FACT SHEET

When to Transition from Active Remediation to Monitored Natural Attenuation

SEPT 2024

Introduction

Many impacted groundwater sites that employ active remedies have encountered challenges in meeting closure criteria, often due to site complexity and the role of matrix diffusion and other processes in prolonging contaminant persistence. Transitioning from active remediation to monitored natural attenuation (MNA) can be a cost-effective strategy for managing these sites, after constituent levels have been significantly reduced through active treatment. This fact sheet outlines a technical approach for performing transition assessments.

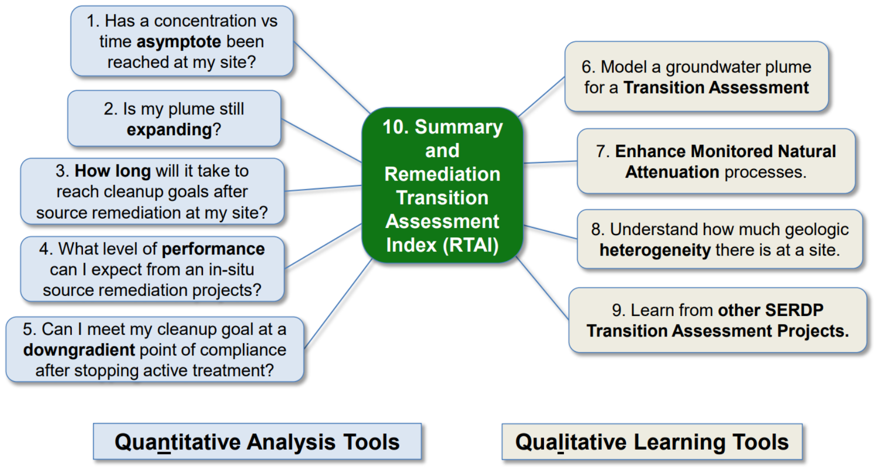


Figure 1. DoD SERDP TA^2 Tool Structure (Courtesy of GSI Environmental, Inc.)

Tool Background

A web-based learning and decision tool, the Transition Assessment Teaching Assistant (TA^2) Tool, was developed as part of a project sponsored by the Department of Defense (DoD) Strategic Environmental Development and Research Program (SERDP) to help practitioners gather information for site-specific transition assessments (Figure 1).

How Does it Work?

The TA^2 Tool is a web-based, interactive platform that includes a series of individual modules designed to answer specific questions or research relevant topics. Users can engage with those modules pertinent to their site or go through all the modules for a thorough, step-by-step summary of relevant issues. Five Quantitative Tools include assessing asymptotic groundwater concentrations from monitoring well programs, evaluating plume stability, estimating remediation timeframes after a hypothetical source removal project, forecasting remediation performance if a particular technology is applied in the field, and projecting concentrations at downgradient points of compliance. Four Qualitative Tools provide information on matrix diffusion, enhanced attenuation options, geologic heterogeneity, and related projects. Finally, the Summary Tool compiles metrics from the other tools and provides additional guidance on conducting site-specific transition assessments. Each TA^2 Tool module is described in Figures 2 through 7.

How Can it Help?

The TA^2 Tool provides a sound framework to guide site management decisions regarding if and when to transition to MNA. The tool provides for the evaluation of different types of sites, including those with active treatment or where source zone remediation is under consideration. It helps determine if transitioning from active mass removal to MNA is appropriate based on site conditions and/or ongoing or prospective remedial performance, and it can also be used as part of a Feasibility Study (FS) to help evaluate the effectiveness of active remedies and/or MNA. By following key steps and checklists, the tool ensures necessary information is gathered to support a technically rigorous site-specific transition assessment.

Quantitative Modules | Qualitative Modules | TA^2 Tool Case Study

The Five Quantitative TA^2 Transition Assessment Modules

Tool 1 – Asymptotes:

Are you approaching a concentration vs. time asymptote?

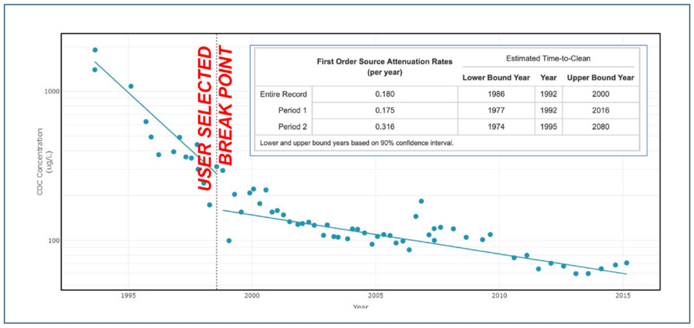


Figure 2. Tool 1 allows users to determine if asymptotic conditions are present at specific locations or across the site by calculating source attenuation rates from monitoring well concentration vs. time data. It also estimates the time to reach a user-specified cleanup goal based on the concentration trends.

Tool 2 – Plume Stability:

Is your plume expanding, stable, or shrinking based on a spatial and temporal analyses of your monitoring well data?

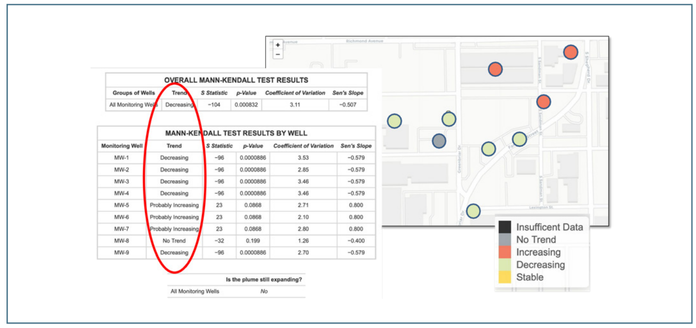


Figure 3. Tool 2 evaluates plume stability by using concentration vs. time data to calculate trends in monitoring well data, determining if increasing or decreasing trends are present, and displaying results on a base map generated from user-entered geographic coordinates.

Tool 3 – Remediation Timeframe:

If I remove the source now, how long will it take to reach my cleanup goal?

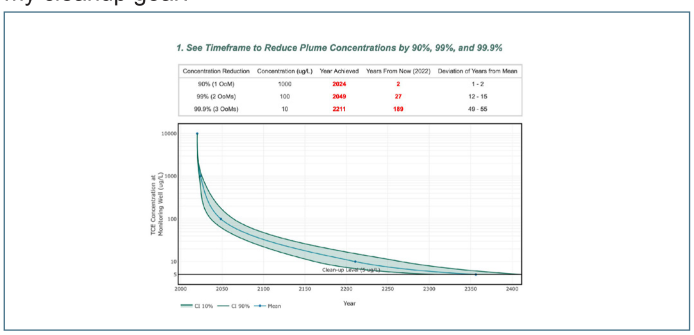


Figure 4. Tool 3 estimates the number of years required to reduce chlorinated solvent plume concentrations by 90%, 99%, or 99.9% after complete source removal, using an empirical match to hundreds of model runs based on site-specific information. This module includes Monte Carlo analysis to show the uncertainty in the timeframe estimates.

Tool 4 – Remediation Performance:

What level of performance can I expect from in-situ remediation?

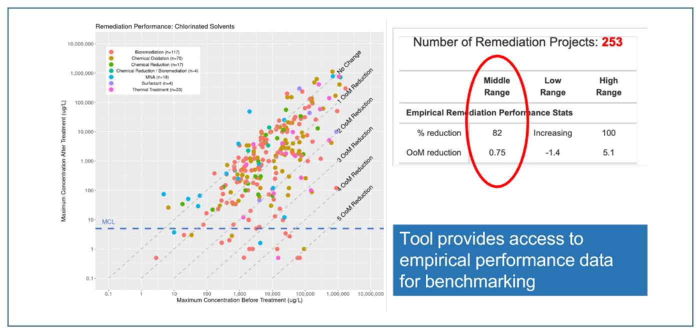
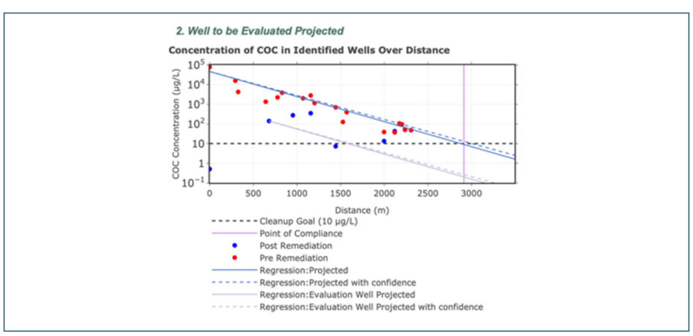


Figure 5. Tool 4 predicts the level of performance (i.e., reduction in concentration) that might be achieved at a particular site using a database of remediation performance at 235 chlorinated solvent groundwater sites, displaying relevant performance data in a "triangle chart" and estimating the performance relative to site-specific cleanup goals.



Tool 5 – Meet Cleanup Goal After Transition Assessment?

Can I meet my cleanup goal at a downgradient point of compliance after transitioning from active treatment?

Figure 6. Tool 5 evaluates if concentration-based cleanup goals will be exceeded at a downgradient point of compliance after transitioning from active treatment to passive treatment (e.g., MNA) by estimating a site-specific attenuation rate constant and projecting the concentration vs. distance from the contaminant source.

Note: All images on this page are courtesy of SERDP.

The Four Qualitative TA² Transition Assessment Modules and Summary Tool

The Four Qualitative TA² Transition Assessment Modules

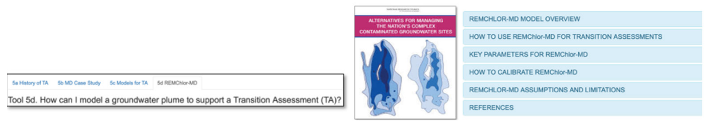
The TA² Tool also includes four qualitative tools (Figure 7). These tools serve as resource modules and simple calculators and provide users with access to more detailed tools, protocols, and guidance. Tool 6 summarizes the current understanding of matrix diffusion's role in influencing long-term concentration trends and remedial performance, as well as different modeling approaches for quantifying its effects. Tool 7 describes various enhanced attenuation options for sites where MNA alone may be insufficient to manage the plume, acting as a bridge between intensive source treatment and MNA. Tool 8 provides a site-specific assessment of the geologic heterogeneity that contributes to matrix diffusion, using user-entered data from boring logs to characterize the potential impact of matrix diffusion on remediation based on simulations performed using the REMChlor-MD model. Finally, Tool 9 presents additional DoD SERDP tools, guidance, and publications.

Remediation Transition Assessment Index

Tool 10, the Summary Tool, includes the Remediation Transition Assessment Index (RTAI), which is a simple metric that reflects the relative persistence of contamination at a site due to matrix diffusion and other site-specific considerations (Figure 8). It summarizes the results from relevant tools within the TA² Tool, assigning an RTAI value to each result. An RTAI value of 5 indicates that the site is a strong candidate for transitioning to MNA or enhanced attenuation approaches, while an RTAI value of 1 suggests that the site is a poor candidate. The RTAI incorporates key assessment metrics, as listed in Figure 8. Users can see the RTAI values generated by each tool and assign an overall RTAI for the site based on the weight of evidence. The RTAI's main advantage is its ability to provide a quick, high-level assessment of a site's suitability for transitioning away from active treatment.

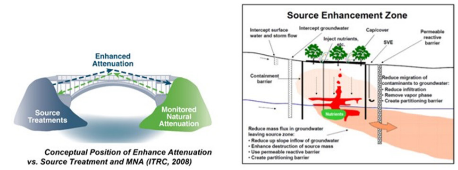
Tool 10 also has a flow chart that starts with several "bright line" criteria that are often required at MNA sites. These can include: 1) determining that the concentration goal at the point of compliance can be met with MNA and 2) determining if the remediation timeframe for MNA is reasonable, and/or similar to the timeframe after source remediation. These bright line criteria should be met if they are relevant for a particular site. Tool 10 also has a series of checklists to ensure that all site information for transition assessments has been adequately documented.

Tool 6 – Understanding and Modeling Matrix Diffusion:



Tool 7 – Enhanced Attenuation Approaches for:

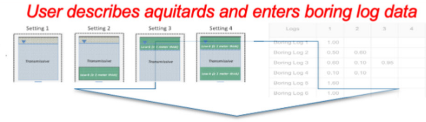
- Chlorinated Solvents
- Inorganics-radionuclides
- PFAS



Tool 8 – Geologic Heterogeneity Calculator:

Tool 8 indicates the relative impact of **matrix diffusion** on remediation

User describes aquitards and enters boring log data



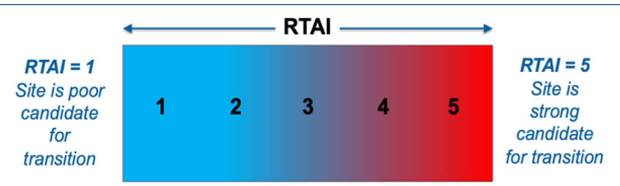
Example Result: *"Combining values from all steps, the overall impact of heterogeneity on matrix diffusion is expected to be **High**."*

Tool 9 – Learn from Other SERDP Transition Assessment Projects:

SERDP Project Number	Title
ER20-1079	Development of Predictive Tools for Assessment of Natural Attenuation Capacity and Treatment Transition at Chlorinated Solvent Sites
ER20-1203	Quantifying the Distribution of Biotic and Abiotic Transformation Rate Constants in Low Permeability Clay Zones for Improved Assessment of TCE Impacts to Groundwater at DoD Field Sites
ER20-1270	Quantitative Assessment of Long-term Abiotic Transformation Rates of Chlorinated Solvents

SERDP Project Number	Title
ER20-1357	Developing a Quantitative Framework for Predicting Abiotic Attenuation under Natural and Transitional Site Management Scenarios
ER20-1368	Development of Protocols to Quantify Abiotic Transformation Rates and Mechanisms for Chlorinated Ethenes in Water Supply Aquifers
ER20-1374	Field Deployable ORP Kit for Quantitative Assessment of Abiotic Monitored Natural Attenuation Rates

Figure 7. The four qualitative tools in the DoD SERDP TA² Tool.



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

Figure 8. 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.

Objective and Background

The TA² Tool was used to evaluate a former DoD site (Plattsburgh Air Force Base) with a chlorinated solvent plume consisting of trichloroethene (TCE) and its anaerobic breakdown products. The plume was managed by a groundwater extraction system for over 10 years (Figure 9). The objective was to demonstrate how the tool could have been used to support a transition assessment for this site. Specifically, the tool output was reviewed related to transitioning from the existing pump-and-treat system to MNA. The plume at this site was present in a sandy aquifer with a high seepage velocity overlaying low-permeability clay till. In 2015, TCE concentrations were between 10 and 100 µg/L and shutting off the source area extraction wells at the site and transitioning to MNA was under consideration (and eventually implemented).

TA² Tool Results for Plattsburgh Air Force Base

Based on the rate and timeframe estimates in Tool 1 and Tool 3, concentrations at the site were already progressing towards acceptable levels (i.e., below maximum contaminant levels) within a reasonable timeframe. The impact of matrix diffusion on the performance of the existing technology was low given the lack of asymptotic behavior (Tool 1) and the relatively simple geology (Tool 8). Together, these indicate that transitioning to more aggressive technologies may have also achieved meaningful concentration reductions (Tool 4). Using only these modules, the RTAI values would have all been 1 or 2, meaning the site was not a strong candidate for transitioning to MNA. However, for this site, the critical metrics were declining concentration trends and plume stability (Tool 2) and meeting concentration goals at the point of compliance with MNA (Tool 5; Figure 10) in a reasonable timeframe (Tool 3). These are considered "bright line" criteria for this type of site where a risk management approach is applicable. In particular, the Tool 5 assessment showed that the constituent of concern (COC) concentration (in this case cis-1,2-DCE) was projected to attenuate rapidly with distance due to natural processes, and parallel lab-based studies showed the observed natural attenuation was due to abiotic processes that degraded the groundwater contaminants (Figure 10). The concentration data collected after the extraction wells were shut down showed that the rate constant for attenuation was even faster than the rate constant before shutdown (Figure 11).

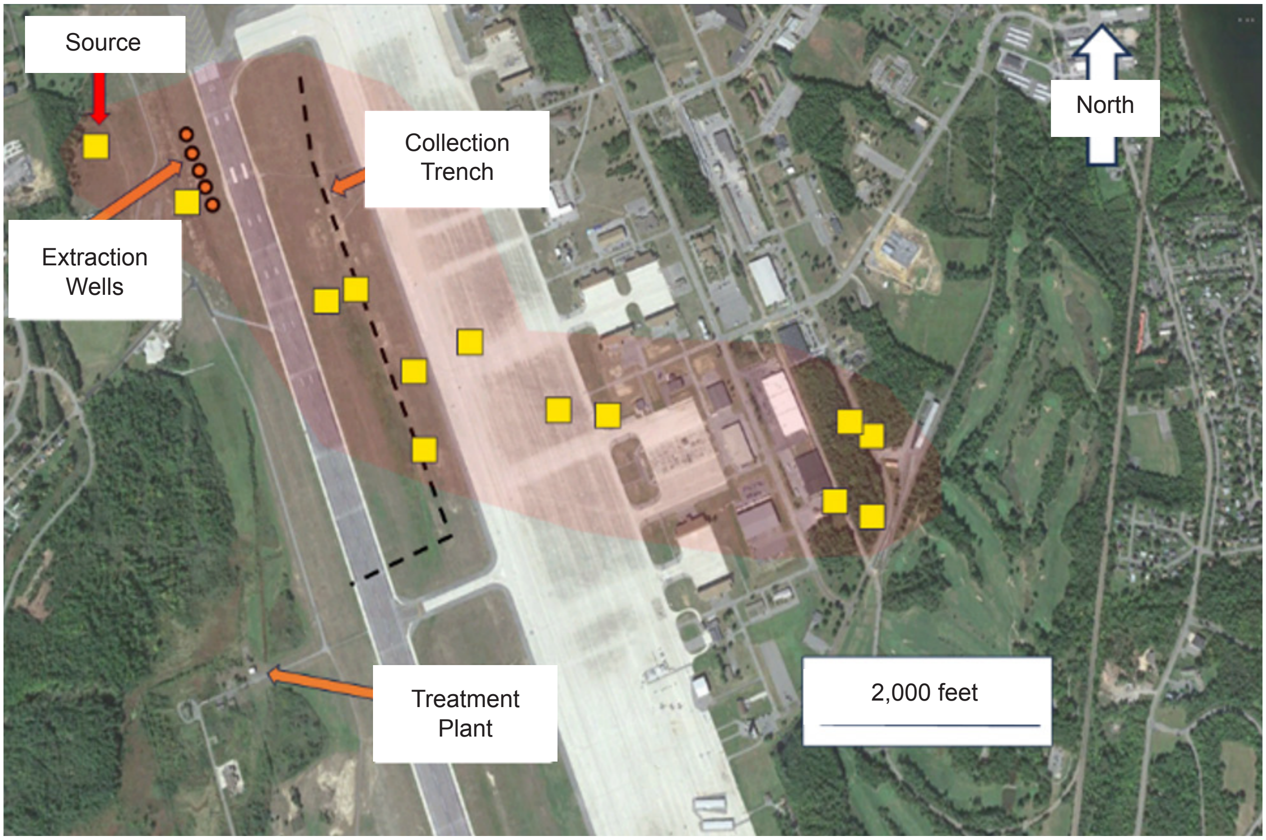


Figure 9. Site Overview. Note: Groundwater flow is southeast from the source area. (Modified from Arcadis, Bhate, AFCEC, and CIBE 2022)

TA² Tool Case Study (Continued)

Conclusions for Plattsburgh Air Force Base

The results from applying the TA² Tool would have provided technical justification for transitioning this site to MNA, because data analysis showed that natural attenuation processes were active and helping to achieve site objectives. This assessment would have been useful in supporting the decision to shut down the treatment plant and transition the site to a more passive and less resource-intensive approach.

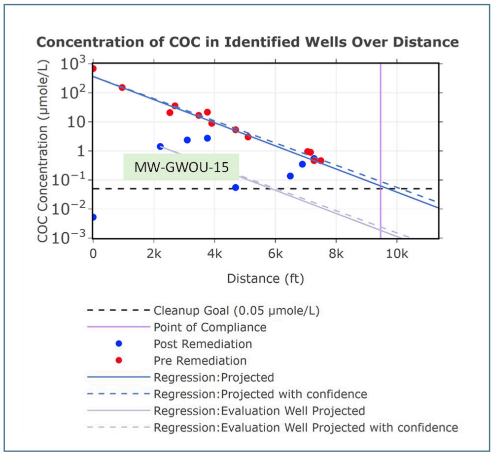


Figure 10. Results from Tool 5 showing that calculated "pre-remediation" rate constant for natural attenuation is projected to reduce concentrations from well MW-GWOU-15 below the cleanup goal at the downgradient point of compliance during "post-remediation" period. (Courtesy of SERDP)

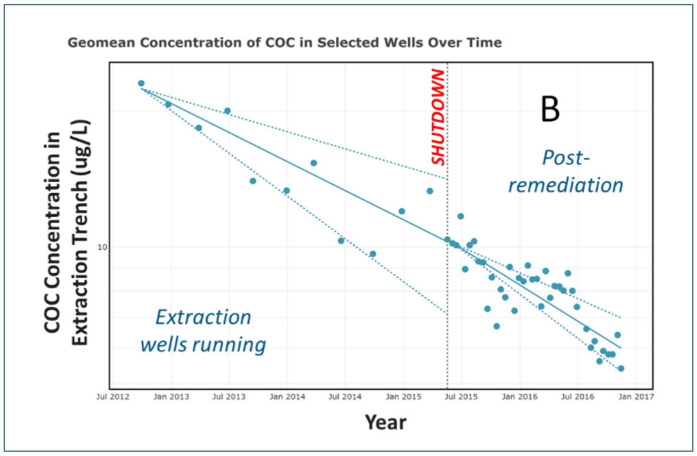


Figure 11. Results from Tool 1 showing that concentrations were declining at a faster rate in the post-remediation period after the extraction wells were shut down. The slopes of the solid blue lines represent the rate constants for each period and the dotted blue lines represent the 95% confidence intervals. (Courtesy of SERDP)

TA² Tool More Information

The SERDP DoD TA² Tool can serve as the technical basis for sound decision-making on technology transitions, including evaluating transitions from active remediation to MNA, and helps to foster consensus among stakeholders. For more information, visit the project profile below to access the tool. It is a free web application that does not require downloading or installing files on your computer.

Disclaimer

References

Arcadis, Bhate, AFCEC, and CIBE. 2022. Final Operations Report (September 2020-June 2021), Former Plattsburgh Air Force Base (NYSDEC Site 510003), New York. January. AR# 613833.

SERDP. 2024. "Transitioning from Active Remedies to Monitored Natural Attenuation." SERDP Project ER-20-1429. https://serdp-estcp.mil/projects/details/350cbc0b-893a-43a6-8a0c-c9c057bacac0/er20-1429-project-overview