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L.U.S.T.LINE

A Report On Federal & State Programs To Control Leaking Underground Storage Tanks

30 YEARS OF FEDERAL UST REGULATION

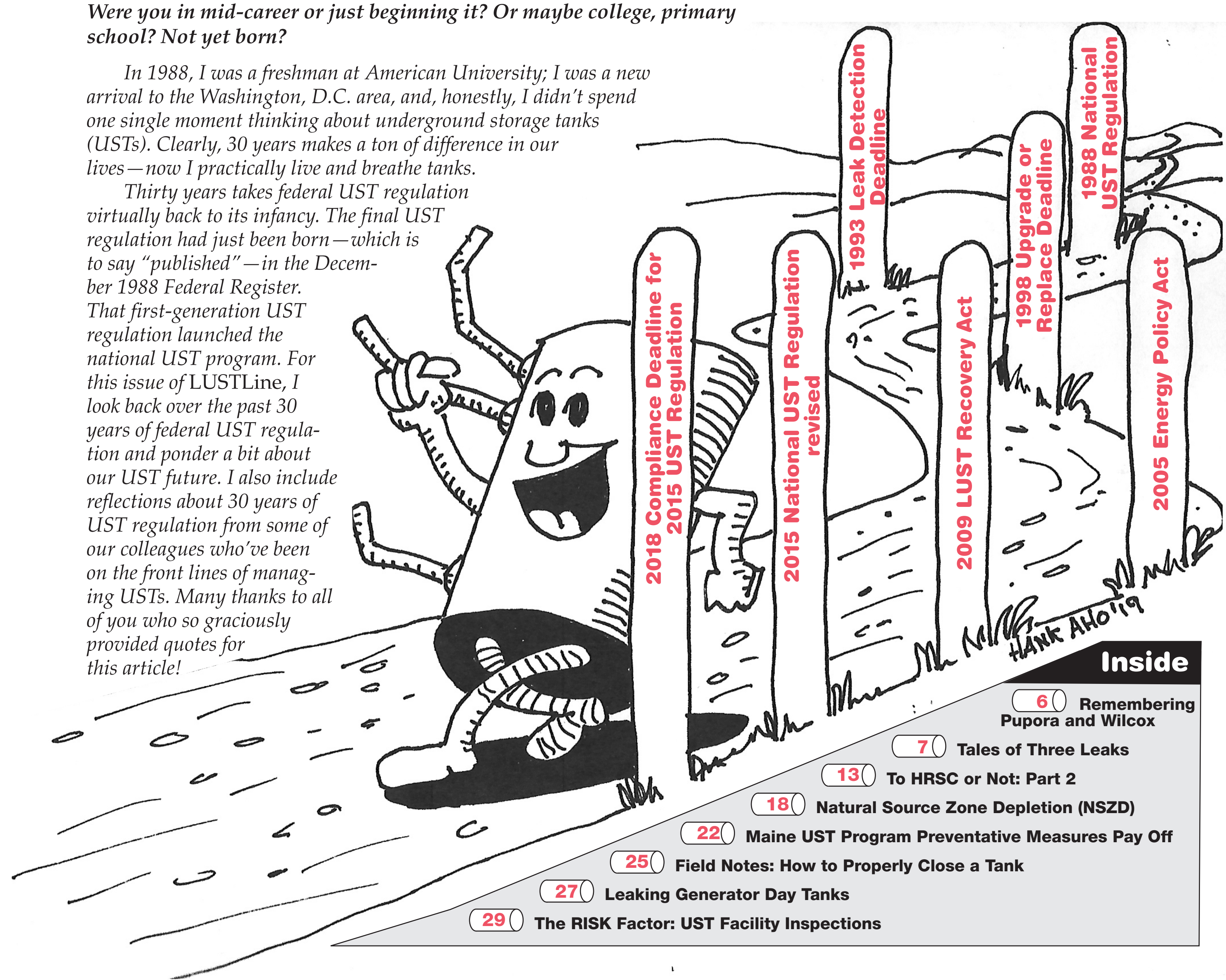
Looking Back; Going Forward

by Carolyn Hoskinson

Think back: ***Where were you 30 years ago? What were you doing then? Were you in mid-career or just beginning it? Or maybe college, primary school? Not yet born?***

In 1988, I was a freshman at American University; I was a new arrival to the Washington, D.C. area, and, honestly, I didn't spend one single moment thinking about underground storage tanks (USTs). Clearly, 30 years makes a ton of difference in our lives—now I practically live and breathe tanks.

Thirty years takes federal UST regulation virtually back to its infancy. The final UST regulation had just been born—which is to say "published"—in the December 1988 Federal Register. That first-generation UST regulation launched the national UST program. For this issue of LUSTLine*, I look back over the past 30 years of federal UST regulation and ponder a bit about our UST future. I also include reflections about 30 years of UST regulation from some of our colleagues who've been on the front lines of managing USTs. Many thanks to all of you who so graciously provided quotes for this article!*



Inside

6 Remembering Pupora and Wilcox
7 Tales of Three Leaks
13 To HRSC or Not: Part 2
18 Natural Source Zone Depletion (NSZD)
22 Maine UST Program Preventative Measures Pay Off
25 Field Notes: How to Properly Close a Tank
27 Leaking Generator Day Tanks
29 The RISK Factor: UST Facility Inspections

■ 30 Years of Federal UST Regulations *from page 1*

Looking Back

The UST universe is significantly smaller than it was 30 years ago, when it was estimated to be 2.1 million USTs. In 2018, states and territories reported that over 1.8 million USTs have been closed, and our active universe of USTs now hovers around 550,000 USTs at approximately 199,000 facilities. That's a significant reduction in the size of our UST universe.

Our UST world has also seen a significant evolution in owners and operators. Facilities have consolidated, and in many instances, major oil companies have divested of their neighborhood gas stations.

Indeed, for both prevention and cleanup, our UST world has changed dramatically over 30 years. We are seeing improved technologies and materials, upgraded equipment, and better methods for preventing and addressing petroleum releases from USTs. But we are also seeing an aging infrastructure, where new tank systems that were installed 30 years ago are now potentially nearing the end of their useful lives.

> **"The culture of the collective tank program nationwide is collaborative. Other programs could learn from our fraternity approach."**
>
> ***–Ben Thomas, UST Training***

On the prevention side, compatibility of substances stored in USTs was a requirement in the 1988 federal UST regulation, and it remains an essential requirement. With the ongoing introduction of new and emerging fuels as well as the changing fuel supply in the United States, we are seeing the need to reinforce the compatibility requirement as it applies to biofuels. We did that in the 2015 federal UST regulation.

On the cleanup side, methyl tertiary butyl ether (MtBE) was not in the forefront of the UST program in 1988, but it moved to the forefront during the late 1990s and early 2000s. In recent years, use of MtBE in gasoline sold in the United States has virtually ceased, and the national UST program's work has contributed greatly to reducing soil and groundwater contamination from MtBE.

Preventing and cleaning up UST releases were priorities from the beginning of the UST program, and they remain so today. How we implement those priorities and the techniques, approaches, and technologies we use may change over time, but doing our job is a constant. Our commitment to working collaboratively with our state, territorial, tribal, and industry UST partners remains a constant, enduring, and unique characteristic of the national UST program. That dedication to cooperation is also a source of great pride for many of us in the national UST program.

■ Preventing and Detecting UST Releases Over 30 Years

The 1988 federal UST regulation provided a comprehensive framework to guide us in shaping the UST program for its first 25 years. The 1988 regulation focused on requiring owners and operators to put the appropriate equipment in place, demonstrate financial responsibility for taking corrective action, and compensate third parties for bodily injury and property damage from releases of USTs containing petroleum. The regulation also included requirements for state program approval.

> **"Back when I started working in the field as a tester, there was no such thing as a sump that contained the STP for easy access and they certainly did not exist for any type of secondary containment purposes. There was a small square lid in the concrete, the STP was buried in dirt or stone and we were lucky if we saw the top of the mechanical line-leak detector sticking out of the dirt when we opened the lid. We had to dig out the STP by hand so we could remove the leak detector from the pump in order to perform a line tightness test. We've gone from tightness testing the single-walled piping to make sure it wasn't leaking directly into the ground, to ensuring that containment sumps are liquid-tight to contain a potential release from a double-walled piping system. Things have certainly changed for the better!"**
>
> ***–Edward S. Kubinsky, Jr., Crompco, LLC***

The 2005 Energy Policy Act UST provisions focused on preventing releases and expanding eligible uses of the Leaking Underground

L.U.S.T.Line

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> **"During early years of volumetric tank testing, it often required many tedious hours, sometimes extending all night long, for the data collection to determine if a tank was leaking or "tight." Now it takes about an hour per tank if all goes well. Sometimes 2 – 3 hours."**
>
> ***–Brad Hoffman, Tanknology Inc.***

Storage Tank (LUST) Trust Fund for prevention activities. It also included requirements for inspections, operator training, delivery prohibition, secondary containment, financial responsibility, and cleanup of releases that contain oxygenated fuel additives. Because the Energy Policy Act provisions did not apply in Indian Country and certain states, we recognized the need to ensure the same preventive requirements would apply to all USTs in the United States.

After significant consultation with our partners, we issued the **2015 federal UST regulation,** which was the first major revision to the federal UST regulation since 1988. It strengthened the 1988 regulation by: increasing emphasis on properly operating and maintaining UST equipment already in place; addressing previously deferred UST systems; ensuring UST equipment works properly, even as the fuels stored continuously change; establishing federal requirements similar to key portions of the Energy Policy Act of 2005; and ensuring that all USTs, including those in Indian Country, meet the same minimum standards. We also issued the **2015 state program approval (SPA) regulation,** which updated SPA requirements in 40 CFR part 281 and incorporated changes to the 2015 regulation. This required the 38 SPA states plus Puerto Rico and the District of Columbia re-apply in order to maintain their SPA status. Other states indicated they, too, would apply for SPA.

In 2004, we began **measuring the significant operational compliance (SOC) rate,** which helps us assess how UST facilities in states, territories, and Indian Country are doing in complying with release detection and release prevention requirements. This measurement tells us what percentage of UST facilities have equipment in place—and that the equipment is being used, functioning, and maintained properly. Since we began measuring SOC, we've seen a steady increase in operational compliance…and that is good!

- For the first 7 years of reporting between 2004 and 2010, the national SOC rate hovered between a low of 62 percent and a high of 68.6 percent.
- During the last 8 reporting years between 2011 and 2018, the SOC rate has been in the 70 percentages.

For the last 10 years, the **number of releases detected each year has stabilized**, ranging from a high of 7,100 per year to a low of 5,500 per year; 55,000 releases were reported between 2009 and 2018. That is a significant difference and improvement, as shown in Table 1 above, compared to the first 10 years after issuing the 1988 federal UST regulation, when states and territories reported approximately 367,000 releases, or 68 percent of all releases reported since 1988. This shows that our prevention work is doing what is it supposed to do: help keep petroleum from contaminating our environment.

Table 1. UST releases reported between 1989 and 2018.

Time Period	Releases Reported	
	Number	Percent Of Total
2009-2018	55,000	10%
1989-1998	367,000	68%
Cumulative 1988-2018	544,000	100%

Cleaning Up UST Releases Over 30 Years

Years ago the national UST program began evaluating leaking UST sites with the goal of cleaning up all pollution from USTs. Cleaning up sites to the point where all traces of contamination are removed can be hugely expensive, but we soon realized that we can protect human health and the environment in a less expensive, but still protective manner using **risk-based corrective action** (RBCA). A strategy developed by the American Society of Testing Materials (ASTM), RBCA helped states embrace the importance of identifying receptors and risk to UST releases, and if both are absent, ask what level of cleanup and amount of effort is needed.

> **"We've had some great successes and some mild setbacks; RBCA has taken over many state cleanup programs, lab-in-a-bag has gone the way of the dinosaur. Whatever the outcome, the LUST program has always been willing to innovate."**
>
> **–Richard Spiese, Vermont LUST Program**

When we make cleanup decisions based on the risk each UST release poses to human health and the environment, we are making good use of limited resources—time, personnel, and money. For decades, many states have been using risk and exposure assessment methodology to make determinations about the extent and urgency of corrective action, as well as the scope and intensity of corrective action oversight. Applying RBCA ensures we are adequately protecting human health and the environment, even if allowing some contamination to remain in place, when appropriate,

■ *continued on page 4*

■ 30 Years of Federal UST Regulations *from page 3*

or using institutional controls to prevent exposure during future uses.

In 1988, we began **tracking the cumulative number of releases cleaned up**, as well as other performance measures. In the 30 years since then, we see that states, territories, tribes, and industry have completed an astonishing number of cleanups: as of September 2018, approximately 478,000 or 88 percent of all cleanups were completed.

That is good news! We are tackling the remaining approximately 65,000 releases, or 12 percent of the backlog, even though the remaining releases may well be technically challenging, lack financial responsibility, or be abandoned.

Our **2011 backlog study** helped us take a detailed, data-driven look at the releases remaining to be cleaned up, and we used the study as an opportunity to identify strategies for bringing more releases to closure. We are also seeing that Petroleum Brownfields money can be a productive way to address low priority releases in the backlog, because a leaking UST site's potential for redevelopment and reuse can help drive cleanup.

Over the last 30 years, we've seen significant **advancements in assessment and cleanup technologies**. New and more sophisticated site characterization technologies using sensors and increased computing power now give us a better understanding of UST releases. As a result, we are better able to characterize sites, identify where the contamination is located and how it behaves, and determine the extent of contamination. This in turn helps us determine and tailor the best cleanup approach for each release site.

Gone are the days of defaulting to pump and treat at release sites, and while dig and haul still may be the preferred approach in certain situations, the options for in-situ remediation grow.

It is interesting that, after all this time, we are continuing to evolve and improve our understanding of how to assess and remediate subsurface contamination. For example, high-resolution site characterization strategies and techniques use scale-appropriate measurement and sample density to define contaminant distributions—and the physical context in which they reside—with greater certainty.

Over the years, **state funds** have played an important role in the national UST program. Even though many states envisioned state funds as a short-term solution to historical contamination, they have endured as critical sources of money for newly discovered releases as well. Over the course of the national UST program, state funds have contributed tens of billions of dollars to cleaning up releases.

What's Ahead?

The year 2048 certainly feels far, far away. I wish I had a crystal ball and could see our UST future. Given the inexorable evolution of technology, we don't even know what the future need for USTs will be. But I imagine USTs will still be a critical part of the transportation infrastructure for decades to come.

In the short term, I do know the UST program will focus on the following work.

- We will continue to conduct 3-year inspections, train training operators, and make UST records available to the public.
- States will continue to develop and implement their revised state regulations that mirror the 2015 federal UST regulation.
- SPA states will continue to apply for re-SPA under the 2015 federal UST regulation, and USEPA will work with those states that apply.
- Beginning in April 2019, 18 states and territories with revised state UST regulations that were effec-

> **"The world of UST management has changed dramatically over my 35 years in the industry. The constant is we still bury tanks in the ground and pipe fuel to a dispenser or a pump as we did in the early 80s. Today our construction processes are far superior and our sophistication is such that we can remotely monitor and diagnose most any issue. Long gone are the days of rolling a tank off of a trailer on to tires and rolling on tar to coat the bare steel tank."**
>
> **–Ron Fulenchek, Gasoline Environmental Compliance & Remediation, 7-Eleven Inc.**

> **"30 years ago, I began my quest to understand UST corrosion protection and that weird thing that no one could even pronounce known as cathodic protection. In those days, we were only concerned about external corrosion protection and those mysterious "anoids" did the job. Although I thought I had corrosion under control, it turns out there is a whole new world of UST corrosion protection that has nothing to do with cathodic protection. The bizarre, virtually uncharted territory of internal corrosion and "ethanol corrosion" within containment sumps has presented a whole new universe of challenges that we are only just beginning to understand. While I think I know what I'm talking about when it comes to UST cathodic protection and I will never quit learning, but it will probably be up to some brave young whippersnapper to conquer this strange new world! Will that be you?"**
>
> **–Kevin Henderson, former state UST official and current UST consultant**

> **"Thirty years ago, groundwater contamination from leaking underground storage tanks was news. Frequently, there were articles in the Sunday edition of the local newspaper, and short segments on TV. That is no longer the case. Thanks to thirty years of intelligent and effective work by the state agencies, there is much less of a problem. The dragon has been driven back to its lair. Now the challenge is to keep it there."**
>
> ***–Dr. John Wilson, retired USEPA scientist***

tive October 2018 will begin reporting on their technical compliance rate (TCR) measures and additional compliance measures. Other states will follow suit when they fully implement their revised state regulations. This will help document states' progress in implementing their revised regulations.

- USEPA will continue our partnership with tribes as we implement the 2015 federal UST regulation in Indian Country.
- We will work with the research and industry sectors to identify options for addressing corrosion in UST systems.
- USEPA will coordinate with states to ensure their funds are viable options for UST owners and operators in meeting their financial responsibility requirements, and we will continue to monitor the evolving insurance market.
- We will work to identify barriers to cleaning up challenging UST-release sites and explore what we can do to help move them forward.
- We will continue readying release sites, so they can be reused and redeveloped.

And for the long term, there are some uncertainties that could impact the UST program, such as:

- The migration to new fuels and fuel additives, and associated challenges they may present to storage equipment, as well as assessment and remediation of releases.
- Advances in prevention, detection, assessment, and remediation technologies.
- The continued evolution of the business structure of the tank-owning community.
- The availability or affordability of financial responsibility instruments.

> **"Comparing today to 1988, we know the storage equipment is more robust, the spill prevention and leak detection equipment is greatly improved, bare steel tanks have been removed from the nation's installed base, installations have been turned over to longtime professionals working under the watchful eye of a knowledgeable tank owner, and cooperation among regulators, UST owners and equipment suppliers/testers has never been better.**
>
> **So much has improved over the last 30 years, and everyone in the industry is confident it will continue to get better. Imagine the tank program 30 years from now . . ."**
>
> **–Bob Renkes, Fiberglass Tank & Pipe Institute (Petroleum Equipment Institute 1979-2017)**

- The impact of aging tank systems' infrastructure.

Back to the Present

As I think of the limited resources—both people and money—of the national UST program compared to the magnitude of the problem we've already conquered and the challenges we continue to face, I am inspired by how much our state, territorial, and tribal UST partners have accomplished...and in partnership with tank system owners and operators, equipment manufacturers, UST trainers, service providers, and others. I am particularly grateful for the dedication of the many people who've worked and continue to work on UST issues.

Your dedication and scope of accomplishments remind me of Mahatma Gandhi's quote, "A small body of determined spirits fired by an unquenchable faith in their mission can alter the course of history."

We are a small but determined collection of people, and 30 years of UST regulation guided us in making a significant difference in and improvement to our environment. Congratulations to all of you. I thank you for your determination and commitment to protecting our country's soil and groundwater from underground storage tank petroleum releases. Current and future generations are indebted to you. ■

Carolyn Hoskinson is Director of USEPA's Office of Underground Storage Tanks. She can be reached at hoskinson.carolyn@epa.gov.

Remembering Steve Purpora and Ken Wilcox

Two Pivotal Leak Detection Pioneers

Steve Purpora

Passionate. Coach. Cheerleader. These are some of the words mourners chose to try to capture the essence of Steven Purpora. Steve left us on February 2, 2019, but to many in the UST world, he will not soon be forgotten.

Steve began his career in underground storage systems earlier than most. He first went out with his dad to conduct tank tests when he was all of eight years old. His dad, Bill, founded the UST testing company Protanic in 1972. It was the first company formed specifically to identify leaking USTs using the then recently developed Kent-Moore testing equipment.

From Protanic's earliest days, Steve was at his dad's side. At 14, Steve was serving as an associate field technician. He had a company truck and was testing UST systems on his own at 16. Steve remained in the field, testing many thousands of USTs before transitioning to a management role in the company in the early 2000s. When his father died in 2002, Steve took the helm of Protanic and steered it to be a global player in the realm of UST testing and training.

Steve's knowledge of the UST world, especially leak detection technology and procedures, was deep. But it was not his knowledge so much as his personality that set him apart. After any panel of presenters had completed their talks, it was always Steve that the audience talked about afterward. Not only because of the content of his

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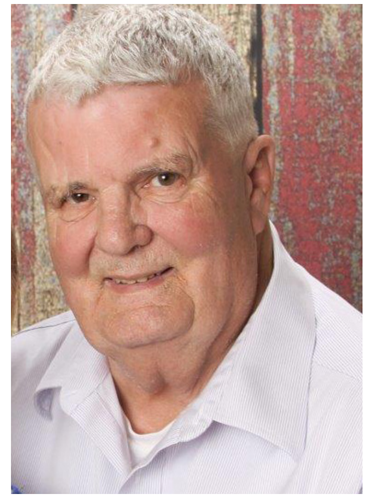
Ken Wilcox



As some of you are aware, Ken Wilcox passed away on October 14, 2018. If his name does not sound familiar to you, you may not have spent much time looking at the bottom right corner of the National Work Group on Leak Detection Evaluations (NWGLDE) leak detection equipment listings, where you will find the name of the evaluator of the leak detection equipment. The vast majority of these listings have Ken's company name, Ken Wilcox Associates (KWA).

Before performing third-party evaluations of leak detection equipment with his own KWA, he was performing third-party evaluations at Midwest Research Institute (MRI) in Kansas City, Missouri. The NWGLDE members first met Ken when we held a meeting in Kansas City in 1993, and visited the MRI facility.

From that first meeting with Ken, we were very impressed with his knowledge of the leak detection industry. He attended most all of the NWGLDE meetings, and almost always made a presentation about leak detection equipment that he was evaluating at that time. He would typically point out problems with adapting one of the original six USEPA Standard Methods for Evaluating Leak Detection Methods to fit the leak detection equipment he was evaluating. He even wrote new protocols for leak detection equipment that could not be evaluated using any of the USEPA protocols.

Though the vendors of the leak detection equipment paid Ken to perform the protocols, he did not give in to the temptation to make the equipment pass the evaluation, even when pressured to do so by the vendors. In fact, he indicated to us that he had failed a significant number of evaluations quite a few times before submitting a passing evaluation to the NWGLDE for review.

Ken said it was often difficult being in the middle between the vendors and the NWGLDE, but that he always had a lot of respect for and saw the value in the NWGLDE as gatekeepers of the leak detection industry. Even though he was continuously in the middle, he never lost his sense of humor. For example, he once kidded with us saying "Ten years from now we will all be sitting around drinking a beer, saying 'You

■ continued on page 12

Three Tales of Leak Humdingers

The UST world has improved dramatically since the 1988 regulations, and the number and volume of releases have been reduced to a relative trickle from what they once were. But there are still hundreds of thousands of USTs in service, so there are ample opportunities for Murphy's Law to come into play. The three releases described in the following articles serve to remind us that vigilance over UST systems on many levels is still required.

Catastrophic Gasoline UST Leak in Provo, Utah

by John Menatti, Therron Blatter, Sean Warner, and Doug Hansen

On March 13, 2018, a gasoline leak was reported at the Stadium Chevron located in Provo, Utah. Subsequent investigations confirmed that approximately 55,000 gallons of gasoline had been released from a double-walled fiberglass tank into the subsurface soils and groundwater. The gas station is located across the street from Lavell Edwards Stadium and the campus of Brigham Young University. The underground storage tanks (USTs) have been replaced and the gas station is now back in business.

What's What?

The UST that failed was a 10,000 gallon double-walled Owens Corning UST installed in 1989, prior to the existence of the state oversight program for UST installations. On April 2, 2018, the UST was removed and a large, nearly vertical crack was observed near one end. Although records of construction details were not available, it appears that a few factors may have contributed to the failure of the UST.

At the time of the UST removal, it was observed that the burial depth of the UST was somewhat shallower than we see in current installations. The surface immediately above the end of the UST was also the junction of concrete and asphalt paving and happened to be where the fuel delivery trucks would drive, and sometimes park, to fill the USTs. Although we may never know for certain, the thin overburden, location of surface stress points, and possible issues with compaction may have contributed to stresses that led to the crack in the UST.

In addition to factors leading to the failure of the UST itself, several additional factors contributed to the severity of the release. The UST leak detection was provided by a Gilbarco EMC upgraded with a continuous statistical leak detection (CSLD) package. Figure 3 shows inventory records from October 2017 to March 2018. The green arrows indicate dates when passing automatic tank gauging (ATG) tests were documented.

After analyzing this data, it appears that the crack initially formed near the top of the UST at the end of November 2017. The ATG provided passing tests whenever the product level was below the lower extent of the crack (somewhere around the 6,000 gallon level). Because a passing test result was available each month, the operator did not suspect a problem.

Figure 1. *Stadium Chevron gas station with Lavell Edwards Stadium in the background.*

Figure 2. *10,000-gallon double-walled fiberglass UST with red paint on the crack.*

In late February, the crack appears to have extended downward until it ran along nearly the entire height of the tank as shown in Figure 2. At this time the leak rate became high enough that the ATG registered a "No Idle Time" alarm. At this facility, the ATG was located in a cabinet in the middle of the C-store, rather than in a back room where employees would be more likely to observe an alarm.

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Three Tales of Leak Humdingers continued

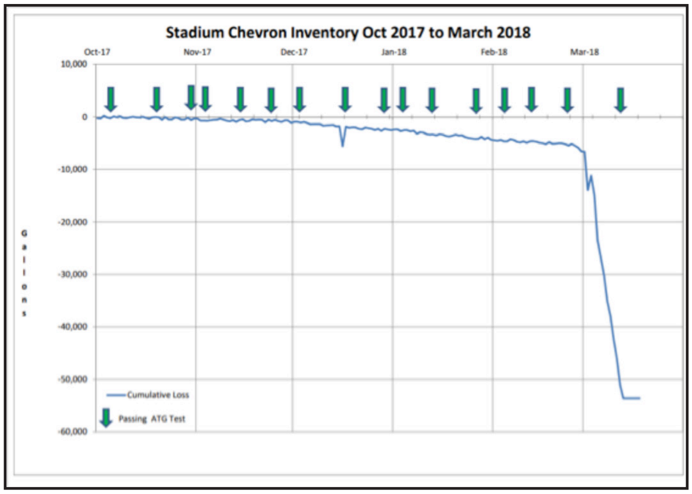


Figure 3. *Graph of UST Inventory Records.*

Figure 4. *Aerial photograph showing lateral extent of gasoline free-product (red circle) at about 35 feet below the ground surface (bgs) in April 2018.*

It is also our understanding that the facility was set up on an automatic fuel delivery schedule where the fuel level in the UST was reported to the distributor who would then send a load when a certain fuel level was reached in the UST. Inventory records for March indicate that the facility received a fuel delivery every day of the month until the leak was discovered on March 13, 2018. Moreover, on three days, two fuel deliveries were ordered.

If a person had been involved in ordering the fuel, it would have likely been apparent that the fuel sales did not warrant these deliveries. In addition, daily inventory reconcilation was typically conducted for the facility, but was interrupted for a time while the employee responsible for doing it was on vacation. The combination of leak detection and inventory tracking factors contributed to the volume of fuel released into the environment.

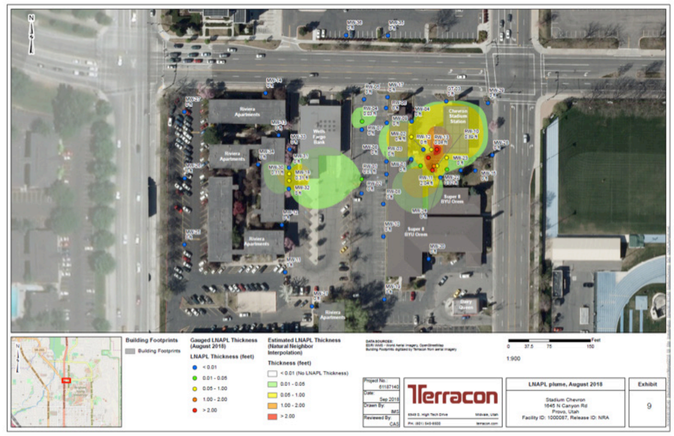


Figure 5. *The lateral extent of gasoline free-product at about 35 feet bgs in August 2018 after several thousand gallons had been removed using soil vapor extraction.*

Remediating the Plume

By April 10, 2018, the gasoline free-product plume (Figure 4) had spread out to about 300 feet in diameter at about 35 feet below the ground surface (bgs). The gasoline free-product plume was under the western portion of the Stadium Chevron gas station, the Super 8 Motel, Wells Fargo Bank, and Riviera Apartments.

As of October 28, 2018, about 38,212 gallons of gasoline have been removed from the subsurface using soil vapor extraction. Most of the gasoline was removed by CalClean's mobile multi-phase extraction trucks and RSI's internal combustion engines. The extracted gasoline vapors are treated using thermal and catalytic oxidation. A permanent soil vapor extraction system was installed and is operating at the site.

In order to determine if gasoline vapors were diffusing upward and into overlying buildings (i.e., Super 8 Motel, Wells Fargo Bank, and the Riviera Apartments), the consultant (Terracon) installed 23 soil-gas sampling wells. During July and August 2018, soil-gas samples were collected from all of the wells and the results indicated that vapor intrusion was not occurring.

Utah's Division of Environmental Response and Remediation (DERR) and Terracon continue to work on the cleanup of this large gasoline release. ■

John Menatti is Manager of Utah's Petroleum Storage Tank Trust Fund, DERR. He can be reached at jmenatti@utah.gov Therron Blatter is Manager of the UST/LUST Branch, DERR. Sean Warner is Inspector of the UST Compliance Section, and Doug Hansen is Manager of the UST Compliance Section.

Inventory records for March indicate that the facility received a fuel delivery every day of the month until the leak was discovered on March 13, 2018. Moreover, on three days, two fuel deliveries were ordered.

Three Tales of Leak Humdingers continued

Thwhack!

Private Plow Trucks Meet Dispensers in Maine

by Ted Scharf

March 14, 2018 turned out to be the date of the last good snowstorm of the season in Maine. By the end of the storm, about 12 inches of snow had fallen, mostly under the cover of darkness during the early morning hours. The plow truck drivers were out most of the night trying to stay ahead of the accumulating snow. During that storm, private plows hit dispensers at two convenience stores. Let's just call them Stores "A" and "B."

At store A a pickup truck with a plow backed into a dispenser very early in the morning and drove away. The accident was recorded by a security camera, so we know exactly what happened. Almost 1,900 gallons of product from a 6,000-gallon aboveground gasoline tank was lost before the leak was discovered by an off-duty firefighter who had been up all night plowing.

At store B a pickup hit a dispenser with the plow. The tanks were underground and only the product already in the dispenser piping was spilled.

The day after the accidents occurred, a coworker and I visited both facilities to get the details. Our first stop was at store B, where only a little fuel was lost and contained in the under-dispenser sump. (store B has two double-walled underground tanks with flexible, double-walled, pressurized piping.) Two Maine Certified Tank Installers (CTIs) were on site replacing the top halves of the two crash valves in the dispenser. They confirmed that both crash valves had worked as designed. When the dispenser was hit, the crash valves had closed completely.

The same CTIs had been to store A the previous day. The dispenser had been knocked off its mount and the two crash valves had completely broken, as they were designed to do. This should have caused the valves to close. The CTIs told us that one of the two crash valves in the damaged dispenser at store A had closed completely but the other had not.

What's the Deal with Store A?

At store A, we talked with the owner and the Maine Department of Environmental Protection (MDEP) responder in charge of the cleanup. The aboveground tank associated with the release had double-walled, pressurized underground piping with a mechanical inline leak detector, and a mechanical anti-syphon valve. I'll get to those later

The store had operating security cameras. The video footage showed that the person who plows their lot backed into the dispenser on March 14 and then drove away. Two hours later, another plow truck driver arrived to get coffee when the convenience store opened. This driver, an off-duty firefighter, smelled gasoline and saw that the dispenser was badly damaged. He notified the local fire department and kept people away until firefighting personnel arrived.

Dispenser when it was found by the fire department. Notice the streams of fuel.

When the fire department arrived, fuel was still flowing out of the broken crash valve that had not completely closed. When MDEP Response Services staff arrived, they stopped the flow with a formable plug. Then they hired a cleanup company to scoop up the snow and gasoline into roll off dumpsters. The free product and saturated slushy snow were recovered by a vacuum truck with a "liquid ring" pump rated for flammable liquids

When the owner of store A got there, he quickly figured out he had lost about 1,898 gallons of gasoline. The video indicated that approximately three hours had lapsed between the hit to the dispenser by the plow truck and the plugging of the leak by Response Services. This worked out to a flow of approximately 10.5 gallons per minute. This seemed like a very high flow rate, but the owner confirmed the submersible pump was not operating when he arrived at approximately 4:15 AM.

The Analysis

Now, our big question was how did a facility with properly installed and operating equipment lose that much fuel in such a short period? As mentioned, the facility had crash valves, submersible pumps with inline leak detectors, and a mechanical anti-syphon valve.

It also turned out that the facility had been inspected by a CTI eight days prior to this incident. At that time, the crash valve and inline leak detectors should have been tested for proper operation. Unfortunately, however, neither the manufacturer nor the MDEP is aware of an approved procedure to test a mechanical anti-syphon valve.

The anti-syphon valve was properly installed between the pump and the inline mechanical leak detector. You would think a mechanical anti-syphon valve is

Three Tales of Leak Humdingers continued

Contaminated snow removal a day after the spill

pretty simple. It has a spring inside that pushes a poppet against a seat. When the pump is turned on, the pressure of the pump pushes against the spring and opens the poppet so product flows. If the valve spring is correctly calibrated for the hydraulic head in the line it should work properly.

We measured the head at 12 feet and found the valve was designed for zero to 15 feet of hydraulic head. According to the manufacturer it should have stopped the flow. I was given the valve after it was replaced and the spring is in it and it seemed to close as it should. However, after the dispenser was replaced, we were getting flow through a simulated leak at the dispenser with the pump off. If the anti-syphon valve were working, there should have been no flow through the simulated leak.

I discussed the situation with a technician for the manufacturer, who could offer no reason why the anti-syphon valve did not work as designed. He also told me that model of anti-syphon valve is no longer being sold.

We could not determine why the mechanical anti-syphon valve was not functioning properly, but on May 3, 2018 at the installer's recommendation, the owner installed electric anti-syphon valves, so the piping would have a positive shutoff that could be tested. I was later told it is possible to test a mechanical anti-syphon valve by shutting off the power to the submersible pump and opening the test port on the crash valve. No product should flow.

A few days after the spill incident, a CTI tested the inline leak detector. When he opened a test valve to simulate a leak, the flow never slowed down to the expected 3 gpm when the pump was turned on. The inline leak detector failed the test.

After the electric anti-syphon valve was installed, I observed the testing of the same inline leak detector. With a calibrated leak rate of 3 gallons per hour when the pump was turned on, flow held at 3 gpm, indicating that the leak detector was working. When the valve simulating the leak was closed, and the CTI opened the nozzle, he had full regular flow. All that is as expected.

This testing seems to tell us that the leak detector failed to work when a mechanical anti-syphon valve was present, but did work when an electrical anti-syphon valve was installed. Both anti-syphon mechanisms were correctly installed between the submersible pump and the leak detector, so in theory they should not have affected the operation of the leak detector. Bottom line, we don't know why the inline leak detector did not restrict the flow at the time of the accident.

DEP doesn't get thanked very often. A week after the spill.

Three Tales of Leak Humdingers continued

Now to the device most people believe would be the first and simplest way to stop the flow of fuel: the emergency shut-off valve or crash valve at the base of the dispenser. These have been around for just about as long as submersible pumps and pressurized piping. If a dispenser is damaged in an accident the flow of fuel must be stopped as quickly as possible. That is what a crash valve is designed to do.

Crash valves have been required by fire code since the 1960s. If a dispenser is hit, the top section breaks at a weak point and an internal poppet valve on a spring closes. In the case of the March 14 collision, one of the crash valves only closed about two thirds of the way and became stuck. Close inspection determined that the rod around which the poppet rotated was slightly bent. In talking with CTIs and the manufacturer's technicians, no one could explain how the crash valve could be damaged internally in the way it was. It seemed unlikely that the damage was a result of the March 14 collision. You could not see the damage from looking at the valve from the outside. You would only know about the damage by testing the valve for functionality.

One of the things a CTI should do during an annual inspection is close the valve manually and try to pump product. If the crash valve is working properly you should not be able to dispense any product from the nozzle. That the valve was not closing completely should have been discovered by the CTI who conducted the annual inspection only eight days earlier on March 6, 2018.

But Does It Work?

So here we have two facilities that suffered a significant impact to a dispenser during a snow storm. At store B, the crash valve worked properly and only the fuel in the dispenser piping was lost. But even if a crash valve at store B had not closed properly, the fuel loss would have been minimal because the tank was underground. But at store A, three pieces of equipment (the mechanical anti-syphon valve, the inline leak detector, and the crash valve) did not work as they should to stop or reduce the amount of product lost from this aboveground tank. I wonder how many other facilities like that are out there? This is also an example where underground tanks would not have had as large a release.

This experience highlights the need for regular inspection and testing of these devices to insure they will work properly when an accident occurs. Even when inspections are conducted, one of the ongoing difficulties is making sure inspections are being done properly so that improperly working equipment is identified.

The good news for store A is the crash valves have been replaced and tested. In addition, the facility now is equipped with electric anti-syphon valves and the inline leak detectors are working properly. ■

Ted Scharf is an Environmental Specialist at Maine Department of Environmental Protection. He can be reached at e-mail address Ted.Scharf@maine.gov

Small Defects Spur Massive Response

by Omer Shalev and Lyndsey Tu

The Red Hill Bulk Fuel Storage Facility is an active installation, located east of Pearl Harbor, Hawaii, that provides fuel for military operations in the Pacific. The facility includes twenty massive underground storage tanks originally constructed in the 1940s and mined directly into the basalt mountains of O'ahu. Each tank is approximately 100 feet in diameter, 250 feet high, made of reinforced concrete with a ¼ inch steel-lined barrel, a ½ inch steel-lined base, and capable of storing roughly 12.5 million gallons of fuel. The facility is connected to Pearl Harbor via 2.5 miles of pipeline, and dispenses fuel to ships at the pier and to jets at nearby Hickam Air Field.

In January 2014, the U.S. Environmental Protection Agency (USEPA) and the Hawaii Department of Health increased their oversight of the facility following Navy reports of a 27,000-gallon fuel leak. The cause of the leak was determined to be poor repair welds and a lack of appropriate quality assurance procedures during one tank's routine maintenance cycle. The Navy's environmental investigation and development of remedial options in response to the release is ongoing, but due to the location of the tanks inside a mountain and the fractured basalt geologic setting, it is difficult to locate and remediate the release. The Navy plans to submit a groundwater model to regulators in October 2019.

After the release, USEPA, the State of Hawaii, and the Navy and Defense Logistics Agency reached a comprehensive 22-year-long enforceable agreement, or Administrative Order on Consent (AOC) to guide facility improvements and study the surrounding environment. The intent of the work under the AOC is to implement best technologies and practices to protect the groundwater resource and ensure that the facility is operated in an environmentally protective manner. Additionally, the AOC requires that tank systems used for storing fuel be upgraded to a regulatory-agency-approved design by the AOC deadline of 2037 or be removed from service until they are upgraded.

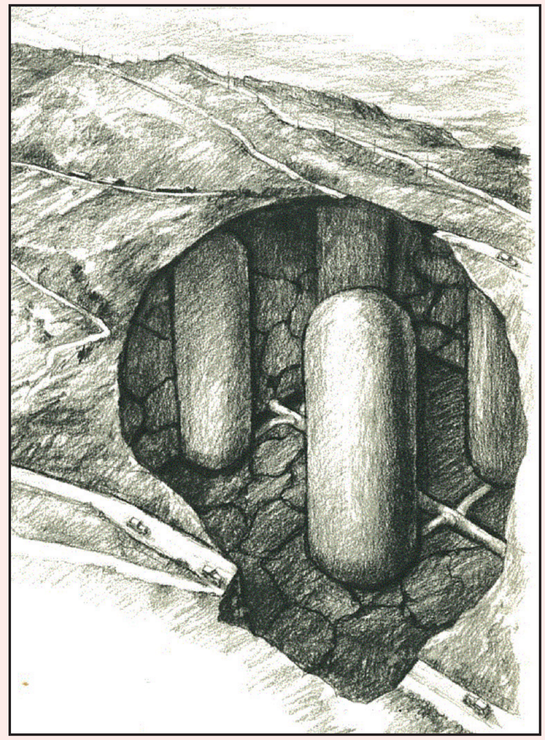
The facility sits approximately 100 feet above a drinking water aquifer. Three major drinking water supply wells are nearby, producing about 1/3 of the water for the city and county of Honolulu. To date, drinking water resources have not shown impacts other than trace levels at a Navy supply well. Contamination has been found in groundwater directly underneath the tanks, though no measurable floating product has been found and most detections in monitoring well samples are low.

For additional information on the Red Hill Facility, visit *www.epa.gov/red-hill or watch a video on the facility here: https://www.youtube.com/watch?v=0Bx81rD206A* ■

Omer Shalev is an environmental engineer with USEPA Region 9's Underground Storage Tanks Office. He is currently USEPA's Red Hill Project Coordinator and has been working on the project since the release in 2014. He can be reached at: shalev.omer@epa.gov

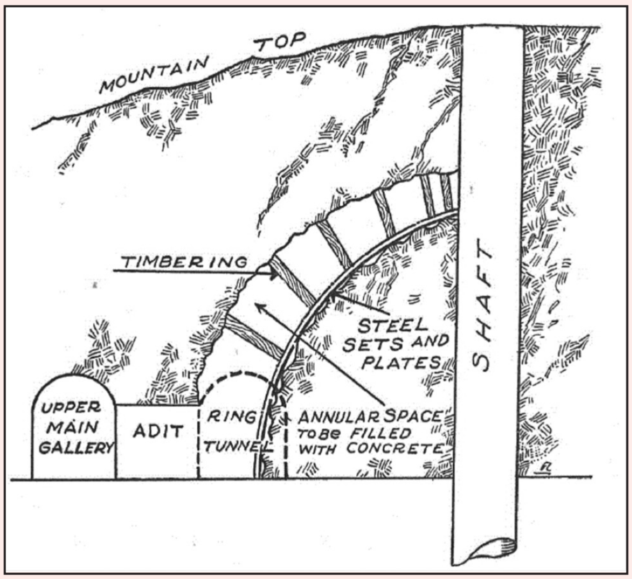
Lyndsey Tu is a physical scientist with USEPA Region 9's Underground Storage Tanks Office. She works primarily on the environmental response and release investigation aspects of the Red Hill Facility. She can be reached at tu.lyndsey@epa.gov

Builders for Battle



The Red Hill fuel storage facility is an engineering marvel because of its radical design. But even more amazing is that it was constructed essentially by hand in several years' time by some 3,000 men working in conditions of which OSHA would hardly approve. For the history buffs among you, the story of the construction of the Red Hill tanks is told in some detail in a book by David Woodbury entitled *Builders for Battle – How the Pacific Naval Air Bases Were Constructed,* published in 1946. The book tells not only of the construction of the Red Hill Facility, but of the string of naval air bases that were built on remote Pacific atolls (e.g., Midway, Johnston, Wake) in the years immediately before the Japanese attack on Pearl Harbor. It is the presence of these bases that helped turn the tide of the war in the Pacific. The book is out of print, but some copies are still available if you search online.

Courtesy of Marcel Moreau.



Drawings Depicting Tanks in Mountain from Woodbury 1946

Remembering Steve Purpora and Ken Wilcox continued

Steve Pupora *continued from page 6*

presentation, but because of his enthusiasm for the topic at hand and passion for encouraging everyone to do a better job.

He was passionate about leak prevention, leak detection, protecting people, and the environment. Steve's goal was not only to share knowledge, it was to instill motivation. Whether speaking to regulators or tank owners, he was much more than a teacher. He was a coach and cheerleader, urging his audience on: "This isn't right. We have to do better!" His body was alive with energy, his voice reminiscent of a bible thumping preacher.

Steve inspired, motivated, prodded, and gently led by the hand nearly everyone he met. His mission was not only to protect human health and the environment. It was to inspire anyone he spoke with to be a more conscientious tank owner or operator, and a more competent and determined regulator.

Thanks to Marcel Moreau, petroleum storage specialist and author of LUSTLine's *Tank-nically Speaking column, for preparing this tribute to Steve.*

Ken Wilcox *continued from page 6*

know, none of this stuff really works.'" Geeze, I HOPE he was kidding!

Ken Wilcox's presence in the Leak Detection industry will be greatly missed! But as luck would have it, his son Craig is doing a great job carrying on his legacy. Lamar Bradley, a retired Vice Chair of the NWGLDE who knew Ken very well, sums it up best. "He was a true pioneer of leak detection and literally helped write the book on Leak Detection. The leak detection industry is in a far better place because Ken was involved in it. I was fortunate to have known him and I miss him as a colleague and as a friend." Likewise, I believe all current and former members of the NWGLDE who dealt with Ken were fortunate to have known him and will greatly miss him.

Thanks to Curt Johnson, retired NWGLDE Chair and retired Alabama DEM Environmental Engineer, for preparing this tribute to Ken.

[Note: See page 24 for an additional tribute to Ken Wilcox.]

PART 2: To HRSC or Not? Cost vs. Benefits

by Stephen Dyment and Thomas Kady

In the last issue of LUSTLINE *(Bulletin #84, August 2018) we made an impassioned plea for leaking underground storage tank (LUST) owners, investigators, consultants, and regulators to consider the use of High-Resolution Site Characterization (HRSC) tools and strategies. We also highlighted decades of experience at Superfund, Brownfields, and LUST sites indicating significant correlation between good site characterization and conceptual site model (CSM) development practices with effective and efficient remedy design and performance.*

While we believe HSRC tools and strategies are essential to achieving sufficient characterization and robust CSMs to support effective LUST site remediation, a majority of LUST sites in the national portfolio still do not employ these techniques. Common challenges to implementing HRSC strategies often cited by LUST project teams include: limited project resources, limited availability of HRSC tools\qualified contractors, a mismatch between regulatory benchmarks/tool outputs, and limited need for complex direct sensing and field tools due to perceived limitations in LUST site complexity.

For regulators addressing LUST sites via delegated state programs challenges such as large site portfolios and workloads, additional data evaluation requirements for "screening" technologies, and limited consultant knowledge/experience with these tools and techniques further limit potential applications.

Cost and benefit for implementing any characterization strategy is always an important consideration. With LUST sites we are not only keenly aware of the costs associated with traditional characterization approaches and HRSC implementation, but also with the magnitude of the problem nationally.

As of the end of fiscal year 2018, OUST listed 550,379 active tanks, 543,812 confirmed releases, and 478,366 cleanups completed nationally. (See *https://www.epa.gov/sites/production/files/2018-11/documents/ca-18-34.pdf.*) More than 65,000 sites, therefore, remain in various stages of the assessment and remediation process nationally, representing a large universe of LUST sites requiring further characterization and cleanup activity. Sites in stages such as those in early characterization mode with highly heterogeneous aquifer materials and contaminant distributions—in early system design, or with poorly performing operational remedies—all offer opportunities to cost effectively integrate HRSC tools and strategies into the process.

Part II of this HRSC discussion, therefore, focuses on the economics and costs associated with LUST site characterization and remediation. Using available national data sources and state-specific examples we attempt to illustrate not only how HSRC tools and strategies fit within the cost structure of a typical LUST site cleanup, but also how they offer significant improvements to the performance and efficiency of remediation and risk mitigation strategies.

Opportunities

In Part 1 we stressed the importance of time and data density in the LUST cleanup process (time-is-of-the-essence and the cost-of-being-fooled). We also introduced the concept of return-on-investment for applying HRSC tools and strategies during characterization in support of remedy design. A review of data from hundreds of environmental cleanup sites in Superfund, Brownfield, and LUST programs indicates that for most sites expenditures for remediation and site cleanup exceed expenditures for site characterization.

At Superfund sites it is not uncommon to find remediation costs that exceed an order of magnitude (10X) over resources expended on site characterization. While site-specific features dictate actual data needs and costs, it is fair to say that while characterization may be considered expensive, failed or underperforming remediation systems cost much more over a project's life cycle. Project life-cycle costs remain a challenge at many sites, however these realities also offer opportunities for project teams to employ HRSC tools and strategies in adaptive frameworks to significantly improve decision making, risk management, and remedy design and performance.

The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) provides an annual tanks state fund survey that captures state-specific and total expenditures for states responding to the survey request. (See *http://astswmo.org/category/tanks/*.) (At the time of this publication the latest ASTSWMO survey results are from 2017.) Survey responses from individual state programs are highly variable and do not account for private insurance or other LUST cleanup costs not reimbursable by state funds, limiting our ability to draw some conclusions. That being said, the data contained in the ASTSWMO surveys offer one of the most comprehensive data sources available and provide much of the information used for analysis in this article.

While informal discussions with state LUST program staff were limited, we observed the following generalizations:

- 5-10% of sites are currently using some form of HSRC and direct sensing tools like membrane interace probe (MIP), laser induced fluorescence (LIF) or optical image profiler (OIP.)
- In states with active HRSC programs, HRSC investigations cost about $35,000-$40,000 on average which includes direct sensing, consultant oversight, and deliverables.
- In these same states, LUST investigations using traditional approaches minimally involve a phase I investigation (averaging around $15,000) and a phase II

■ continued on page 14

■ **Part 2: To HRSC or Not**
from page 13

investigation (averaging around $30,000).

It is difficult to quantify a return on investment derived by utilizing HSRC tools and strategies, however, anecdotal information indicates that the use of HRSC is net positive in terms of overall project lifecycle costs. The larger data sets estimating average UST site cleanup costs for all state responses per year or over a 10-year period do offer useful information in considering typical cost ranges for LUST site characterization and remediation. Other trends, such as number of sites exceeding $1 million in expenditures, offer additional opportunity for HRSC considerations.

Also, in preparation for this article we reached out to LUST program managers in Alabama, Colorado, and Virginia to gain a greater understanding of the use and limitations of HRSC in their respective programs. While such testimonials provide limited data, they offer state-specific comparisons to data and conclusions derived from the larger ASTSWMO data set.

Dorothy Malaier
Environmental Manager
Alabama Department of Environmental Management

Over the years, too many sites across the country have been subject to selected remediation strategies that have been used year after year to little or no avail. Why is this? Soil type? Lack of useful knowledge of contamination location? Possibility that other unknown product types have been released?

In Alabama, we have utilized High Resolution Site Characterization (HRSC) tools over the last five years at sites in various stages of assessment and remediation. These tools are often applied at sites where the corrective action plan is being developed and an injection technology is being proposed. We want to know what zones appear to contain the highest contaminant concentrations. Are there preferred pathways? Is there shallow contamination that may pose an inhalation risk? Is there submerged free product or free product in otherwise unknown areas?

These tools are also used at sites where remediation has not been effective. We need to find out what we don't know. Again, where are the zones of highest contaminant concentrations, and what have we missed? HRSC investigations have yielded results where second releases and/or releases of a different product type have been identified. Data interpretation has provided additional information on plume stability, which can lead to a decision to close out a site where continued efforts could otherwise go on for years. Combining the newly acquired data with traditional soil and groundwater data provides a much more detailed view of the subsurface.

There is a cost to these specialized investigations and it can be significant. However, for sites in an active remediation operation, such as Dual Phase Vapor Extraction, the cost for a quarter of O&M can often run from $25,000 to $30,000. For a little more than this amount, an HRSC investigation can in the long run save money on the tail end of the project by providing better data today to improve system operation. It's the pay me now or pay me later concept.

Over the last few years, we have approved HRSC plans and authorized funding from the Alabama Tank Trust Fund for over 63 different sites in the state. Approximately $2.5 million dollars have been approved for expenditure at trust fund-eligible sites for HRSC activities, yielding an average approval cost of $42,000 per site. This amount includes the HRSC company charges, as well as the trust fund contractor's cost to prepare a report and be in the field during the investigation. While this is a significant cost, the implementation of more strategic corrective action plans and the optimization of current corrective actions should yield overall cost savings and a more effective and efficient remediation of Alabama's UST releases.

So what do you get for even a modest increase in characterization expenditure using HRSC techniques? According to states with active HRSC programs advantages include:

- Updated and higher density soil data (soil data collected using traditional techniques are often very limited [collected in phase I or early phases using a few borings and samples])
- Identification of mass storage and transport zones
- Improved, high-quality CSM
- HSRC results and improved CSMs that provide a powerful communications tool for technical teams, stakeholders, and the public
- Real-time decision making and collaborative data interpretation that lead to fewer comments and shortened review times for investigation deliverables.

Improved CSMs help target remediation technologies in both the mass-transport and mass-storage zones, leading to more efficient and effective remediation system designs. HRSC data sets and real-time visualization allow for the development of a robust CSM, further limiting necessary comment and review timeframes while providing a project management tool for technical teams and a powerful communication tool for stakeholder engagement. HRSC tools are not without their challenges, as several states noted challenges with:

- Drilling environment and ability to use direct-push technologies
- Limited regulator influence on tools/strategies where responsible party consultants have the lead
- Availability of qualified service providers.

Interestingly, some states also noted ongoing informal efforts to target HSRC for certain site attributes, recognizing the benefits for sites with:

- Continuing LNAPL questions (lateral connections, vertical thickness)
- Challenges with product removal
- Catastrophic release sites
- Legacy sites

- Sites approaching a state cap ($1- $2.5 Million)
- Sites with injection or sparging technologies planned for remedy implementation.

Sites with these attributes likely represent higher expenditures than the averages presented in the ASTSWMO and state data and may therefore offer additional opportunities to justify use of HRSC.

Rob Herbert, Remediation Supervisor
Colorado Division of Oil and Public Safety

The Colorado Division of Oil and Public Safety (OPS) has found high-resolution site characterization (HRSC) to be a useful and effective tool in assessing and cleaning up petroleum releases at leaking underground storage tank sites in Colorado. While there are higher upfront costs with HRSC, we soon learned that more accurate source area definition and LNAPL distribution obtained through HRSC enabled the development of better conceptual site models and identification of targeted treatment areas, which resulted in more effective, expedient, and cost-effective corrective actions.

OPS promotes HRSC not only at new release sites, but perhaps more importantly at old release sites where conventional site characterization methods resulted in ineffective remediation efforts due to inadequate source area characterization. At many of these older sites, HRSC is now being used to re-evaluate and find residual petroleum sources and LNAPL pockets that may have been missed using conventional methods, as well as to identify targeted treatment areas to implement more effective remedies resulting in more quicker site closures.

In addition to identifying LNAPL distribution for remedial purposes, OPS has used HRSC data (LIF, OIP, UVOST) in conjunction with LNAPL transmissivity test data to demonstrate that LNAPL recovery is not practical and the LNAPL does not pose a saturation-based risk. This has resulted in better risk-based decision making and more prudent time/fund management by preventing unnecessary expenditures on ineffective recovery efforts. We have also had success using HRSC tools such as MiHPT, a combination of two high resolution tools—the MIP (membrane interface probe) and the HPT (hydraulic profile tool)—to better characterize heterogeneity of hydraulic conductivity and to identify mass storage and high flux zones, which results in better remedial designs and more effective and timely corrective actions.

Based on OPS experience, the cost of HRSC ranges from $4,000 to $6,000 per day depending on the bid package. However, the effectiveness of any cleanup is contingent on the thoroughness of the site characterization. Embarking on LUST cleanups can cost several hundred thousand dollars, so without spending a fraction of that upfront on a thorough assessment is being pennywise and pound-foolish.

Show Me the Money

State partners with active HRSC programs and Part I of this *LUSTLINE* discussion illustrate opportunities for HRSC at LUST sites; however, some questions regarding cost remain. Can we afford to use HRSC at every site? Can we afford not to? Here we will use state testimonials and ASTSWMO survey results to consider these important questions.

According to ASTSWMO survey results, in 2017 the average expenditures for characterization and remediation at an UST site was $147,309. Those costs have ranged from $119,186 in 2009 to $157,347 in 2015 over the last 10 surveys with an average of $150,922 (annual survey reports 2007-2017, Table 3). Using the 10-year average of $150,922, if we estimate that a third of expenditures relate to characterization and two-thirds to remediation for a typical LUST project, then expenditures on characterization averaged $49,804 while typical site remediation costs during this 10-year period averaged $99,609.

Using the 10-year average (ASTSWMO 2007-2017), typical LUST site characterization costs approach $50,000 while the informal state discussions place the average HRSC investigation at $35,000-$40,000 and a traditional phase I and II investigation at $45,000, each falling below the average characterization costs ($49,804) we derive from the larger 10-year ASTSWMO data set.

So, as a community of practice, can the LUST regulatory community afford HRSC at every site? According to informal state discussions and long-term averages derived from the ASTSWMO surveys, the answer is a resounding yes!

Given that most LUST site characterization budgets can support HRSC tools and strategies, we can explore providing data at the necessary density, considerations of time, and remedy effectiveness by asking the question: Can we afford not to use HRSC at all sites?

Conservatively, if we consider combining the average HRSC investigation with a typical phase II investigation, average characterization costs might approach $65,000. Returning to the ASTSWMO data set if we estimate that two-thirds of expenditures applied are for remediation, then the average UST remediation cost is $99,609 (2007-2017). In this case the extra $15,000, a combined HRSC/phase II investigation may add to average characterization costs need only improve remedy design and performance by 15 percent to essentially pay for itself. In our experience, remediation design and implementation efficiencies gained from the modest investment of applying HRSC techniques and strategies far exceed the costs.

In the ASTSWMO survey, Table 2 provides information on funding for state UST programs. Many states have caps ranging from $1 million to $2.5 million placed on the amount of resources a state fund can apply to a site. Indeed, the most expensive LUST sites can cost more than a million dollars and reach $2.5 million in characterization and remediation fund expenditures. As reported in the 2017 ASTSWMO survey, there were 11,508 sites with outstanding claims, with 3,117 (27%) of those sites exceeding $1 million in reimbursable expenses. These 3,117 sites represent more than $3 billion dollars of expenditures over

■ *continued on page 16*

■ Part 2: To HRSC or Not
from page 15

the lifetime of these programs, while cumulative state UST/AST funds total $2.024 billion.

Further, OUST's *Semiannual Report of UST Performance Measures: End of Fiscal Year 2018* (see *https://www.epa.gov/sites/production/files/2018-11/documents/ca-18-34.pdf*) lists the national total of cumulative completed UST cleanups at 478,366, while cumulative totals of sites spending in excess of $1 million (Table 2 ASTSWMO 2017) includes 3,117 sites. These costly sites therefore represent only 0.65 percent of national cleanups completed but account for more than $3.117 billion or almost 18 percent of the $17.764 billion spent on UST sites as of 2017 (Table 3 ASTSWMO 2017).

Table 1 compares the ASTSWMO 2017 Table 2 cumulative results for sites exceeding $1 million in expenditures to total cumulative cleanups completed in the OUST 2018 report. Only states providing specific data or reporting one or more sites >$1 million in the ASTSWMO 2017 report are included (34 states). As noted previously the national average for sites spending more than $1 million calculated from reported values in the ASTSWMO 2017 and OUST 2018 reports is 0.65%. However the rates calculated from 34 states reporting in Table 1 are 0.92% percent of sites exceeding $1 million in expenditures. This represents discrepancies between the ASTSWMO 2017 and OUST 2018 data sets while suggesting a range of 0.65% – 0.92% nationally.

Of the 34 states providing data, eight have higher calculated rates of costly sites (>$1 million), while four states fall in the national average range indicating significant opportunities to integrate HSRC in site characterization efforts. Twenty two states fall below this range, however states in this range with 20 or more sites exceeding $1 million offer additional opportunities for HRSC deployments.

So, as a community of practice, can the LUST regulatory community afford not to use HRSC at every site? Here conclusions derived from informal state discussions and the ASTSWMO surveys are more challenging.

Unfortunately, existing data sets do not provide the specificity to

Table 1 ASTSWMO 2017 Cumulative Sites Exceeding $1 Million in Expenditures vs. OUST 2018 Cumulative Cleanups Completed by State

State*	ASTSWMO 2017 Survey Table 2 Cummulative Sites >$1M	OUST 2018 Cumulative Cleanups Completed	% Cumulative Sites >$1M
California	1,354	41,144	3.29%
Florida	555	18,097	3.07%
Indiana	162	8,844	1.83%
Arkansas	25	1,556	1.61%
Nevada	34	2,451	1.39%
Oklahoma	69	5,080	1.36%
New Hampshire	33	2,106	1.57%
Massachusetts	61	6,137	0.99%
Table Calculated Value for National Average Rate of Sites Exceeding $1 Million in Expenditures*			**0.92%**
Alabama	103	11,136	0.92%
Colorado	72	8,222	0.88%
Connecticut	24	2,450	0.98%
Louisiana	38	4,891	0.78%
ASTSWMO 2017 and OUST 2018 Reported National Average Rate of Sites Exceeding $1 Million in Expenditures*			**0.65%**
Texas	132	26,850	0.49%
Rhode Island	5	1,290	0.39%
Virginia	43	12,240	0.35%
Illinois	85	20,061	0.42%
North Dakota	3	860	0.35%
Mississipi	19	7,628	0.25%
Vermont	5	1,572	0.32%
Nebraska	14	5,878	0.24%
Maine	6	2,959	0.20%
Montana	5	2,390	0.21%
Washington	10	4,408	0.23%
Tennessee	20	15,333	0.13%
Kansas	6	4,002	0.15%
Delaware	3	2,831	0.11%
Utah	5	4,829	0.10%
Georgia	12	13,496	0.09%
Missouri	5	6,557	0.08%
Minnesota	6	11,797	0.05%
Kentucky	6	16,411	0.04%
Iowa	2	5,740	0.03%
Ohio	10	30,637	0.03%
South Carolina	1	7,936	0.01%
Calculated Table Totals	**2,933**	**317,819**	**0.92%**
ASTSWMO 2017 and OUST 2018 Reported Totals	**3,117**	**478,366**	**0.65%**

* States with reported cumulative sites exceeding $1 million in expenditures.
States not included in this table either listed 0 sites exceeding $1 million or did not provide the information in the ASTSWMO 2017 survey.

Alex Wardle
Environmental Geologist, Virginia Department of Environmental Quality, Petroleum Program

In 2017, a release of almost 6,000 gallons of petroleum occurred over three days at a gas station in northern Virginia. Petroleum was discovered in subsurface sumps in adjacent high-rise buildings and vapors caused the temporary closure of one building and restrictions on use in another.

Virginia DEQ recommended the use of HRSC techniques to identify the location of the gasoline in the subsurface and assist with designing an appropriate remedial response. Unable to find an HRSC provider able to immediately mobilize to the site, the consultant chose readily available conventional investigation technologies, such as drilling four 50-foot-deep wells around the gas station and carrying out a day of direct-push investigation. This investigation suggested groundwater at 40 feet deep and identified no shallow contamination.

A month after the release, a subsequent HRSC survey was completed, including MIPs, LIF, and HPT testing. This showed that the most highly contaminated area was, in fact, within 15 to 20 feet of the surface. Finding this narrow band of fresh gasoline with LIF was a challenge due to the discrete pathway followed and the relatively low fluorescence signal generated by fresh gasoline with relatively low PAH concentrations. The combined use of MIPS and LIF and careful review of the data was important in ensuring effective delineation.

The high-resolution characterization has allowed an appropriate remediation system to be designed and will likely save significant costs in the construction and operation of a remediation system that would likely have been incapable of cleaning up the main area of contamination.

- The approximate cost of HRSC is $35,000 for five days.
- The approximate cost of the conventional investigation (including the drilled wells that had to be replaced) was $25,000.
- The estimated avoided cost of an ineffective remediation system installation and operation is $250,000.

consider traditional vs. HRSC costs, number of mobilizations, and remedy performance improvements resulting from HRSC. While existing data indicate that most projects can support deployment of HRSC tools and strategies within the site cost structure, for the purposes of this analysis, we will conservatively estimate that adding HRSC to every site will result in an average increase of 30 percent ($15,000) in characterization expenditures. When applied to all sites, the result would be an additional $982 million in characterization costs for the 65,446 sites remaining to be characterized and cleaned up.

If we also assume site costs exceed $1 million in the range of 0.65 – 0.92% of site cleanup totals as historical data indicate, then the 65,446 cleanups remaining would result in an additional 425 – 602 sites expected to exceed $1 million in cost. With total national expenditures for these sites likely exceeding $600 million and potentially approaching $900 million, it's easy to see how programmatic costs for less than 1% of sites approach the $982 million investment estimated to apply HRSC across the 65,446 cleanups remaining nationally.

If HRSC applications can average 30 percent improvement to remedy performance and life cycle costs at these costly sites, this would generate $128 – 181 million in savings. Using these assumptions, savings derived solely at high-cost sites can therefore not achieve net positive results alone for the entire program.

Of course, one can expect some benefit from deployment of HRSC strategies at lower-cost sites, as well. For example, if we remove the 425 – 602 costly sites from the data set, even modest improvements in remedy performance for the remaining 64,844 – 65,021 sites has significant program implications. For these sites, if we use the 10-year ASTSWMO average cost and assume a two-thirds ratio for characterization/remediation expenditures, the average LUST site will spend $50,000 on characterization and $100,000 on remediation. The remaining 64,844 – 65,021 are therefore expected to cost upwards of $6.50 billion in remediation costs. Achieving a 15% reduction in remediation costs by applying HRSC at these sites would result in a savings of $975 million, about the cost conservatively estimated for applying HRSC at all 65,446 sites remaining in the national portfolio.

The Challenge

In recent years, the Interstate Technology and Regulatory Council's (ITRC) dense non-aqueous phase liquid (DNAPL) (see *https://www.itrcweb.org/Team/Public?teamID=14&teamID=14*) and light non-aqueous phase liquid (LNAPL) (see *https://www.itrcweb.org/Team/Public?teamID=18*) teams have promoted the combination of system performance metrics and remediation endpoints through "SMART" objectives. That is, developing objectives that are Specific, Measurable, Applicable, Relevant, and Timely (SMART) as a means to efficiently and effectively remediate sites.

A review of the recently published 3-part web document entitled *Light Non-Aqueous Phase (LNAPL) Site Management: LCSM Evolution, Decision Process, and Remedial Technologies* or LNAPL-3 (see *https://lnapl-3.itrcweb.org/*) highlights the critical role of a comprehensive LNAPL conceptual site model (LCSM) in establishing and defining SMART objectives. ITRC specifies that the guidance can be used for any LNAPL site regardless of size and site use and provides a systematic framework to:

- Develop a comprehensive LNAPL Conceptual Site Model (LCSM) for the purpose of identifying specific LNAPL concerns;
- Establish appropriate LNAPL remedial goals and specific, measurable, attainable, relevant, and timely SMART objectives for identified LNAPL concerns that may warrant remedial consideration;
- Inform stakeholders of the applicability and capability of various LNAPL remedial technologies;
- Select remedial technologies that will best achieve the LNAPL

■ *continued on page 28*

Natural Source Zone Depletion (NSZD)

A Key Part of the LNAPL Conceptual Site Model

by Jenna DiMarzio, M.Sc. and Julio Zimbron, Ph.D. (E-Flux)

Following a Light Non-Aqueous-Phase Liquid (LNAPL) spill, characterization activities, including high-resolution site characterization (HRSC), are often used to determine the spatial extent of the contaminant, the location of the source, and the severity of the impacts on both soil and groundwater. After this initial characterization, the site owner must confront the crucial question: What's next? Most site owners and regulators will at this point turn their attention to remediation design, with the legitimate goal of restoring the site to its previously pristine condition.

While we environmental professionals are busy planning our responses to spills, natural soil processes are already underway. Soil microbial populations begin to adjust to the introduction of LNAPL compounds, resulting in the awakening of metabolic pathways capable of using the energy stored in LNAPL. These microbial mechanisms ultimately result in the biodegradation of petroleum, yet are often ignored or overlooked by site owners. However, biodegradation processes, collectively called Natural Source Zone Depletion (NSZD) have recently been recognized as crucial to the contaminated site's life cycle and are a key part of the formulation of the LNAPL conceptual site model (CSM).

NSZD includes microbially driven processes that result in the transformation of petroleum contaminants into dead-end inorganic products. This conversion, called *mineralization*, relies on the presence of microbes capable of degrading the contaminants, as well as the availability of electron acceptors like oxygen. Alternative electron acceptors (e.g., sulfate, nitrate, iron, manganese oxides) typically present in soil can be used by microbes for anaerobic pathways when oxygen is not available until they, too, are depleted. Because oxygen is preferentially used by microbes as an electron acceptor and soil has a limited oxygen transport capacity, it is typically absent near the LNAPL source.

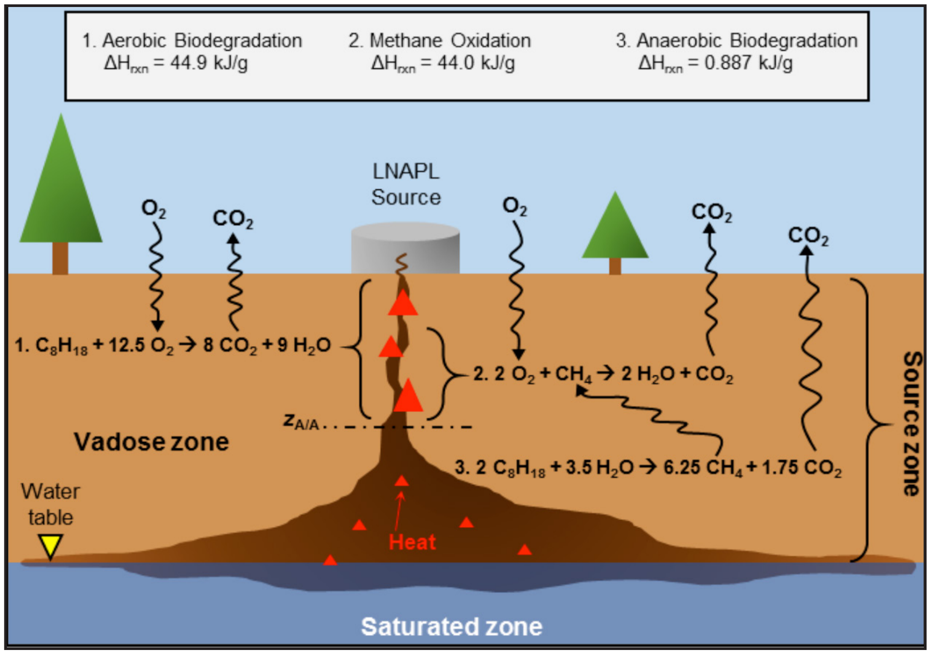


Figure 1. *Schematic depiction of subsurface processes at an LNAPL spill*

Although aerobic biodegradation is traditionally considered to be faster than anaerobic biodegradation, the relative importance of both processes at a site might be determined by the extent of contact between electron acceptors and the contaminant. Both aerobic and anaerobic pathways ultimately result in the production of carbon dioxide (CO_2). This LNAPL-derived CO_2 will rise through the soil column and eventually escape into the atmosphere.

In addition to those processes using "external" electron acceptors (i.e., those migrating toward the contaminant due to air or gas transport), many LNAPL-contaminated sources undergo methanogenesis, which results in the degradation of petroleum products into methane (CH_4) and CO_2. This reaction, which does not require external electron acceptors, takes place below the aerobic/anaerobic interface within the soil column. As the upward-moving CH_4 reaches this interface and contacts oxygen, it is typically rapidly oxidized to CO_2. If the flux of biodegradable carbon sources (including CH_4) exceeds the soil's oxygen transport capacity, incomplete CH_4 oxidation might occur. This situation, which can result in explosion hazards and increased risk of vapor intrusion, has been observed at a large ethanol-containing biofuel spill (Sihota et al., 2013).

Why Are These Processes Important?

Acknowledging the interactions between soil microbes and petroleum contaminants has strong implications. First, it helps us better understand local soil and groundwater geochemistry in the context of a contaminated site. Second, it helps us realize that these processes will result in the in-situ mass depletion of organic contaminants.

From a practical viewpoint, NSZD can be a useful tool at all stages of a contaminated site's life cycle. Using NSZD principles (i.e., increased CO_2 emissions from contaminated soils) to identify a geochemical footprint in the vadose zone can help delineate the LNAPL source, which in turn helps site owners choose the locations of monitoring wells in order to better characterize the site and inform remedial decision making. At later stages, such as during remedy selection or transition, a quantitative measurement of the NSZD rate can provide a meaningful reference for the performance of the considered remedies. Additionally, NSZD reactions occur even when active remedies are in place. If we are willing to designate significant financial resources to site remediation, a sensible goal might be to increase the contaminant mass removal rate above the site's natural depletion rate.

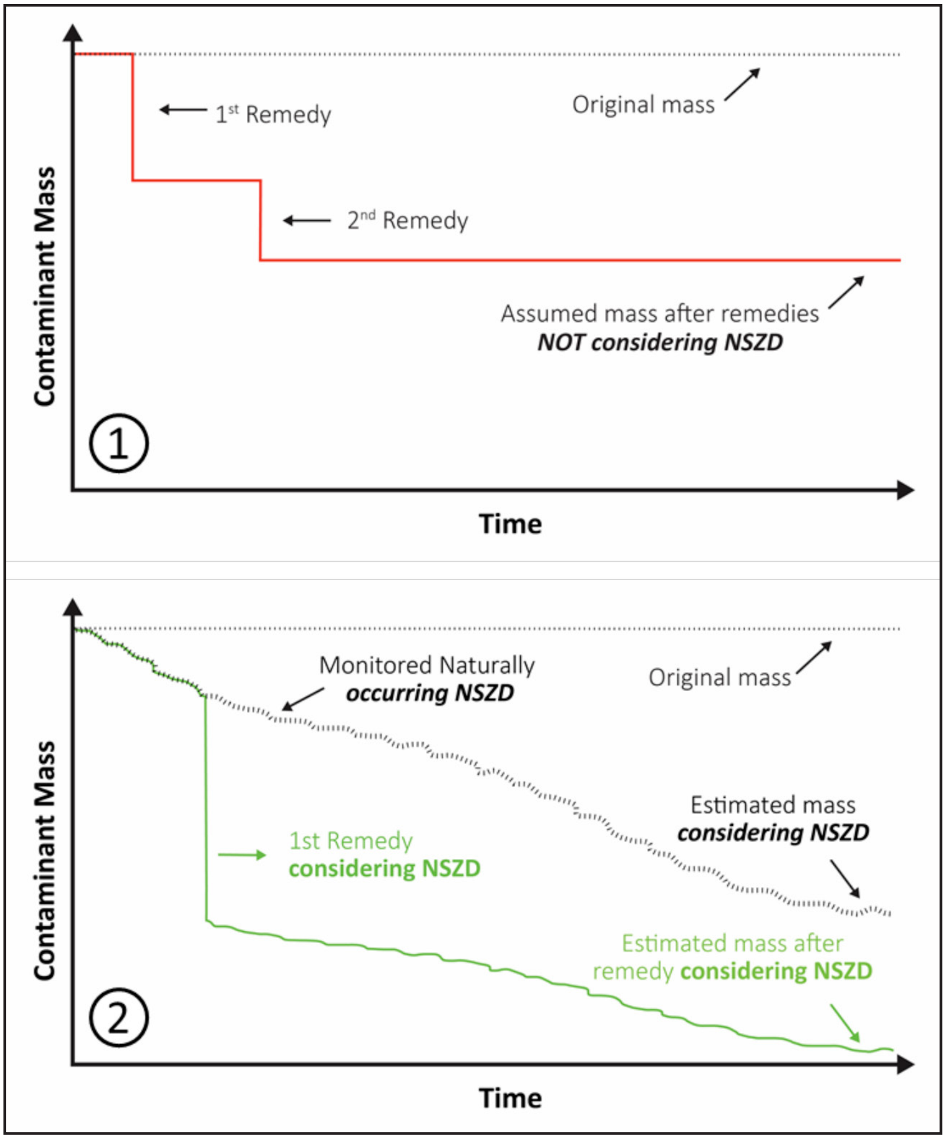


Figure 2. *A conceptual depiction of mass losses over time at a hypothetical contaminated site: 1) accounting for only active mass removal remedies, and 2) also considering mass losses due to NSZD.*

Measuring NSZD Rates

NSZD has been shown to occur at most petroleum-contaminated sites, and many techniques can be used to measure the rate at which these processes take place. The most common methods are based on the measurement of CO_2 efflux at or below the soil surface. The three CO_2-based methods, namely the **concentration gradient method**, the **dynamic closed chamber method**, and **passive CO_2 flux traps**, deliver quantitative NSZD rates. Like all field sampling techniques, each of these methods has its own advantages and limitations.

The concentration gradient method was the first technique used to estimate NSZD rates and involves sampling soil CO_2 concentrations at different depths in the subsurface. The change in concentration at a particular plane in the soil column is proportional to the diffusive flux, according to Fick's law of diffusion. However, this method requires vertically distributed soil gas probes to be installed at the site, and the quality of results relies on an accurate determination of the soil's effective diffusion coefficient.

While the concentration gradient method is used to measure soil gas fluxes at specific soil depths, the other two methods, namely the dynamic closed chamber (DCC) and passive CO_2 flux traps, measure fluxes at ground level. The DCC is a vented chamber installed at the soil surface that is used to measure soil gas concentration changes. Several concentration measurements are taken as the chamber fills with soil gas, and the CO_2 flux is calculated from the slope of the concentration-time regression. The DCC is most often used to measure soil gas fluxes during short deployments (typically a few minutes). However, long-term fluxes can be estimated with the DCC if enough repeated measurements are taken over an extended period to account for short-term CO_2 flux variability.

Passive CO_2 flux traps are deployed at the ground surface, where they capture CO_2 over an extended time period (e.g., 2 weeks) using a sorbent. After field deployment, the sorbent from each trap is analyzed for its CO_2 and 14C concentrations. This isotopic correction allows the method to account for only fossil-fuel-derived carbon during the quantification of NSZD rates. Passive CO_2 flux trap measurements provide long-term time-integrated average fluxes and are robust to daily barometric fluctuations.

All three of these methods rely on free-gas-transport pathways, meaning there can be no impermeable barriers to gas flow in the subsurface. NSZD rates measured at field sites using these three methods range from a few hundred gallons per acre-year to a few thousand gallons per acre-year.

A fourth measurement method, which makes use of soil temperatures and thermal gradients, is currently in development and is not considered quantitative. All pres-

■ continued on page 20

■ **Natural Source Zone Depletion** *from page 19*

ently available NSZD monitoring methods are described in detail in a recent American Petroleum Industry (API) guidance document and in other technical literature (see "Timeline of Important NSZD Developments" and Additional Resources).

The Importance of NSZD

If properly assessed, NSZD rates can provide an operational baseline for active remedies. No matter how advanced the remediation system, there comes a time when it is impossible or economically inefficient to remove any more contaminant from the ground because of low soil concentrations. NSZD can be particularly helpful in this situation—if NSZD rates are comparable to the performance of a remediation system, it might be possible to take advantage of this natural contaminant depletion rate. Evidence from the field, as well as the considerable body of literature backing up NSZD processes, should give us peace of mind in accepting that soil microbes will continue to remove contaminant left in the ground long after active remedies have stopped working. Monitoring this natural depletion rate, therefore, keeps site owners up-to-date on the progress of contaminant removal efforts and informs regulators about the advisability of site closure.

Frequently Asked Questions

Q. ***How fast does petroleum biodegradation occur?***

A. A recent study found that NSZD-based loss rates measured at several field sites ranged from 700 to 2,800 gallons per acre-year (Garg et al., 2017). Although these rates are larger than expected, they are not high enough to achieve rapid site cleanup. For example, an apparently high NSZD rate of 1,000 gallons per acre-year only amounts to a free petroleum thickness decrease of about 1 mm. If an extraction or cleanup system is pushed to the point that it yields the same results as the natural microbial rate, this could be an indication that nature is achieving more than the active remedy. Sustained monitoring of NSZD rates is, therefore, crucial to the efficient and cost-effective management of active remedies.

Q. ***What factors affect NSZD rates?***

A. Temperature has a very strong effect on the speed with which microbes break down petroleum products. As a result, NSZD rates at field sites are seasonally dependent, and rates are typically at a maximum in the fall. In general, 35°C to 40°C is the upper temperature tolerance limit for subsurface microbes, while microbial activity may be very slow or completely stopped at temperatures near or below freezing. Site-specific models can help us understand the relationship between temperature and microbial activity by assessing the depth distribution of local soil temperatures; an example of such a model is available for free at *BiogenicHeat.com*.

Another important factor impacting NSZD rates is the availability of electron acceptors. Some progress has been made by treating dilute dissolved plumes with external electron acceptors, such as sulfate (e.g., Kolhatkar and Schnobrich, 2017). In general, the success of these remedies is limited by the efficiency of contact between the contamination and the electron acceptors.

Timeline of Important NSZD Developments

2006 **Lundegard and Johnson measure spilled LNAPL mass losses using a mass balance applied to both the vadose (unsaturated) zone and to groundwater. Mass losses in the vadose zone were shown to be two orders of magnitude higher than those in groundwater.**

2009 **A new ITRC LNAPL Guidance Document describes mass balance methods for quantifying NA (Natural Attenuation) and NSZD rates in groundwater and in the vadose zone.**

2011 **A research group led by Dr. Uli Meyer at the University of British Columbia uses an agronomic technique to measure soil gas fluxes at grade, and correlates the changing concentrations with NSZD activity.**

2014 **A research team at Colorado State University develops a passive sampling technique which, when integrated with radiocarbon analysis, yields long-term CO2 fluxes corrected for modern CO2 contributions.**

2017 **The American Petroleum Institute publishes a Guidance Document and NAVFAC publishes "New Developments in LNAPL Site Management," both describing different methodologies for the measurement of NSZD rates and the usefulness of those rates.**

2018 **An updated ITRC LNAPL Guidance Document highlights the importance of NSZD with respect to the LNAPL conceptual site model, and adds additional methods for measuring NSZD rates (incorporating those present in the 2017 API Guidance Document).**

Q. *How are LNAPL natural attenuation (NA), natural source zone depletion (NSZD), and monitored natural attenuation (MNA) related?*

A. According to the ITRC LNAPL update document (ITRC, 2018), natural attenuation (NA) encompasses all natural processes that result in loss or neutralization of the contaminant without human intervention. NA includes both natural source zone depletion (NSZD) and monitored natural attenuation (MNA). NSZD specifically refers to mass loss from the unsaturated source zone caused by both physical and chemical processes, including biodegradation reactions. MNA is used to assess the rate of contaminant removal through the aqueous phase (see USEPA's OSWER Directive No. 9200-4.17). Because methanogenesis does not require external electron acceptors and its by-products (CO_2 and CH_4) preferentially partition into the gas phase, field-measured NSZD rates often cannot be explained solely by the consumption of electron acceptors. Mass losses attributed to NSZD mechanisms are much larger than those related to MNA mechanisms (Lundegard and Johnson, 2006).

Q. *Can NSZD rates be estimated based on the depletion of external electron acceptors?*

A. Biodegradation reactions can be either aerobic (in the presence of oxygen) or anaerobic (in the absence of oxygen). Methanogenesis (an anaerobic process) is not reliant on external electron acceptors. This makes it impossible to estimate NSZD rates using only the degree of source zone electron acceptor depletion. However, aerobic and methanogenic NSZD pathways both ultimately produce CO_2, meaning that in most cases NSZD rates can be accurately estimated using LNAPL-derived CO_2 fluxes.

Q. *Can a site be completely cleaned up by NSZD processes in a few years?*

A. NSZD is a long-term process. For a typical terrestrial petroleum spill, it might take decades for NSZD to remove significant contaminant mass. However, if active mass removal methods have achieved some success, and the remaining contaminant mass poses a low risk to public and environmental health, performing NSZD calculations or studies may inform stakeholders about the usefulness of active and passive remedies in achieving site closure.

Q. *Can NSZD monitoring be used at any LNAPL-contaminated site?*

A. In general, yes, NSZD monitoring can be useful at most LNAPL-contaminated sites. NSZD rates can also be used to reinforce the conceptual site model in combination with other sources of data at all stages of the site's life cycle. For example, LNAPL-derived CO_2 fluxes can be used to delineate the extent of the contaminant during early site characterization, or NSZD rates can be used to assess the performance of various active remedies. Keep in mind that some site conditions, such as the presence of gas-impermeable/wet layers, interfere with the characterization of NSZD processes.

Q. *Can NSZD be a final remedy for any LNAPL-contaminated site?*

A. Yes, in the sense that we can sometimes take advantage of NSZD processes to let nature remove the last remnants of a contaminant in the subsurface following implementation of an active remedy.

Q. *At how many LNAPL sites has NSZD been monitored to date?*

A. NSZD rate measurements have been taken at hundreds of LNAPL sites and several DNAPL sites across North America. The widespread use of NSZD as a passive remedy and monitoring tool continues to grow every year, and NSZD is also quickly gaining acceptance in Europe and Australia.

Q. Does NSZD affect all LNAPL compounds equally?

A. This is likely not the case. It has been shown that microbes prefer certain compounds, such as those with lower molecular weights, over others. This means that the composition of the LNAPL contaminant is likely enriched in less biodegradable compounds with time. It is therefore very important that we understand how these compositional changes affect the management of contaminated sites over the long term. ■

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Dr. Julio Zimbron holds M.Sc. and Ph.D. degrees in chemical engineering from Colorado State University, where he is now affiliated faculty. Dr. Zimbron's work in the areas of natural source zone depletion (NSZD) and NAPL distribution and mitigation includes patents, technical papers, and guidance documents. He presents multiple times a year at national and international conferences and workshops and can be reached at jzimbron@soilgasflux.com

Additional Resources

American Petroleum Institute (2017) Quantification of Vapor Phase-related Natural Source Zone Depletion Processes, First Edition. *https://bit.ly/2Et9C43*

Garg S., Newell C.J., Kulkarni P.R., King D.C., Adamson D.T., Renno M.I., and Sale T. (2017) Overview of Natural Source Zone Depletion: Processes, Controlling Factors, and Composition Change. *Groundwater Monitoring and Remediation* 37, 62-81.

ITRC (2009) LNAPL Guidance Document. *https://bit.ly/2pRfSIk*

ITRC (2018) Updated LNAPL Guidance Document. *https://lnapl-3.itrcweb.org/*

Kolhatkar R. and Schnobrich M. (2017) Land Application of Sulfate Salts for Enhanced Natural Attenuation of Benzene in Groundwater: A Case Study. *Groundwater Monitoring & Remediation* 37, 43-57.

Lundegard P.D. and Johnson P.C. (2006) Source zone natural attenuation at petroleum hydrocarbon spill sites—II: Application to a former oil field. *Groundwater Monitoring & Remediation* **26**, 93-106.

NAVFAC (2017) New Developments in LNAPL Site Management. *https://bit.ly/2OmKhxb*

Sihota N.J., Mayer K.U., Toso M.A., and Atwater J.F. (2013) Methane emissions and contaminant degradation rates at sites affected by accidental releases of denatured fuel-grade ethanol. *Journal of Contaminant Hydrology* **151,** 1-15.

Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites (OSWER Directive 9200-4.17). *https://bit.ly/2CKBe1o*

Performance Monitoring of MNA Remedies for VOCs in Ground Water (EPA/600/R-04/027). *https://bit.ly/2C0mLg7*

How Hard Can It Be?

Maine's UST Program Preventative Measures Are Paying Off

by David McCaskill

Over the seven years since I last wrote about USTs in my LUSTLine *"Tanks Downeast" column. I've spent most of my time dealing with other compelling issues. For example, there is the ongoing problem with aboveground residential home heating oil tanks. We still see, on the average, 1.5 spills per day due to internal corrosion, physical damage, and overfills involving these tanks. With almost 400,000 residents using fuel oil to heat their homes, the numbers really work against you.*

I am also working proactively with the Maine Drinking Water Program, Maine Rural Water Association, and Water Districts across the state performing table-top exercises (some call them "spill drills") to prevent the problems like those caused by the 2014 Elk River Chemical Spill in Charleston, West Virginia (see LUSTLine *#74).*

I haven't had as much time to think about UST/LUST as I have in the past. On the other hand there has been little reason to do so. Surely I jest? Okay, let me explain. Maine's UST program is a mature 33 years old. Here's a brief history of the preventative measures we've taken over the years, and the current state of affairs.

Please hold on to your inspection notebook or mobile device, because I'm going to fly through 30 plus years pretty fast.

Honing the Program Step by Step

In 1985, Maine developed an interim UST/LUST rule. In 1986, our current Chapter 691 UST rule hit the streets. This rule included the standard menu—registration, installation, corrosion protection, leak detection, spill and overfill prevention, and closure requirements.

Also, during that time, we developed our first-in-the-nation, state-level Certified Tank Installer (CTI) program. A Board of Underground Storage Tank Installers (BUSTI) oversees the program. (I am currently a Board member.) Recognizing that we would never have sufficient staff to adequately inspect everything, the CTI program relies strictly on the people doing the work to make sure that UST systems are installed properly. We developed a Certification of Proper Installation form the installer must sign and send to MDEP to certify the work they have done.

I've often wondered if we should have required MDEP staff to inspect the tank top prior to backfilling the piping, a requirement in most other states. We don't have any serious installation problems though, so I guess the proof is in the pudding. That being said, early in the program, we did find some serious installation issues that led BUSTI to revoke some installer certifications. Quality of installations improved substantially when the industry saw that BUSTI meant business.

Not to say that our UST world is perfect. For example, we find improperly anchored crash valves on a good many of the first generation replacement tanks. But remember that before the days of dispenser sumps, anchoring crash valves was not an automatic thing. Thankfully, as with most of the current generation of UST installation technology, the new designs make it hard not to get it right.

One decision that we never regretted was promulgating a ten-year mandatory removal schedule for all bare steel, single-walled tanks in 1989. No retrofitting bare steel with cathodic protection or internal tank lining for us, despite the heavy lobbying on the matter by industry. By 1999, all of our federally regulated bare steel tanks had been replaced.

In 1991, we added our UST insurance fund, mandatory secondary containment for both tanks and piping, and a mandatory removal requirement for new tanks at the end of their manufacturer's warranty period (i.e., 30 years).

Skip ahead to 2001, when we added our siting law to provide setbacks and restrictions for the installation of USTs in proximity to public and private drinking water wells and over significant mapped sand and gravel aquifers. In 2008, we also developed a similar siting law for aboveground storage tanks.

In 2003, we implemented our annual UST facility inspection requirement whereby a facility owner/operator is required to hire a certified installer or inspector (two different types of certification) to inspect all the corrosion, leak detection, and spill/overfill prevention gadgets to make sure they are functioning properly. Once there has been a passing inspection (i.e., things may have to be corrected), then the inspection form is submitted to MDEP. Problems found through the inspection program (or the lack of an inspection) help guide our own compliance inspections, as well as red tag enforcement.

Prior to 2003, our 1991 tank rules required that this equipment be inspected annually and repairs documented, but the results were not required to be sent to MDEP. In the mid 1990s (during the throes of our mandatory bare-steel-tank removal schedule) we started reminding owners of this requirement and even designed a form to use and provided guidance. Still, with no requirement to send the forms in to us, it was hard to know who was doing these inspections, who wasn't doing them, and whether problems found were actually being fixed.

We commissioned a study to review these inspections and learned

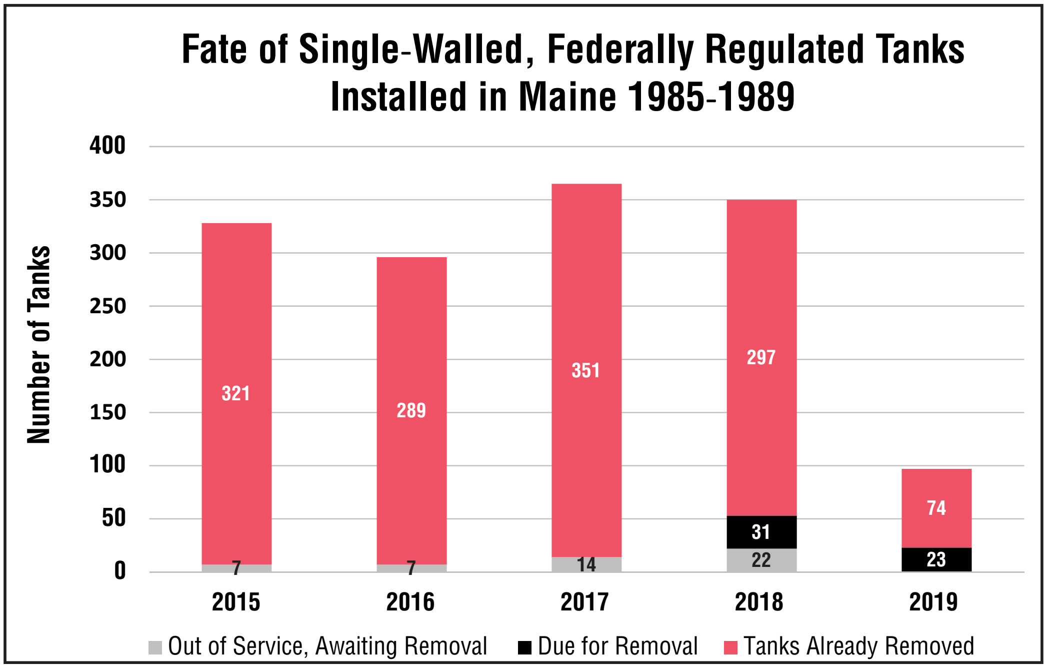


Figure 1: *Maine requires that federally regulated tanks be removed at the expiration of their warranty, which for tanks installed in 1985 through 1989, was 30 years. Consistent with our experience over the past few years, the two columns on the right of this chart show that the majority of tanks due for removal have already been removed. Thanks to good education, outreach efforts, and planning on the part of many facility owners, a chaotic last minute tank removal/replacement rush has been avoided.*

that a majority of UST owners "couldn't find the inspection results," and that many owners who did conduct inspections failed to correct problems—year after year. This information helped pass legislation for our current annual inspection program. Second to mandatory secondary containment, I believe that this is the best thing we ever did to prevent releases.

In 2004, we required the installation of monitored dispenser sumps at all new motor fuel facilities and a retrofit when piping is replaced.

Finally, in 2006, we implemented our online TankSmart program to train A, B, and C operators (*https://www.maine.gov/dep/waste/tanksmart/index.html*)

Phew! Busy time. So what now? We are in the process of updating our rules to meet the new federal requirements—for Maine, this boils down to sump testing. We are leaning toward the high-level test (i.e., testing to 4" above any penetrations).

Good Hygiene

We are now in the middle of the first wave of our 30-year tank removal schedule (that mandatory end-of-manufacturer warrantee removal requirement for fiberglass and corrosion-protected steel tanks). We are finding very little contamination when we dig these tanks up. What little contamination found is typically from material left over either from when the bare-steel tanks were removed and the first-generation of new tanks went in or from dispenser releases at facilities lacking under-dispenser containment.

Why are we not seeing a lot of UST problems? Is it the honing of requirements over the years? Or is it something more basic, such as good hygiene? Afterall, there is no preventative shot for the common cold and only a better-than-nothing immunization for the flu, but how do you really keep from contracting these maladies? Good hygiene. You wash your hands before you eat, keep your fingers out of your mouth, and get plenty of sleep.

Why are we not seeing a lot of UST problems? Is it the honing of requirements over the years? Or is it something more basic, such as good hygiene? Afterall, there is no preventative shot for the common cold and only a better-than-nothing immunization for the flu, but how do you really keep from contracting these maladies? Good hygiene.

The same is true of the early years of our UST program. For the first time, many contractors were faced with what amounted to good UST hygiene requirements to carefully install USTs in well-drained, granular, non-corrosive backfill. The same was generally true of the piping. We have not seen any sign of external corrosion. So besides the handful of tanks requiring retrofitting of new anodes, cathodically protected tanks with their pre-engineered systems seemed to have worked for the last 30 years.

We have seen internal corrosion from double-walled jacketed tanks (constructed to UL standard 1746), where the steel inner tank was allowed to be made of thinner steel than a tank constructed to UL standard 52, which specifies thicker steel to provide for a corrosion allowance.

Interestingly enough, we have also seen premature failure of the inner-wall of cathodically protected double-walled steel tanks. The leaks have been contained in the interstitial space so no fouling of the environment has occurred, but many of these tanks only reached half of their 30-year warranty life before they failed. With all the past problems with flex pipe, double-walled FRP piping is becoming the standard along with rigid FRP piping sumps for the larger regional chains. It only took a 30-year nationwide field experiment to figure out what works.

■ *continued on page 24*

■ Maine UST Preventative Measures *from page 23*

As for the contaminated soil that we do find at tank removals, the levels are not usually high enough to require removal and disposal (usually at a secure, special waste landfill), but the soils need to be removed to make way for engineered backfill for the new tanks and piping. We are developing new standards for these "surplus soils" that are not required to be removed but are "in the way," so to speak. Our UST insurance fund will cover the cost of removing these soils and require they end up going to a secure landfill, unless the UST facility can use them on site.

The 30-Year Removal Schedule

By 2019, all of our 368 single-walled motor-fuel tanks will have been removed, while the rest of our 1,542 double-walled 20th century tanks will be removed and possibly replaced by 2028. (See Figure 1.) We do have a provision for existing double-walled facilities to receive a ten-year extension on the removal requirement if they tightness-test their systems and update to monitored dispenser sumps, among a few other items. We have seen some interest in this option, but many owners have decided to go through the full upgrade and get it over with. It all depends on their business timelines.

The Glitches?

Here's my take on what's needed to attain near perfection in our UST world:

- Tanks should be made of non-corrosive materials. With all the changes and future changes to our fuel supply (e.g., ethanol), the combination of steel, water, sludge, and bacteria hasn't worked out, at least not with jacketed tanks.
- Install double-walled, 15-gallon spill buckets. You might as well have a spill bucket large enough to catch what is left in the delivery hose, just in case, and double-walled to prevent leaks and simplify your three-year testing requirements.
- If you are going to have leak-detection sensors in sumps, they should control the power to the submersible pumps. This is the surest way to get the owner/operator's attention. These alarms should alert the owner via telemetry at times when the facility is unattended or closed. Most of the new automatic tank-gauging systems have this capability, and everyone has a smart phone to receive the alert. Enough said! This is especially important for unattended fueling facilities (e.g., fleet fueling and retail stations that allow customer fueling after hours).
- We have had good success with the *TankSmart* operator-training program, whereby owners now know how their systems work instead of relying strictly on the contractors. One piece of the fuel-distribution chain that we don't have a good handle on is delivery drivers. There is company and industry guidance (API Recommended Practice 1007), but no real required training. We have continued that trend of providing guidance, but no requirements, by adding a voluntary training module that deals with fuel-truck deliveries to our online *TankSmart* program.

Well that's the skinny from Maine. Our program seems to be working with a few tweaks like dealing with sump testing, surplus soils, updates to our siting rule, and replacing retiring staff!

All should work out though, and as my neighbor always says about a task, "How hard can it be?" ■

David McCaskill is an Environmental Engineer with the Maine Department of Environmental Protection. For several years he authored a LUSTLine *column called "Tanks Downeast." He can be reached at: David.McCaskill@state.me.us*

Remembering Ken Wilcox continued from page 12

An International Tank-Testing Legend

Ken Wilcox was well known in the in the USA and abroad for his encyclopedic knowledge of leak detection. [He did tank testing throughout the world, including the 7 million gallon tanks at Pearl Harbor (see article on page 11)].

Ken had a long-time friendship with folks at the Association for Petroleum and Explosives Administration (APEA) in Europe. He participated in many of APEA's conferences and contributed to the technical specification for the European Standards. He is photographed here in the UK after receiving an Honorary Membership in the APEA for his services to the industry in general and APEA in particular. "This award is not something we give lightly," said Ken's good friend at APEA, Jamie Thompson.

Field Notes ✍

from Rick Long, Executive Vice President, Petroleum Equipment Institute (PEI)

How Do You Properly Close a Tank?

A New PEI Recommended Practice Provides Answers

An owner or operator contemplating the closure of an underground storage tank (UST) or aboveground storage tank (AST) system must deal with multiple complications, including:

- Product or vapors remaining in the tank
- Existing contamination that may be discovered during the course of the job
- The risk of new releases or spills
- Human and vehicular traffic on or near the job site
- Decisions on proper disposal of the tank.

Every aspect of the closure process must be carefully planned and diligently executed to protect human life and property, and to eliminate, reduce, or mitigate environmental harm.

Although always important, the need for proper tank closure procedures is even greater today. To understand why, you have to know a little history and a little math.

In 1988, the U.S. Environmental Protection Agency (USEPA) established strict material and construction standards for the nation's USTs. New gas stations were required to use UL-approved fiberglass, corrosion-protected steel, or composite USTs. Existing stations were given ten years to upgrade, replace, or permanently close any USTs that did not meet the new standards.

Thanks to these requirements, hundreds of thousands of USTs were installed throughout the nation between 1988 and 1998.

Because new tanks typically carry a 30-year warranty, the first tanks installed after the 1988 regulations have now reached the end of their warranty period. Others will follow over the next ten years.

As discussed in the 2018 *LUSTLine* #84 "Field Notes" column, many questions remain about these aging tanks. What is a tank's true useful life? To what extent will insurers be willing to cover the tanks? When will states require removal of out-of-warranty tanks?

Under any scenario, however, it is clear that many of the tanks installed from 1988 to 1998 will soon need to be taken out of service. Indeed, a Sept. 2018 PEI survey suggests that this process already has begun—some 24 percent of PEI distributor and contractor members report an increase in their tank removal work during the previous 12 months.

Introducing RP1700

With no nationwide standards for decommissioning and closing tanks, the result has been a patchwork of often-inconsistent practices across the country.

To bring some order to the confusion and at the request of various industry stakeholders, the PEI Board of Directors authorized development of a recommended practice for tank closures in fall 2016. Soon thereafter, then-PEI president Steve Trabilsy appointed a committee of experts to begin the project.

After two years of work, the PEI Tank Closure Committee has now released RP1700: *Recommended Practices for the Closure of Underground Storage Tanks and Shop-Fabricated Aboveground Storage Tanks.*

Here are the key questions the committee considered and the themes that made their way into RP1700.

What Types of Closures Are Covered?

The committee's first big decision was to determine the scope of the document. Not all tank removals are created equal.

UST closures come in two varieties, each with their own procedures:

- **Temporary closures** occur when a UST system is taken out of service for a limited period of time. For example, an owner may temporarily close a site until a major building expansion project is completed. In other cases, a temporarily closed tank may be awaiting determination of whether to proceed with permanent closure.
- **Permanent closures** occur when the owner removes an UST from the ground or leaves it in place but renders the tank unusable by filling it with an inert, solid, non-shrinking material.

In addition, field-erected and shop-fabricated AST closures have their own unique considerations.

The committee ultimately decided that RP1700 would cover both types of UST closures and recommend closure practices for shop-fabricated ASTs. Field-erected ASTs, and pressure vessels are excluded from the document's scope.

Goal #1: Safety

Safety has been at the heart of every PEI recommended practice, and RP1700 is no exception. In fact, the document's first recommendation is that a written safety and health program be developed and implemented prior to commencing activities. This program, which is used to evaluate and control likely hazards and provide for emergency response, should be made available to all personnel involved with the job.

RP1700 addresses lifting equipment, rigging, fall protection,

■ continued on page 26

Field Notes continued from page 25

electrical hazards, confined space entry, vehicle hazards and other basic safety risks present on many job sites. The document also covers items of particular interest in a tank closure, including:

Fire and Explosion Hazards. Flammable liquids and vapors are often present in tanks slated for removal. To reduce the risk of fire and explosion, RP1700 gives special attention to controlling the three sides of the fire triangle: fuel, oxygen, and ignition sources. For example, the document recommends:

- Banning smoking in the area
- Shutting down open flame-and spark-producing equipment
- Using explosion-proof electrical equipment
- Using non-sparking tools
- Controlling static electricity with bonding or grounding equipment
- Cleaning the tank
- Vapor-freeing the tank through purging or inerting
- Continuous testing for flammable vapors.

Excavation Safety. Excavation work is inherently risky. To underscore this reality, last September the U.S. Occupational Safety and Health Administration (OSHA) updated its trench safety guidelines in response to a recent spike in trench-related fatalities.

RP1700 recommends vigorous safety measures before the job begins, as well as during excavation and removal of the tank. This includes setting up barricades, walkways, lighting, and signs around the perimeter of the excavation.

To reduce the risk of cave-in, the document also recommends that excavated materials be placed a minimum of two feet away from the trench walls. Finally, the document reminds readers of special excavation risks involved in UST closures, including:

- Tanks floating as a result of high groundwater
- Potential destabilizing of adjacent building
- Damage to underground utilities
- Heavier-than-air gasses, which may displace oxygen.

Goal #2: Protect the Environment

With product, vapor, and sludge often present in tanks, piping, and other components, careless or insufficiently planned closures may lead to spills and other releases. To minimize these risks, RP1700 includes recommendations to help owners, operators, and contractors:

- Follow environmentally sound closure practices during closure activities
- Identify and contain existing contamination discovered during closure
- Prevent future releases from tanks that are taken out of service.

During Closure. Before work commences, RP1700 recommends development of a plan for containing small spills, cleaning the tank, and disposing of its contents (including the water used to rinse the tank). If a spill does occur, it should be contained and cleaned up immediately.

In a temporary closure, environmental safeguards should continue for the entire period the tank system is out of service. These safeguards may include:

- Corrosion protection and required testing
- Inspections
- Removal of stored product from the tank, lines, nozzles, and any other system components
- Release detection, if the tank's product volume is 2.5 centimeters or more
- Turning off power to the pumps, dispensers, and submersible turbine pumps (STPs).

Existing Contamination. During tank closure activities, the contractor may discover soil or water contamination caused by a previous release. The pre-closure plan should assess this potential and include special stockpiling or handling procedures that will be used if such contamination is encountered. Discovery of past contamination typically will require notification of the authority having jurisdiction (AHJ) and steps to mitigate the damage.

Future Releases. Closed tanks that are not destroyed on site should be labeled appropriately—including the date of closure, the tank's former contents, and warnings that the tank is not vapor free or suitable for storage of food or liquid. If the tank once held or might have held leaded gasoline, the label should advise that lead vapors may be released if heat is applied to the tank shell.

Closures in place require additional precautions to prevent future releases, such as:

- Removing remaining product from the tank and piping
- Cleaning the tank thoroughly
- Disconnecting and removing the vent line, or, if the vent line is not accessible, capping both ends
- Removing accessible piping and fittings
- Capping or plugging piping and fittings that cannot be reached
- Disconnecting electrical power
- Filling the tank with a solid, inert material approved by the AHJ.

To Learn More...

With hundreds of thousands of tank system closures quickly approaching, PEI believes RP1700: *Recommended Practices for the Closure of Underground Storage Tanks and Shop-Fabricated Aboveground Storage Tanks* is the right document at the right time.

To learn more about RP1700, see a complete table of contents, or purchase your copy, visit *www.pei.org/rp1700*. PEI recommended practices are $40 for PEI members and approved regulators, $95 for nonmembers. ■

Leaking Generator Day Tanks

Coming to a Facility Near You!

by Mike Juranty

Most emergency electrical generators located in or on buildings are fueled by small day tanks that are automatically supplied by much larger ASTs or USTs located outside of the building. If these day tanks lack proper tank rupture and redundant overfill prevention controls, the large ASTs or USTs may empty into the top of the building.

Because UST systems storing fuel solely for emergency power generators were previously deferred in the federal regulations, many regulators may not be familiar with the day tanks associated with the majority of these installations. It is important for regulators to gain awareness of day tank existence, the widespread disparity between common installation practices and code requirements, the resulting human and building safety issues and how they can be corrected. It is also important to educate facility owners, contractors, municipalities, and sister agencies regarding the life safety and building safety issues presented by improperly installed and operated day tank systems.

Case In Point

On October 13, 2010, building service workers in New Hampshire were wondering what the red liquid was dripping from the ceiling in the third-floor boiler room of a county nursing home. It turns out that it was heating oil from the 20,000-gallon UST that automatically supplied a day tank located in the third floor boiler room and that was vented up through the roof of the building. The day tank was lacking any overfill alarms or controls other than an overfill return pipe to the UST, which had started to clog. Luckily only a few hundred gallons of heating oil had been discharged onto the roof before it was observed and the transfer pumps could be manually shut down, thereby avoiding a fire catastrophe.

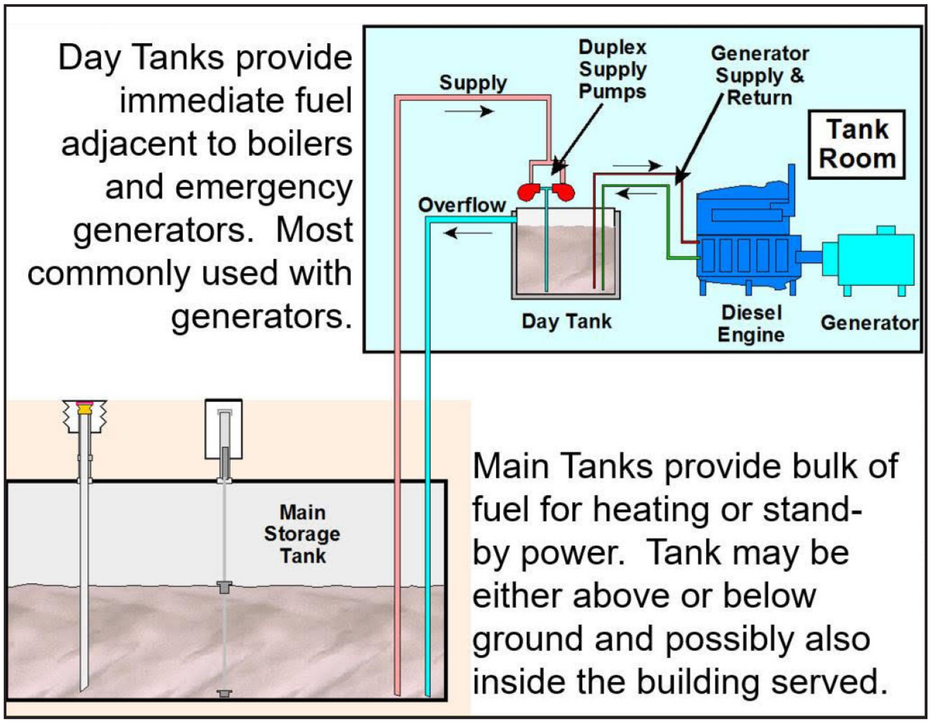


Figure 1. *Day Tank schematic. Courtesy of John V. Cignatta, PhD, PE, Datanet Engineering, Inc.*

Figure 2. *An example of what can happen when a day tank on a building lacks appropriate overfill prevention and tank-rupture controls that would prevent the automatic emptying of the main storage tank onto or into the building. The visible staining on the front of this building is diesel fuel.* [Photo Courtesy of Guam EPA]

After the county nursing home incident, and on account of many more incidents that happened previously and since, the New Hampshire Department of Environmental Services has in conjunction with the State Fire Marshal's Office been inspecting all day tanks and interior piping system components associated with USTs at heating oil and emergency power generator facilities. We have

■ continued on page 28

■ Leaking Generator Day Tanks

from page 27

found that almost all historic day-tank installations have very serious compliance issues that could lead to loss of the entire contents of a suppling UST into the building or out the day tank vent.

To prevent this from happening, fire and industry codes have important secondary containment, venting, and overfill prevention requirements. Only the appropriate regulator can identify these requirements, provide educational outreach, and work in partnership with owners and other regulatory agencies in your state, territory, or tribe to correct these issues before it is too late.

For more information on day tank issues and requirements, visit the 26th National Tanks Conference & Exposition Archive at *http://neiwpcc.org/our-programs/underground-storage-tanks/national-tanks-conference/2018-ntc-archive/* to view the presentations given under the heading "Leaking Generator Day Tank: Coming to a Facility Near You!" on Tuesday, September 11, 2018, by Conchita San Nicolas Taitano, Guam EPA, John V. Cignatta, PhD, PE, Datanet Engineering, Inc., John Bell, Missouri Dept. of Agriculture, and Michael W. Juranty, PE, NH Dept. of Environmental Services.

Another valuable resource is the Petroleum Equipment Institute's *Recommended Practices for the Design and Installation of Fueling Systems for Emergency Generators, Stationary Diesel Engines and Oil Burner Systems*, 2014 edition (PEI RP 1400) available at *http://pei.org*. ■

Mike Juranty is with the Waste Management Division of the NH Department of Environmental Services. He can be reached at: michael.juranty@des.nh.gov

■ Part 2: To HRSC or Not

from page 17

remedial goals for a site, in the context of the identified LNAPL concerns and conditions;

- Describe the process for transitioning between LNAPL strategies or technologies as the site moves through investigation, cleanup, and beyond; and
- Evaluate the implemented remedial technologies to measure progress toward an identified technolog- specific endpoint.

Reviewing this and other ITRC guidance, it is easy to see how a comprehensive CSM forms the basis upon which SMART objectives are designed and remediation technologies are evaluated, selected, and adaptively implemented to reach endpoints. Get the CSM right and in sufficient detail and your ability to benefit from the use of SMART objectives and adaptive technology implementation goes way up. Ignore low data density and high uncertainty in your CSM and each of those subsequent steps can be sabotaged or limited in effectiveness.

Our ability to quantify life-cycle and remedy cost improvements derived specifically from the application of HRSC vs. more traditional characterization efforts remains difficult with available data. Differentiation of characterization vs. remediation expenditures in the ASTSWMO survey would dramatically improve programmatic assumptions made for these evaluations.

Despite this, we are confident that the cost structure of most LUST characterization and cleanup efforts can support the use of HRSC tools and strategies. As use of HRSC tools and strategies continues to rise, the challenge for LUST regulators, the regulated community, vendors, and consultants will be to integrate HRSC services into existing project cost structures.

We recognize that each LUST site is unique and that source mass, release mechanisms, geology/hydrogeology, site features, regulatory programs, cleanup thresholds, remediation technologies, and a variety of other factors drive lifecycle site cost. Remember, time is of the essence for LUST site characterization and remediation efforts and the cost of being fooled can be significant. HRSC tools and strategies provide the data density necessary to drive timely decision making and improve remedy design.

If at a LUST site, one can expect to spend $50,000 or more using traditional characterization techniques and $100,000 or more in remediation costs, then HRSC tools and strategies are expected to provide a net positive return on investment through improvements to the conceptual site model, risk mitigation/management strategies, and improved remedy design and performance. Below these averages derived from the 2007-2017 ASTSWMO surveys, the ability of HRSC tools and strategies to provide net positive results decrease as overall site expenditures decrease. What available data do not tell us is how many of those $500,000 or $1 million remedies could have cost far less for effective remediation through modest investments in HRSC tools and strategies?

ITRC documents recognize the need to define zones where most of the contaminant mass resides for effective and efficient remediation, and our analysis also indicates that most LUST sites can support the use of HRSC tools and strategies that help define those zones in a LCSM.

So what are you waiting for? LUST technical teams can continue to pan for nuggets using traditional characterization approaches and accept low remediation efficiency at many sites, or, you can take a dip in the HRSC pool to define the mother lode and quickly address it with SMART objectives and adaptive technology management strategies. Come on in, the water's fine. We will be waiting for you! ■

Stephen Dyment is a chemist and Superfund Technology Liaison for USEPA's Office of Research and Development located in Denver, Colorado. He can be reached at: dyment.stephen@epa.gov

Tom Kady is an engineer with the Office of Superfund Remediation and Technology Innovation (OSRTI) and a member of the Environmental Response Team (ERT) located in Edison, New Jersey.

The RISK Factor | by Patrick Rounds

Patrick Rounds is president of Petroleum Marketers Management Insurance Company (PMMIC), an Iowa-based insurance company that provides insurance for owners of petroleum USTs. The company was created by and is owned by UST owners. Pat can be reached at: PJR @pmmic.com

UST Facility Inspections

What's Working, What's Not Working, What We Need to Do? Part II

Since 2001, PMMIC has been conducting loss-control inspections at our insured facilities. We use professional, independent compliance inspectors to perform the inspections. The inspectors do not own or operate the facility, they do not perform repair or maintenance services, nor do they sell equipment or other services. The inspector's only motivation is to inspect the facility and report accurately. These detailed, visual inspections have proven to be an excellent loss-control tool capable of identifying leaks, compromised UST system components, and operational concerns. These inspection results, correlated with current release data, help us improve both our underwriting requirements and operator training programs, as well as reduce the number and severity of releases from our insured facilities.

In Part I of this series, we analyzed data from our inspections and release history and reported the following:

- **Spill Prevention.** 30-day walk-through inspections of spill basins required by the new federal regulations are supported by the existence of liquid or debris in spill basins ranging from 55% to 69% of facilities every year over a 10-year period.
- **Overfill equipment.** Our annual visual inspections of overfill equipment have reduced releases caused by overfills to less than 3% of all releases. Removing overfill equipment for testing purposes will impose significant costs to tank owners while producing limited improvements.
- **Dispensers.** Dispensers are the most significant source of leaks and releases. Installation of under-dispenser containment (UDC) may be the most valuable upgrade for any facility that does not have UDC today. Due to the frequency of leaks, dispensers should be inspected on a monthly basis.
- **Unknown source releases.** Undocumented surface spills are a significant source of releases. A possible cause may be improper on-site disposal of liquids from containment sumps. Operators should be trained on the proper handling and disposal of sump liquids.
- **Inspectors.** Inspections are only as valuable as the qualification of the inspectors. Walk-through inspections should be conducted by persons with a Class B certification or greater.

In Part II we provide our findings related to leak detection, containment sumps, leaks, biofuel-compatibility, and frequency of inspections.

Leak Detection

Leak detection and inventory control identify 10% of our reported releases. We review leak detection records for compliance with monthly leak detection requirements and for indications of unusual operating conditions, such as ATG alarm histories. In our most recent year of inspections, 69% of all facilities rely on ATGs as the primary leak detection method with an additional 6% relying on ATG measurements for SIR. 20% of tanks and 23% of lines use secondary containment with interstitial monitoring (SCIM), and 16% of facilities use SCIM for all leak detection. About 2% of facilities use a continuous in-tank leak detection system (CITLDS), and less than 1% use manual tank gauging, vapor monitoring, or water monitoring. Based on our inspections the following issues were identified:

■ **ATGs:**

- 17% of facilities have ATG leak detection issues.
- 1% have ATG equipment issues (e.g., alarm, probe communication).
- 5% of tank compartments contain more than one inch of water.

■ **SCIM:**

- 2% of facilities had a monitored sump that was compromised.
- 9% of facilities have liquid in a piping sump, which prohibits inspection or impedes monitoring of the sump.
- 11% of facilities have liquid in the UDC, which prohibits inspection or impedes monitoring of the sump.

Approximately 1/3 of facilities capable of using SCIM are instead using another leak detection method.

In some cases, owners that have SCIM-capable systems that are not required to use SCIM have reverted to other leak detection methods. Some owners have identified the added costs associated with SCIM system tests as the reason to utilize other leak detection methods. It

■ *continued on page 30*

■ **The Risk Factor** *from page 29*

appears that the federal regulations are discouraging the installation and use of SCIM as a leak detection method.

48% of releases are discovered at closure or by other soil and groundwater testing. Only 4% of these releases are related to leaks from tank or piping that were not identified previously by leak detection methods. These numbers confirm that leak detection systems are working well to identify leaks from tanks and piping.

Sumps

We inspect all sumps to determine if the sump and all components are intact and capable of performing as designed. Components that are damaged, demonstrate material degradation, or have indications of compromise require evaluation and possible repair or replacement by a licensed installer. While compromised sumps may pass some liquid tests and may still perform as designed, the compromised component will eventually fail. A compromised sump may be better than no sump, but eventually it will fail and should be addressed before the failure occurs.

■ **Containment sumps.**

- 62% of inspected tanks have turbine or piping sumps that are designed to be liquid-tight.
- 28% of these containment sumps demonstrate indications of compromise that will require further evaluation or repair.
- 62% of sumps had liquid or debris present.

■ **Under-Dispenser Containment (UDC).**

- 62% of inspected tanks have UDC.
- 31% of UDCs demonstrate indications of compromise, requiring further evaluation or repair.
- 63% of UDCs have liquid or debris present.

■ **Leak Containment.**

- 17% of all facilities had observable leaks that were contained and 14% had leaks that were not fully contained. Of all observed leaks:
  - 93% occur at the dispenser.
  - Frequent inspections catch small leaks before they become big releases.
- Approximately 2% of leaks are suspected releases requiring a release investigation.

Biofuel Compatibility

Iowa has had ethanol in its fuel stream since 1980. In 2000, more than 50% of fuel sold in Iowa contained E10 or greater blends. Today nearly 90% of gasoline sales contain ethanol; 96% of facilities sell ethanol. Two hundred seventy one facilities sell E85 (100 using blender pumps offering mid-level blends) and 168 facilities sell E15. Four hundred thirty eight tank systems are dispensing E15 or greater blends of ethanol. We inspect most of these facilities. We have 17 years of experience inspecting E10 systems, 13 years of inspecting E85 systems, and 7 years inspecting E15 systems. In the past five years, biodiesel up to B20 accounts for 50% or more of diesel sales. In 2017, 36% of facilities that sold diesel, sold some blend of biodiesel.

Regulations require that UST systems must be compatible with the product stored. When E15 entered the market, there were no specific E15 UL standards for components. There were E10 and E85 standards. We are not the regulator. We did not request E15 compatibility documentation if the systems were compatible with E10. While these systems may be compatible with E15, we did not ask for documentation. This is what we have learned about biofuel compatibility issues:

- 1% of all facilities have sump or dispenser components with accelerated corrosion.
- Most accelerated corrosion related to ethanol-blended fuel occurs in unvented sumps sealed with liquid-tight lids.
- Most tank-system components produced in the market today are compatible with E10.
- Most system components were listed as compatible with E10 or E85. For most components, the E15 listing did not exist.
- We have not identified compatibility issues with E15 stored and dispensed through E10-listed components. For compatibility purposes we treat E15 like E10.
- We have documented catastrophic losses of E85 stored in pre-upgrade (1988) tanks that were not subject to a compatibility assessment prior to the introduction of E85.
  - E85 should only be stored and dispensed from systems that are known to be compatible with E85.
  - Rubber, plastic, and aluminum components and various elastomers may be compromised by E85.
- Literature indicates that biodiesel in excess of 20% can impact rubber and plastic components (e.g., O-rings, gaskets, seals). Compatibility assessments should be conducted before storing or dispensing biodiesel in excess of 20%.
- We have not identified any releases related to biodiesel compatibility issues.

Inspection Frequency

We have experimented with inspections on a three-year, two-year, annual, and multiple-inspection annual schedule. Annual inspections provide the most cost-effective approach for our loss-control program. More frequent inspections may be valuable for very high volume facilities.

Visual inspections performed by a properly trained professional can effectively determine the soundness of containment sumps. Our inspection protocol has also nearly eliminated overfills and has confirmed the effectiveness of leak detection systems. Our inspection program has reduced our average loss severity to approximately a third of the national average. If you are responsible for paying to address a release, you will reduce your overall expenditures by inspecting your tank system frequently.

Summary

Our data from annual third-party, independent, professional inspections has provided insight to the following critical operational issues:

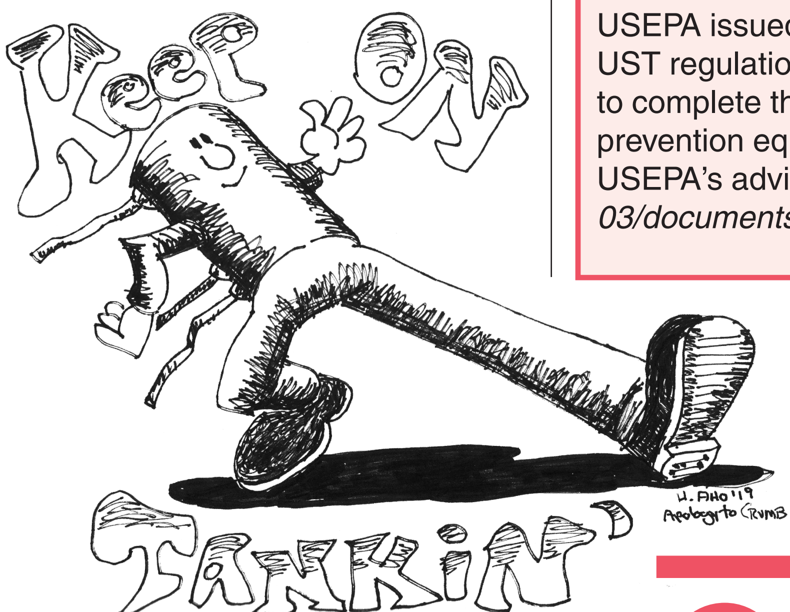
- Leak detection systems are working for the components being monitored.

- Dispensers are the most significant source of leaks and should be monitored regularly.
- Regulations should be reconsidered to encourage, not discourage, the installation of containment sumps and use of SCIM. Containment reduces release frequency. Some containment is better than no containment.
- E15 has not demonstrated any compatibility issues in the systems we have inspected.
- Biodiesel blends up to B20 have not demonstrated compatibility issues that result in a release. ■

USEPA's Compliance Advisory About Testing and Inspection Requirements In 40 CFR Part 280.35

In March 2019, USEPA issued a compliance advisory reminding UST owners and operators in states without state program approval and in Indian Country that they must comply with testing and inspection requirements in 40 CFR Part 280.35. That means owners and operators must test their spill prevention equipment every three years to ensure it works as intended and is able to hold liquid. Also, owners who use interstitial monitoring for piping must test their containment sumps every three years to ensure the release detection is working and will contain product that escapes their USTs. In addition, this includes inspecting overfill equipment every three years to ensure it is working as intended.

USEPA issued the advisory because in implementing the 2015 UST regulation, we observed that some UST facilities failed to complete these requirements on time: sump testing, spill prevention equipment testing, and overfill inspection. Read USEPA's advisory at *www.epa.gov/sites/production/files/2019-03/documents/compliance-advisory-ust-regs-3-11-19.pdf.*



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Tank News From NEIWPCC........

Thank you for joining us in Louisville, Kentucky, for the 26th National Tanks Conference & Exposition (NTC) in September of 2018. Please visit the Conference website for archived presentations, webinar recordings, attendee contacts, and more: *http://www.neiwpcc.org/ntc2018*. The date and location of the next NTC is to be determined, but keep an eye out for announcements on our website and in future issues of *L.U.S.T.Line*.

NEIWPCC continues to collaborate with our partners to plan training opportunities for state, tribal, and territorial employees. Our UST Inspector Training Webinar Series is aimed mainly at UST inspectors and release prevention professionals. Archived webinars from the series can be found here: *http://www.neiwpcc.org/inspectortrainingwebinararchive.asp*. For those interested in LUST issues, we will continue to offer training through our LUST Corrective Action Webinar Series. Please visit our archive to view previous webinars from this training series: *http://www.neiwpcc.org/lust-cawebinararchive.asp*. If you are interested in attending our live webinars, please stay tuned for announcements related to training offerings in 2019.

If you have any questions about NEIWPCC's UST/LUST program, please contact Drew Youngs at DYoungs@neiwpcc.org.

L.U.S.T.Line Index

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