VA
(Meadows 2025)

St. Juliens Creek Site 21 Background

- 20.8-acre area within SJCA with historical industrial and maintenance activities
- TCE and degradation products in groundwater
- Subsurface consists of Columbia aquifer underlain by Yorktown confining unit

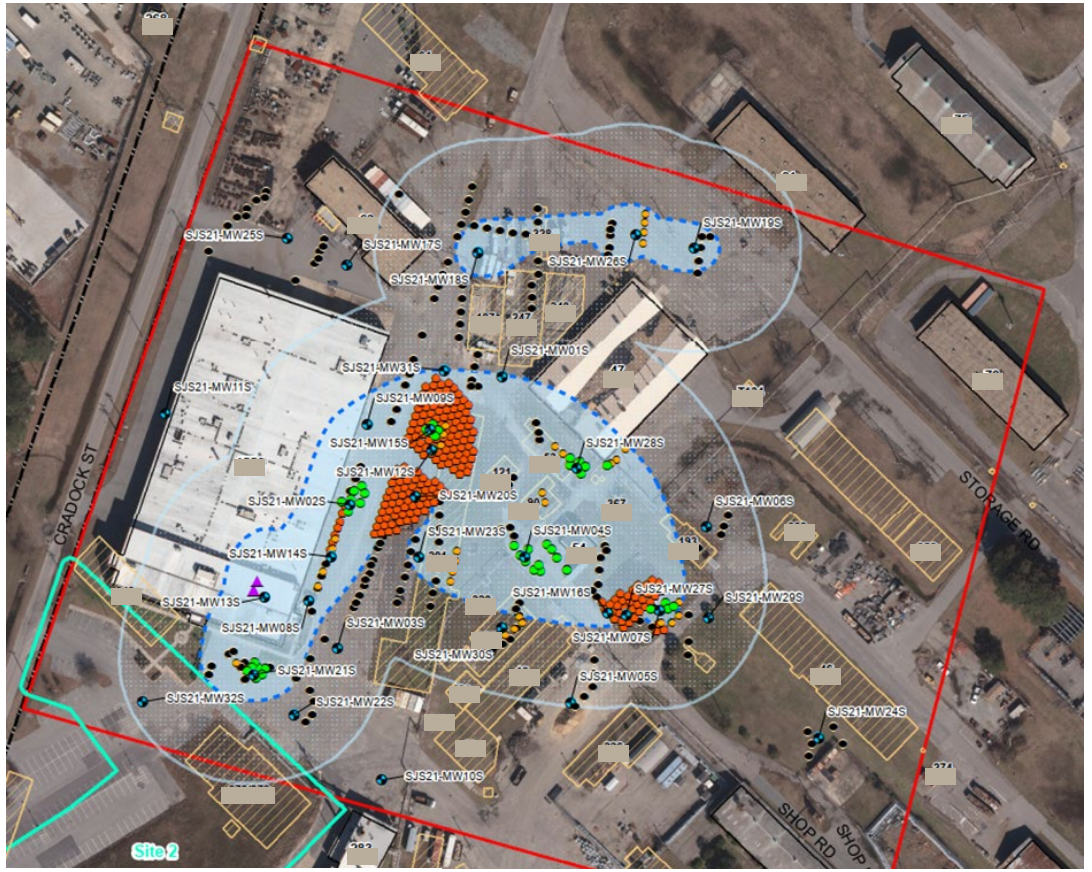


Groundwater Monitoring Well Network
(Meadows 2025)

SJCA: St. Juliens Creek Annex

2011 ROD Selected Remedy

- In situ chemical reduction conducted using ZVI (orange) and ERD (black) using EVO and LUCs for groundwater use and building use (blue)
- Remedial implementation was completed in 2012, with polishing EVO injections in 2014 and 2019/2020 (green)
- Site is in RA-O phase, with semiannual groundwater, stormwater, and vapor intrusion monitoring, and annual LUC inspections



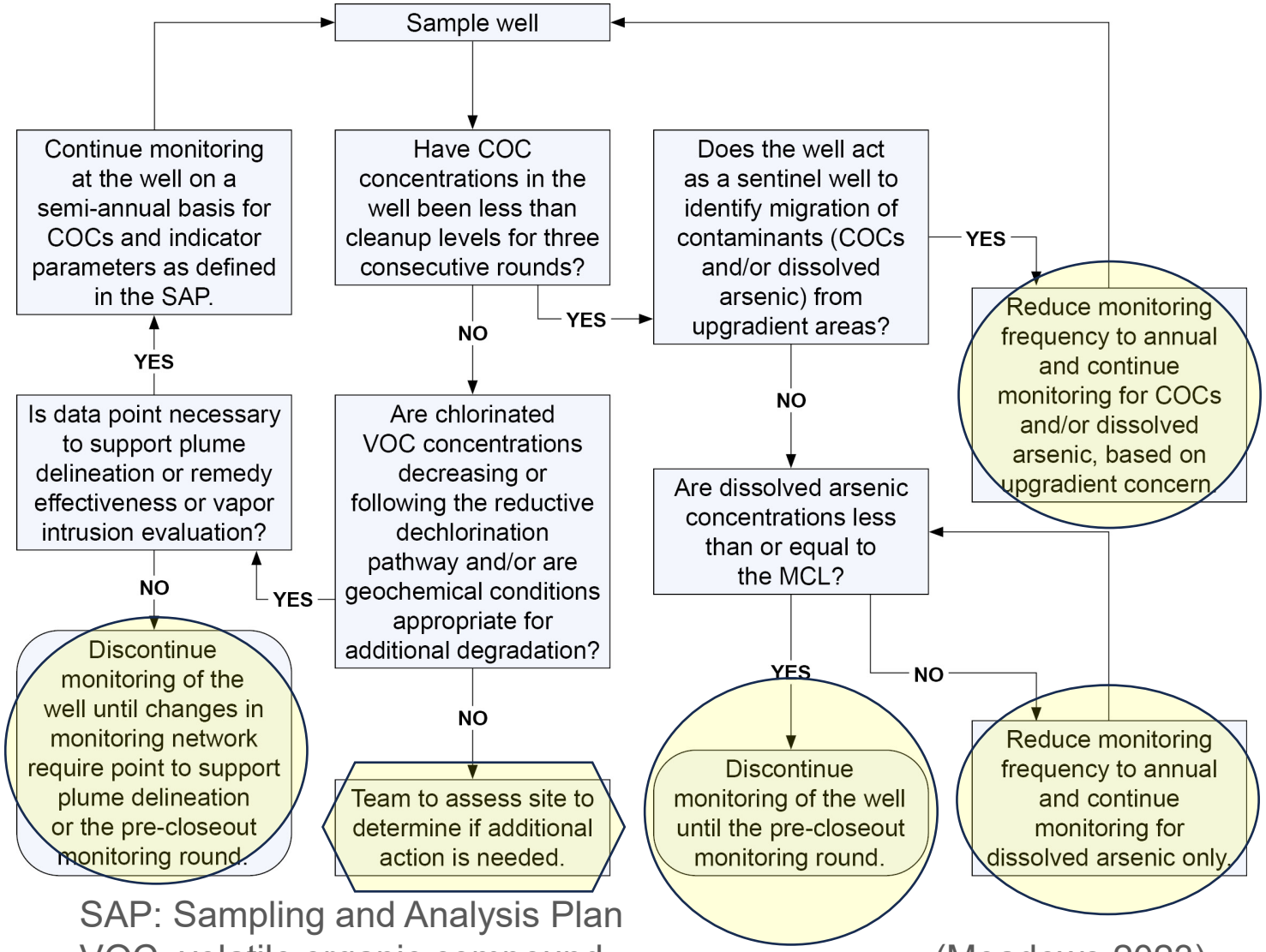
(Meadows 2025)

Legend

- Monitoring Well
- Proposed Temporary EVO & DHC Injection Location (2019/2020)
- Permanent EVO Injection Well*
- Temporary EVO Injection Location (2014)
- Temporary ZVI Injection Location (2011)
- Temporary EVO Injection Location (2011)
- Demolished Building
- Land Use Control Boundary - Groundwater (Inhalation)
- Existing Building
- Site 2 Boundary
- Site 21 Boundary
- Former Site 2 Inlet
- St. Juliens Creek Annex Boundary
- Land Use Control Boundary - Groundwater (Potable use)
- Cumulative COC Groundwater Plume

EVO: emulsified vegetable oil
ZVI: zero-valent iron

Decision Logic for Optimizing Sampling



SAP: Sampling and Analysis Plan
VOC: volatile organic compound

(Meadows 2023)

Decision Logic for

- Which parameters are sampled
- When they are sampled
- How often they are sampled
- Conditions for well exiting the sampling network

= favorable outcome

= unfavorable outcome

TCE Changes Over Time

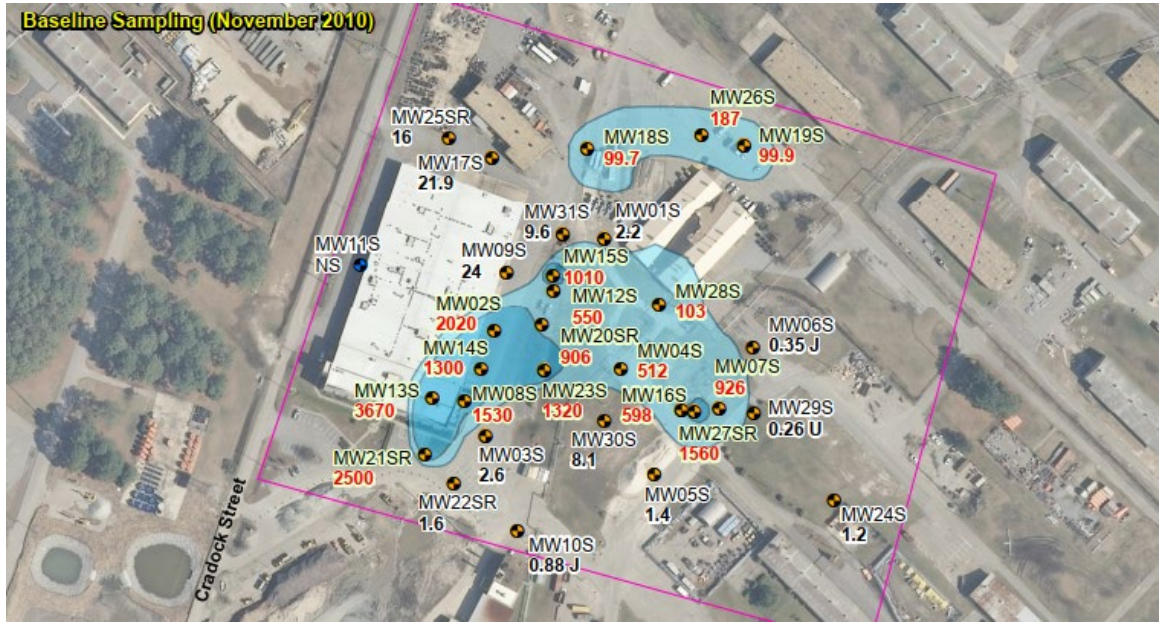
Significant Progress

(Meadows 2025)

FYR: Five-Year Review

Cis-1,2-DCE Changes Over Time

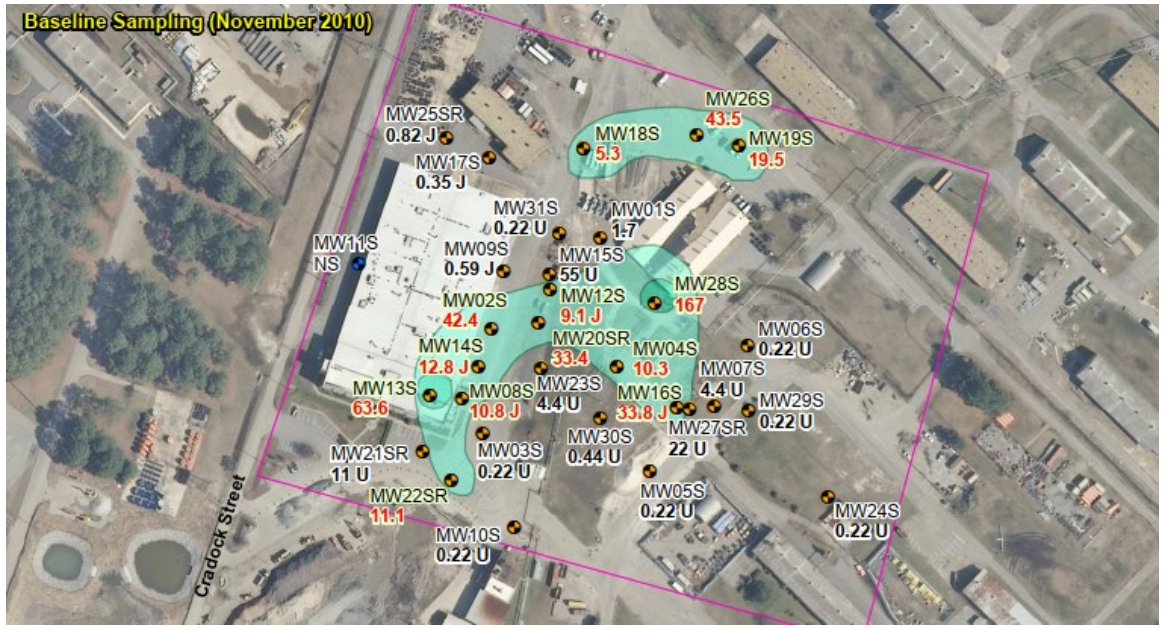
Significant progress but several pockets remain

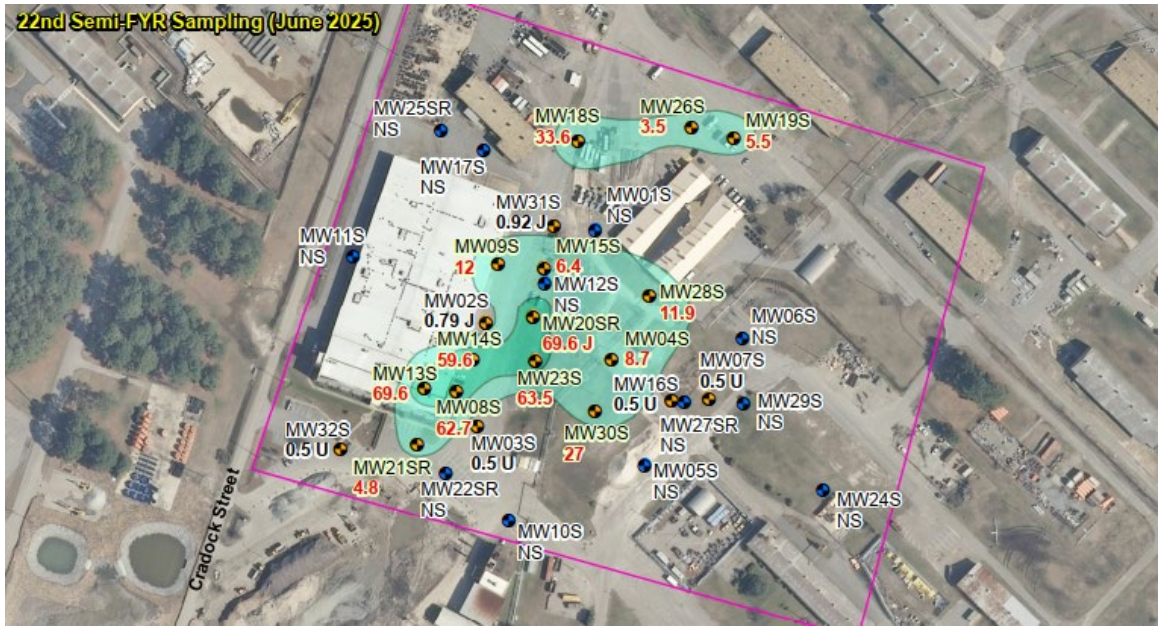


(Meadows 2025)

VC Changes Over Time

Expanded footprint and slightly higher concentrations, compared to pretreatment conditions

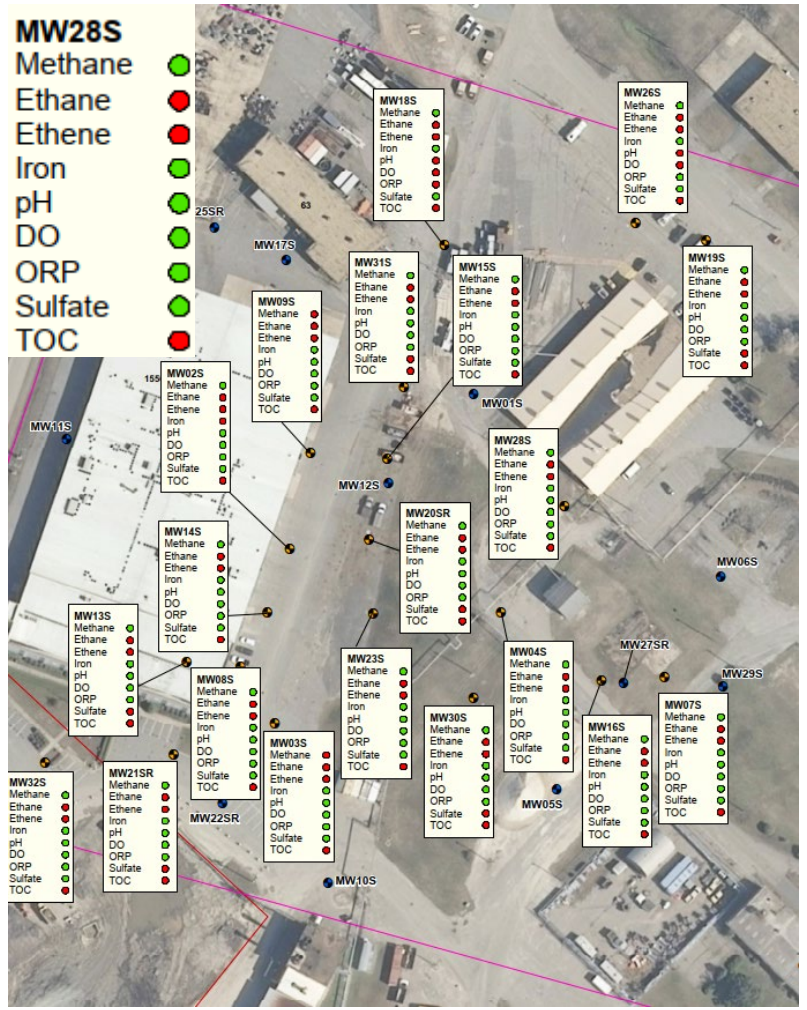




(Meadows 2025)

Remedial Action Monitoring

- Chlorinated ethenes, arsenic, and NAIPs were collected semiannually from December 2011 through November 2022
- Results documented in semiannual reports
- Flowchart was evaluated and recommendations made
- Several wells were able to exit network (between higher concentrations areas and sentinel wells)
- Progress was slower than anticipated
- Optimization study was recommended



(Meadows 2025)

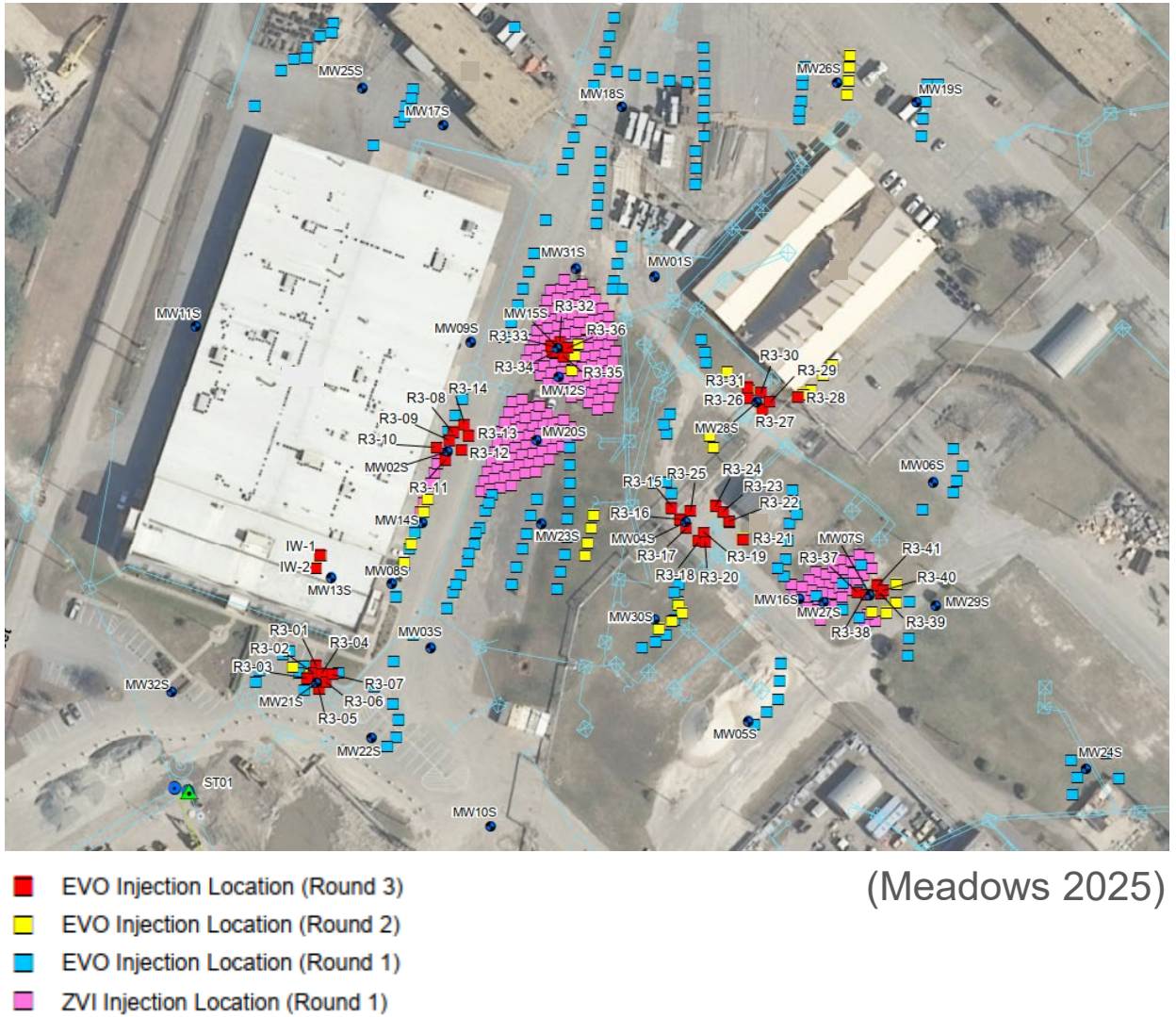
LEGEND

- Within ideal PIL range
- Out of ideal PIL range

NAIP: natural attenuation indicator parameter
PIL: project indicator limit

2019 Optimization Study Focus

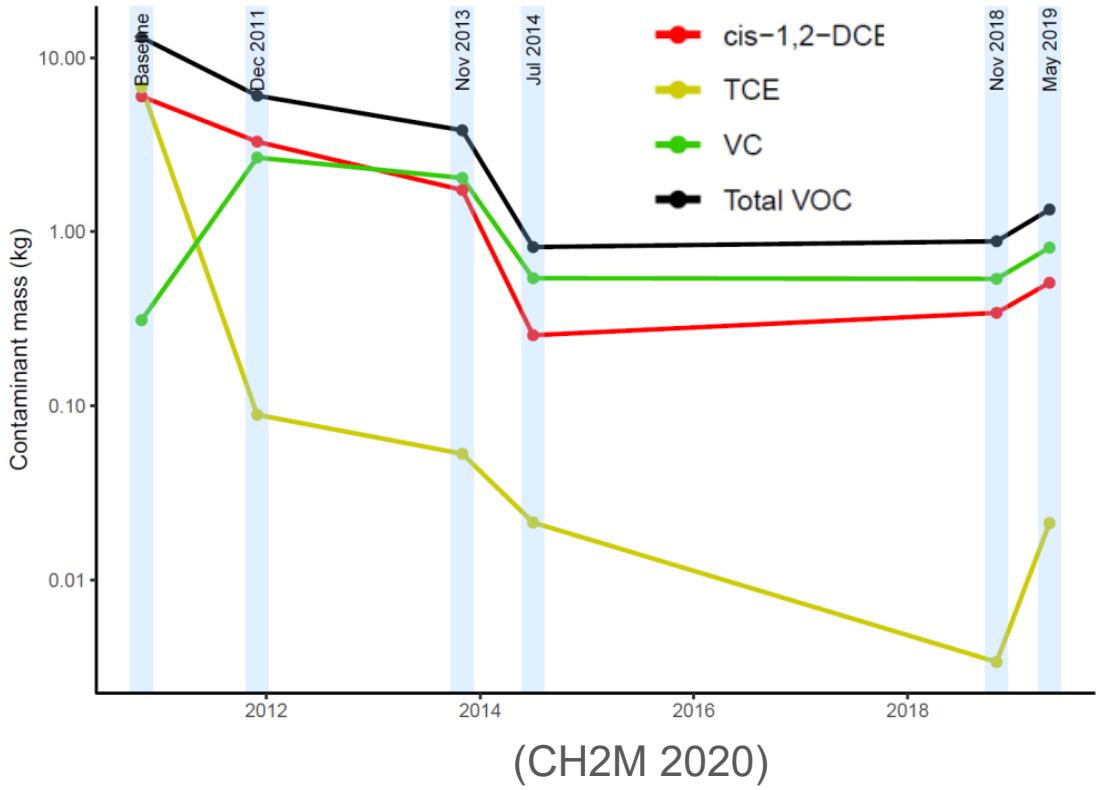
- Assessing contaminant mass trends since remediation began
- Estimating time frames to achieve cleanup goals using modeling and trend analyses
- Identifying optimization opportunities for existing remedy based on those results



(Meadows 2025)

Estimating Contaminant Mass

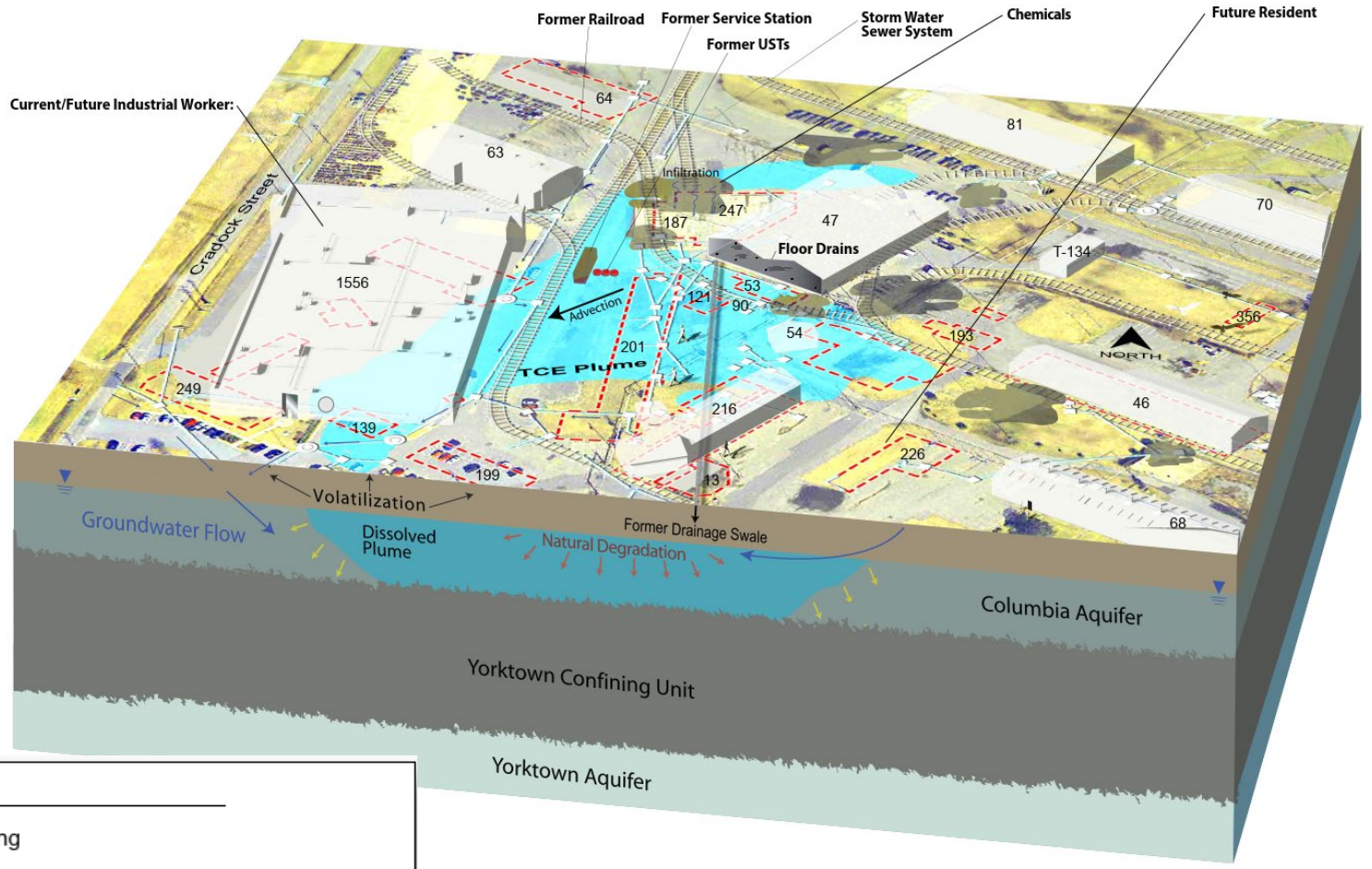
- Well-by-well analysis showed only part of story
- Holistic view of site mass changes as necessary
- Evaluated mass estimates over since baseline levels through 2019
- Optimization findings identifies:
  - Matrix diffusion
  - Depletion of organic carbon
  - Possible migration of higher-concentration “pockets” between monitoring wells

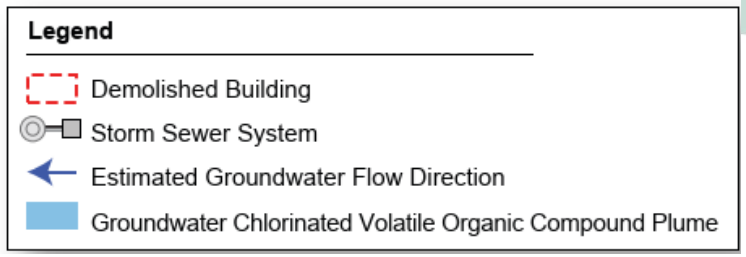


(CH2M 2020)

Matrix Diffusion Evaluation

- Columbia aquifer interlayered with lower-permeability clayey materials (contaminant reservoir)
- Groundwater concentrations leveling off or rebounding
- REMChlor-MD modeling was used to forecast performance





(CH2M 2023)

REMChlor-MD Conclusions

- Modeling concluded matrix diffusion was significant factor in plume persistence
- Likely outpaced degradation of contaminants
- REMChlor-MD predicted extended remediation time frames with conservative scenarios (designed to avoid underestimating remediation frames)

- 4 of 7 wells – decreasing cis-1,2-DCE trends (3 increasing)
- 2 of 7 wells – decreasing VC trends (5 increasing)
- Remediation time frames with increasing or stable concentrations cannot be predicted

Estimated Time to Meet MCL for Cis-1,2-DCE (does not consider VC production)

Well ID	Years to reach MCL (70 µg/L)
MW2S	5.2
MW4S	NC
MW7S	9.8
MW13S	19.3
MW15S	NC
MW28S	NC
MW26S	4.3

(CH2M 2020)

µg/L: microgram(s) per liter
NC: not calculated, concentration increasing

Optimization Recommendations and Benefits

Optimization Recommendations

- Evaluate supplemental or alternative treatment technologies
- Perform cost-benefit analysis comparing life cycle costs of continued LTM versus additional active treatment
- **Reduce sample frequency from semiannual to twice every 5 years (implemented)**
- Collect NAIP and microbial parameters

Optimized LTM Benefits

- Provides seasonal variation
- Provides two rounds of data for Five-Year Reviews
- Reduces sampling and reporting costs by 80%
- Provides data for Five-Year Reviews

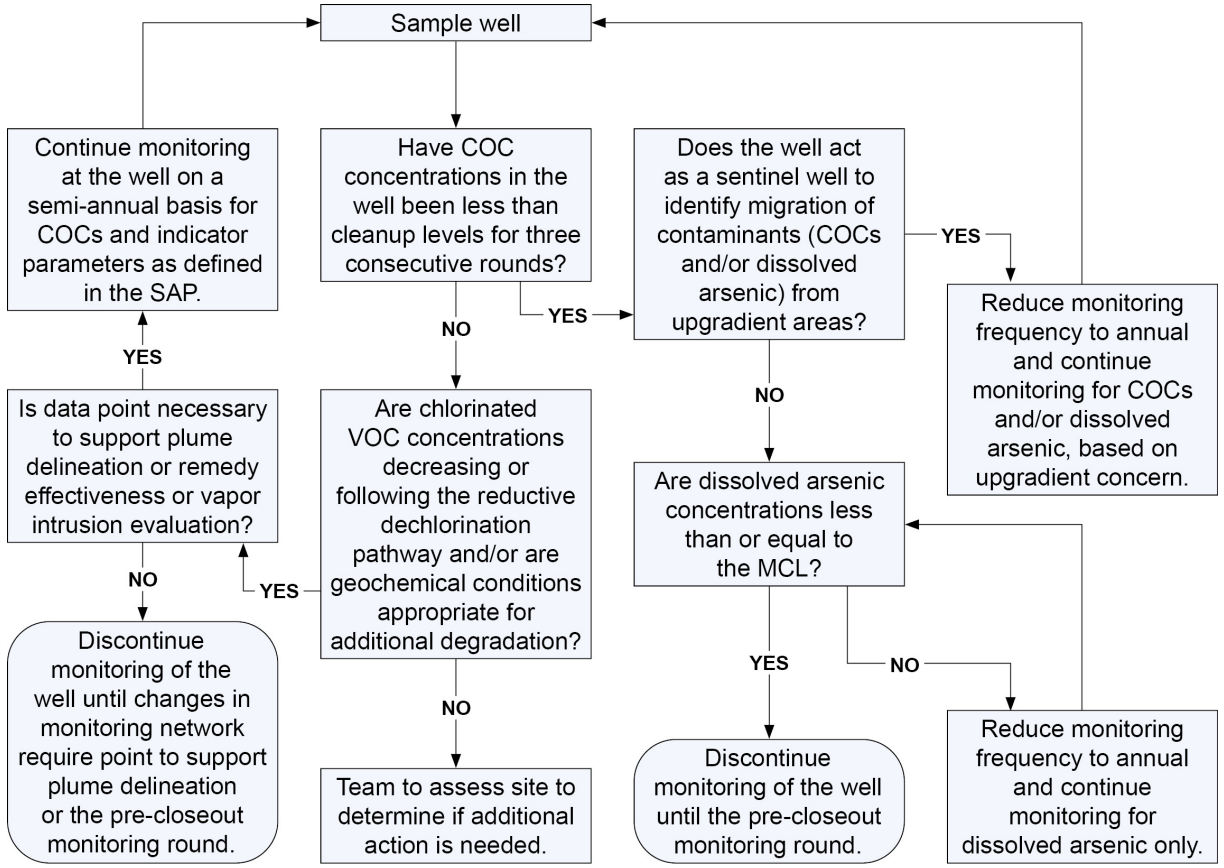
KEY POINT

Team selected reducing sampling frequency (waiting on PFAS investigation and potential impacts on treatment technologies).

PFAS: per- and polyfluoroalkyl substances

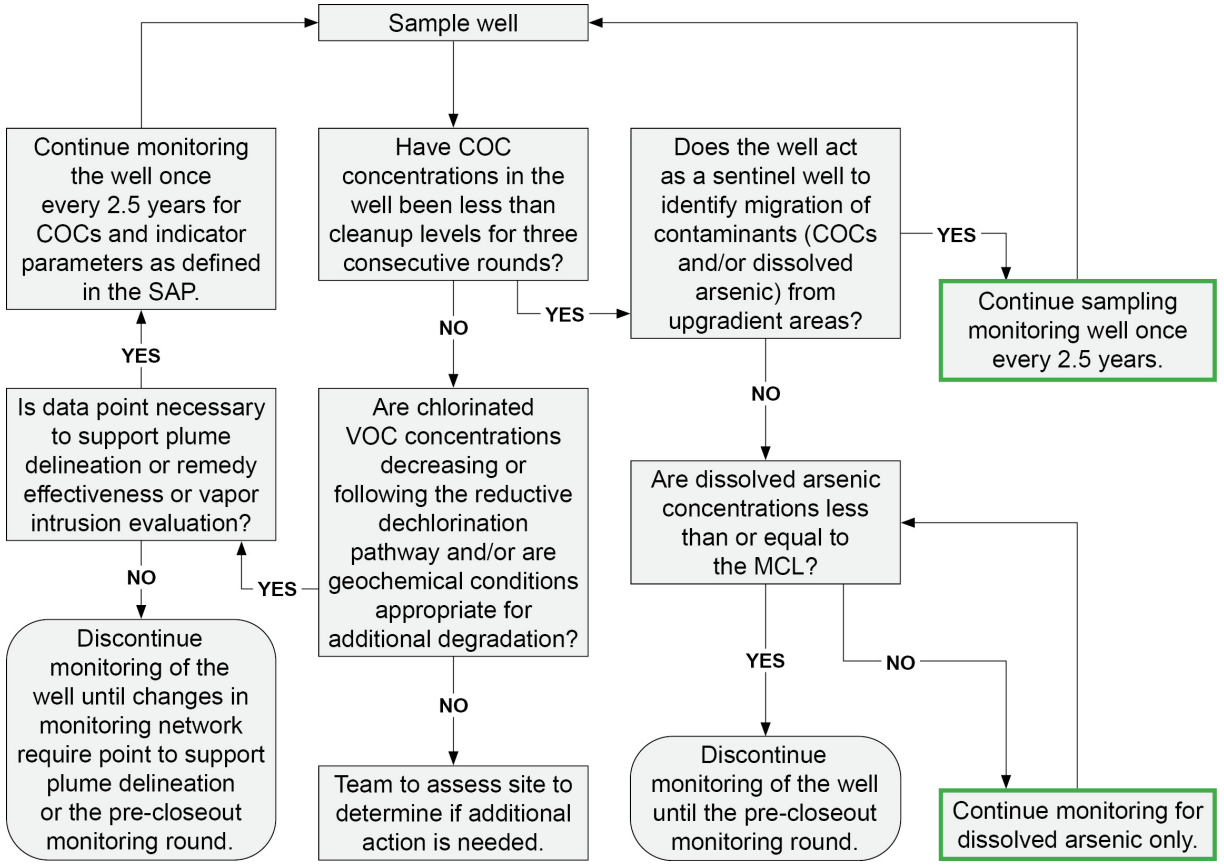
Updated Decision Logic for Well Network

Original



(Meadows 2023)

Optimized



Adjusted decision logic after optimization study

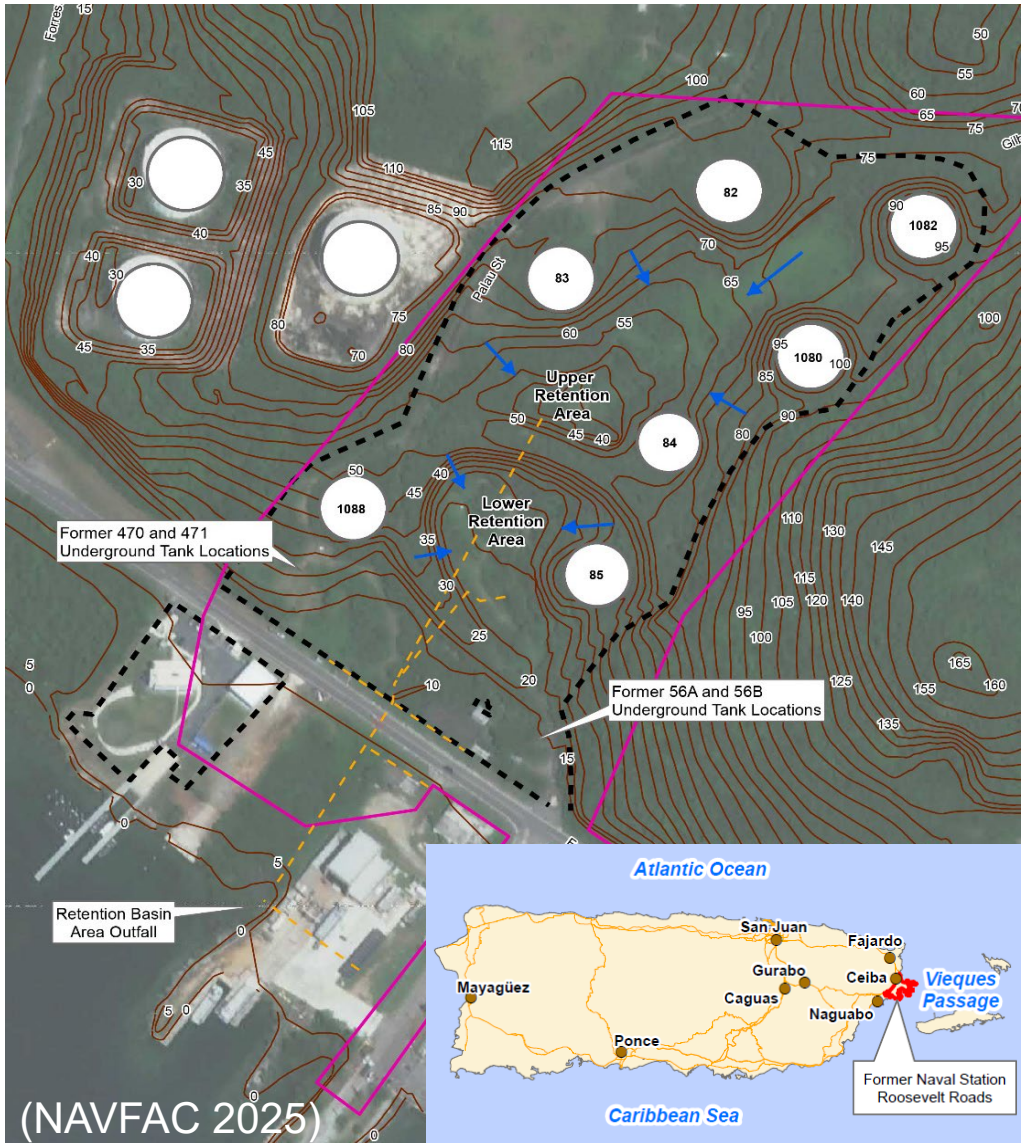
(Meadows 2025)

Case Study 1 OPTI Award Criteria Evaluation

- [x] Improves return on investment or avoids costs
- [ ] Accelerates reaching remedial goal
- [ ] Use of innovative technology or approach
- [x] Required extra/unique stakeholder negotiations

Case Study 2: NAPR SWMUs 7 and 8 Site History Transition Assessment and Exit Strategy

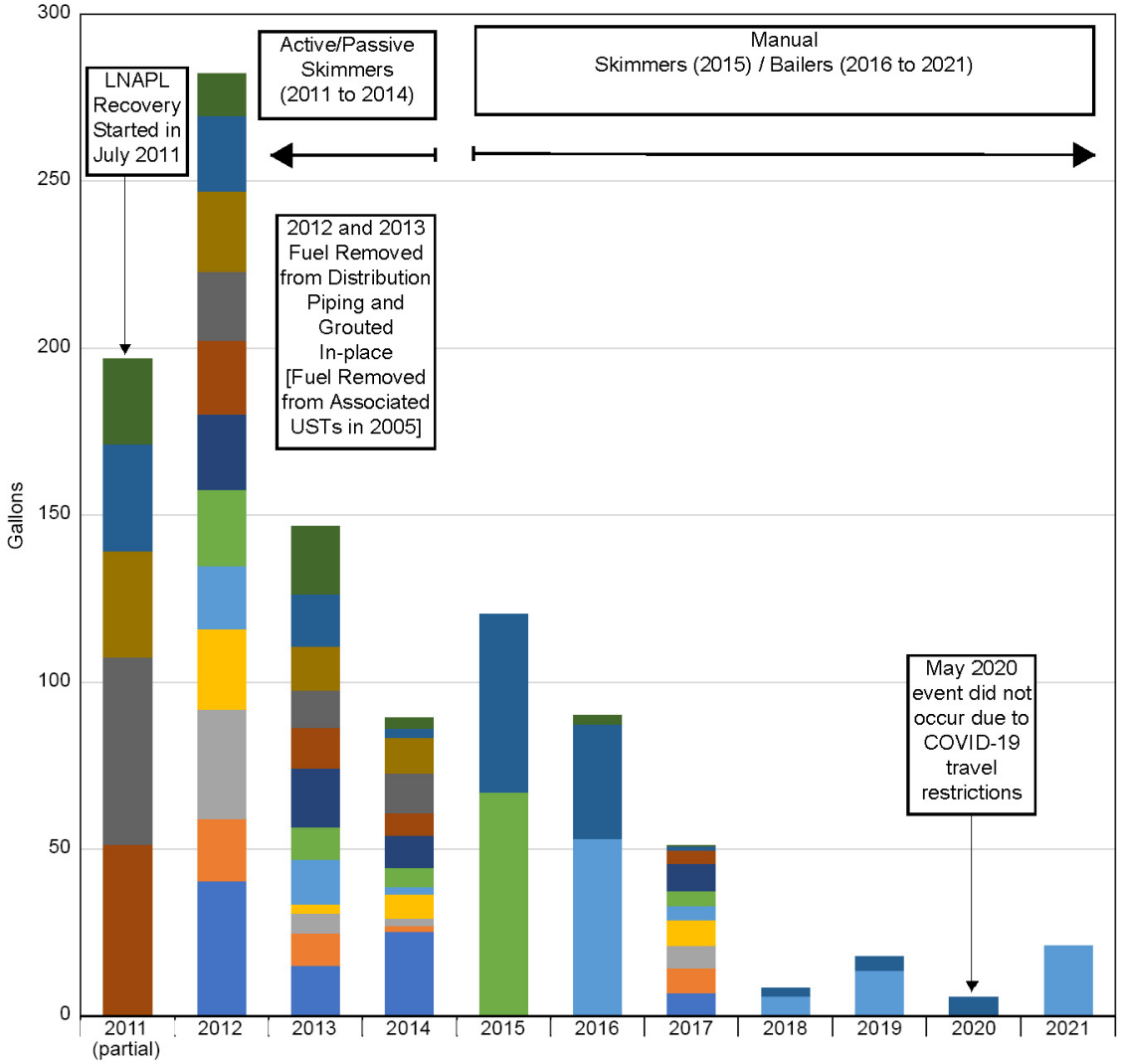
- Former TWFF constructed in 1957 and ceased operation in 2004
- Eleven USTs
- CAOs
  - LNAPL goal of 0.01 foot or less in-well thickness
  - The CAOs for 1,2,4-TMB, ethylbenzene, and TCE were achieved in 2015
  - Benzene remained, groundwater goal of 160 µg/L
    - Based industrial worker inhalation of benzene from groundwater vapors in an industrial building



CAO: Corrective Action Objective
NAPR: Naval Activity Puerto Rico
SWMU: solid waste management unit
TMB: trimethylbenzene
TWFF: Tow Way Fuel Farm

LNAPL Removal Activities

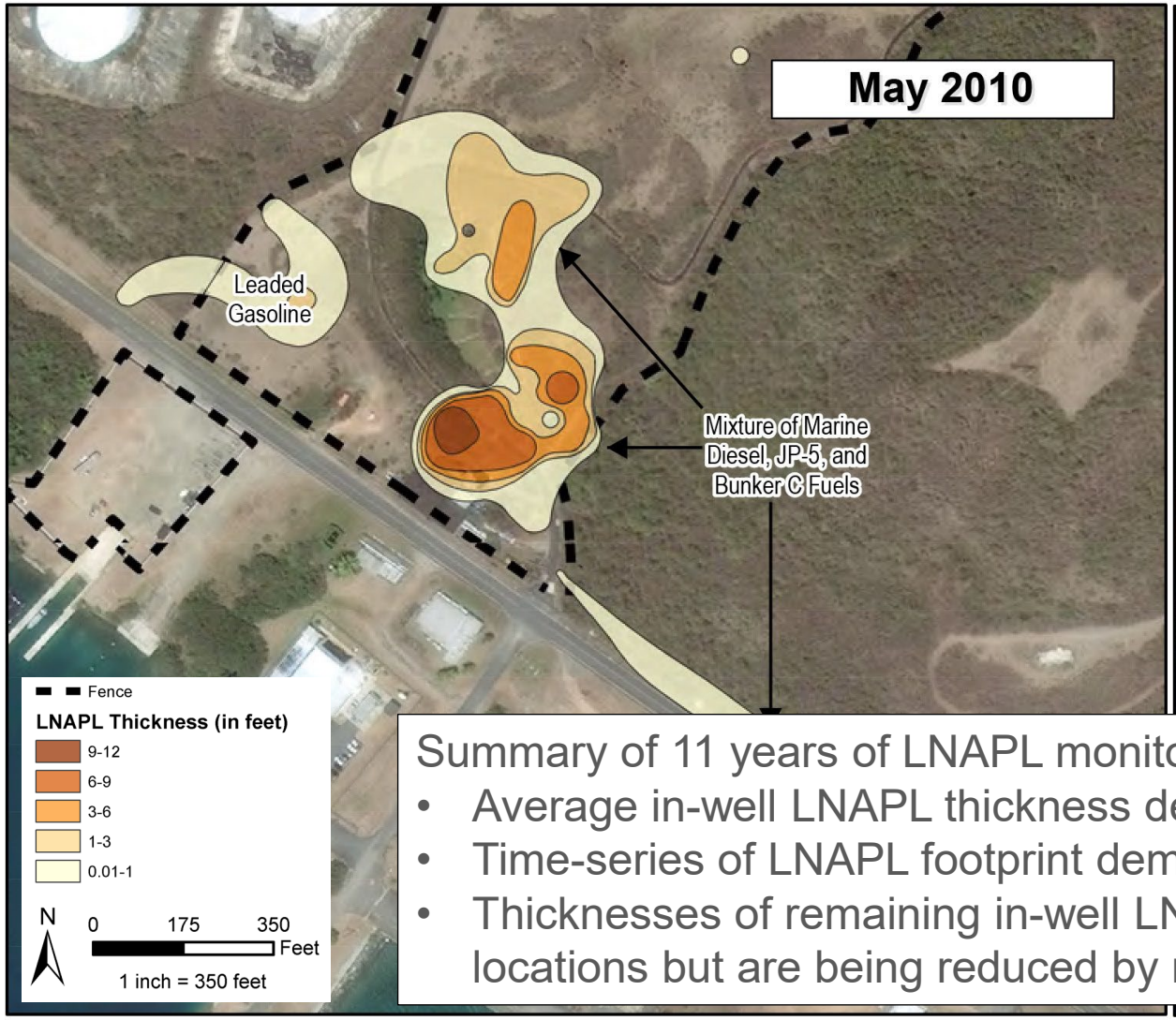
- Since 1994: Biodegradation by natural processes
- 1994 to 1996: Multi-phase product recovery
- 1996 to 2010: Clean-Ox injections, pneumatic fracturing, aggressive fluid vacuum, SVE, and total fluids recovery
- 2011 to 2014: Full-passive/active skimmer system
- 2015 to 2023: Manual product recovery



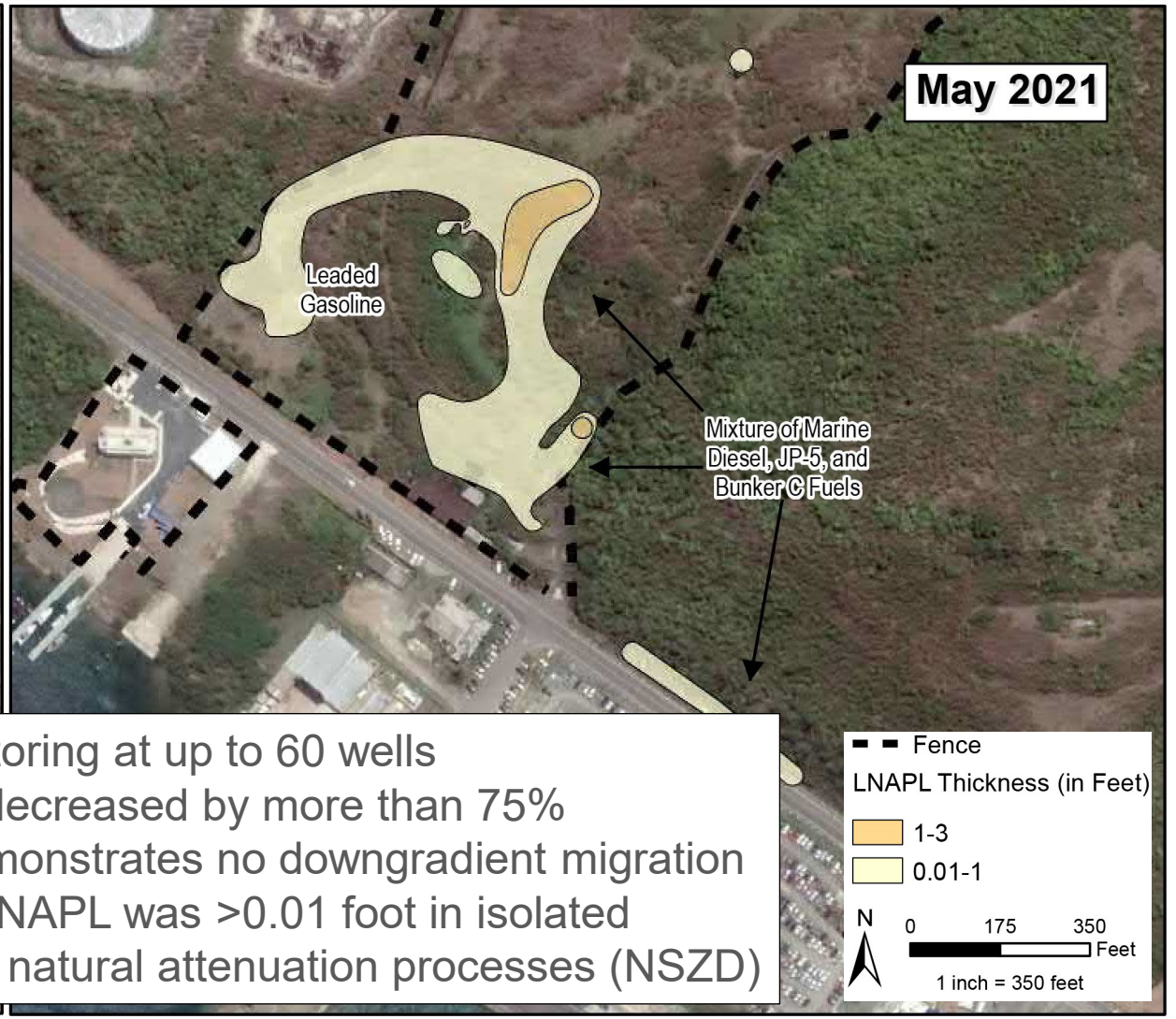
(CH2M 2023)

SVE: soil vapor extraction

In-well LNAPL Thickness Reductions



(AGVIQ-CH2M 2012)



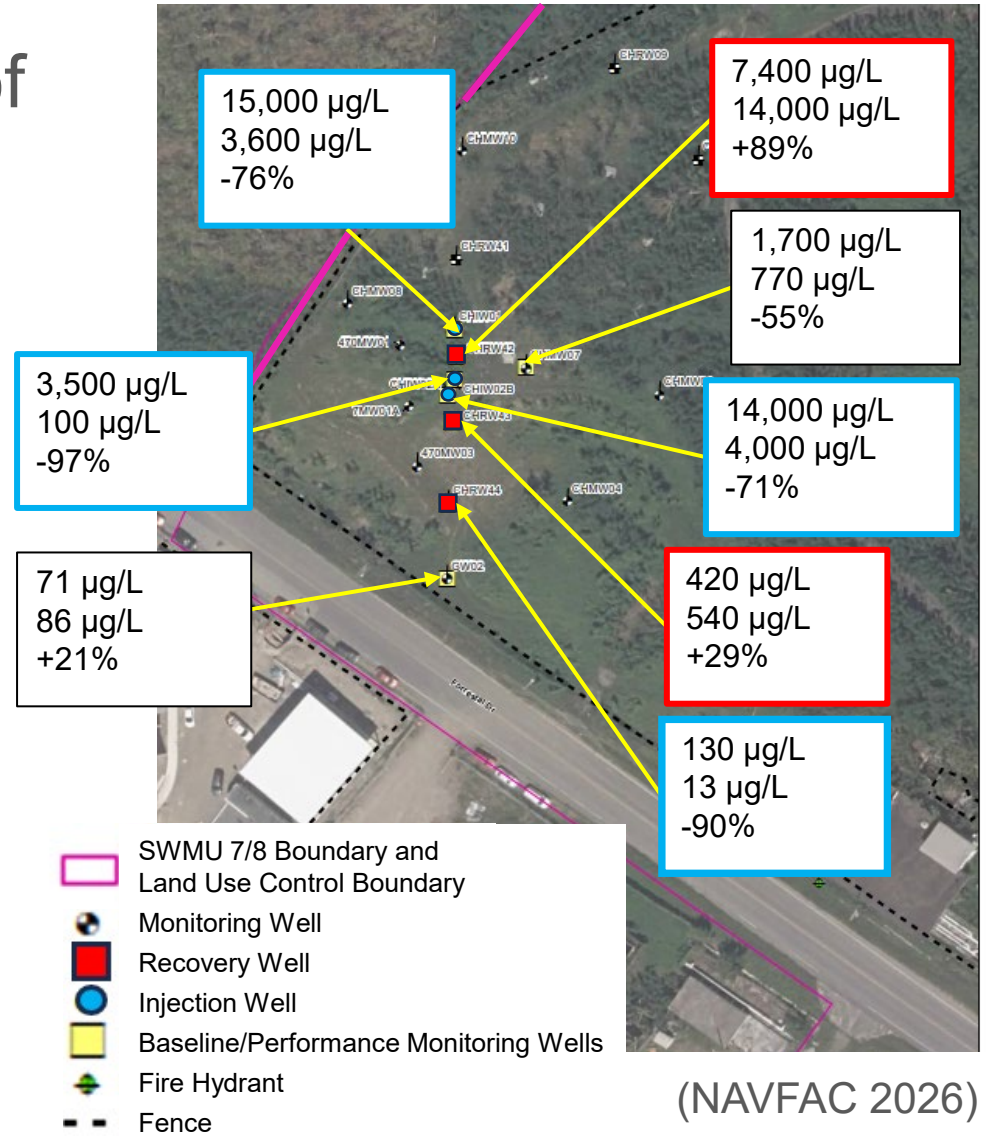
(CH2M 2023)

Summary of 11 years of LNAPL monitoring at up to 60 wells

- Average in-well LNAPL thickness decreased by more than 75%
- Time-series of LNAPL footprint demonstrates no downgradient migration
- Thicknesses of remaining in-well LNAPL was >0.01 foot in isolated locations but are being reduced by natural attenuation processes (NSZD)

Remedial Optimization for Benzene Plume

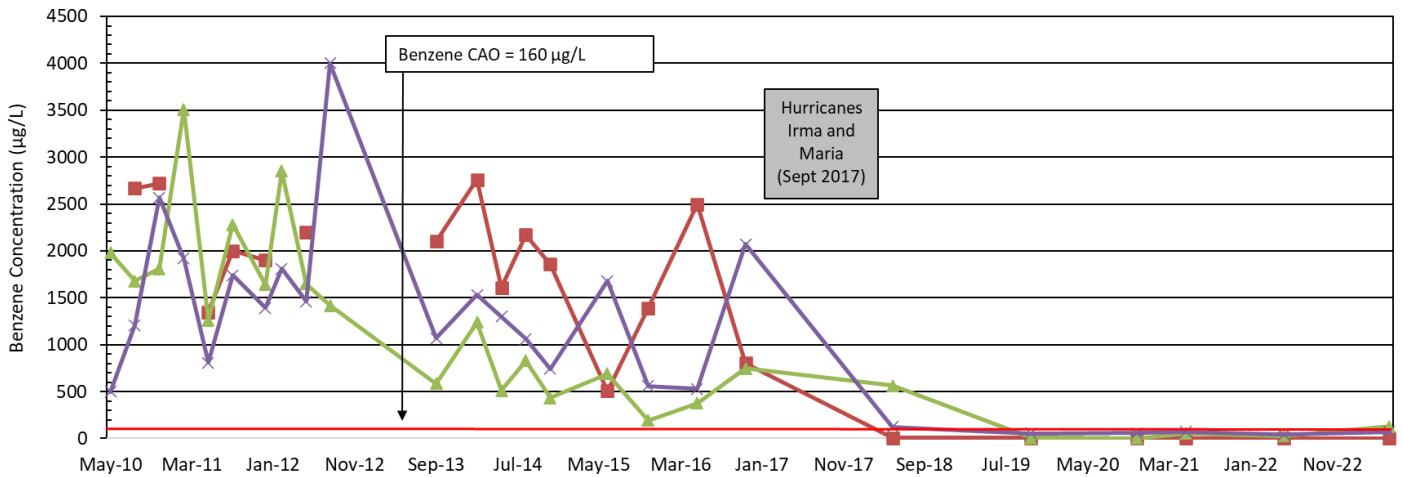
- Pilot study – enhance natural attenuation of persistent benzene in residual LNAPL core
- Approximately 81,000 gallons of sulfate solution injected into three wells in August 2023
- Findings after 14 months
  - Benzene concentrations decreased at some locations and increased at others
  - Mixed results suggest inconsistent sulfate distribution and persistence

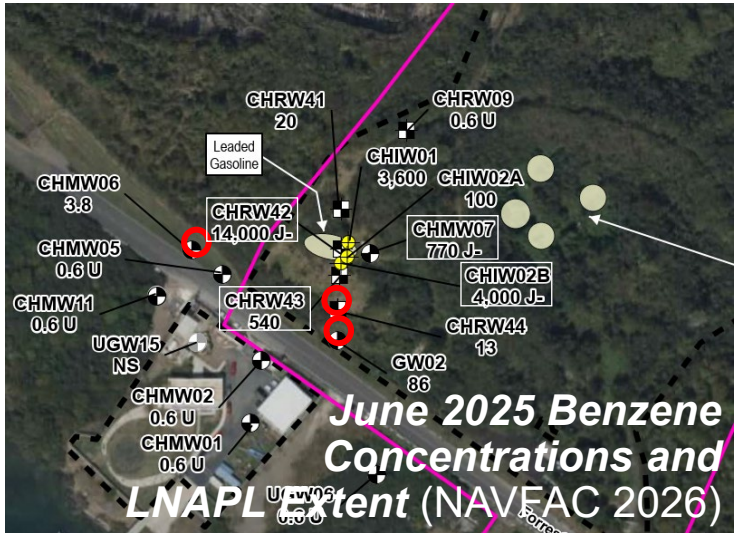


(NAVFAC 2026)

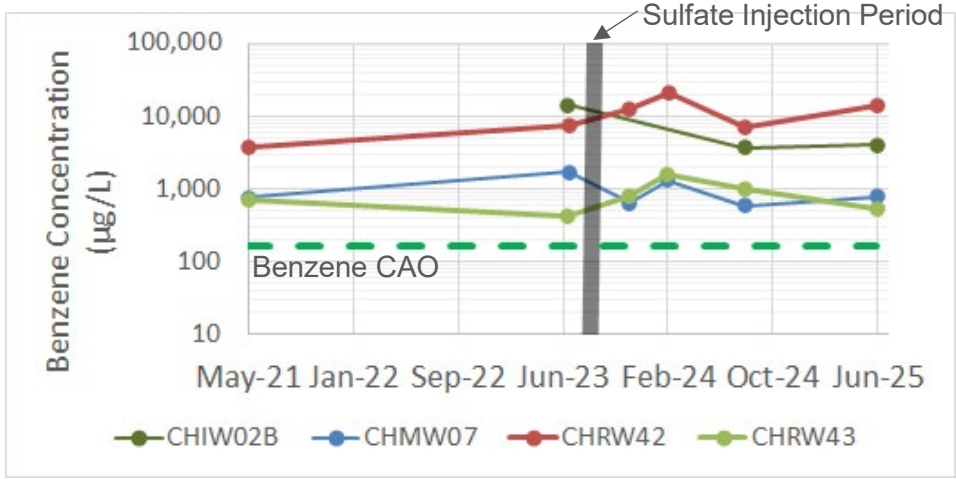
Benzene Reductions

Distal Well Benzene Concentrations (NAVFAC 2024)





- Natural attenuation reduced benzene concentrations downgradient of LNAPL by more than 96% from 2010 to 2021
- After pilot test, source area benzene concentrations remained above CAO of 160 µg/L



Post-sulfate Pilot Test Source Well Benzene Concentrations (NAVFAC 2026)

LNAPL: Phase 1 Optimization

- As described in RITS 2025 Optimization topic, worked through NAVFAC (2021) four lines of evidence to document no lateral migration, restricted exposure, impractical recoverability, and effective natural attenuation
- But also showed persistence of in-well LNAPL above CAO of 0.01 foot
- Made risk-based argument for revision to CAOs to remove in-well thickness requirement
- This will be the third iteration of a CAO change (previously in 2012) based on applying new science

Benzene: Phase 2 Optimization

- Performed pilot test to evaluate treatability of benzene in LNAPL source zone but results were inconclusive
- Initial recommendation was to evaluate additional remedial options such as air sparging or MNA and revisit the benzene CAO
- EPA receptive to revisiting risk-based evaluations driving current CAOs

Next Level Optimization: Revise CAOs

- The in-well LNAPL goal of 0.01 foot (circa ITRC 2006) not consistent with current science or site conditions
- Basis for in-well LNAPL CAO revision
  - ITRC (2018) and EPA Office of Underground Storage Tanks (2023) stepped away from 0.01 foot
  - Puerto Rico EQB Regulation for the Control of USTs (2018 update) permitted use of risk-based cleanup
  - Publications suggest more effective means to monitor remediation of LNAPL bodies
- Work performed
  - Intact soil coring, pore fluid saturation, and water drive mobility analysis to document residual and immobile nature of LNAPL at downgradient edge of LNAPL body
  - Baildown testing to measure LNAPL transmissivity and document it below ITRC recoverability threshold
  - Measurement of efflux to estimate NSZD rates surpass mass removal achieved by ongoing mechanical and manual methods

EQB: Environmental Quality Board

Next Level Optimization: Revise CAOs

- The 160 µg/L benzene in groundwater goal (circa 2012) not consistent with current science or site conditions
- Basis for groundwater benzene CAO revision
  - Based on outdated version of EPA's RSL Calculator (November 2011)
  - Johnson and Ettinger Model (EPA 2012) excluded biodegradation of petroleum hydrocarbons in oxygenated vadose zone
- Work performed
  - Ran EPA's RSL Calculator with 2024 toxicity values, target cancer risk of $1x10^{-6}$, and target hazard quotient of 1
  - Used EPA's PVIScreen model (2016) to incorporate aerobic biodegradation into vapor intrusion-based CAO

RSL: Regional Screening Level

Revised CAOs: Exit Strategy Adapted

- DRNA and EPA endorsed revised LNAPL CAO, revised benzene CAO pending the following actions
  - Reduce groundwater benzene concentration to less than 12,570 µg/L
  - Demonstrate continued plume stability by gauging and sampling 10 downgradient wells
  - Enforce existing industrial LUCs restricting contact with subsurface LNAPL, groundwater use, and excavations deeper than 10 feet
- Set basis for revised exit strategy
  - RC achieved with pending regulatory approvals of revised Statement of Basis
- Set clear and attainable requirements for LTMgt milestone

KEY POINT

Consider current science and adapting remedial objectives during optimization.

DRNA: Department of Natural and Environmental Resources

Knowledge Check: NAPR SWMUs 7 and 8

Question: What actions led to decision to revise CAOs at NAPR SWMUs 7 and 8 site?

Answers:

a. It was incidental to ongoing optimization activities and evolved as a sensible and effective recommendation to advance remedial progress
b. CAO revision was targeted early in optimization project because it was obvious they were not consistent with current science
c. It happened by accident, was not initially intended, and came up randomly during a project team discussion
d. Both a and b

Knowledge Check: NAPR SWMUs 7 and 8

Question: What actions led to decision to revise CAOs at NAPR SWMUs 7 and 8 site?

Answers:

BENZENE **a. It was incidental to ongoing optimization activities and evolved as a sensible and effective recommendation to advance remedial progress**

LNAPL **b. CAO revision was targeted early in optimization project because it was obvious they were not consistent with current science**

c. It happened by accident, was not initially intended, and came up randomly during a project team discussion.

d. Both a and b

KEY POINT

Appropriate CAOs are critical to a cost-effective exit strategy. Revision requires careful scientific consideration and stakeholder consultation.

Case Study 2 OPTI Award Criteria Evaluation

- ☑ Improves return on investment or avoids costs
- ☑ Accelerates reaching remedial goal
- ☑ Use of innovative technology or approach
- ☑ Required extra/unique stakeholder negotiations

Case Study 3: Naval Base Point Loma Exit Strategy

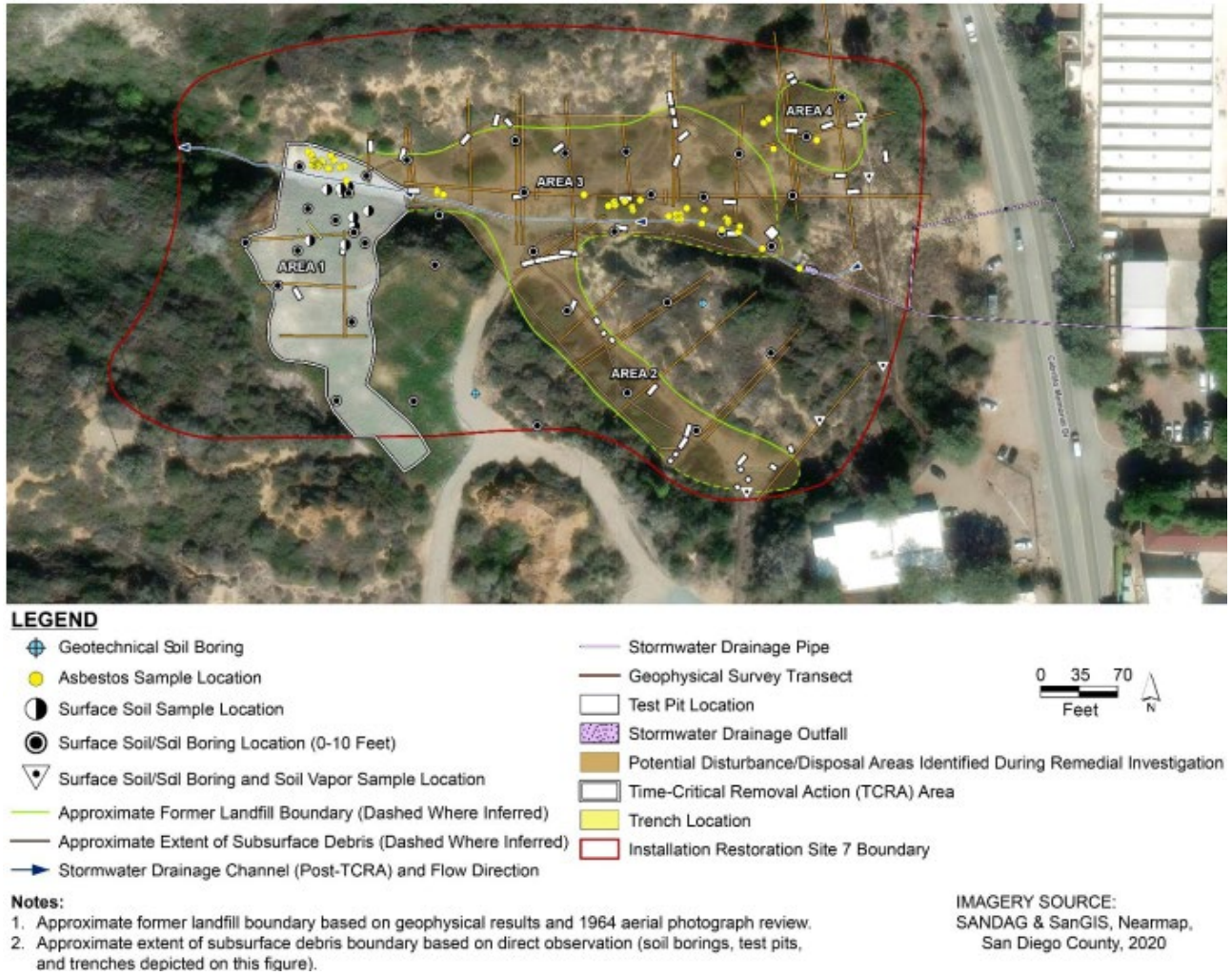
(NAVFAC 2024)

- IR Site 7 is approximately 5.8 acres (landfill)
- Site is adjacent to Point Loma Ecological Conservation Area, Cabrillo Memorial Drive (main road through Peninsula), and Command Third Fleet Office Area

IR: installation restoration

Naval Base Point Loma Background

- NBPL manages 22 active IR sites, munition response sites, and UST sites
- IR Site 7 is a landfill on a peninsula, approximately 100 feet above Pacific Ocean
- Site is highly visible, important to military operations, and valued by the surrounding Point Loma community



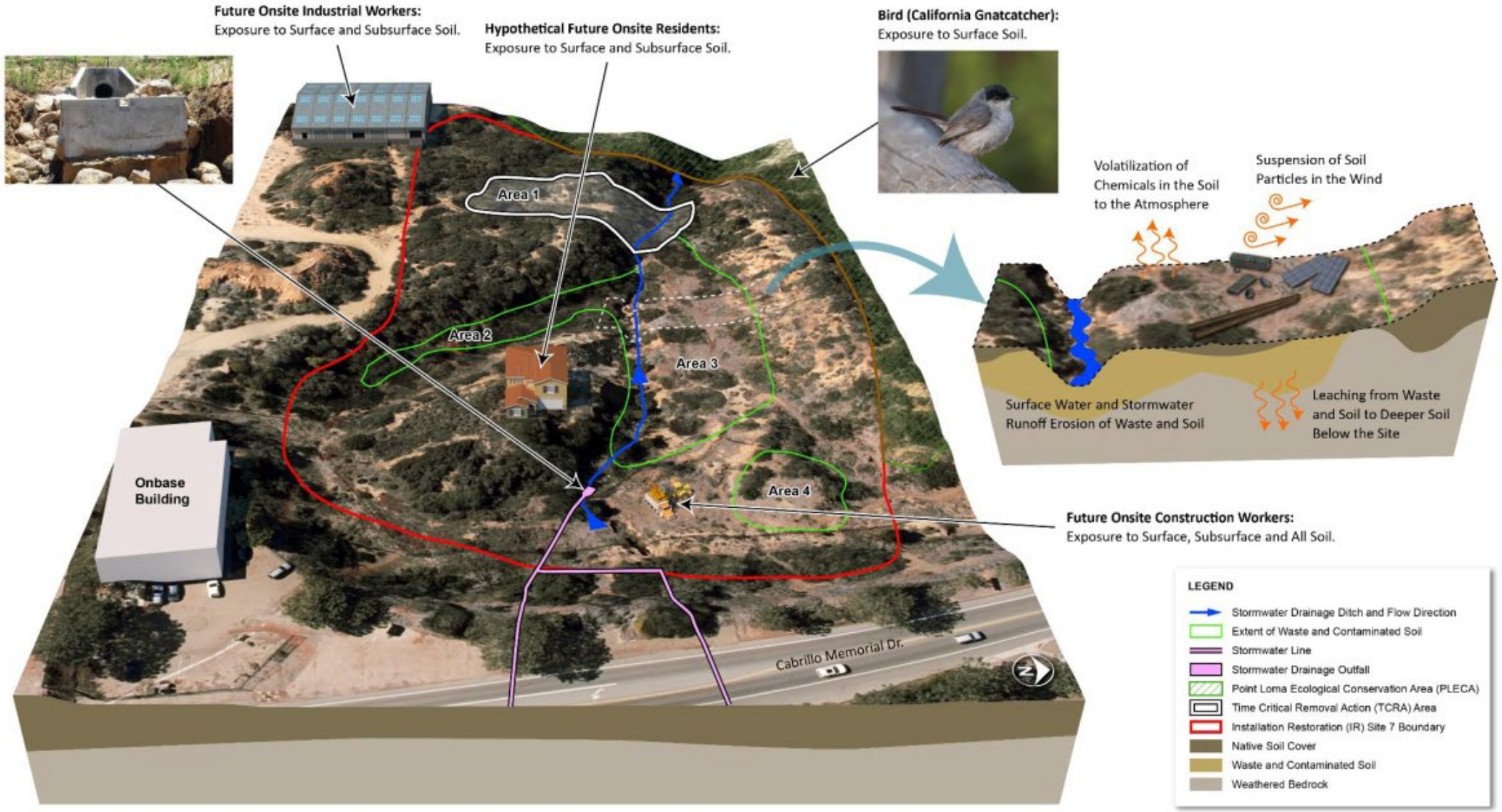
(NAVFAC 2024)

NBPL: Naval Base Point Loma

Problem Statement and Drivers

- Stormwater from an adjacent road discharges onto IR Site 7
- Heavy stormwater flows traveled through a channel across the site
- Concerns: Potential impacts on human health and ecological receptors and offsite migration

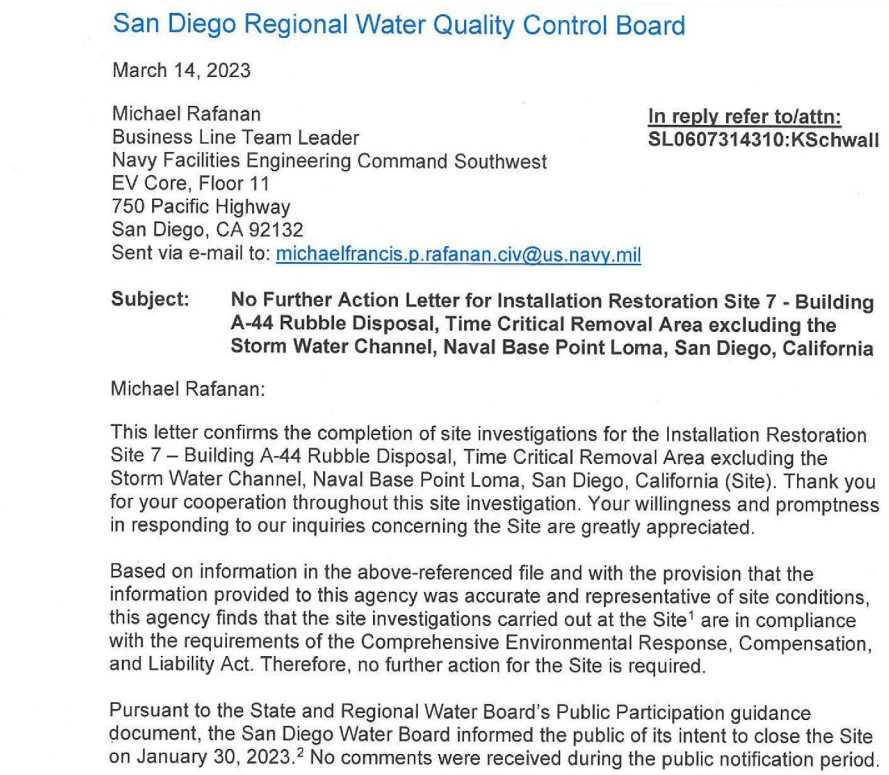
Conceptual Site Model



(NAVFAC 2024)

Early Actions and TCRA

- Based on RI/FFS, TCRA was implemented to meet human health and ecological protection goals (Area 1)
- Action addressed immediate risks associated with erosion and stormwater impacts at site
- Removal of approximately 5,600 cubic yards of soil and debris, 4 to 19 feet below ground surface
- Subsequent work (additional test pits during TCRA) further refined site conditions and informed later FFS Addendum and the Proposed Plan/ROD



San Diego Regional Water Quality Control Board

March 14, 2023

Michael Rafanan
Business Line Team Leader
Navy Facilities Engineering Command Southwest
EV Core, Floor 11
750 Pacific Highway
San Diego, CA 92132
Sent via e-mail to: michaelfrancis.p.rafanan.civ@us.navy.mil

In reply refer to/attn:
SL0607314310:KSchwall

Subject: **No Further Action Letter for Installation Restoration Site 7 - Building A-44 Rubble Disposal, Time Critical Removal Area excluding the Storm Water Channel, Naval Base Point Loma, San Diego, California**

Michael Rafanan:

This letter confirms the completion of site investigations for the Installation Restoration Site 7 – Building A-44 Rubble Disposal, Time Critical Removal Area excluding the Storm Water Channel, Naval Base Point Loma, San Diego, California (Site). Thank you for your cooperation throughout this site investigation. Your willingness and promptness in responding to our inquiries concerning the Site are greatly appreciated.

Based on information in the above-referenced file and with the provision that the information provided to this agency was accurate and representative of site conditions, this agency finds that the site investigations carried out at the Site[1] are in compliance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act. Therefore, no further action for the Site is required.

Pursuant to the State and Regional Water Board's Public Participation guidance document, the San Diego Water Board informed the public of its intent to close the Site on January 30, 2023.[2] No comments were received during the public notification period.

FFS: Focused Feasibility Study
TCRA: Time-Critical Removal Action

TCRA Completion Report 2023

- Navy received concurrence from state regulatory agencies to consider the TCRA action to require NFA
- RPM saw NFA as success and path to potentially reach SC with full removal of waste and soil (i.e., no groundwater issues)
- Success achieved in closing portion of site and reducing portion of site eligible for UU/UE
- Because of good collaboration with agencies, agencies concurred

NFA: No Further Action

Decision Considerations and Cost Evaluation

- Consolidation and capping ($6.8 million) alternative included LTMgt and was originally preferred, with perpetual costs estimated in NORM
- Full-scale excavation, estimated at $10.1 million, was viewed as potential pathway to site closure if additional funding could be secured

View of site from Cabrillo Memorial Road (facing west)
(Jacobs n.d.)

Community Engagement and Decision Support

- Public outreach through RAB meeting presented tradeoffs between long-term landfill management and full excavation
- Community members expressed support for full-scale removal to achieve SC rather than managing site indefinitely

NBPL RAB members participating in site tour (NBPL 2026)

RAB: Restoration Advisory Board

Proposed Plan Flexibility

Flexible Proposed Plan Text

"However, to ensure the integrity of the landfill cap as part of Alternative 4, the adjacent ravine must have sufficient flow capacity for a 100-year storm event which is currently being evaluated. Based on the results of this evaluation, Alternative 4 may prove less favorable to implement and the excavation alternatives (Alternatives 5 or 6), resulting in UU/UE of the entire site, are identified as contingency measures and one of these alternatives would be selected as the remedy in the ROD."

(NAVFAC 2023)

- Following TCRA Completion Report in 2023, San Diego Regional Water Quality Control Board issued NFA determination for portion of the site (i.e., no groundwater issues)
- Report demonstrated full excavation could achieve UU/UE
- Proposed Plan presented consolidate and cap remedy but left placeholder in public meeting for full removal, pending availability of funds
- It included acknowledgment that closure with UU/UE on Point Loma peninsula could be possible
- ER,N Southwest manager discussed with Headquarters and received funding

KEY POINT

Proposed Plan leaves door open for another alternative.

ER,N: Environmental Restoration, Navy

Remedy Change and Record of Decision

- State regulatory agencies concurred with Navy decision to perform a TCRA at IR Site 7
- ROD included a "significant changes" section to support full-scale excavation

Revised ROD Text

"…**the Navy, with state agency concurrence, subsequently determined that an alternative other than the Preferred Alternative provided the most appropriate balance of trade-offs among the alternatives** with respect to the evaluation criteria. As detailed herein, **this significant change could be reasonably anticipated based on information available to the public** in the Proposed Plan …"

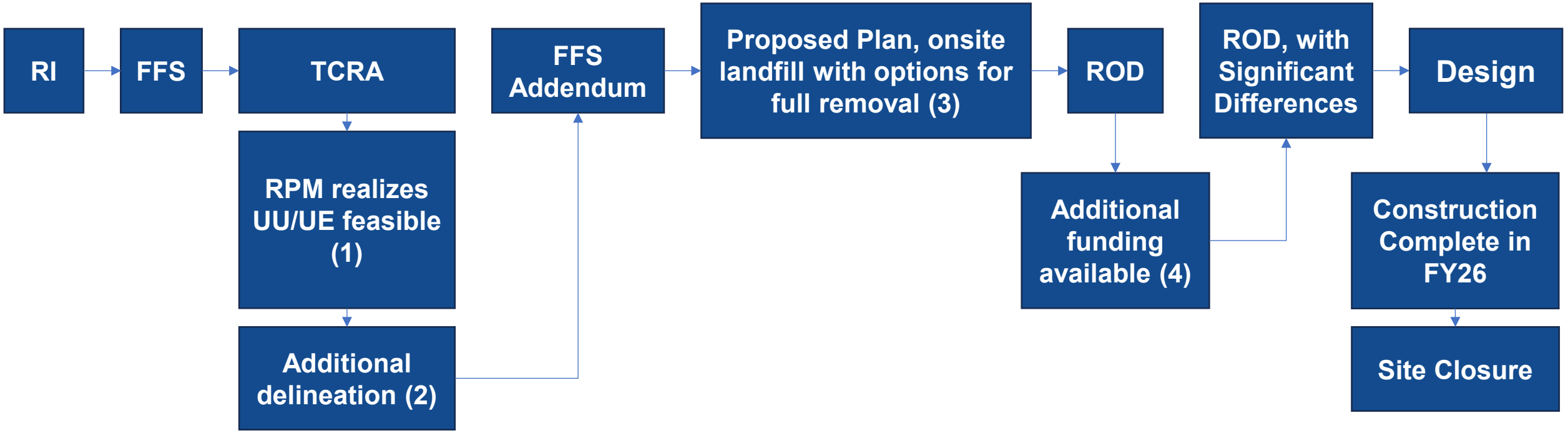
(Jacobs 2024)

Keys to Success

- Cost plus contract (CLEAN and RA-C) allowed flexible funding
- RA-C was awarded to same contractors as TCRA, which increased confidence in remedy
- Teamwork included
  - Cohesive team of CLEAN and RA contractors
  - NAVFAC's strong regulator relations

RA: remedial action

CERCLA Process for IR Site 7



KEY POINT

1. RPM was aware UU/UE was feasible
2. Additional delineation provided basis for confident remediation quantities
3. Proposed Plan had flexibility
4. Headquarters identified funding

Knowledge Check: NBPL IR Site 7

Question: Which factor most directly enabled NBPL IR Site 7 project team to change selected remedy and advance site toward UU/UE?

Knowledge Check: NBPL IR Site 7

Question: Which factor most directly enabled NBPL IR Site 7 project team to change selected remedy and advance site toward UU/UE?

Answer:

Additional site characterization and risk reduction achieved through TCRA, combined with stakeholder and regulatory concurrence

KEY POINT

This case study demonstrates that maintaining flexibility in CERCLA process allows teams to capitalize on new information, stakeholder support, and funding to achieve SC.

Case Study 3 OPTI Award Criteria Evaluation

Improves return on investment or avoids costs

- [x] Accelerates reaching remedial goal
- [x] Use of innovative technology or approach
- [x] Required extra/unique stakeholder negotiations

Presentation Overview

- Introduction
- Overview of Exit Strategy Options
- Decision Frameworks
- Transition Assessments
- Case Studies
- Overcoming Challenges
- Wrap Up

Overcoming Challenges During the Journey

Category	Challenge	Approach to Overcome
Technical	Evolving understanding of contaminant behavior and remediation processes	Stay current on site science (fate/transport, matrix diffusion, natural attenuation, emerging contaminants)
	CSM uncertainty (spatial/temporal variability, matrix-bound mass, data gaps)	Periodically update CSM and revisit assumptions, performance metrics, and decision logic
	Balancing data density, frequency, and cost	Focus data collection on critical gaps that support optimization and progress toward SC
	Changing risk-based criteria and emerging contaminants	Stay current with evolving regulatory standards and adjust evaluation metrics accordingly
Cost	Upfront investment and long-term ROI uncertainty	Allocate program funds to support periodic evaluation of exit strategy and remedy performance

Overcoming Challenges During the Journey

Category	Challenge	Approach to Overcome
Administrative	Indifferent or absent regulators	Proactively engage regulators and maintain consistent communication on strategy and progress
	Ambiguous regulatory pathways	Leverage Navy–EPA–State partnering and discuss options early to reduce uncertainty
	Shifting administrative priorities	Keep regulators informed of anticipated changes and align on exit strategy adjustments
Programmatic	Complacency/loss of focus on closure	Maintain focus on achieving SC (or LTMgt where appropriate) and routinely revisit exit strategy
	Timing constraints and competing pressures	Be patient and implement strategy changes when conditions are favorable
	Need for sustained life cycle engagement	Make evaluation and refinement of exit strategy a routine part of project management

KEY POINT

Achieving site closure requires persistence, informed decision-making, and consistent engagement throughout the project life cycle.

Presentation Overview

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Wrap Up – Advancing Towards LTMgt and SC

- **Exit Strategy and Endpoints**
  - Plan for LTMgt and SC early, even when exit strategies are not fully defined
  - Recognize that LTMgt can be a planned, defensible endpoint (not a failure) when SC is not achievable
- **Decision Frameworks and Transition Thinking**
  - Use decision frameworks and flowcharts to identify optimization, transition, and contingency actions
  - Apply transition assessments to develop defensible, data-driven pathways from active remediation to passive strategies or optimized LTM
- **Data-Driven Decision-Making**
  - Make the best decisions with available information, recognizing that site understanding will evolve
  - Monitoring alone does not equal progress; data must be evaluated and translated into decisions
  - Maintain and continually update the CSM to support decision-making

Wrap Up – Advancing Towards LTMgt and SC

- **Optimization and Life Cycle Management**
  - Apply optimization principles throughout the project life cycle
  - Optimization can generate significant cost savings and improve ROI
- **Stakeholder Engagement and Adaptability**
  - Engage regulators and stakeholders early and often to build alignment and avoid delays
  - Remain flexible and opportunistic, leveraging new data, improved science, funding, and stakeholder alignment

KEY POINT

Achieving site closure requires persistence, informed decision-making, and continuous alignment of strategy, data, and stakeholders throughout the project life cycle.

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OTI Workgroup

Please reach out to Nate, Angela, and/or your respective OTI Workgroup Member with ANY optimization needs – we are here to support!

- Nate Delong, NAVFAC Headquarters/Lead
- Bob Fisher, NAVFAC Headquarters
- Angela Paolucci, NAVFAC EXWC/Facilitator
- Karla Harre, NAVFAC EXWC/ER Manager Link
- Grace Petersen, NAVFAC EXWC
- Laura Cook, NAVFAC Atlantic
- Bryan Peed, NAVFAC Mid-Atlantic
- Paul Young, NAVFAC Mid-Atlantic
- Alex Scott, NAVFAC Washington
- Mike Singletary, NAVFAC Southeast
- Joel Morales Visbal, NAVFAC Southeast
- Christine Gaines, NAVFAC Southwest
- Cathy Weber, NAVFAC Northwest
- Tracy-Joy Ibarra, NAVFAC Pacific
- Hanna Zheng, NAVFAC Hawaii
- Jamie Butler, BRAC

BRAC: Base Realignment and Closure

Points of Contact

Presenter

Paul Favara

Jacobs

paul.favara@jacobs.com

Topic Champion

Michelle Yam

NAVFAC EXWC

michelle.h.yam.civ@us.navy.mil

Presenter

Kim-Lee Yarberry

Jacobs

Kim-Lee.Yarberry@jacobs.com

NAVFAC
Naval Facilities Engineering Systems Command
EXWC Engineering and Expeditionary Warfare Center

Questions