NEIWPCC
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L.U.S.T.LINE

A Report on Federal & State Programs to Control Leaking Underground Storage Tanks

Michigan's Backlog Story: Thirty Years with a Backlog of 8,000 Open LUST Releases

By Steve Beukema

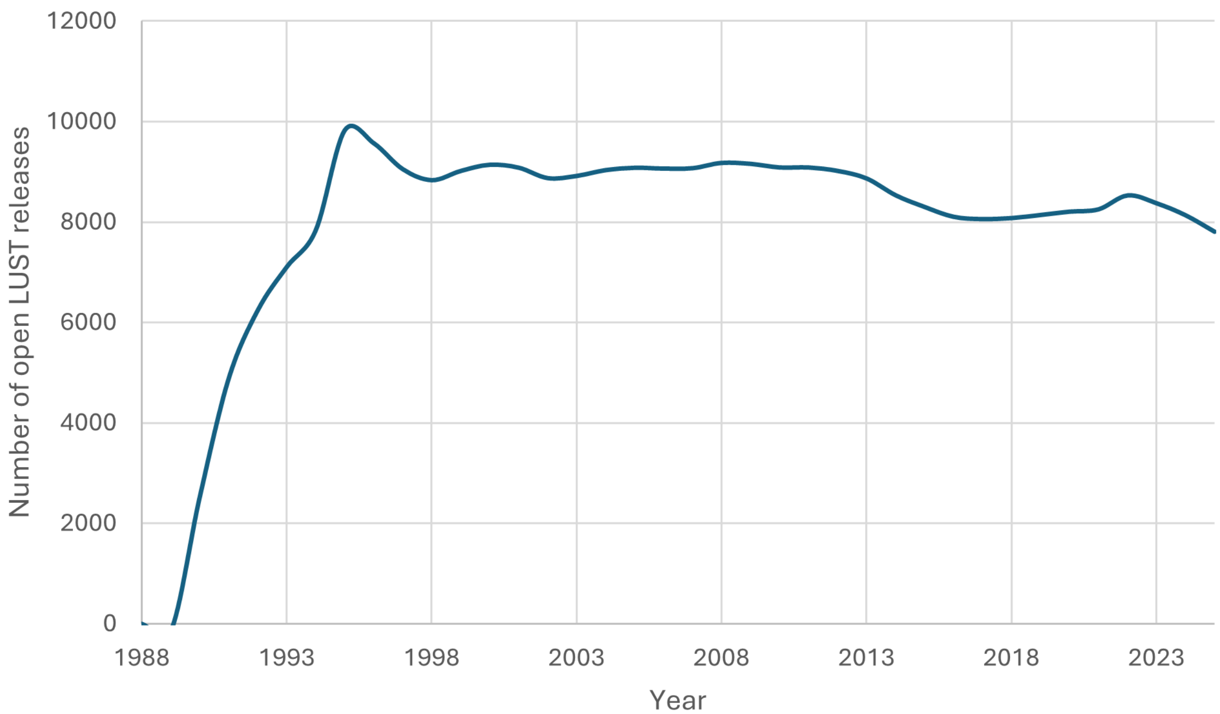

Figure 1. Michigan's LUST backlog from 1988-2023.

Introduction

In 1995, Michigan's backlog climbed to more than 8,000 open LUST releases, where it remained for 30 years, not getting much higher, but not getting any lower. It was a steady backlog that was just a fact of life for the LUST universe in Michigan. It is something we have always had, and something that will always be there.

In 2020, following a few years of an increasing trend in our backlog, Michigan teamed up with the United States Environmental Protection Agency (U.S. EPA) to undertake a backlog study to determine its root causes and potential solutions. Separate from this, Michigan convened an internal workgroup

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Figure 2. An abandoned gas station after being restored with topsoil and hydroseed (2024).

to determine obstacles to closure and potential solutions, and hired an outside expert in the ASTM International risk-based corrective action (RBCA) process to evaluate Michigan's RBCA program. Here is what we found.

Evaluating the Backlog: Root Causes and Obstacles to Closure

Michigan's backlog problem is not the result of a single factor. Rather, several factors have contributed over the years to a large and stagnant backlog.

Like many states in the 1990s, Michigan had a state reimbursement fund: the Michigan Underground Storage Tank Financial Assurance (MUSTFA). This fund was alive and well during the heyday of confirmed releases in the 1990s. But even though MUSTFA guaranteed reimbursement for cleanup, it soon became insolvent, leaving owners and operators on the hook for the costs of addressing thousands of releases. In 2014, a new reimbursement fund called the Michigan Underground Storage Tank Authority (MUSTA) was established; however, only releases that occurred after 2014 are eligible for reimbursement. More than 90% of open releases are therefore not eligible for MUSTA reimbursement.

In 1995, Michigan adopted a causation-based liability standard for LUST releases. The benefit of this was to provide a mechanism to encourage the redevelopment of contaminated properties without new owners taking on liability. While this has encouraged redevelopment, it presents a challenge for identifying parties liable to address LUST releases, particularly when releases remain open for 20 to 30 years.

In 2002, Michigan's Storage Tank Division (STD) of the Department of Environmental Quality — now the Department of Environment, Great Lakes, and Energy (EGLE) — merged with the Environmental Resource Division (ERD) to become the Remediation and Redevelopment Division (RRD), which still exists today. The STD had staff and processes that efficiently evaluated and addressed LUST releases. After the two divisions merged, there was a tendency to treat the LUST program (Part 213) the same as the non-LUST program (Part 201). Over time, the process to approve a single LUST closure went from a simple decision made by the project manager and supervisor to a process involving separate peer review groups for each technical issue related to the release.

In addition to the root causes of Michigan's backlog as described above, the LUST program was also influenced in 2016 by the Flint water crisis, in which a series of events related to a change in the city of Flint's drinking water source resulted in the population being exposed to lead in their municipal drinking water. Fingers were pointed in many directions for blame, and criminal charges (that were later dropped) were pressed against state regulators. Following this, the predominant decision on LUST closure report audits in the RRD was either "deny" or

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more frequently "insufficient information to make a decision." While these results were supported by technical arguments, under the surface there was a hesitancy to approve a closure report unless an overwhelming amount of data supported it.

Concurrent with the EPA backlog study, the RRD convened an internal LUST workgroup tasked with determining obstacles to closure and potential solutions. The LUST workgroup polled RRD staff and determined that several obstacles to closures exist, including: an inefficient decision-making process for closures; requiring restrictive covenants for any contamination above Tier 1 Risk-Based Screening Levels (RBSLs) and often even below Tier 1 RBSLs; burdensome requirements for delineation; and an overly complex process for evaluating vapor intrusion. Recommendations from the workgroup include developing a more efficient decision-making process; making changes to restrictive covenant requirements; and simplifying RRD's approach to vapor intrusion to align with what staff observe at sites.

An external review of Michigan's RBCA program concluded that Michigan's LUST program does not follow the ASTM RBCA process, despite the statutory requirement for a RBCA-based LUST program.

Figure 3. Contaminated soil being removed from an abandoned gas station using a trench box.

Addressing the Backlog: Solutions for Decades-Long Challenges

Just as the backlog was not caused by one single factor, the backlog problem cannot be solved by a single solution; rather, it must consider all aspects of the LUST program. The first step toward addressing the backlog was to establish a goal of obtaining 400 closures per year for five years. To achieve this goal, we had to develop tools for RRD staff and the regulated community to address the backlog. The tools we created are divided into four categories: 1) technical updates; 2) program and policy changes; 3) staffing and funding; and 4) culture change.

1. Technical Updates

We updated guidance documents for all technical areas with the focus on making guidance align with the most recent science and field observations, be practical to implement, and be protective of public health and the environment. The biggest change was related to the practicality aspect. The RRD historically had numerous guidance documents that were technically and legally correct, but were often not practical to implement. In the area of vapor intrusion, we separated petroleum vapor intrusion (PVI) from nonpetroleum vapor intrusion and created a PVI guidance document that greatly simplifies RRD's approach to vapor intrusion at petroleum LUST sites. The updated PVI guidance document emphasizes evaluating PVI risks using soil gas data rather than groundwater or soil data and aligns with the Interstate Technology and Regulatory Council's PVI approach based on screening distances.

2. Program and Policy Changes

In this broad category, the RRD district offices engaged in a letter-writing campaign to re-engage owners and operators at stalled LUST release sites. To help transition liable parties back into compliance, we developed a "compliance plan" option in which a party can commit to accomplishing certain activities with a schedule to return to compliance. Compliance plans have been a great success. Over 90% of parties that voluntarily submitted compliance plans have implemented the activities according to the proposed schedules.

To facilitate efficient decision making, we established a streamlined decision process in which a closure decision is made by the project manager in conjunction with the supervisor, rather than requiring a peer review group's input on the decision. This change aligns with the historic STD decision-making process and is consistent with processes in other states.

One challenge with Michigan's LUST statute, Part 213, is that it is written to specify a liable party's obligations with respect to LUST releases but provides little direction regarding what EGLE can or cannot do, or how to bring a release to closure if there is no liable party. To provide guidance for EGLE staff, we established a new file review closure process. The process is a mechanism for EGLE staff to review site files, particularly legacy orphan LUST releases, and bring them to closure if warranted by the site data.

Regarding Michigan's RBCA program, EGLE worked with an external consultant to develop a Michigan RBCA (MIRBCA) technical guidance document with accompanying report forms and computational software to develop Tier 2 Site-Specific Target Levels (SSTLs). Although Part 213 has referenced the ASTM RBCA process since the mid-1990s, Michigan did not have any guidance documents regarding how to implement the RBCA process or how to calculate SSTLs. The process outlined in the MIRBCA guidance document presents a paradigm change for implementing corrective actions in the LUST program, and we expect that this will greatly streamline LUST work after the regulated community and EGLE staff become familiar with the new approach.

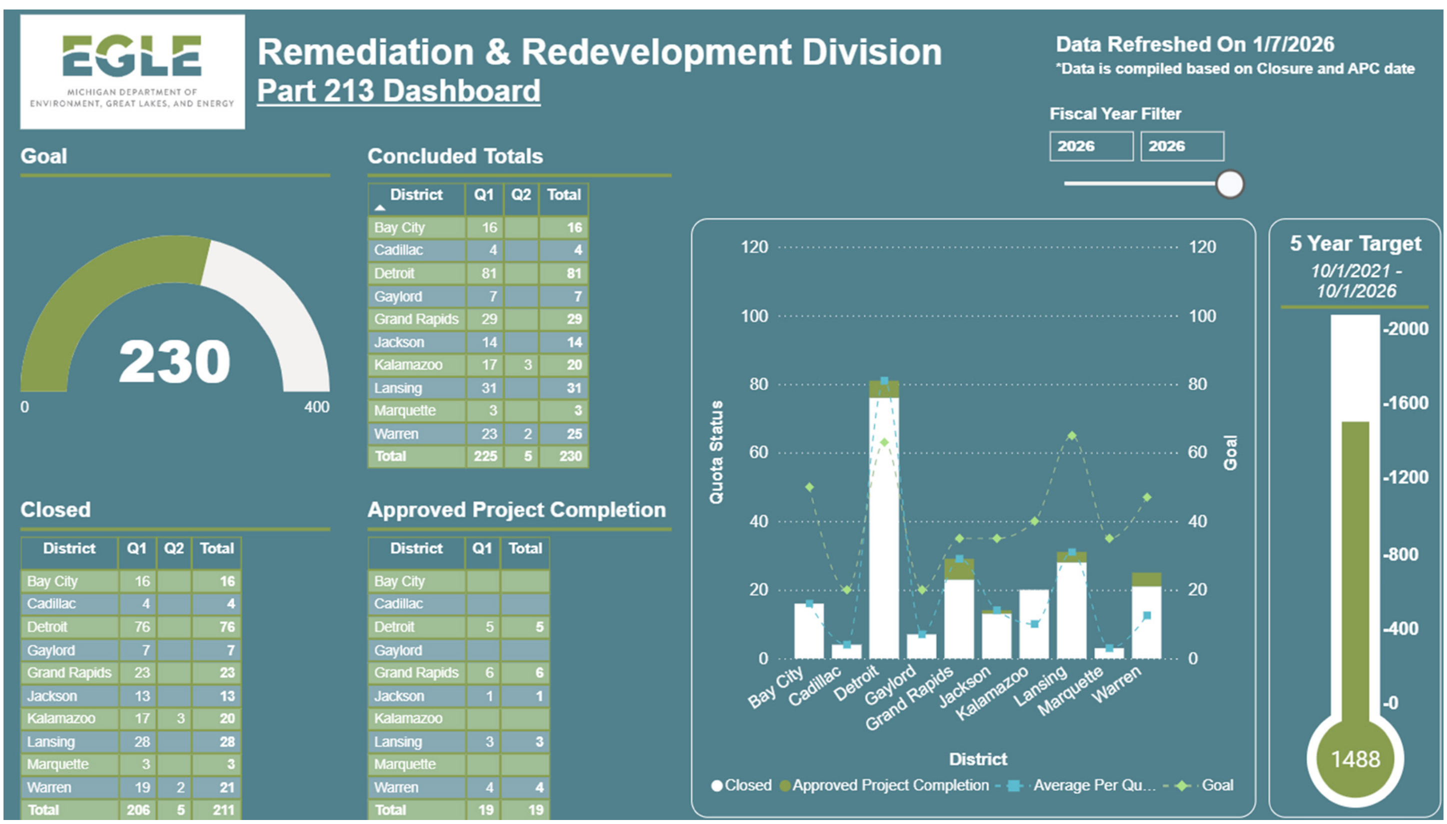
3. Staffing and Funding

The obvious solution in this category is to increase staffing and funding. We doubled the funding for EGLE's triage program. This is a program where EGLE field geologists conduct a 1-2 day mobilization of ground-penetrating radar, soil borings, groundwater samples from temporary wells, and soil gas samples, often at orphan sites that have little data. Staffing in the LUST program also increased, but a more significant change was how staff are organized. Prior to 2024, project management staff split their time working on both LUST and non-LUST contaminated sites. To gain efficiency, we divided our project management staff by program, with staff in each office dedicated to either the LUST or the non-LUST program. "Tank teams" of project managers dedicated to LUST work were created in all 10 district offices across the state. Project managers work independently on LUST sites but also collaborate with the team. Each district tank team has metrics based on the number of open releases in the district (more on this in the next section).

We created two critical new staff positions to help the overall division organization, as well as to provide leadership in addressing the LUST backlog. Technical specialists were reorganized into a new section (the Technical Support Section) with the Toxicology Unit, and a Section Manager position was created to provide leadership over the section and technical issues related to addressing the LUST backlog. A Part 213 (LUST) Program Coordinator position was also created to provide leadership for the LUST program and over program and policy issues related to addressing the LUST backlog.

4. Culture Change

Changing technical guidance, policies, and increasing and reorganizing staff are positive changes but are not likely to result in a significant decrease in the LUST backlog without changes to the underlying culture within the RRD. In the work culture, priorities were driven by reports from active sites that have statutory review deadlines, which can leave little time for project managers to evaluate stalled backlog sites.



Concluded Totals

District	Q1	Q2	Total
Bay City	16		16
Cadillac	4		4
Detroit	81		81
Gaylord	7		7
Grand Rapids	29		29
Jackson	14		14
Kalamazoo	17	3	20
Lansing	31		31
Marquette	3		3
Warren	23	2	25
Total	225	5	230

Closed

District	Q1	Q2	Total
Bay City	16		16
Cadillac	4		4
Detroit	76		76
Gaylord	7		7
Grand Rapids	23		23
Jackson	13		13
Kalamazoo	17	3	20
Lansing	28		28
Marquette	3		3
Warren	19	2	21
Total	206	5	211

Approved Project Completion

District	Q1	Total
Bay City		
Cadillac		
Detroit	5	5
Gaylord		
Grand Rapids	6	6
Jackson	1	1
Kalamazoo		
Lansing	3	3
Marquette		
Warren	4	4
Total	19	19

Figure 4. A dashboard created by the Remediation and Redevelopment Division, which shows progress toward release closure goals by district.

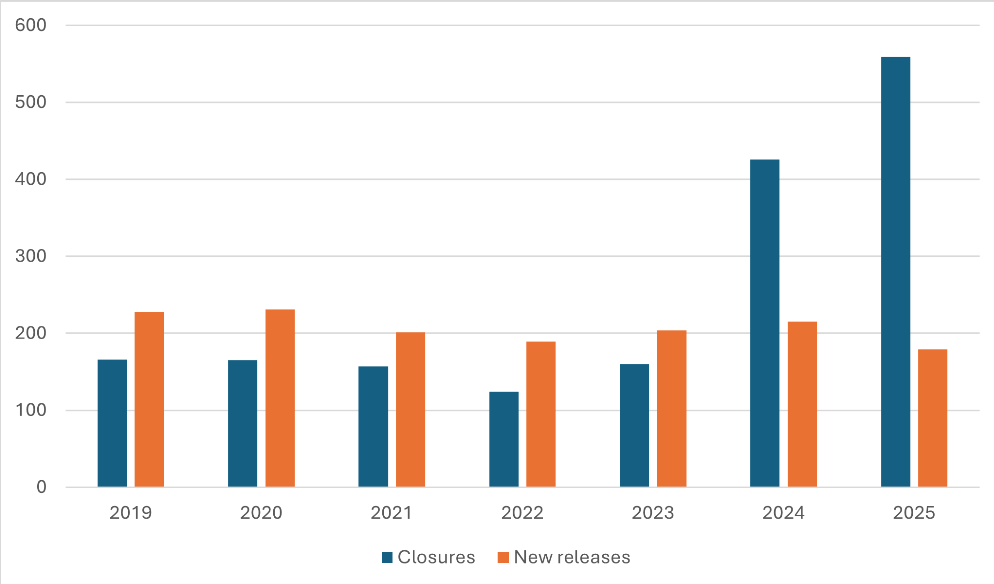


Figure 5. A bar graph showing the number of closures and new releases from 2019-2025.

The report review process has historically focused on delineation and site characterization, even if the data are not used to make risk decisions or would not change a risk-based decision. The most common conclusion for a closure report audit was that there was insufficient information to make a determination. We were good at picking apart sites and reports and finding areas where more data would be useful. We are changing our approach, particularly with the legacy sites, to looking at the data and the receptors holistically for lines of evidence that would support release closure.

Culture is the hardest aspect of the LUST program to change and there are several ongoing efforts. In 2022, the RRD established a goal of closing 400 releases per year over a five-year period. Each of the 10 district offices has its own closure goal based on the number of open releases in the district. A dashboard was created on the RRD's SharePoint page in a way that tracks each district's progress and is visible for all districts and staff to see, providing both goals and accountability among the districts (see Figure 4).

There is an ongoing effort to train staff and continually emphasize aspects of the petroleum lifecycle, including biodegradation, dissolved plume stability, and typical lengths for dissolved petroleum plumes. This gives LUST project managers starting assumptions about the site based on the nature of petroleum contamination rather than requiring data to prove something that can be reasonably assumed.

We are shifting the focus away from delineation and characterization and toward risk and asking questions about characterization. What decision will be made with newly requested data, and can that decision be made with the existing data? What is the exposure scenario that is being evaluated with the data?

Lastly, we are encouraging staff to use professional judgment. The new messaging is twofold. First, policies are written to address 80% of the common scenarios, and not all sites will fit perfectly into the policies. Staff should use judgment where it makes sense. And second, "risk" is the chance of an adverse health effect, which can occur only when a receptor is exposed to contamination. Exposure rarely occurs at typical LUST sites with current use and even in reasonable future exposure scenarios.

Results

The efforts to evaluate the LUST program and reduce the backlog began in 2020, and the closure goals began in 2022. The efforts span across technical, program and policy, staffing and funding, and culture. The first few years of effort saw no change in the backlog, with closures continuing to lag behind the number of newly reported releases.

These efforts started to show results in 2024 when the annual closure goal was met for the first time with 426 closures. In 2025, the number of closures increased to 559. These numbers do not reflect the new MIRBCA program that was introduced late in 2025. Continuing this momentum and adding the new MIRBCA program, Michigan EGLE expects to see even greater number of closures in 2026 and beyond.

Figure 6. Site of a contaminated gas station in Detroit, prior to any restoration efforts (2018).

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A Message From Carolyn Hoskinson

Director, U.S. EPA's Office of Underground Storage Tanks (OUST)

The Days Are Long, But the Years Fly By: Celebrating Ten Years of the Modern-Day UST Program

This past year brought many changes for me both personally and professionally. The best change is that I returned to the UST program! I'm so excited to be back in the Tanks community and can't wait to reconnect with everyone. This year also marked the 10-year anniversary of a major regulatory update to the UST program. Anniversaries and birthdays are great times to reflect, and in this article, we will reflect on how far the UST program has come and how the 2015 regulations continue to help ensure clean air, land, and water for every American.

In the early days of the national UST program, EPA and partners worked to understand the UST universe and establish a foundational program to protect human health and the environment from UST releases. The 1988 regulations created the framework for a national program. Once the initial program setup was completed, EPA and other stakeholders could focus on refining the program requirements to ensure that it continued to be a safe, sustainable, and protective program that reflected state-of-the-art industry standards and practices.

A major step forward for updating the program happened back in 2005 with passage of the Energy Policy Act. The "EPAct" drove the program forward to incorporate and implement requirements that ensured a stronger UST program. At the same time that EPA was working to implement EPAct requirements in Indian country, we also recognized the need to update and improve operation and maintenance of USTs across the country. In order to ensure a strong yet practical program, we sought out and considered significant stakeholder feedback. Indeed, EPA held more than 100 public meetings as part of this rule making process. Dedicated EPA staff in the regions and at headquarters shepherded the rule making through many years of procedural requirements and other challenges. As a result, the final regulations focused on release prevention, recognized UST industry modernization and improvement efforts, and included new requirements designed to protect the environment while providing flexibility.

The 2015 UST regulations changed certain portions of the 1988 underground storage tank technical regulation. Procedures and practices that today are industry standard and perhaps taken for granted were captured in the 2015 regulations. Major changes included:

- Addition of periodic operation and maintenance requirements for UST systems.
- Addition of requirements to ensure UST system compatibility before storing certain biofuel blends.
- Removal of past deferrals for emergency generator tanks, airport hydrant systems, and field-constructed tanks.
- Updated codes of practice.

Implementing the 2015 regulatory changes has been a relentless effort on many fronts and by many people. Ten years later we are reaping the benefits with a high performing national program that protects the public and our natural resources. EPA has its many program partners to thank for the UST program's continued success.

"I am so pleased to recognize the tremendous long-term progress due in large part to the day-to-day efforts of those in the amazing UST community."

A Message From Carolyn Hoskinson...continued

State Implementation...No Small Feat

When it comes to implementing the 2015 UST regulations, no amount of thanks is too much for our state partners. State agencies embraced the painstaking, day-to-day work to update their regulations and work their way through the State Program Approval process. States worked with the public, state legislatures, and EPA to update their regulations to match the federal regulations, while often wrestling with complex systems and situations within their state (e.g., emergency power generators, airport hydrant systems). Today, 40 states and territories have State Program Approval for the 2015 regulations, helping to provide a nationally consistent and environmentally protective program, with several states choosing to go beyond the federal requirements with more stringent standards.

States also worked with EPA to develop a technical compendium of over 50 questions and answers that address regulatory uncertainties and unique situations. The compendium has been a useful "living" resource for clarity and compliance assistance.

Individual states and organizations representing state implementing agencies contributed to the success of the program. NEIWPCC and ASTSWMO provide invaluable forums to get states and EPA together so that we can continue to collaborate with each other. Just a few months ago we held our 28th National Tanks Conference, a successful event where we continued to learn from and support one another.

Today, states still face ongoing challenges from funding constraints to staffing shortages. Despite the challenges, the states have made impressive progress and continue to uphold a rigorous UST inspection cycle with tens of thousands of inspections completed each year. We cannot thank our state partners enough for the day-to-day, often invisible work to make the UST program a success.

Industry Involvement, Critical to a Modern and Flexible UST Program

Industry also played a big part in the implementation success of the 2015 regulations. Industry got to work right away to develop standards that made sense and that provided flexibility for meeting the intent of the regulations with room for innovation and technology improvements. For example, several industry groups representing UST owners and operators approached EPA and states seeking flexibility on requirements for hydrostatic sump testing. In response, EPA allowed a new standard for sump testing that uses less wastewater, providing an economic and environmental benefit.

The 2015 regulations raised the bar for the

Our Tribal Partners Are Key to a Successful Tanks Program in Indian Country

EPA is a direct implementer of the UST program in Indian country, working hand-in-hand with our tribal partners. The 2015 regulations are directly applicable to UST owners and operators in Indian country. EPA developed a Strategy for an EPA/Tribal Partnership to Implement Section 1529 of the Energy Policy Act of 2005 that helped to inform the 2015 UST regulations. EPA and Tribes collaborated to develop the strategy which recognizes the need for both flexibility and information sharing to successfully implement an UST program in Indian country.

The EPAct provisions, codified in the regulations in 2015 brought program implementation and capacity challenges to EPA and Tribes. For example, the 2015 regulations added the workload and logistical challenge for EPA to conduct inspections of all USTs in Indian country at least once every three years. Our federally credentialed tribal inspectors are key to helping EPA meet our inspection goals. Tribes and tribal consortia provide critical compliance assistance to UST facilities in Indian country. Other provisions such as fuel delivery prohibition, owner/operator training, and secondary containment are part of long-term communication and coordination efforts between EPA and Tribes to meet program goals. Recently, EPA worked with NEIWPCC to develop a free online training and exam for the federal Operator A and B requirements added under the 2015 regulations. For owners and operators of facilities in Indian country, successful completion of this training and exam fulfills the operator training requirements under Subpart J of 40 CFR Part 280.

Flexibility and information sharing are strong components of the UST Tribal program to this day. EPA continues to work with Tribes and other owners and operators in Indian country to address their unique challenges. EPA remains committed to strong working relationships with Tribal partners, including compliance assistance efforts.

A Message From Carolyn Hoskinson... continued

sound manufacture, installation, operation, and maintenance of USTs storing petroleum. While decades prior, a single walled steel tank was the norm for an UST, industry made great strides in designing secondarily contained equipment, both steel and fiberglass. In addition, the UST service provider industry flourished, creating jobs, vocational training, and business opportunities all across the country. Technological innovation led to a safer, modern petroleum storage system that keeps our country moving.

Today, industry remains heavily involved in setting standards, for everything from ongoing leak detection methods to the ASTM Moving Sites to Closure standard. This makes for a stronger regulatory program better in touch with the practical realities of owning and operating tanks.

Conclusion

In the 10 years since the 2015 regulations, we have seen the fruits of our labor pay off in improved program performance. Since we started tracking compliance rates on a national level, we have seen steady progress and increase in spill, overfill, and corrosion protection compliance rates. The Total Compliance Rate performance measure — which is a combination of a few different measures — has been consistently high and trending higher with each passing year. Compliance testing companies have provided anecdotal data showing their average passing rates for triennial tests improving each 3-year period, and annual confirmed releases continue to trend downward over time. You can explore our semiannual performance measure reports and see the positive trends in data on our website. We continue to get feedback and information formally and informally about the impact of the 2015 regulations, as well as needs for regulatory clarifications and training. If you have any information or insights that you would like to share, please contact OUST.

USTs are the backbone of our country's vehicle fueling infrastructure. Nearly every community in the country has a gas station with USTs. Safety and environmental protection are paramount for such a localized and nationalized network of fuel storage. The 2015 UST regulatory requirements led to many advances in equipment, systems, monitoring, and testing that improved release detection, reduced spill and overfill incidents, and empowered owners and operators. Ten years after those regulations, and as the program matures, we continue to see progress and changes. EPA is tracking many issues and coordinating with states, industry, and Tribes to plan and strategize in advance. For example, we are tracking aging infrastructure issues and the challenges associated with demonstrating financial responsibility. We are working with states to plan for program sustainability given transportation sector changes and to reassess exposure threats at UST release sites. Taking a few moments to reflect on 10 years gone by, and many more years of work in this national program, I am so pleased to recognize the tremendous long-term progress due in large part to the day-to-day efforts of those in the amazing UST community.

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NEIWPCC has published LUSTLine since 1985, and it has become the publication of record for UST matters nationwide.

Do you have an idea for an article? NEIWPCC is currently seeking authors to provide content on a variety of pertinent topics related to release prevention, corrective action, and financial responsibility.

To learn how to become a contributer, please contact James Plummer (jplummer@neiwpcc.org).

NSZD Rate Measurement Variability: It Is All About the Signal

By Julio Zimbron, Ph.D.

In LUSTLine Issue #95, we shared how reported rates of natural source-zone depletion (NSZD), measured using CO_2 passive samplers, have been decreasing as different sources of error have been identified and measurement practices revised accordingly.

This follow-up article explains two important sources of variability when measuring NSZD rates: i) signal shredding caused by soil transport processes on variables used to measure NSZD, and ii) soil processes not related to contamination (noise). Multiple NSZD rate methods account for these two processes differently, generating difficulties in comparing results. A case study will be presented comparing two different methods based on surficial CO_2 fluxes, to illustrate the causes of NSZD rate measurement variability and explaining differences among methods.

After reading this article, practitioners will have an improved understanding of NSZD rate measurement uncertainty, so they can better interpret and use NSZD rate data.

1. Introduction

Natural source-zone depletion (NSZD) rates at field sites are highly variable. For example, the first published NSZD rate measurement guidance stated that estimates of NSZD rates were expected to range by over an order of magnitude (API, 2017). The guidance document explained this was due to: i) the heterogeneous nature of field sites; ii) differences in background biodegradation rates among different methods; and iii) different ways in which methods addressed measurement interferences. At the time, the hope was that variability in NSZD rate estimates would not prevent assessing the usefulness of NSZD for managing NAPL and petroleum contaminated sites (including gas stations). However, since then, NSZD reviews have pointed to the difficulty of reconciling the results using the same method but changing noise-correction practices (Zimbron, 2022) or among different methods (Sookhak Lari et al., 2025). A recent data compilation illustrated how apparently small changes in one type of method implementation yielded larger than one order of magnitude differences in the measured NSZD rates (Zimbron, 2025). Combined, these reports indicate estimated NSZD rates can vary considerably, and that the accuracy of these measurements needs to be taken with a grain of salt.

A rigorous framework to analyze and discuss sources of NSZD rate measurement error has not been developed. A complete treatment of this subject is beyond the scope of this document, but this article will present some basic concepts related to variability and measurement error associated with NSZD rates. The goal is to provide context about measurement uncertainty and help the reader make decisions related to the measurement and interpretation of NSZD rates.

2. How Should NSZD Rates Vary Under Ideal Conditions?

ASTM defines NSZD as the "naturally occurring mass loss of hydrocarbons in NAPL source zones as a result of dissolution, volatilization, and biodegradation" (ASTM, 2022). This definition implies multiple complex overlapping processes. Further complexity arises from the heterogeneity of sites, due to heterogeneous lithology, large seasonal ambient temperature swings, and variable groundwater levels, among other factors. Individually tracking each contaminant in this NAPL mixture through these multiple processes in a complex site environment quickly becomes difficult, if not impossible.

A simpler model is needed to understand high level data trends. This model involves tracking the degradation of the bulk NAPL contaminant mass as a single "pseudo compound" undergoing methanogenic degradation, the anaerobic breakdown of organic matter, through the following reactions:

$$C_8H_{18} + 3.5\,H_2O \rightarrow 6.25\,CH_4 + 1.75\,CO_2 \qquad \text{(Equation 1)}$$

$$6.25\,CH_4 + 12.5\,O_2 \rightarrow 6.25\,CO_2 + 12.5\,H_2O + Heat \qquad \text{(Equation 2)}$$

Most NAPL sources are methanogenic because external electron acceptors (i.e., sulfate or oxygen) are locally depleted and limited by transport from upstream groundwater sources (Lundegard and Johnson, 2005). Equation 1 represents the initial generation of biogas (a mixture of CH_4 and CO_2) upon methanogenic degradation of the NAPL contaminant. Equation 2 describes shallow methane oxidation upon contact with ambient oxygen diffusing downwards from the ground surface. Processes associated with Equations 1 and 2 occur at different depths of the soil column (anaerobic and aerobic, respectively). When combined, Equations 1 and 2 add up to an equation (Equation 3) characteristic of the entire NAPL-impacted soil column, from the ground surface to the deep contaminant location:

$$C_8H_{18} + 12.5\,O_2 \rightarrow 8\,CO_2 + 9\,H_2O + \,Heat \qquad \textit{(Equation 3)}$$

The basis for estimating NSZD rates is done by measuring the rate of production of reaction products (i.e., methane, CO_2, or heat) using either a mass balance or a heat balance. An additional method called the compositional change method, which tracks temporal changes in the composition of the remaining contaminant instead of the reaction products (Hostettler et al., 2013), will not be addressed here. Assuming octane (C_8H_{18}) as an example in Equations 1-3, a CO_2 flux of one micromole of CO_2 per square meter per second produced from the NAPL source results in an equivalence of 625 gallons of NAPL per acre per year of NAPL mass losses. Of course, a different formula weight characteristic of a specific site can be used instead of octane, which typically changes the equivalence by less than 10%.

To understand the variability of NSZD rates, it is useful to consider major factors affecting biodegradation rates. These major factors include:

i) Soil Temperature. Laboratory data suggests that for each 10°C increase in soil temperature, microbial activity nearly doubles in the range between 0-40°C. This increase in microbial activity may impact NSZD, although deeper soil temperatures, around 10 feet below ground surface or higher, are relatively stable (staying at 15 to 16°C year-round). Furthermore, soil temperature will likely affect mass transfer rates (dissolution or volatilization) (Sookhak Lari et al., 2025).

ii) NAPL distribution. NSZD processes are often mass transfer limited, meaning physical transport between the NAPL and surrounding phases is the rate-limiting step. Because mass transfer depends on surface area, broader distribution of NAPL in the soil column (referred to as the "smear zone") will often result in larger NSZD rates because a larger portion of the soil microbiome can participate in the degradation mechanisms (Sookhak Lari et al., 2025).

iii) NAPL composition. Microbial activity is selective towards some NAPL compounds over others

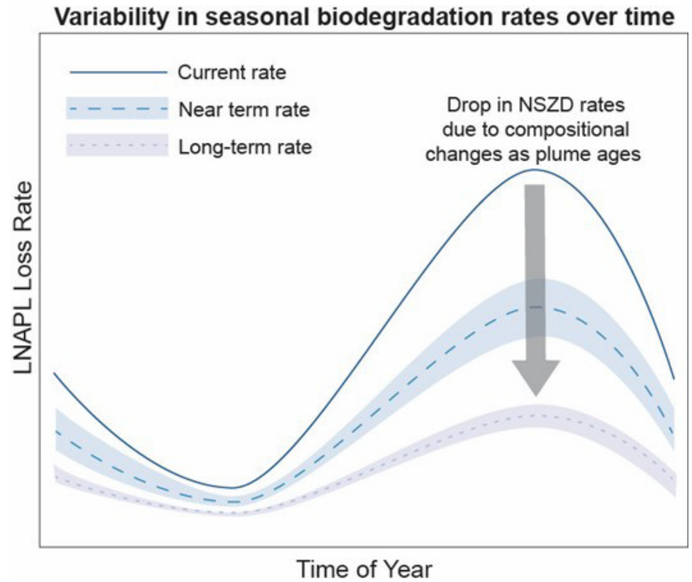

Figure 1. The expected variability of biodegradation rates (NSZD rates) in the short term (one year) and over the long term. Normalizing a base line annual rate (the gallons per acre per year destroyed by NSZD), the long-term rates decades later will likely be a fraction of that amount due to compositional changes in the contaminant.

(Hostettler et al., 2013). As the more biodegradable compounds are preferentially degraded, the NAPL source becomes enriched with less biodegradable (more recalcitrant) compounds, changing the NAPL composition and reducing the long-term NSZD rate. A study tracking long-term NSZD rates at a contaminated coastal petroleum handling site found that diesel NSZD rates were 3-6 times lower after 14 years, while gasoline NSZD rates were 9-27 times lower after a decade (Davis et al., 2022). Using initial NAPL mass estimates, the rates predicted total mass depletion by 2020, but mass measurements conducted that year still showed significant mass remaining (i.e., 25% of the initial gasoline was still accounted for).

Additional parameters might affect NSZD rates. For example, microbial activity requires minimal moisture levels and the presence of trace minerals and nutrients (e.g., nitrogen and phosphorus). However, the impact of these parameters on rates is poorly documented and thought to be minor at most sites. Therefore, a simplified NSZD conceptual model can be created by looking at the effects of the three above variables (soil temperature, NAPL distribution, and NAPL composition) to start analyzing general data trends.

A "stylistic" mathematical model was developed by Zimbron (2016; et al., 2018) based on data from the Bemidji site to estimate the seasonal variability of NSZD rates, primarily accounting for temperature sensitivity. The model used inputs such as ambient temperature profiles and published contaminant distributions (Dillard et al., 1997) to calculate temperature-dependent degradation rates across

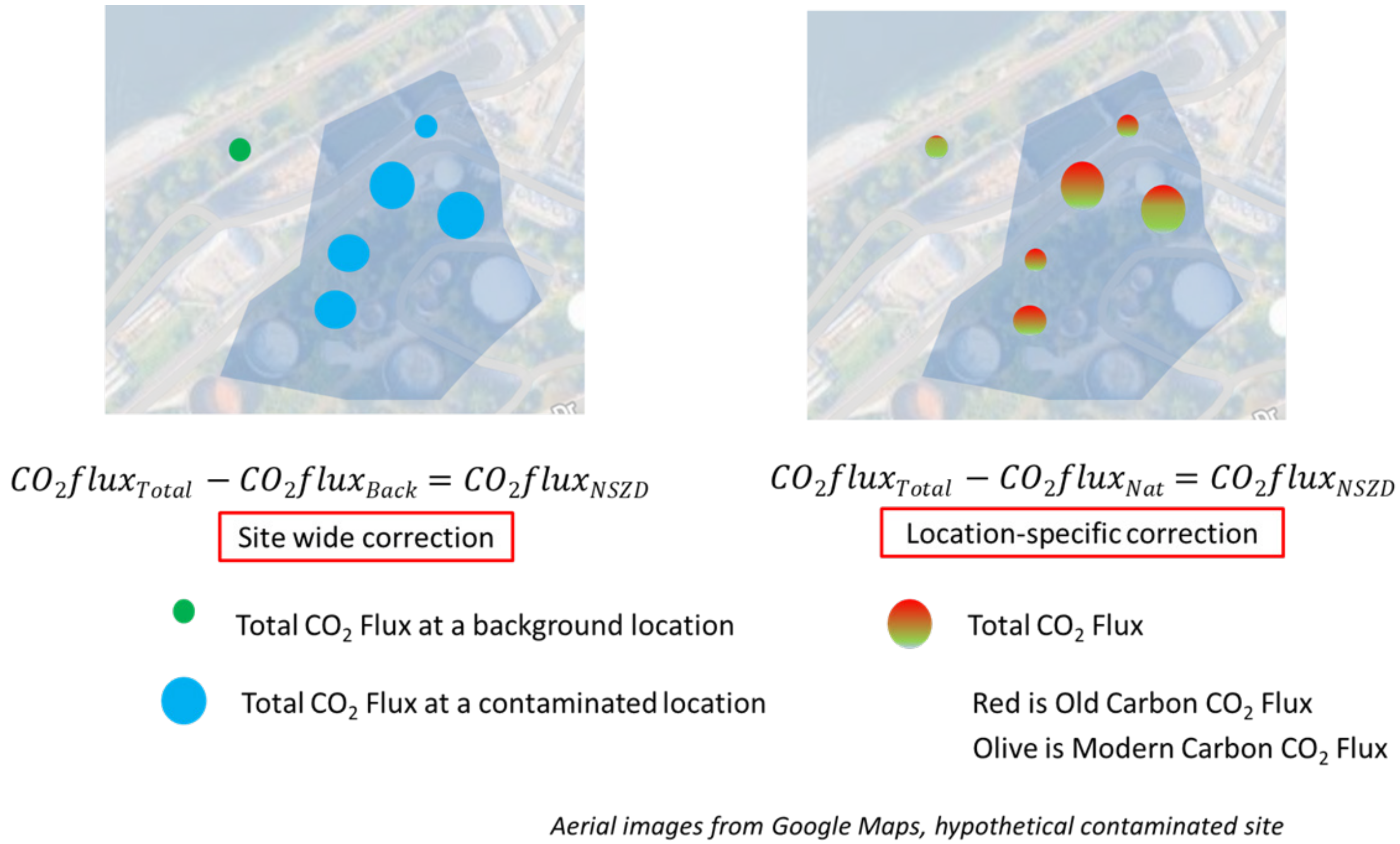

Figure 2. Illustration of the site-wide background correction (left) and a location specific correction (right). A background correction (shown in green) is subtracted from the measurements at the contaminated locations (in blue). An alternative location specific correction is available only for certain NSZD rate measurement methods, such as the modern and old carbon fractions based on radiocarbon measurements (shown as the red and olive portions of the graphic on the right).

the distribution of NAPL. The model predictions were calibrated by adjusting microbial degradation kinetics (obtained from a lab study using contaminated soils from a Canadian site at 22°C) to match published measured bulk NSZD rates. These were collected at different times of the year at one location of the Bemidji site using background-corrected CO_2 fluxes measured with the dynamic closed chamber (Sihota, 2014). Note that this short-term variability will depend on many factors: depth to contamination, local ambient temperature fluctuations, groundwater temperature, etc. The annual rates depicted in Figure 1 represent a shallow, temperate site, but a site with more constant weather and/or deeper contamination might result in smaller seasonal NSZD rate variability.

These results illustrate that ambient temperature fluctuations can explain significant seasonal variability. In this case, the maximum annual NSZD rate might be up to four times the minimal rate. Furthermore, long-term reductions of these initial NSZD rates are likely to occur (in this case, using the results provided by the Davis et al., 2022 data).

3. The NSZD Signal and Its Measurement: Distinguishing Signal vs. Noise, and Signal Shredding

The previous section described a rough approximation of expected NSZD rates over the short term (one year) and long term (decades). An ideal NSZD measurement would generate similar data trends illustrated by Figure 1. In practice, each NSZD measurement method can introduce additional measurement errors that make the data trends even less clear. Two common sources of measurement error are noise and signal shredding. A case study illustrating these concepts will be presented in the next section.

3.1 Noise vs. Signal

The reaction products of NSZD shown in Equations 1-3 are also naturally produced by soils, associated with processes not related to contaminant NSZD, generating a "noise" in the measurement, while the signal related to the NSZD processes (the "NSZD signal") plus the noise adding up to the total or

$$Signal_{Total} = Noise_{\square} + Signal_{NSZD} \qquad \textit{(Equation 4)}$$

unfiltered signal, according to Equation 4.

For example, uncontaminated soils naturally produce CO_2. Similarly, ambient temperature variations generate heat fluxes in soil that interfere with the heat flux of the biogenic heat from Equation 2. Different NSZD rate measurements deal with these interferences (the separation of signal from noise) in distinct ways. Figure 2 shows two different implementations of Equation 4. The first one is the so-called background location correction, in which a site-wide value is subtracted from the values obtained at the contaminated locations. For example, an NSZD rate measurement based on surficial CO_2 flux can be based on the total CO_2 flux, in which the total CO_2 flux at a background location (if available) is subtracted from the total CO_2 flux at the five contaminated locations shown. The second practice, not available for all methods, consists of applying a location-specific correction. When this occurs, the total CO_2 flux at each location can be calculated by using a radiocarbon (^{14}C) analysis to differentiate the modern carbon CO_2 flux (noise) and the fossil fuel CO_2 flux (signal). The radiocarbon analysis has long been recognized as the most reliable correction (API, 2017; CRC Care, 2018). A study based on data from passive CO_2 traps found that the assumption of a single, site-wide value is rarely met and using it might result in large measurement error compared to the location-specific correction using the radiocarbon analysis (Zimbron, 2022).

3.2 Signal Shedding

Carbon dioxide, one of the main products of NSZD (Equation 3), is subject to gas transport between the location where it is generated to the location where it is measured. Similarly, the heat produced by NSZD (Equation 2) is subject to heat transport. Although the rate of these NSZD reactions might be nearly constant at the signal source over the short term (a few days or weeks), the reaction products will show up at the ground surface (or other discrete locations in soil chosen for measurement) at variable rates. For example, biogas (CH_4 and CO_2) produced by anaerobic digestion accumulates in the water phase (i.e., below the water table), forming bubbles. These bubbles grow until they are released episodically from saturated zones due to changes in ambient pressure and temperature in a process called ebullition. Furthermore, gas transport in the unsaturated zone (thought to occur mostly by diffusion), experiences an advective component near the surface caused by ambient pressure fluctuations (Ma et al., 2013). As a result, a NSZD process occurring at a nearly constant rate at the source will result in a variable expression at the location used to conduct the NSZD rate measurement. This effect has been referred to as "signal shredding" (Ramirez et al., 2015). Signal shredding is part of the reason why short-term total CO_2 fluxes from soils vary, following a diurnal sine-wave shape, indicating soil respiration rates can change and even reverse in the short term (Ma, et al., 2013).

The variability of soil property measurements and soil transport, and the added variability to soil transport caused by signal shredding, have been common problems facing soil scientists for a long time. For example, soil porosity measurements will depend on sample size. Large measurement variability will result if the sample volume is similar to the volume of a single particle (for example, using a spoon to obtain gravel samples). Increasing the sample size to the point that is larger than the particle size will result in measurements of soil porosity that are more consistent (have lower variability). The smallest scale at which the results no longer depend on the sample size is called the characteristic scale (or the minimum reference element volume). This broad concept applies not only to the properties of porous media, but also to soil transport processes (i.e., groundwater flow). For example, the characteristic scale of flow in porous media corresponds to the cube of the pore volume (Corey, 1994). In other words, the problem of variability in measurements caused by signal shredding can be addressed by sampling at a scale above the characteristic scale.

So far, the literature describing measurement methods for NSZD rates has lacked an explicit consideration of the characteristic scale. However, this concept and the distinction between signal and noise are key to understanding why results of NSZD rate measurements using different methods can be difficult to reconcile. Paraphrasing John Cherry, known as the father of groundwater contaminant hydrology, you know you have sufficient data when you throw away half of it and you reach similar conclusions (for a more in-depth discussion on this topic, see Cherry, 1990).

4. A Case Study Comparing Two Surficial Carbon Dioxide Flux-Based Methods

This publicly available case study (Malander et al., 2015) involves the use of two measurement techniques of NSZD rates based on surficial CO_2 fluxes: the dynamic closed chamber (DCC) and the passive CO_2 trap. This dataset is the only available case in which the DCC were deployed for an extended period (in this case the same deployment of the passive CO_2 trap, approximately 21 days), offering a unique opportunity to compare both techniques over the same deployment time. Although both methods intend to measure the NSZD rate using the soil CO_2 flux leaving the ground at the surface, they differ in two aspects: the time scale of the measurement, and how they handle the signal vs. noise correction. The DCC is intended to be a short-term measurement that measures the real-time build-up of CO_2, while the passive CO_2 trap uses a CO_2 sorbent to provide a long term, time-integrated measurement of the average total CO_2 flux during the period of deployment (typically 14 days). The passive CO_2 trap also uses a radiocarbon (^{14}C) correction to differentiate the CO_2 of fossil fuel fraction (signal) from the modern carbon CO_2 captured (noise resulting from the natural carbon produced by soil respiration and decomposition). In contrast, the DCC often relies on subtracting the

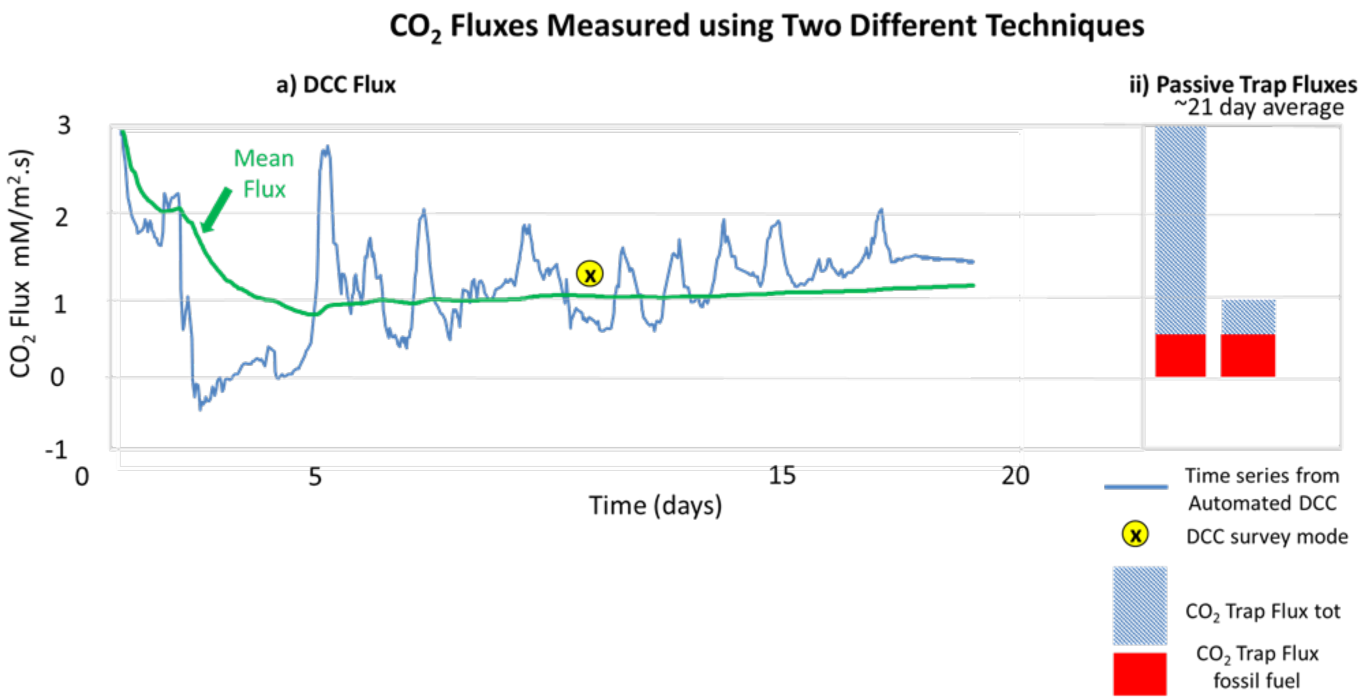

Figure 3. Comparison of surficial CO_2 fluxes using DCC and the passive CO_2 trap. Y-axis scale is the same for both techniques. The time series of the automated DCC is shown in blue, while the average up to each incremental time is shown as a green line. The passive CO_2 trap data (the average for a deployment time equal to the total deployment of the DCC) at two neighboring locations to the DCC shows the ^{14}C-corrected old carbon (used to calculate the NSZD rate) as a red bar, with the modern carbon CO_2 flux (noise) shown in blue. The typical use of the DCC is to sample at discrete times (often as a single snapshot sample, illustrated as a yellow circle with an x).

total CO_2 flux from a non-contaminated location (noise) from that of the total CO_2 flux measured at contaminated locations (noise + signal).

Due to the diurnal cycles in soil CO_2 gas caused by signal shredding, long-term use of the automated DCC is more rigorous than short-term DCC measurements for measuring NSZD rates. However, its practice might be limited to small NAPL-contaminated sites because automated DCC chambers need to be deployed within 50 feet of the CO_2 analyzer (a practical limitation imposed by the operating parameters of the sampling equipment involved). These practical limitations (and additional cost-related ones) in using the automated DCC makes this dataset unique and hard to replicate.

Figure 3 shows the time series of repeated DCC measurements for total CO_2 flux (in blue). Note that after the second day, the site experienced rain, which shut down the soil gas efflux, until the fifth day. At that point, a normal soil gas flux pattern (showing daily fluctuations) was reestablished. Figure 3 also shows the total CO_2 fluxes measured at two neighboring locations using the passive CO_2 traps, and the ^{14}C-corrected data (used as the basis for the location-specific correction for NSZD rates with this technique) at both locations. The results show that the total CO_2 flux measured by the passive CO_2 traps were highly variable (although within the range of the time series measured by the DCC). However, the old carbon CO_2 flux (the ^{14}C-corrected flux used to calculate NSZD rates) were within a few percentage points of each other with the measurement showing high repeatability. The time series from the DCC was used to calculate an average CO_2 flux up to that time shown in red. This data shows that the average soil gas flux of total CO_2 becomes nearly constant after five days. In other words, the characteristic scale of soil respiration process shown by this data set is around five days. Note that most DCC chamber measurements rely on a single time measurement and a background correction (also a single time measurement obtained at an uncontaminated location). Presumably, the total CO_2 flux at a background location would follow a daily pattern (as reported by Ma et al., 2013) and would have a characteristic scale of multiple days (as in Figure 3). Despite this short-term variability, practitioners have applied the ^{14}C correction to single time DCC chamber measurements (for example, see Jourabchi et al., 2018 and Reynolds, 2021). In doing so, the benefits of the ^{14}C high precision correction might be offset by the high variability of a measurement at a scale below the characteristic scale of the problem.

5. A Hypothetical Example

The example provided above is a detailed one, using real NSZD reported data. Here, a more general example will be provided for a hypothetical gas station, using an example provided before (Zimbron, 2025) involving a site (e.g., a gas station) with an existing mass of 32,000 gallons per acre. The initial analysis considered that at a NSZD rate of 700 gallons/acre/year (a mass loss rate of 2.2%), complete LNAPL depletion would be reached in approximately 30 years (ASTM, 2022). Now, consider that the stated rate was measured during the hottest part of the year, but a measurement during cold weather yields 300 gallons/acre/year, resulting in a reasonable annual average NSZD rate of 500 gallons/acre/year. If NAPL compositional changes resulted in lower NSZD rates over the long term by as much as an order of magnitude (as shown by Davis et al, 2022), then the life expectancy of the site can be easily pushed out in the future (by multiple decades). Whereas NSZD is expected to continue over the long term (at ever smaller rates), it would be wise to consider a range of life expectancy scenarios for the site, rather than a single value.

6. Summary and Recommendations

Differences in measured NSZD rates using multiple techniques can be difficult to reconcile, especially when the basis for these measurements is different. Many of the available methods are single time measurements (such as DCC), while others are time-integrated measurements (the passive CO_2 trap). The way that these measurements account for the sources of noise is also different. Some include a site-wide single value (the background location), while others use a location-specific value (for example the radiocarbon correction for CO_2 fluxes). Signal shredding and the lack of discussion about the characteristic scale of these processes create a very uneven field for these different techniques. No wonder practitioners have difficulty reconciling different measurement techniques. This should not be taken as a lack of repeatability of the methods themselves. For example, radiocarbon-corrected CO_2 fluxes using passive CO_2 trap data are within a few percentage points of each other (see Figure 3).

This document explains signal shredding and the distinction of noise vs. signal, which are two key drivers of variability in NSZD rate measurements, as illustrated for surficial CO_2 fluxes. However, additional sources of variability exist. A few examples are provided below:

Some methods measure gas concentrations or temperatures at discrete elevations in the soil column to calculate CO_2 fluxes or heat fluxes (i.e., the CO_2 gradient method or the thermal gradient method, respectively). These methods require the use of a soil transport property (i.e., the soil effective diffusion coefficient or the thermal diffusion coefficient, respectively). Often, practitioners will choose a single value from literature. The reported ranges of these coefficients often span over one order of magnitude. Furthermore, they will change with local soil conditions that rarely remain constant in time, such as soil type, moisture, and temperature. An inferred soil property from literature might differ from the actual (measured) one by orders of magnitude. An NSZD rate measurement obtained without measuring the actual soil properties, or one that is assumed to be constant over extended periods during which soil conditions vary will have large uncertainty.

The number of locations where NSZD is measured per unit area (the aerial sampling density) is another potential source of measurement error. A good practice here would be to pre-screen contaminated locations to define different levels of NSZD expression (i.e., high, medium, and low), over the entire contaminated area, and distribute sampling locations proportionally to the levels found during a pre-screening phase (stratified sampling).

NSZD rate measurements should ideally improve, not contradict, a conceptual site model (CSM). It might be tempting to discard NSZD rate measurements that do not fit the CSM. For example, background corrected CO_2 fluxes that are negative are often taken as null, but these should be taken as an indication that assumptions made while implementing the background correction were incorrect. Higher NSZD rates during colder weather, or the inverse, should be taken as a potential indication that the CSM needs further refinement or that the NSZD rate measurement is missing critical components of the CSM.

The CSM is unique to each site, and some sites have higher levels of complexity than others due to a variety of factors such as lithology, LNAPL distribution and site history. The risks associated with contamination are unique to each site, too. The suitability of NSZD as a remedy or as a reference for the performance of an active remedy will be site-specific. The practitioner must weigh these factors against the tolerance for uncertainty and the way that each method addresses measurement uncertainties before deciding on how to use NSZD rate data.

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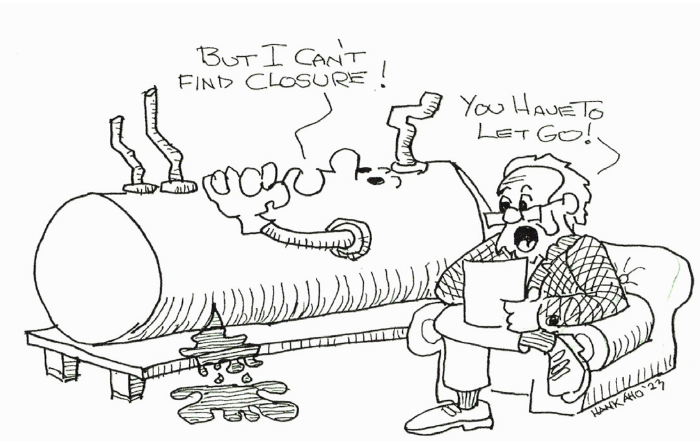
ASTM's Standard for Moving Petroleum Release Sites to Closure (MStC) is Published

By Tom Schruben



Summary

"ASTM E3488-25 Standard Guide for Moving Sites to Closure (MStC) for Petroleum Underground Storage Tank (UST) Releases" is now final and can be previewed and purchased online. MStC provides a framework, based on the latest science and best practices, for moving open petroleum UST releases to closure. It is a protective approach that focuses on addressing exposure to human and ecological receptors. It has sections on assessing the adequacy of the conceptual site model, evaluating alternative closure criteria, overcoming non-technical barriers, and assessing cleanup progress and determining when to change strategy.

Note to Reader: The MStC standard was published in May 2025, and now EPA and ASTM are focusing on outreach and training. The 2023 LUSTLine article, "Into the MStC – Developing A New Standard for Moving Petroleum Release Sites to Closure," (LUSTLine #93), describes some of the historical and scientific bases the MStC Task Group relied on when developing the standard. If you have not read that article, please go back and read it before diving into this article.

Introduction

Since its inception, the national Underground Storage Tank program has completed more than 527,000 UST cleanups. Through these efforts, we have learned a lot about keeping drinking water safe and preventing petroleum vapors from entering confined spaces and indoor air. Approximately 54,000 sites remain to be cleaned up nationwide, with the potential for more release discoveries as facilities close or replace their USTs. It is going to take our best collective efforts to resolve these old cases and to keep up with new release discoveries. As part of these collective efforts, ASTM recently published the "E3488-25 Standard Guide for Moving Sites to Closure (MStC) for Petroleum Underground Storage Tank (UST) Releases" to help implementing agencies complete the remaining cleanups. A 90-person Task Group of stakeholders from the petroleum cleanup community — regulators, scientists, owners, Tribes, insurance, and state funds — worked through ASTM's consensus-building process to develop the final MStC standard.

At a Glance...Possible UST Cleanup Program Benefits From Adopting the MStC Standard

- A fresh look at open cases identifying previously unrecognized exposures and improving corrective action decisions.
- Improving communication through exposure evaluations.
- Closing low threat release cases in states with groundwater non-degradation cleanup goals.
- Improving understanding of closure criteria.
- Allowing alternative closure criteria for more efficient corrective actions.
- Scientifically based LNAPL control requirements leading to more efficient corrective actions.
- Decreasing long-term monitoring costs and allowing programs to focus resources on releases that pose exposure threats.
- Optimizing remedies and bringing cases closer to completion.

EPA and ASTM are providing introductory webinars and workshops for states, Tribes, and other stakeholders that are interested in learning more about MStC. If you would like to learn more about MStC or schedule training, please reach out to me.

The U.S. Environmental Protection Agency developed a companion policy statement, "Reassessing Exposure Threats from Petroleum Underground Storage Tank Releases," to encourage UST cleanup programs to take a fresh look at the threats posed by their open petroleum UST releases. Assessing current exposures helps identify higher threat sites that may need additional attention and low-threat sites that may be suitable for closure. This policy statement provides broad guidelines that implementing agencies can tailor to their UST programs. It can help implementing agencies focus time and resources on higher priority releases and increase the number of UST release sites progressing toward closure. The policy statement refers to the MStC framework as one possible approach for incorporating threat assessments into corrective action programs.

How Does the MStC Standard Work?

The MStC standard offers a framework for overcoming technical and non-technical barriers to closure and improving cleanup strategies. This includes:

- Technical obstacles such as issues with the Conceptual Site Model (CSM), closure criteria, and ongoing exposure threats.
- Non-technical obstacles such as site access, lack of a viable owner/operator, or a lack of funding.
- Techniques for evaluating the effectiveness of current remedies and developing improved remedies.

The standard is flexible, allowing implementing agencies to adopt and implement the framework wholly or partially. Additionally, implementing agencies can adjust the recommended closure criteria to their needs.

How Might the MStC Standard Benefit My Program?

The MStC standard is a practical framework that implementing agencies can adopt and adapt to help bring UST releases to closure. It is based on current science and best practices developed from completing 527,000 UST release cleanups since 1988.

Adopting the MStC framework could lead to major changes and improvements in UST corrective action programs. Every UST cleanup program in the U.S. and around the globe is different and corrective action processes vary, so adopting MStC will affect each program differently. Some of the major changes and potential benefits for UST corrective action programs include:

- **A fresh look at open cases identifying previously unrecognized exposures and improving corrective action decisions**. Reexamining open release cases with current scientific knowledge and best practices helps ensure exposures are being fully recognized and managed. The cleanup goals for many open release cases were established over 20 years ago, based on a limited understanding of the sources, pathways, and receptors, and the potential for petroleum natural attenuation. Previous assessments might have overlooked an exposure such as vapor intrusion. A fresh look will often improve decision making, whether the examination shows a need for additional remediation or no further action.
- **Improving communication through exposure evaluations**. Increasing transparency and openness during the exposure evaluation process leads to better dialogue and collaboration among the involved parties, especially with complex release cases. Communication is critical when implementing agencies decide to close cases that have not met initial cleanup goals but where it is now clear there is a low threat of exposure. Providing an open and transparent process facilitates meaningful stakeholder understanding and contribution.
- **Closing low threat release cases in states with groundwater non-degradation cleanup goals.** The MStC framework allows a pathway to closure for states with groundwater non-degradation statutes assesses the potential threat of exposure to human and ecological receptors while natural attenuation degrades the remaining petroleum. Natural attenuation can be as effective or more effective than active remediation at a certain point in a release life cycle and long-term monitoring is not needed once it is clear that the plume is stable and not reaching receptors. This approach can be consistent with groundwater non-degradation statutes, which typically require cleanup of groundwater contamination to drinking water standards and remediating soil that could be a source of groundwater contamination.
- **Improving understanding of closure criteria.** Alternative closure criteria may be descriptive and easier to interpret than concentration-based closure criteria (such as 5 ppb benzene in groundwater samples). For example, non-groundwater professionals can more easily understand descriptive and visual metrics for closure criteria like plume stability and buffer distances. A simple paragraph can provide a clear, understandable picture of the contamination, its behavior, and a buffer distance from the leading edge of the plume to potential receptors.
- **Allowing alternative closure criteria leads to more efficient corrective actions**. For example, MStC allows demonstration of groundwater plume stability by either groundwater concentration trends or plume retraction. Trend analysis is

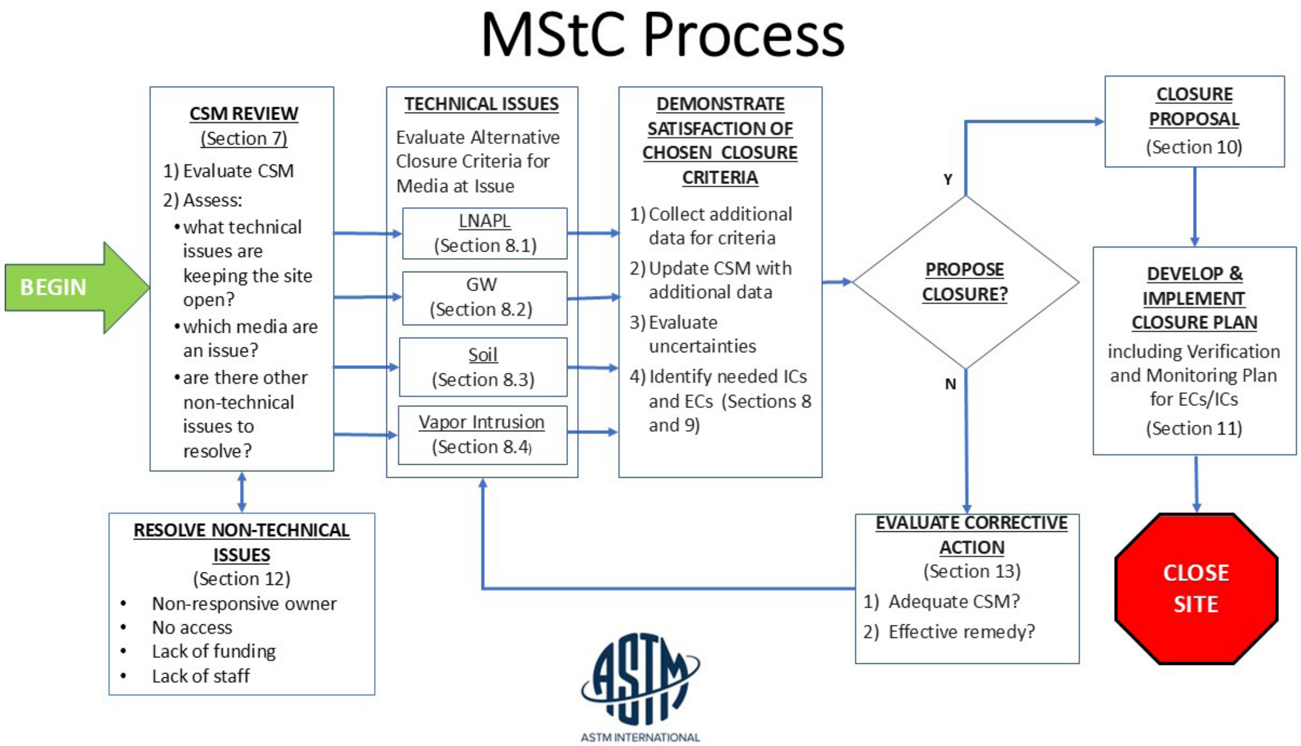


Figure 1. Schematic Diagram of the MStC Framework.

a widely used technique, but use of plume retraction has not been widely reported. Trend analysis involves evaluating the concentrations of chemicals of concern in groundwater, as well as assessing the effects of fluctuating (rising and falling) groundwater levels. Plume retraction is a snap-shot assessment of where biodegradation has occurred past the leading edge of the dissolved petroleum — the extent of the plume was once larger and is now decreasing. Plume retraction can be demonstrated in one site visit and thus may be more convenient at sites that do not have monitoring wells. Either method may be appropriate depending on site circumstances. The MStC standard allows flexibility to select the most efficient demonstration method.

- **Scientifically based LNAPL control requirements leading to more efficient corrective actions.** There has been a long-standing debate among petroleum remediation professionals regarding the significance of LNAPL accumulating in monitoring wells. In the MStC framework, it may be acceptable to leave residual and mobile LNAPL in the ground if they are not causing a vapor intrusion concern or an expansion of groundwater plumes. Some implementing agencies prohibit closure at sites where LNAPL continues to accumulate in monitoring wells. If this prohibition were removed, it would represent a significant program policy change and may remove a significant barrier to closing sites.
- **Decreasing long-term monitoring costs and allowing programs to focus resources on releases that pose exposure threats.** The benefits of long-term monitoring in the natural attenuation process have been debated for years. The MStC framework does not require monitoring once the stability of the release has been demonstrated. No one in the 90-person Task Group could recall an instance where monitoring of a naturally attenuating plume led to discovery that the plume was once again expanding or that active remedies were needed.
- **Optimizing remedies and bringing cases closer to completion**. Remediation efforts often outlive their usefulness, becoming inefficient or unnecessary. Implementing the MStC framework allows for increased assessments of remediation effectiveness and change to a more effective remedy.

How Can I Learn More About MStC?

While this article provides an overview of the MStC standard, there will be many more opportunities to learn about it. Some of the outreach initiatives include:

- Articles about MStC-related activities are coming out soon.
- EPA and ASTM are providing awareness training for state UST programs. This initiative also includes comprehensive 3-to-4-hour workshops scheduled for various conferences and national meetings.
- EPA and ASTM are developing a generic 2-day training program for UST remediation stakeholders (regulators, owners, cleanup

consultants, and other relevant parties) that can be tailored to individual state UST remediation programs.

Some states have already expressed interest in learning more about MStC and EPA's Exposure Threat Assessments policy and two state UST programs have said they want to adopt MStC. All states are encouraged to take advantage of the learning opportunities and determine if MStC and exposure threat assessments will help their program and identify whether changes in guidance, regulations, or statutes might be needed to implement the changes. Please write me if you would like to learn more about MStC training opportunities.

More About the MStC Standard

This section of the article describes the MStC process and the key sections of the MStC standard. I encourage you to look at the standard in its entirety after reading this article, and to reach out to me with any questions.

Conceptual Site Model (CSM)

The first step in the MStC process is to determine if the CSM is complete enough to understand the threats to receptors and to make corrective action decisions with confidence. The questions below help the user to determine if their CSM is complete enough to evaluate alternative closure criteria and remedy effectiveness:

- Are any receptors currently exposed to the release? If yes, what type of receptors?
- Is there a potential for exposures to receptors, including anticipated future receptors? Is there a potential for LNAPL migration?

If the answer to any of the LNAPL and receptor exposure questions above is "Yes," then ask:

- Are dissolved groundwater contaminants likely to migrate to current and anticipated future receptors? In other words, do pathways and a sufficient mass of contaminants exist for the dissolved groundwater contamination to reach current and potential receptors?
- If there is a likelihood of remedial action, what subsurface characteristic could affect removal or treatment of the LNAPL, soil vapor, and groundwater contamination?

Technical Barriers and Alternative Closure Criteria

The next step is to identify and address technical concerns that are preventing closure, such as not meeting target cleanup concentrations in groundwater. The standard helps determine if the release poses a low threat of exposure to human and ecological receptors by comparing site conditions. The site must meet the following four minimum conditions before considering alternative closure criteria:

1. The release has stopped.
2. There are no current impacts to receptors.
3. LNAPL is not migrating.
4. There is a basic CSM.

MStC provides information on each alternative criteria to help identify the criteria that are most appropriate for demonstrating that a site poses a low exposure threat. Using this criterion is essential for a cost-effective assessment. For example, the five peer reviewed criteria listed below demonstrate that LNAPL is not migrating.

1. Decreasing LNAPL extent thickness (gauging) demonstrated by a trend analysis in the CONCAWE LNAPL Tool Kit.
2. Stable or decreasing groundwater plume.
3. Residual LNAPL located beyond the footprint of mobile or migrating LNAPL.
4. LNAPL transmissivity low – for example, less than 0.8 ft^2/day.
5. Residual LNAPL in the soil immediately outside a monitoring well is much thicker than the gauged LNAPL thickness (e.g., greater than five times thicker).

Considering mobile and residual LNAPL (evaluation of groundwater, soil, and soil vapor) is the next step for identifying low-threat conditions. Each assessment should be made separately for groundwater, soil, and vapor intrusion and be based on three classes of criteria.

1. Distance screening. Implementing agencies use screening distances for vapor intrusion and direct soil contact. The MStC framework includes screening distances for groundwater receptors as measured from the leading edge of stable plumes to current or future receptors. The California State Water Resources Control Board (SWRCB) Low Threat Closure Policy applies screening distances of 250 to 1,000 feet depending on the presence of mobile LNAPL, the contaminant of concern (COC) plume length, record of plume stability in areal extent, and the maximum COC concentration.
2. Measurement of contaminant concentrations. Concentration-based closure criteria involve the evaluation of COC concentrations in groundwater, soil, or soil gas. A site project manager could assess the natural attenuation rate in groundwater or soil to determine if corrective action levels will be achieved within a reasonable time period or prior to the expected use of any potentially affected media.
3. Mass flux/discharge modeling. Mass (flux/discharge) of COCs in media are below levels that prevent COC concentrations from exceeding background or corrective action levels at points of exposure. Mass flux/discharge estimates generally require a detailed understanding of:
    - Spatiotemporal variabilities of COCs in

groundwater.

- Mass flux/discharge (either measured or modeled).
- Rates of groundwater flow within specific hydro-stratigraphic units.

The certainty of mass flux/discharge estimates generally improves with increasing data collection and additional site assessments, particularly for large releases in complex geologies.

The standard provides considerations for institutional controls (ICs) and engineering controls (ECs) for each media. In addition, a section is devoted to general considerations for EC and IC implementation and summarizes applicable portions of more detailed ASTM standards. MStC also includes a checklist for assessing whether certain ECs and ICs will adequately achieve the stated goals.

Non-Technical Barriers to Closure

Often non-technical issues, such as non-responsive owners and lack of site access, prevent an open release site from progressing to closure. Resolving non-technical issues takes time and effort but is imperative to moving the site remediation forward. These barriers rarely resolve themselves and often become more difficult with the passage of time. The MStC standard provides a checklist of barriers that are divided into 16 categories. This should help implementing agencies track barrier prevalence and group sites by barrier type. Tracking and grouping these non-technical barriers helps implementing agencies resolve the barriers efficiently.

The standard also includes best practices for resolving non-technical issues that implementing agencies have encountered over time. MStC encourages owners, operators, regulators, consultants, development officials, lenders, and investors to work together to overcoming non-technical barriers.

Corrective Action Evaluation

The Corrective Action Evaluation section of MStC outlines the process and tools for evaluating corrective action when conditions do not allow closure under alternative criteria or the site is not ready for closure. Corrective action, including the CSM, cleanup goals, and remedies, can then be modified to move the site towards closure. When there are CSM uncertainties or when the responsible party is unwilling to commit to long-term engineering or institutional control monitoring obligations, all parties involved (i.e., the owner, regulator, and other stakeholders) should evaluate the corrective action and create a plan that addresses concerns that are preventing closure. The plan will identify measures to better achieve the corrective action goals. Elements of the plan could include:

- Filling any data gaps in the site CSM.
- Aligning the corrective action and closure goals.
- Reducing uncertainty in remedial concerns and objectives.
- Assessing corrective action performance.
- Gathering metrics to support transitioning corrective action approaches. Transition points might include transition from active to passive remediation or reducing or eliminating monitoring.
- Using available tools to inform corrective action decision making.
- Reviewing the corrective action to determine if regulatory endpoints are attainable, or whether alternative closure approaches are warranted.

And, like the other sections of MStC, an example checklist is included to summarize the Corrective Action Evaluation.

Conclusion

With nearly 54,000 UST release sites, and the possibility of many more release discoveries in the future, the UST community has significant work to do to move corrective actions toward closure, reduce the number of open releases, and ensure that cases with unresolved threats are addressed.

ASTM's MStC standard is a comprehensive framework for addressing UST release sites. Adopting the standard may provide substantial benefit to your cleanup program in terms of ensuring protective cleanups, realizing resource efficiencies, and improving stakeholder relationships.

EPA, ASTM, and other partners are committed to offering quality training opportunities for implementing agencies.

Tom Schruben is a physical scientist at the U.S. EPA's Office of Underground Storage Tanks. He is also chair of the ASTM's MStC Task Group. Tom can be reached at Schruben.Thomas@EPA.gov.

Live Webinar

Wednesday, February 18, 2026

(2-3 p.m EST)

Into the MStC: ASTM's E3488-25 Standard Guide for Moving Sites to Closure (MStC) for Petroleum Underground Storage Tank (UST) Release

Register here

Sponsored by: U.S. EPA
Office of Underground Storage Tanks (OUST)

News and Resources

A Message From NEIWPCC's UST/LUST Program Coordinator: James Plummer

As we approach the 100th issue of LUSTLine, I have started looking through past issues for ideas for recurring segments to include in future issues. I am a fan of repeating bits. Bits create a sense of continuity across issues. They are also ideally brief enough to get folks hooked, but substantive enough to provide value without sending readers on an information goose chase.

Readily consumable and fresh content keeps folks engaged in these fast times. Although, there's something special about slowing down to skim through photocopied issues from the early days. It's really motivating to be part of and see the paper trail of a decades-long legacy (of good work, not releases).

LUSTLine has printed recurring features (which you should check out in the LUSTLine Archive) with legends in the field like "Tank-nically Speaking" with Marcel Moreau, "Tanks Down East" with David McCaskill, and "Field Notes" with Robert Renkes.

Although the pixels on your screen do not smell like fresh printed pages and your laptop keys do not convey the coziness of paper, the content of LUSTLine continues to echo the efforts of the tanks community. There's a lot to be optimistic about in our arena and we need more ways to showcase all that goodness. Has your state crafted new legislation that you're stoked about? Has your tribe cleaned up a release in record time? Has your organization developed a guidance document with even more acronyms? Let us know!

Potential Bits

If you do not have a 20-page manifesto and just want to throw us a few sentences highlighting the good stuff you and your team are doing, we would be more than happy to include more bits like that in LUSTLine. Bits inspire ideas and foster connection. Someone might read your bit and say, "Hey, I should reach out to [cool person name] to find out more about how they were able to [important accomplishment]." Help us help you help others help themselves!

Another bit I have been mulling is a recurring interview segment to capture the institutional knowledge of our more seasoned peers. The value baked into the perspectives of 30+ years of experience is overwhelming. It feels imperative that we harness this expertise. If you know anyone getting ready to retire who's made great contributions to the industry or someone recently retired that we can still get in touch with, please connect us. I'm thinking for the title of the segment we can reference 1985 (the year the first issue of LUSTLine was published) with a top 100 hit song like "Don't You (Forget About Me)" or "We Built This City" or "Smooth Operator".

In thinking about all the articles in the past 95 issues of LUSTLine, so much great information has

News and Resources

Message From James Plummer (continued)

been compiled over the years. If you find an article from a past issue that stands the test of time or that we could revisit with a new lens, reach out and we'll give you a shout out if we spotlight it in a future issue.

Issue 97

While we were thinking we will roll out bits... well, bit-by-bit... someone at the National Tanks Conference requested we focus on the newer staff in the industry. Shout out to whoever that was who contributed the idea. We are thinking of designing Issue 97 as a roadmap to enter the tanks community. This might include highlighting where to look for resources, who to reach out to with specific questions, what to watch, what to attend, and aim to highlight the work of various organizations operating in this industry. The goal would be to give these folks the most bang for their buck (LUSTLine is free, but still...) in the easiest format possible. Let us know of any resources or organizations that newer staff should know about.

NEIWPCC Project Updates

In September, NEIWPCC hosted the National Tanks Conference in Spokane, Washington. Following a fruitful National Tanks Conference, we buckled in and completed our free, self-paced, online Class A and B Operator Training and Exam in coordination with the folks at EPA OUST. Read more about these new projects below.

Down the road, we are excited to be working on additional self-paced courses, short explainer videos, and an online community for regulators to connect, ask questions, and share resources.

James Plummer can be reached at jplummer@neiwpcc.org or 978-349-2520.

Self-Paced Training Delivers Educational Resources Directly to Tribal Operators

NEIWPCC recently collaborated with the EPA to create a free self-paced training course, designed to educate operators in Indian Country about how to properly maintain and operate UST systems. The course was designed to make training resources more accessible to Class A and B tribal operators, who are required to adhere to federal UST regulations requirements.

In-person trainings can be expensive and require traveling long distances, which can prove too costly for owners and employees at independent gas stations. Through its self-paced formatting, this new course allows operators to partake in training on their own time, and from any location nationwide.

The training begins with an introduction to the regulations surrounding USTs, including which tanks are regulated, why these rules exist, and the training requirements for operators who work with these systems. It then covers more technical aspects of the job including how to prevent, detect, and report releases, demonstrate financial responsibility for potential leaks, perform inspections, and keep up to date records.

At the conclusion of the course, participants are required to take the online operator exam. The certification designates that individuals have properly completed the training and know how to maintain compliance with the EPA's regulations. Additionally, operators who have completed prior training are permitted to take the exam, without having to complete the accompanying course.

The Class A and B operator training was developed in cooperation with and reviewed by the EPA, as well as members of NEIWPCC's Tribal UST/LUST workgroups. NEIWPCC is also working on two additional self-paced training courses focused on UST inspections and LUST remediation.

News and Resources

National Tanks Conference Draws Large Turnout in the State of Washington

NEIWPCC hosted the 28th National Tanks Conference in Spokane, Washington, a bustling three-day event focused on the UST industry. NEIWPCC has planned and hosted the conference since 2005 in partnership with the EPA's OUST and the Association of State and Territorial Solid Waste Management Officials (ASTSWMO).

The National Tanks Conference addresses some of the most pressing concerns facing the industry today: upgrading or replacing aging USTs, responding promptly to releases, moving sites to closure, managing abandoned tanks, training owners and operators and maintaining sound financial assurance funds. The event brought nearly 600 state, tribal and territorial professionals, federal regulators, tank inspectors and cleanup and industry specialists from across the country into one space to collaborate on these issues.

The conference began with a series of optional workshops and activities for participants looking to gain specific skills or networking opportunities. During the UST compliance "speed dating" session, attendees sat at small roundtables to hear 10-minute pitches from industry innovators. The groups then rotated, allowing individuals to hear about various digital programs, products and apps that help prevent releases and keep USTs in compliance with state and federal regulations. Additionally, an introductory workshop on the Interstate Technology and Regulatory Council's (ITRC) petroleum hydrocarbon technical documents provided training on using tools that offer guidance on addressing sites that have been contaminated by oil and petroleum products.

The audience heard from a panel of experts which included representatives from federal, state, tribal and private industry workplaces. The panel fielded questions about interagency relationships, as well as hardships and successes they have dealt with at their agencies in recent years.

As participants moved through various sessions over the next few days, they had the opportunity to pick from presentations focused on compliance and prevention, release cleanup, financial responsibility, or cross-programmatic topics. One session featured presentations about the impact of natural disasters on USTs and the importance of emergency response planning. Other sessions discussed artificial intelligence, cybersecurity concerns, aging USTs, remediation techniques, case studies, release prevention, and attracting a new generation of industry workers.

The conference included several networking events, designed for attendees to meet others who work in the field and catch up with old colleagues. Additionally, the venue featured an exhibitor hall with booths for vendors, states, tribes and federal agencies to showcase their tanks-related products and services. The hall also displayed posters showing the results of recent research efforts for attendees to look over during breaks between sessions.

Participants took advantage of this time being in-person to host small group meetings, including the EPA, Tribes, the National Leak Prevention Association and the National Work Group of Leak Detection Evaluations. The next National Tanks Conference is expected to be held in 2028.