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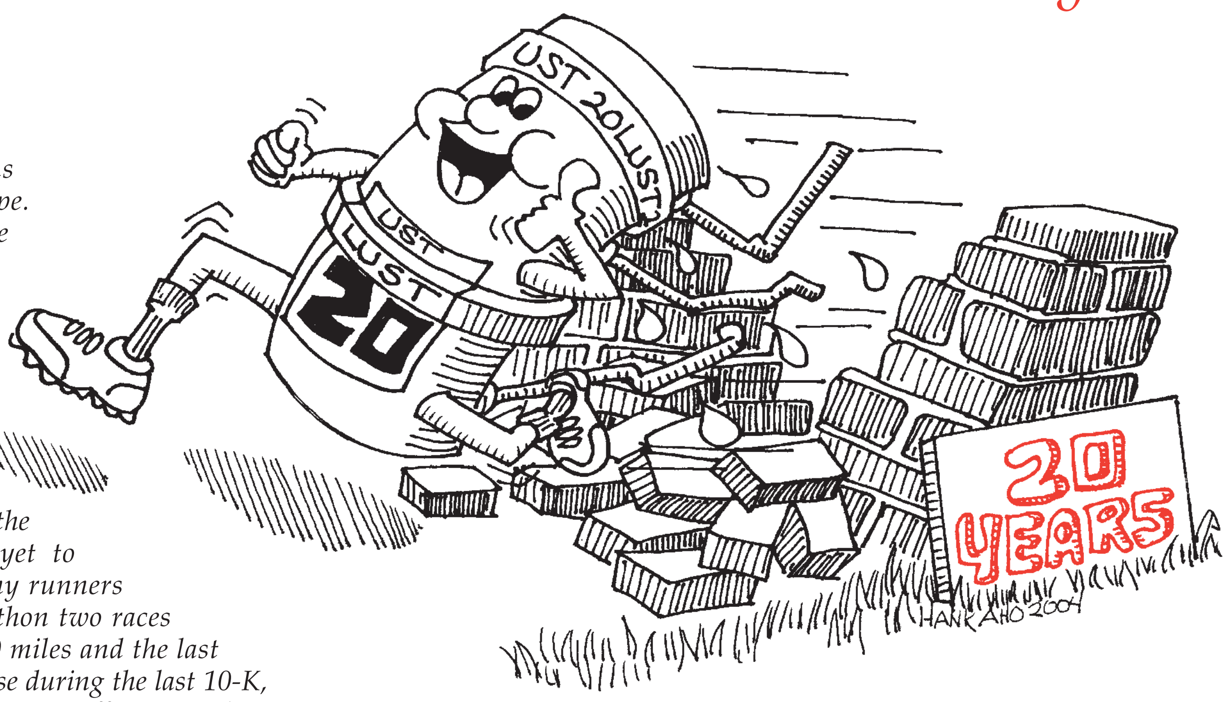
L.U.S.T.LINE

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

FINISHING STRONG

A Glance Back, A Look Forward at the UST/LUST Program

by Robert Renkes



I run marathons to stay in shape. Marathons are 26.2 miles long and, for most runners, the last 6.2 miles (or 10 kilometers for you metric fans) means you're close but also that the toughest part is yet to come. In fact, many runners consider the marathon two races in one: the first 20 miles and the last 10-K. That's because during the last 10-K, you're exerting the most effort. Your legs are complaining, your body has run out of glycogen, and your head feels like a typical day in Seattle (i.e., cloudy). Some call it "hitting the wall"; others have names for it that I can't mention here.

The underground storage tank program is kind of like a marathon, and we're now at the 20-mile mark—a lot closer to our destination than some of us ever dreamed possible back in the mid-1980s. But the next phase of this LUST-busting endeavor is going to be difficult, and I'll share my thoughts on why that is. First, however, I think it's worth taking a glance back to somewhere just before the starting line, so we can gain some perspective on where we are today and on what it will take to finish strong.

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Inside

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Do the Locomotion

We have been storing oil and petroleum products for over 140 years. The locals in Titusville, Pennsylvania, rushed tubs, washbasins and whiskey barrels into use to collect and contain crude oil from the first well in 1859. In those days oil was used principally as kerosene for lighting. But when Thomas Edison's lightbulb hit the scene in 1882 and the Duryea brothers' gasoline-powered car hit the streets of Springfield, Massachusetts, in 1893, a sea change was about to take place. Gasoline, which had been a nuisance waste product of oil refined for kerosene, was about to set the stage for the 20th century.

As the automobile industry grew, so did the number of service stations. The stations that appeared on the scene in the early 1900s had minimal storage capacity. At the turn of the century, Sylvanus Bowser sold a "self-measuring gasoline tank" that delivered coal oil from a barrel for $10. It wasn't long before Bowser pumps were used to dispense gasoline from 50-gallon containers permanently placed outside in a wooden cabinet.

As urban areas became more congested, underground tanks became a more popular choice for petroleum storage. The first underground tank was installed in 1902. It allowed service station owners to use their real estate for more productive purposes, kept the service area safe from vandalism and vehicle collision, and was more aesthetically pleasing.

> ***In some respects, we're at the point where we can either hit the wall or crash through it, and resolve and stamina will be especially crucial if we are to have a strong finish.***

If the installation and operation of underground storage tanks (USTs) were regulated at all, responsibility usually rested with local fire officials. Occasionally, communities issued local fire regulations that defined how storage tanks should be handled. The National Fire Protection Association (NFPA), a publisher of recommended codes concerning fire safety, issued NFPA 30 in 1913. The Inflammable Liquids Code, as it was known back then, was incorporated by reference into local fire codes as the basic regulation for underground tanks.

Early UST Systems

The first steel tanks were small, made of galvanized steel sheet, and riveted. Arc welding replaced the riveting process in the 1920s and 1930s. World War II created a shortage of galvanized steel and the industry turned to black carbon steel.

During the 1950s, manufacturers generally coated steel tanks with red lead primer or a thin asphaltum-based paint. Although such coatings prevented atmospheric corrosion, they were nearly useless for protection against corrosion in many underground environments.

Early entrepreneurs, such as Roger Wheeler of Tulsa, Oklahoma, introduced magnesium-anode design kits into the market in the mid-1950s. His company, Standard Magnesium, exhibited at the Petroleum Equipment Institute's (PEI's) trade show from 1952 to 1955, but stopped supplying the market when not enough tank owners bought the anodes. Even back then, tank owners weren't interested in adding costs to the operation of their storage systems.

The first fiberglass-reinforced plastic (FRP) tanks were marketed by Owens-Corning in 1965. Interestingly, it was the cost to replace lost product that flowed through the corrosion holes of bare steel tanks—not environmental protection—that drove the the development of FRP tanks.

FRP-coated tanks made their first appearance in 1968. The STI P3 design—which included a dialectic coating of the outer shell, galvanic magnesium anodes, and isolation of the tank from steel piping—was introduced in 1969. By the end of the decade the petroleum equipment industry was able to produce a variety of tanks that would not corrode in the ground.

An Industry Problem

The equipment industry knew in the 1970s that it had a problem with corroding tank systems. In a 1975 speech, Howard Upton, my predecessor at PEI, predicted that state and federal controls related to tank and piping leaks would proliferate. He also said that U.S. EPA was here to stay and that we would have to learn to work with the regulators. He was right on target.

At about the same time, the American Petroleum Institute's (API's) Operations and Engineering Committee recognized that UST leaks presented a growing industry problem and formed a task force to recommend procedures for detecting and dealing with leaks.

API studied the UST problem from 1977 to 1980 and, in a report published in February 1981, noted that its members did not have a single leak in a tank protected by sacrificial anodes and that the only failures of FRP tanks were installation errors. In other words, the new state-of-the-art tanks developed in the mid- and late 1960s worked. Still, after 15 years of commercial availability, less than 10 percent of all USTs in the ground were protected from corrosion.

L.U.S.T.Line

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Why weren't all the tanks replaced at that time? Simply stated, it wasn't required. Many tank owners are motivated by economic incentive, and the new generation of tanks cost more than bare steel. And the thought of digging up a perfectly good bare-steel tank to replace it with a new-technology tank appealed to only a few tank owners. New tanks increased costs, didn't increase sales, and there was no incentive at the time to be labeled "environmentally friendly."

Fire officials, whose main concern was the safe handling of many types of stored liquids, often had neither the awareness nor the interest in the environmental impacts of UST systems. But tank failure and product leakage did occur, sometimes resulting in serious environmental damage.

Emphasis shifted in the early 1980s from tank regulations for safety reasons to regulations for protecting the environment and public health. Pressure to deal with the impacts of leaking USTs on groundwater mounted when *60 Minutes* aired a disturbing segment on leaking underground service station tanks. Congress stepped in with the 1984 Subtitle I RCRA Amendments, directing U.S. EPA to establish programs to prevent, detect, and clean up releases from UST systems containing petroleum or hazardous substances. Federal UST regulations were promulgated in 1988.

Tanks in the 1980s

There were over two million underground storage tanks in 1984. Many of them were bare steel that were corroding and leaking fuel into the ground. At that time, over 85 percent of the USTs were made of unprotected steel. By 1988, somewhere from 10 to 48 percent of existing tanks failed a tank tightness test, depending on which study you believed. And when you consider that from 8 to 20 percent of all USTs had releases, UST regulators inherited a real mess.

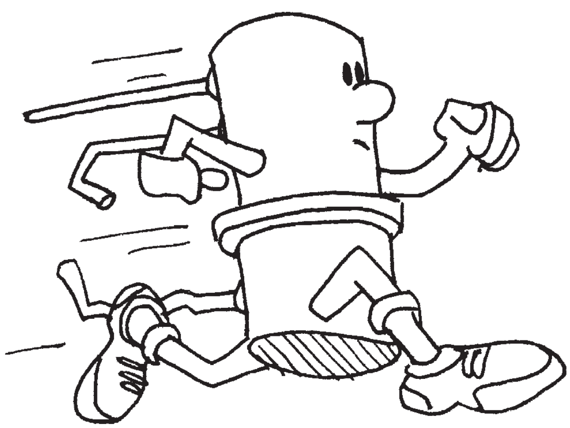
During the 1980s 73 percent of all UST systems were owned by small companies, or what we called "Mom and Pop" operators. We predicted they would be hit the hardest, and we were right. Many of them closed their refueling facilities or placed their storage aboveground. We also had a regulated community with the attitude that you buried underground tanks and forgot about them.

The 10-K Challenge

So where are we today? For starters, one and a half million USTs have been closed and almost 285,000 petroleum leaks have been cleaned up. Today, we have better equipment in place, and most of the UST systems are protected from corrosion and have leak detection and spill and overfill prevention devices. There is much to celebrate. The decisions made 20 years ago and the efforts of many people have served the country well. Our environment is better because of this work.

But, in some respects, we're at the point where we can either hit the wall or crash through it, and resolve and stamina will be especially crucial if we are to have a strong finish. Why?

First, some tank owners don't necessarily care whether we finish this race or not. Somehow, we have to have them on our side.



Second, a number of issues have come up since we started this race that were not expected when the regulations were promulgated. For example, there is widespread leakage under dispensers, spill buckets are not typically liquid-tight, sump-penetration fittings don't seem to age very well, and hydrocarbon vapor is sometimes found in the soil outside newly installed piping systems. We have to find a way to deal with these and other technical issues.

Third, we found that our pre-race strategy of getting operators into compliance worked pretty well, but we found that we didn't have a good method for keeping them there. Operational compliance is a necessity if we want to finish strong. Let's examine these points a little more closely.

The Tank Owner

Now that we've upgraded our storage systems, it's time to upgrade our tank owners. We all know the truth and must face it head-on: For most tank owners, actively managing their storage systems is very low on their priority list. Service station owners these days are more worried about turning a profit than they are about managing their tanks. Fleet owners only seem to worry about their tanks when something goes wrong and they have to don the UST manager hat that they put away years ago. And private business owners are always busy doing something else.

Many tank owners live by the watchwords that you have heard time and time again: "If it ain't broke, don't fix it" and "Out of sight, out of mind" and "If it's not in the regs, I don't have to do it" and "Wow, I didn't know I had to do that" and "I've spent a fortune upgrading these tanks and now you want me to do *what?*"

On the retail side of the industry, things are changing quickly. Major oil companies are reducing their capital investments in downstream operations so they can use their assets to make more money upstream. The oil companies are pruning underperforming stations that lose money and are selling them—often with long-term supply contracts—to anyone with some cash. And along with the stations go most of the retail engineering personnel that rode herd over the construction and operation of the tank systems.

For example, look at ConocoPhillips. It owned and operated around 2,500 retail outlets in the United States at the start of 2003. The company expects to have only 300 to 350 by the end of 2005, in addition to simply supplying product to roughly 13,000 wholesale sites around the country. That means ConocoPhillips will own and operate only around

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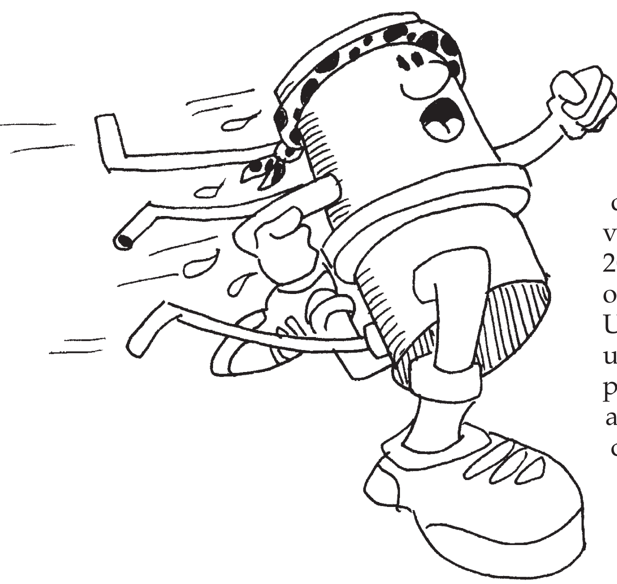
■ **Finishing Strong** *from page 3*

1,000 tanks in less than two years. That's quite a change from 20 years ago.

Mom and Pop operators—those that own just one station—now account for at least 70,000 of the 125,000 convenience stores in the United States, and that number is growing. But many of these new owners did not own the sites when they were upgraded and some care more about stocking the shelves with salty snacks than they do about the little red light that always glows on their leak detectors.

I attended a two-day meeting in February 2004 with leaders in the petroleum marketing and convenience store industries as they discussed issues of importance in 2004. Not once were the words "underground storage tanks," or "operational compliance" or "UST system upgrading" used. That's not meant to knock our customers; it's simply acknowledging the relatively low priority UST systems are assigned today.



Let me make one final comment about tank owners. For most tank owners, everything is a business decision. Because of this, they will continue to specify the lowest quality materials that meet the regulations and give work to the contractor with the lowest bid. Like it or not, that's business, and that's reality.

Change the Rules, or It Won't Happen

The second point I'd like to make about the future of the tank program is related to the first and it is this: If you have a problem with something and your rules don't require doing anything about it, change the rules and require it. Otherwise it won't get done. That goes for secondary containment, licensing of contractors, leak detection standards, equipment-testing schedules, spill-containment buckets, dispenser pans, and other similar issues.

Let me give you an example of what I mean. Under-dispenser containment is required in some states; in others it's not. There have been several studies and surveys on the subject, and although none of us are certain of how pervasive dispenser leaks are, I think most of us would agree that under-dispenser containment (UDC) is necessary to ensure that a site stays clean. In new installations, UDC costs about $1,000 per dispenser, installed—and about $2,000 per dispenser to retrofit.

Considering that the marketer has about $1 million invested in each site—or $1.5 million with a car wash—you'd think it would be a no-brainer to include under-dispenser containment. Yet a survey of our members conducted in 2003 indicated that only 64 percent of new installations would put in UDC if it were not required by regulation. The other 36 percent simply wouldn't spend the money. We also asked our members what percent of dispensers currently installed have retrofitted UDCs each year in states that do not require them by regulation. The answer was 9 percent.

I understand that adding new regulations is always a tough sell politically and that you always have to weigh the cost of additional prevention against the price you are willing to have tank owners pay for an incremental reduction in loss ratio. That's the real world, too. But if it is worth the cost, and if you can endure the screams from the regulated community, write the regulation. If you wait for the vast majority of tank owners to do it on their own, you might be waiting forever.

Oh Yeah, Operational Compliance

My third and final point concerns operational compliance. In my opinion, high operator turnover makes operator training a necessity. Tank-owner indifference requires that you make operational compliance programs a requirement. And experience and word from the field suggests that routine, mandatory inspections need to be a reality. Why? Because we all recognize that the best equipment and systems will not function as they should unless they are installed properly, programmed correctly, maintained well, and responded to quickly when an alarm is triggered or something goes wrong.

Without an ongoing operational compliance program, those problems you think were solved a long time ago will come back and hurt the programs you have developed and implemented over the last 20 years—and the ones you implement in the future. You might as well consider increasing the fines for noncompliance while you're at it, because who in their right mind would want to do anything if the cost of compliance is higher than the cost of noncompliance?

Tech-Development Incentives

I recently contacted most of the manufacturers that currently produce UST-related equipment. I was struck by how many companies are no longer in the UST business—API/Ronan, Amprodux, Armor Shield, Corespan, Joor Tank, Pollulert, In-Situ, Leak-X, and a host of others are all gone. Of those remaining, 80 percent have plans for either a new or enhanced environmental UST product on the drawing board, in testing, or at UL awaiting listing. I'm not at liberty to tell you what they are, but I can say this about the products in general:

- Ninety-five percent of them were developed as the result of regulations—not at the request of a customer. Regulators drive new technology, not tank owners.
- The products will involve less human intervention in the installation process.
- There will be more electronic options.
- Designs will be more robust.

- Materials used in manufacturing will be more durable.
- More sophisticated testing will be involved with testable elements that California and a few other states are driving.

Please understand that I'm not here to tell you that you should pass new technical regulations, inspect more sites, train the owner/operator, put more teeth into enforcement efforts, and change the way your state fund programs work. If the status quo works for you, or if your state is not allowed to be more stringent than the federal rules, it will certainly work for the tank owners. And that's okay, we still have fewer problems than we did 20 years ago.

The Finish?

But I sincerely think we can do better. Let's go back to my marathon analogy for a moment. We are in the last six miles of a 26-mile race. The first part—in our case, the first 20 years—has been relatively easy. In marathon circles, it is known that any distance runner can run the first 20. But it does get tougher the closer you get to the finish line. The last six miles are more difficult than the first 20.

Some runners can't finish, and spectators applaud their efforts nonetheless—at least they tried. Some—and I speak from personal experience—finish the race as best they can, are glad it's over, but know that they could have done better. And there are some marathoners who crash through—not hit—the 20-mile wall and receive a medal and recognition from their fellow runners as being the best in that particular race. Which do you want to be?

I'm young enough and hopefully will be around to see who finishes the last half of the UST program and how they do it. I assure you, the rest of the race, including the home-stretch and the finish, will be interesting to watch. ■

Robert Renkes is Executive Director of the Petroleum Equipment Institute in Tulsa, Oklahoma. He also writes a regular LUSTLine *column called "Field Notes." This article was adapted for LUSTLine from Bob's speech at the 16th Annual UST/LUST National Conference in New Orleans in March 2004.*

A MESSAGE FROM CLIFF ROTHENSTEIN

Director, U.S. EPA Office of Underground Storage Tanks

Celebrating 20 Years

On November 8, 1984, President Ronald Reagan signed a law that for the first time created a federal underground storage tanks (USTs) program. The Solid Waste Disposal Act of 1984 established a federal program that set consistent, minimum standards for the installation and operation and maintenance of UST systems, as well as a requirement to clean up leaking tank systems. We have certainly come a long way from those bare steel tanks that were first buried at the turn of the last century.

In the course of its 20-year history, EPA's Office of Underground Storage Tanks (OUST), with the help of states, tribes, and industry, has dramatically reduced the number of leaking buried tanks throughout the United States, improved compliance, and cleaned up hundreds of thousands of petroleum releases.

Formed in 1985, OUST began working with the states, tribes, and industry to effectively and efficiently bring all UST systems into compliance with new federal leak-prevention and leak-detection standards. The challenges were great and there was intense pressure as the 1998 deadline approached, and many small owners and operators were for the first time faced with having to comply with the regulation of their UST systems. But we worked in partnership with states, tribes, and the private sector to make sure that all UST systems in use today meet federal environmental protection standards.

Together with state and local UST programs, EPA and states closed over 1.5 million substandard tanks that were corroding and leaking petroleum into the nation's groundwaters. Today the upgraded UST systems, when properly monitored and maintained, are much less likely to leak and cause significant environmental problems. In fact, the number of new leaks discovered each year has dropped dramatically, from a high of over 66,000 in 1990 to roughly 12,000 last year.

As old tanks were pulled out of the ground and new leak-prevention technology was installed, more than 400,000 petroleum releases were discovered. The good news is that through our diligent efforts more than 70 percent of these releases have been cleaned up—a huge accomplishment we can all celebrate.

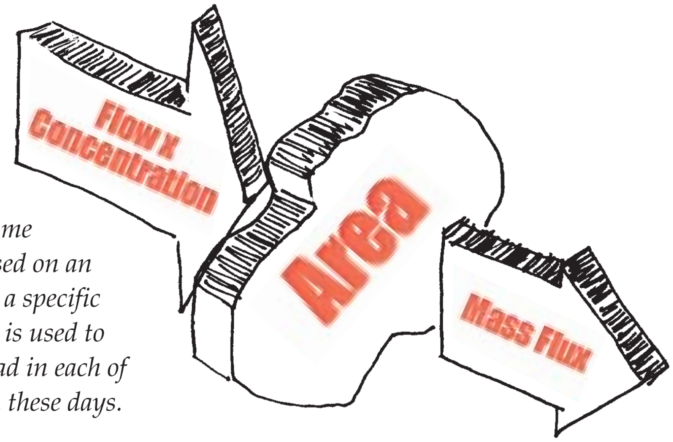
While we are proud of these accomplishments, we cannot lose sight of the enormous challenges that still lie ahead. There are more than 136,000 cleanups that still need to be completed and 200,000 or more petroleum brownfield sites that await cleanup and reuse. We also must strive to more effectively combat petroleum releases from UST systems. Despite the fact that UST owners have spent a significant amount of money upgrading their UST systems, some are not maintaining or operating their systems properly. Finding new ways to reach these owners/operators to educate them about their responsibility in overseeing and maintaining these systems will be an ongoing challenge in the coming years.

This year marks not only the 20th anniversary of OUST, but also 20 years of innovative and effective underground storage tank initiatives. More important, through 20 years of strong partnerships we have developed and implemented programs that have resulted in greater protection of the nation's drinking water and of human and environmental health. As we begin our third decade, we will continue to act based on the principles of cooperation and continuous improvement so that future challenges are met with the same innovative spirit exemplified throughout the tank program's history. ■

Flux Redux

Using Mass Flux to Improve Cleanup Decisions

by Eric Nichols and Tracy Roth



A consultant for a tank operator with an MtBE groundwater plume proposes to implement a particular remediation technology based on an evaluation of mass flux. At another site, a consultant proposes a specific level of flux reduction as a remedial goal. At yet another site, mass flux is used to evaluate the significance of natural attenuation. Detect a common thread in each of these decisions? Contaminant mass flux is getting increasing attention these days. So what is mass flux, how is it evaluated, and what can it tell us?

re•dux [ree dúks], *adj.*: revived; brought back, especially in being restored to former importance or prominence

What Is Mass Flux?

Contaminant mass flux is the rate at which a chemical passes through a defined cross-sectional area. As used here, mass flux is the product of the *rate of groundwater discharge* and the *concentration* of the contaminant. This definition is actually the rate of *dissolved-mass discharge,* but the terms *mass flux* and *total mass flux* are often used to describe dissolved-mass discharge, and this convention is used here. Similar definitions could also be applied to fluxes of soil gas or mobile LNAPL.

Flux combines two important quantities: the *concentration* of the chemical and the *rate* at which the chemical is migrating within the plume. Combined in this way, flux tells us much more than concentration or flow alone. For example, flux tells us the rate at which dissolved mass is leaving (and therefore depleting) the source zone. This can provide insights into the nature, strength, and longevity of the source zone, and can be used to distinguish between small and large releases.

Flux can also tell us the rate at which chemical mass is migrating towards a receptor, if no further attenuation occurs. This can provide a measure of the threat posed by the plume to a downgradient water supply well. It can be used to determine how much treatment (i.e., flux reduction) is needed to reduce that threat. It can also provide a measure of mass loading to an in-situ or ex-situ treatment remedy. If the magnitude of the flux varies at different locations within a plume, this may be an indicator of natural attenuation, or it may be evidence of variations in historical source conditions, or both.

Once chemical mass leaves the source zone, the total flux within the plume should remain constant as the plume migrates downgradient, unless mass is removed by natural attenuation processes. This concept of *flux continuity* can be very useful when developing or testing conceptual models of a site. It's similar to the concept of continuity of flow within a pipe: the pipe (plume) may get wider or narrower, and the water may move faster or slower, but the fluid discharge (mass flux) within the pipe (plume) should remain the same, if everything is at a steady state. Changes in total mass flux over time or space may represent unsteady source conditions, natural attenuation, the effects of remediation, or errors in measurement and interpretation.

How Is Mass Flux Evaluated?

Several methods can be been used to estimate contaminant mass flux. These include:

- Using transects of monitoring wells across a plume
- Capturing a plume by supply wells or remedial extraction wells
- Using in-situ, down-hole flux meters
- Using solute transport modeling, in combination with field data collection and interpretation

Each method is described in more detail in the following paragraphs.

■ Transects of Monitoring Wells

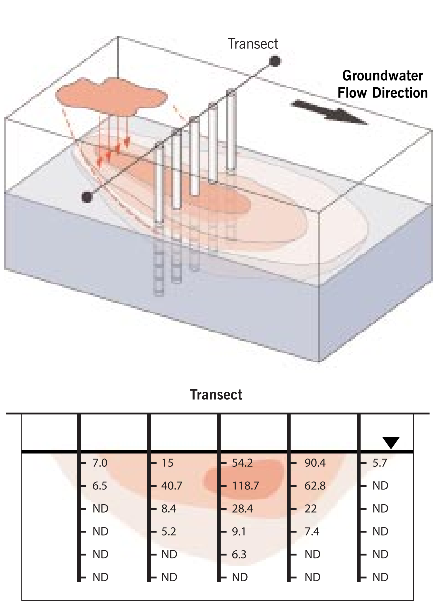
This method relies on groundwater samples from single- or multi-level monitoring well data interpolated along a transect across the plume, perpendicular to groundwater flow. A vertical cross-section across the transect is divided into any number of sub-areas, each representing a discrete area of uniform concentration and groundwater flow (discharge). The total mass flux is simply the sum of the fluxes from each of these sub areas, as illustrated in Figure 1.

Figure 1 shows an example of a transect and vertical cross-section for a site with a multi-level well network. A similar but lower-resolution approach can be applied using single-level monitoring wells. The multi-level data allow for a more refined, detailed concentration and/or flow profile. Although the figure shows the monitoring wells to be evenly spaced, this is not necessary.

Depending on the degree of complexity in the hydrogeologic system, and the available information, the groundwater discharge can be estimated for each discrete sub-area, or averaged over the entire transect. Discharge is calculated using Darcy's Law (the product of hydraulic conductivity, hydraulic gradient, and area).

The accuracy of mass flux estimates across a given plume transect is sensitive to the sampling-point density. Typically, monitoring net-

FIGURE 1. *Multi-level monitor well (3-D) transect mass flux.*



7.0	15	54.2	90.4	5.7
6.5	40.7	118.7	62.8	0
0	8.4	28.4	22	0
0	5.2	9.1	7.4	0
0	0	6.3	0	0
0	0	0	0	0

$$M_f = \sum_{i=1}^{n} C_i \times A_i \times q_i$$

works at most sites are designed for plume delineation and quantifying chemical concentrations along an apparent plume axis. Consequently, detailed sampling points across a plume transect are often not available. In such cases, it may be more cost-effective to install temporary high-resolution monitoring points for groundwater sampling and hydraulic testing (e.g., aquifer pumping tests, slug tests) using direct-push techniques.

Although the transect method allows for an improved understanding of the concentration distribution across a plume and is easy to calculate, the underlying assumptions (e.g., that the monitoring well transect adequately describes the plume) and data required may impart an unknown degree of uncertainty in the resulting mass-flux estimate. Reducing uncertainty with this method may require that many samples be taken in space and over time, with potentially higher analytical costs.

■ **Capture of a Plume by Extraction Wells** If an extraction well (or series of extraction wells) fully captures a contaminant plume, contaminant mass flux can be calculated. Figure 2 illustrates the concept. The rate of contaminant mass extracted can be a reliable estimate of the mass flux within a plume.

This approach assumes the well fully captures the horizontal and vertical extent of the contaminant plume. In addition, the extraction well must be located far enough downgradient from the source area such that it would not significantly affect groundwater flow conditions within the source zone, which could affect contaminant mass flux. Unsteady pumping rates or unsteady concentrations may also affect the reliability of mass-flux estimates .

One advantage of this method is that extraction wells often yield relatively large volumes of groundwater, which tends to integrate flow and concentration data. This inherently reduces the degree of uncertainty associated with hydrogeologic complexities.

This method also has relatively few data requirements, provided that data exist to verify hydraulic capture. Performance data from remedial extraction wells can also be used. Disadvantages include the need to dispose of large volumes of extracted water and address altered contaminant distributions that may result from the extraction of groundwater. The latter may affect ongoing natural attenuation processes and confuse later attempts to monitor mass flux further along the flow path (if the altered plume portion is intercepted by the monitoring network further downgradient).

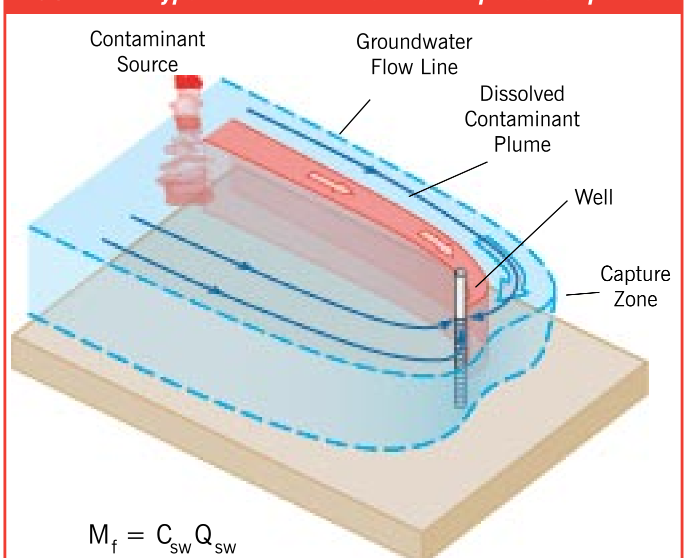
■ **In-Situ Flux Meter Method** Hatfield et al. (2001) have developed an in-situ method that uses a sorptive, permeable medium ("flux meter") that is placed in a monitoring well for a given period of time to intercept contaminants in groundwater flowing through the well. The flux meter also releases tracers. By quantifying the amount of tracer lost and the mass of the contaminant sorbed, the groundwater velocity and time-averaged contaminant mass flux can be calculated for a portion of the plume. Although less extensively used than the previous methods, this method shows great promise as a viable tool for estimating local or small-scale mass flux.

One advantage to this method is that there are limited data requirements other than the analytical costs associated with evaluating the chemical and tracer concentrations in the flux meters. Another advantage of this method is that it allows for an integrated mass discharge over time, which overcomes some problems associated with temporal variability in contaminant distribution and therefore temporal mass-flux estimates.

However, since the method uses point measurements averaged over a small volume of the aquifer, flow paths that are not intersected by the flux meter are not included in the flux estimate. Also, since the method relies on passive flow of groundwater through the well and flux meter, the method may be sensitive to partial or complete clogging of the well or medium. Additionally, the method assumes water flows horizontally through the well, which may not be a valid assumption in flow regimes where even mild vertical gradients exist.

■ *continued on page 8*

FIGURE 2. *Hypothetical extraction well capture of a plume.*



■ **Flux Redux** *from page 7*

■ **Solute Transport Modeling** Several analytical and numerical solute-transport models are available to quantify chemical mass flux. BIOSCREEN (Newell et al., 1997) and BIOCHLOR (Aziz et al., 2000) are two widely used 2-D spreadsheet analytical models that can be used to evaluate the natural attenuation of plumes. Numerical models (e.g., MODFLOW/MT3D) can also be used in situations where sufficient data are available to develop and calibrate the model.

A variation on the preceding methods is the Integral Groundwater Investigation Method, which has been proposed by Teutsch (2000) and Bockelmann et al. (2000). This method combines the use of extraction wells and modeling to estimate mass flux.

Several input parameters are required to evaluate groundwater flow and contaminant transport with both numerical and analytical models. Groundwater flow velocities, contaminant-source release rates, and fate and transport parameters such as dispersion, retardation, and bio degradation rates are input by the user. Numerical models can accommodate spatial variations in parameter values to represent more complex hydrogeologic conditions. The disadvantage of such methods is that the accuracy of the estimates is completely dependent on the quality and reliability of the available data.

Can All These Estimates Tell Us Anything?

Interpolations of concentration… estimates of discharge … estimates of flux. Mass flux has the potential to assist in several areas, including development of a site conceptual model, evaluation of natural attenuation, evaluation of potential receptor impacts, and remedial design and system performance evaluation. But with all this *estimating* going on, how useful and reliable are mass-flux estimates?

In October 2002, the American Petroleum Institute Soil and Groundwater Technical Task Force conducted a one-day workshop to discuss the mass-flux estimate issue. The workshop included presentations by a panel of experts with direct experience in the use of mass-flux estimation techniques. Presentations included evaluations of field techniques used in mass-flux evaluation, the application of mass-flux estimates, quantification of uncertainty, the development of risk-based management tools using mass-flux techniques, and identification of future data-collection needs. Some of the key points from that workshop include the following:

- The use of mass flux is not really new. It is often based on the same data that have been used in site characterization and remedial decision making for many years, including chemical concentrations, water levels, and hydraulic conductivity. What may be new is the *combination* of all this information, along with an increasing recognition of potential benefits and increased research activity into various estimation techniques and applications. The existence of long MtBE plumes may be partially responsible for increased interest in mass flux.
- Mass-flux estimates have uncertainties, but the degree of uncertainty is one to which environmental professionals have become accustomed, since it is based on virtually the same data that have traditionally been used to make decisions at LUST sites.
- Mass-flux estimates, especially those based on monitoring well transects, may underestimate or overestimate flux. The amount of under- or overestimation depends on the location of the well screens relative to the plume (especially relative to the plume “core,” which often represents the bulk of the plume mass) and on the degree of flow-field heterogeneity of the groundwater system. The degree of under- or overestimation probably decreases as the number of monitoring points along the transect increases. There is no general consensus on data requirements within a given mass-flux method or application.
- Although potentially useful for a range of decisions, mass flux is not something that is necessary at every LUST site to make every site-management decision. It’s one more tool in the tool kit to help promote better-informed decisions.
- Mass-flux estimates don’t necessarily require highly detailed site data or computer modeling. Flux estimates can be the first (or only) step toward a more detailed model. Some estimation techniques use simple calculations based on monitoring-well networks and data typical of many LUST sites.
- Because mass-flux analyses link groundwater flow and dissolved chemical concentration data, they provide the opportunity for a more rigorous and internally consistent interpretation of subsurface conditions.
- Mass-flux estimates can provide useful information to decision makers, even though the accuracy of specific methods is still being evaluated. Mass-flux estimation methods continue to evolve.
- Guidance is needed for the determination of cost-effective investigation techniques to evaluate mass flux appropriately and would help to broaden and improve the use of mass-flux techniques. Ideally, a guidance document would discuss how to determine monitoring-well network configuration and spacing, the use of single- versus multi-level monitoring points, delineation of sources, and how to incorporate mass-flux evaluations in site decisions.
- A compilation of site data and mass-flux estimates for decision makers to use for comparative purposes is needed. This could help prevent potentially inappropriate uses of mass-flux techniques and results. Preliminary research suggests low-strength MtBE plumes may have total mass fluxes less than a few grams per day. Such small-magnitude fluxes may emanate from source zones resulting from small liquid releases, vapor-only impacts, or larger but nearly depleted sources. Higher-strength MtBE plumes may have total mass fluxes in the hundreds of grams per day for particularly fast-moving plumes

from high-strength sources. These higher-flux plumes may pose the greatest threat to potential receptors of groundwater.

So is mass flux the key to making better site decisions? It is not the only tool, nor always the best tool, but it can certainly help. As with any quantitative tool or model, mass-flux estimates should not be used as the sole basis for making site decisions; rather they should be considered along with other lines of evidence, including additional data, analysis, and interpretations, where each line of evidence fits within the framework of the site conceptual model. ■

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New Study Shows MtBE Is Absorbed Through the Skin

A new study from U.S. EPA and the Centers for Disease Control shows that contaminated drinking water can lead to exposure by oral, inhalation, and dermal routes. The study was conducted using 14 adult volunteers, who received low doses of MtBE by the three exposure routes. Blood and exhale samples were then obtained. For the first time, researchers found that MtBE could be absorbed through the skin, as well as by the other two exposure routes.

One metabolite, *tertiary* butyl ether (TBA), increased slowly in blood and plateaued but did not return to the preexposure baseline at the 24-hour follow-up. Oral exposure resulted in a significantly greater MtBE metabolism into TBA than by other routes, implying "significant first-pass metabolism." The slower TBA elimination may make it a biomarker of MtBE exposure, but because it is found in other consumer products and can also be used as a fuel additive, it is not a definitive marker.

The study, "Dermal, Oral, and Inhalation Pharmacokinetics of Methyl Tertiary Butyl Ether (MtBE) in Human Volunteers," published in the February 2004 issue of *Toxicological Sciences*, can be found online at *http://toxsci.oupjournals.org/ cgi/content/abstract/77/2/195*. ■

Administration Proposes Increased UST Budget

Funding to states for inspecting USTs would more than triple under the FY 2005 U.S. EPA budget the Bush administration proposed earlier this month. The president's budget request includes $37.9 million for UST grants, an increase of $26 million over FY 2004. EPA said the 217 percent increase over the 2004 appropriation level would strengthen EPA's partnership with the states to allow more federally regulated UST system inspections on a more frequent basis. ■

Tracking Institutional Controls

Connecting Exposure-Management Decisions with Land-Use Decisions

by Matthew Small, Mike Martinson, and Jane Bohn

What are institutional controls? Simply stated, they are procedures, restrictions, covenants, or engineered systems intended to limit human activity. In some cases, institutional controls are used to help prevent contamination or resource damage by designating wellhead protection areas, sole-source aquifers, wetlands, and parks. However, most people think of institutional controls as a means to reduce the potential for exposure to chemical contamination in soil or groundwater at a single site. Many states maintain a database of institutional controls used for contaminated sites, including off-site deed restrictions, highway agreements, engineered barriers, and commercial use restrictions. In this article we will discuss the use and tracking of institutional controls to manage exposure to contamination at leaking underground storage tank (LUST) sites. (See LUSTLine *# 28, "Institutional Controls: A Means to an End at LUST Sites," February 1998, for a more complete discussion of the types of available institutional controls.)*

Why Do We Use Institutional Controls?

Current risk-based approaches to exposure management at LUST sites are focused on cleaning up sources of contamination and controlling the exposure pathways that might allow contaminants to migrate from the source to human or environmental receptors. However, cleanup to concentrations that allow unrestricted future land use may take many years or be prohibitively expensive.

In some cases, institutional controls are used to allow active cleanup efforts to be halted when all current exposure pathways have been controlled or eliminated, even though contaminant concentrations still exceed cleanup goals. Though natural attenuation will continue to reduce concentrations in the long term, the presence of residual contamination at these sites makes them unsuitable for certain uses in the shorter term. Institutional controls are imposed to restrict or prevent activities that could allow receptors to be exposed to the remaining residual contamination.

What Are the Benefits of Institutional Controls?

Institutional controls can allow a contaminated site to be returned to productive use more quickly. Active remediation can be discontinued while site-monitoring activities continue and some control over exposure prevention is maintained. Institutional controls can help increase the comfort level for regulators and the public when allowing natural attenuation remedies. Institutional controls can also help to reduce liability for responsible parties when selling or reusing a contaminated property.

Can Institutional Controls Really Prevent Exposure?

Institutional controls can warn people about the presence of residual contamination. However, for institutional controls to be protective, they must be communicated, obeyed, and maintained over time with consideration for changing site conditions. This is where institutional controls have the biggest potential to fail. Institutional controls are not suitable for every site, as land-use changes can sometimes be hard to control. For example, in some parts of the country prior approval for land-use changes in the form of building and well-drilling permits is not required.

How Can We Ensure that Institutional Controls Are as Protective as Possible?

It is not enough to simply impose institutional controls. We must have mechanisms in place for tracking sites where institutional controls have been imposed, monitoring compliance with controls, and periodically re-evaluating or updating control requirements. Even with our best efforts, we will probably never be able to track all sites with institutional controls. Also, we may end up tracking a large number of sites to prevent a small number of exposures.

Given that we are going to use institutional controls to manage exposure to residual contamination at LUST sites, we must work to ensure that restrictions and exposure-management decisions made by regulatory agencies are tracked and incorporated into the land-use decision-making process at the local level. This will require procedural changes and possibly new regulations. Many states have already been working on ways to track institutional controls and connect exposure-management decisions to land-use decisions. But there is still room for improvement.

Most States Have the Tools to Impose Institutional Controls

State regulatory agencies are usually responsible for making exposure-management decisions at LUST sites. Two surveys of state LUST programs (Martinson and Small, 1998, 10th Annual UST/LUST National Conference, and New England Interstate Water Pollution Control Commission (NEIWPCC), 2003) examined options available to states for long-term management of petroleum contamination. The results of these surveys indicate that approximately 60 percent of states in 1998 and 70 percent in 2003 have requirements or mechanisms available to impose some form of use restrictions at LUST sites as a component of site cleanup and exposure management. The NEIWPCC survey also found that:

- Twenty-five states utilize institutional controls.
- Eleven states employ regional/local institutional controls (e.g., zones with restricted groundwater use or groundwater use classifications).
- Twenty-five states maintain site-tracking databases of former LUST sites.
- Thirty-five states have requirements or available mechanisms for long-term exposure management for residual contamination. These typically include institutional controls, engineering controls, or exposure-management plans.
- Nine states maintain site-tracking databases that include listings of deed restrictions, groundwater management zones, exposure prevention plans, engineering controls/barriers, notifications to utility companies (primarily excavation activities) and permitting agencies (e.g., water supply well and building permits), periodic reevaluations of site conditions (up to five years), or registry of releases listing all properties above regulatory action levels.

These surveys suggest that states have generally improved long-term management practices over the last five years. In fact, many states have well-developed tools for listing and/or tracking institutional controls. But have these improvements fundamentally decreased the risk of someone unknowingly encountering or being exposed to residual contamination? Is it enough to have the tools? Are these tools being used appropriately? Are they accessible to the people who need to know about institutional controls?

Communication Is the Key, But It Ain't Free

Good-quality, easily accessible, reliable information on institutional-control requirements and site status is essential. We need to establish the infrastructure and procedures that allow local land-use agencies and the public to easily access information on institutional controls imposed by regulatory agencies. (Figure 1 on page 12 provides a conceptual flowchart of how this communication might be accomplished.) Partnerships and coordination between all stakeholders will be essential to the success of any procedures set in place. Failures in communication can create numerous problems and potential exposure hazards.

State and local agencies must find a way to finance the administrative burden associated with both tracking and accessing information on institutional controls. This work can be funded through additional permit fees incorporated into Phase I property assessment requirements, or paid by developers. For example, the Washington State Department of Ecology requires financial assurances (e.g., a trust fund, surety bond, or letter of credit) at sites where institutional controls are applied.

Additional costs may also be associated with regulatory agency review of projects that present an exposure potential. With many state and local budgets in the red, agencies may be hesitant to undertake the task of tracking and reviewing institutional controls in the absence of regulatory changes, a legislative requirement, and new funding.

Developing Systems for Tracking Institutional Controls

A number of pilot projects and other initiatives have been undertaken to evaluate ways to improve communication of institutional-control data to stakeholders. Consider the following examples:

- To address the issues of data reliability, some states (e.g., MA and NJ) have implemented audit systems, which provide requirements that institutional controls be inspected on a regular basis to ensure they effectively remain in place. Recognizing the large number of individual databases out there, the International City/County Management Association (ICMA) is seeking to provide a way to link federal, state, and local government IC Web sites.
- EPA is working with state programs to evaluate the use of two-dimensional bar codes as on-site information placards.
- California and other states have used GIS data (GeoTracker) to evaluate LUST-site proximity to drinking-water wells when setting cleanup or exposure management requirements.
- EPA Headquarters, Region 3, and Region 5, along with Wisconsin and Pennsylvania, are working together to evaluate the use of one-call systems, already used to locate underground piping and electric lines prior to excavation, to notify stakeholders of potential land-use restriction issues.
- Rochester, New York, employs a computer-based flagging mechanism and GIS system that links institutional controls to the permit application process managed by the city's building and zoning department. So far the city has only applied this system to parcels currently or formerly owned by the city.

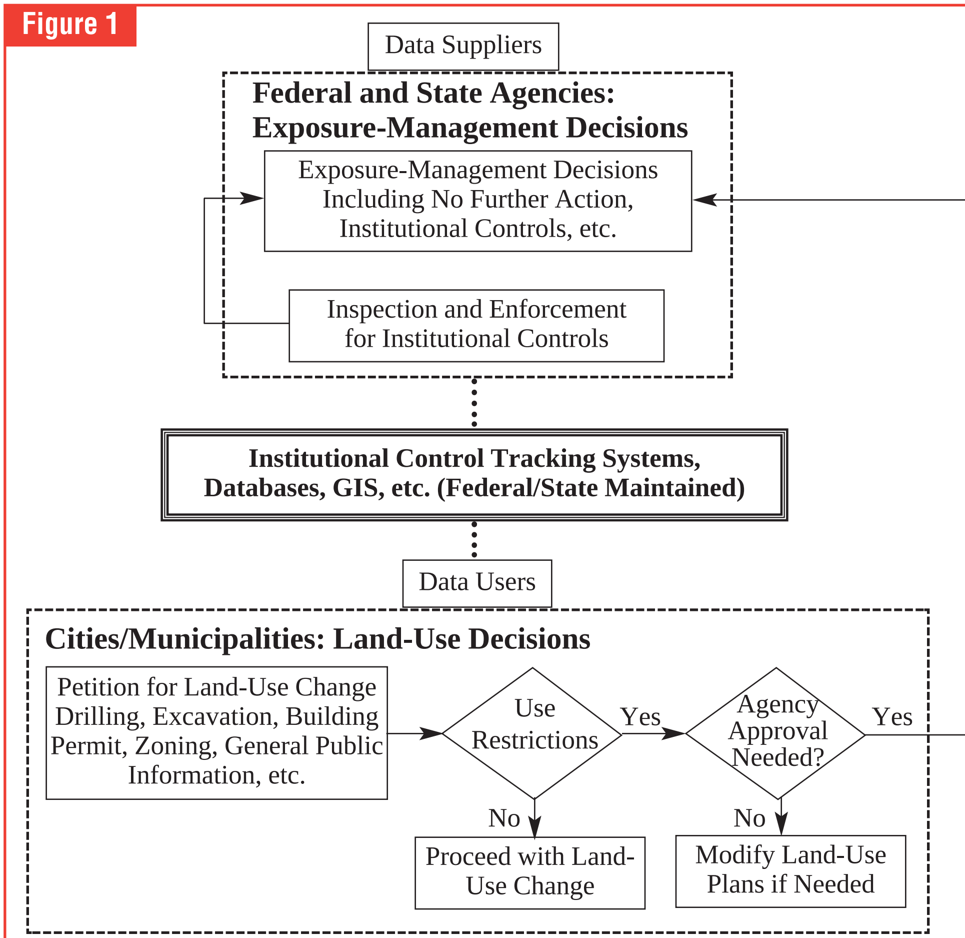
■ *continued on page 12*

■ **Tracking Controls** *from page 11*

- Emeryville, California, used EPA grants to develop a GIS Web application (OSIRIS) to communicate information on soil and groundwater contamination, environmental status, land use, and zoning at more than 500 city properties to interested parties. This system has facilitated city planning and brownfields redevelopment.
- Oakland, California, working with the State of California and EPA Region 9, has implemented a similar system to Emeryville's, using a flag within the building-permits database to identify sites with environmental encumbrances. Projects that involve excavation or other activities that may cause receptor exposure must be reviewed by the agency that issued the NFA letter.
- EPA's Office of Solid Waste and Emergency Response is currently developing an institutional-controls tracking system for all sites where EPA has responsibility for overseeing cleanup. In the UST program, that includes all sites located in Indian Country.

These examples illustrate the wide range of solutions that are being formulated to track and maintain institutional controls. However, most of these approaches have limitations or may not track all aspects of land-use restrictions. As a result, states may need to implement some combination of approaches to fully address the issues associated with institutional controls.

Figure 1



Room for Improvement

Even in states with well-developed tracking systems for institutional controls, there is room for improvement—room to ensure that effective tools are in place for communicating land-use restrictions and engineering controls to the decision makers. The following examples illustrate potential problems.

■ **Stakeholders, such as local governments, permitting offices, and real estate/title companies, may not even be aware that institutional-controls databases exist.** They also may not be adequately equipped with the necessary tools to access and track information. As discussed earlier, most states have the tools to impose institutional controls of one type or another. In addition, property transfer information disclosure requirements and Phase I Environmental Assessment requirements exist in most states. In theory, use restrictions should be uncovered by Phase I Environmental Assessment investigations or title searches. However, discussions with oil company representatives and local agencies indicate that Phase I investigations do not always uncover institutional controls. Also, not all property changes hands prior to redevelopment or land-use changes.

In fact, there are instances where institutional controls have failed or been ignored during the land-use decision-making process. One of the more notable failures occurred at a site where an UST was scheduled to be installed in an area where there was an existing slurry-containment wall around a former Superfund facility. The owner proposed installing the UST system within the slurry wall for additional release protection. This proposal was accepted. However, upon inspection, the regulatory agency observed two other excavation projects that were threatening the integrity of the slurry wall and had not been reported to the agency.

■ **Even if stakeholders are aware of the database, jurisdictions may have no provisions that require stakeholders to access or abide by the information contained in the databases.** Many states maintain a database of institutional controls for contaminated sites; however, this database approach alone does not always provide adequate protection.

For example, in one state, although the database is publicly available, there are no requirements for municipalities or other stakeholders to query the database prior to making land-use decisions. In addition, this database does not provide any details on the restrictions, such as the location of an engineered barrier or limited monitoring required of the responsible party. Although property-owner approval and/or notification are required for imposing restrictions, there is no system to track ownership changes.

In another example, a state maintains a Web-based database system that does not require title recording. The well-drilling community is supposed to access the system prior to drilling to determine if a water-use restriction exists, but this step does not always happen. Property owners are notified, but the system does not track ownership changes.

■ **The information provided in current databases is not necessarily complete or user friendly for the untrained stakeholder attempting to locate information about institutional controls.** For example, one state maintains a GIS-based database of institutional controls. The state also requires proof that a land-use restriction was recorded and/or implemented and has biannual certification monitoring requirements. Property-owner approval is required for implementing restrictions, and there are notification requirements for local governments. The state modifies restriction information, including the description, duration, and conditions, but does not consistently track the changes in the restriction.

Even though some states have implemented permit-tracking systems, these systems may address only a portion of the exposure-management issues. One main issue is that permit-tracking systems are focused on a single site and may ignore potential receptor exposure at sites adjacent to contaminated sites. In addition, not all areas of the country require building permits or approvals. In at least some cases, information on use restrictions is not getting to the people who need it.

■ **The data must be well maintained, up-to-date, complete, and accurate.** Procedures must be in place for ongoing reporting, inspection, maintenance, and enforcement of restrictions to ensure that the information is current. It is extremely important for the data to be reliable. If the data are unreliable, people will probably ignore the tracking system. Consistency in presenting the data (including key elements) is vital to ensuring that sufficient information is available. The American Society of Testing and Materials (ASTM) International is currently working on developing guidance on the minimal elements that should be included in a database or tracking system. EPA and individual states are also working to develop consistent data structures for tracking institutional controls.

Is Legislation Needed for Tracking Institutional Controls?

As mentioned previously, we need up-to-date, easily accessible, reliable data on engineering and institutional-control requirements and site status. We also need to make sure that the data are being accessed and considered by the people who are making land-use and exposure-management decisions. In some cases, states may want to consider using regulatory or legislative means to ensure stakeholders are required to check institutional-control databases prior to issuing permits or making land use decisions.

Some potential benefits of legislation include:

- Improved communication between the agencies that oversee cleanup of contaminated sites and the agencies that oversee permitting of activities that can cause exposure to residual contamination
- Improved environmental protection at sites with residual contamination
- Encouragement of land revitalization
- Improved local support for environmental stewardship
- Increased comfort level for regulators and the public when institutional controls are employed

Some potential challenges of legislation include:

- Legal issues associated with classifying sites or areas for Long Term Exposure Management (the stigma of being on a list of sites)
- Increased burden for permitting agencies
- Increased requirements and costs for agencies and RPs
- Potential for tracking many sites to prevent just a few problems
- May facilitate leaving more contamination in place

A state mandate for tracking land-use restrictions is not a one-size-fits-all solution, and many states are pursuing other options, as mentioned above.

Making the Connection

Institutional controls can help prevent exposure to residual contamination. A variety of approaches are in use and in development across the country. The ultimate goal is to connect land-use restrictions with land-use decisions to manage and prevent exposure to residual contamination over the long term. However, we are still in the initial phases of developing the infrastructure and procedures to fully track and implement institutional controls.

Tracking the large number of institutional controls that have been put in place since risk-based cleanups have been implemented will continue to remain a challenge, and we may end up tracking a large number of sites in an effort to prevent a small number of problems. However, this may be the price we pay for allowing use restrictions to be a part of our risk-management and exposure-management tool box. ■

For More Information

- U.S. EPA main institutional controls site

  http://www.epa.gov/superfund/action/ic/guide/index.htm

  http://www.epa.gov/superfund/action/ic/index.htm

  http://www.epa.gov/superfund/action/ic/survey/index.htm

- U.S. EPA Office of Underground Storage Tanks Web Site

  http://www.epa.gov/OUST/rbdm/instctrl.htm

  http://www.epa.gov/oust/20recycl.htm

- NEIWPCC 2003 Survey Results

  http://www.neiwpcc.org/2003mtbesum.pdf

  http://www.neiwpcc.org/2003mtbecom.pdf

  See Section VIII. Long-Term Management of LUST Sites.

■ *continued on page 14*

■ **Tracking Controls** *from page 13*

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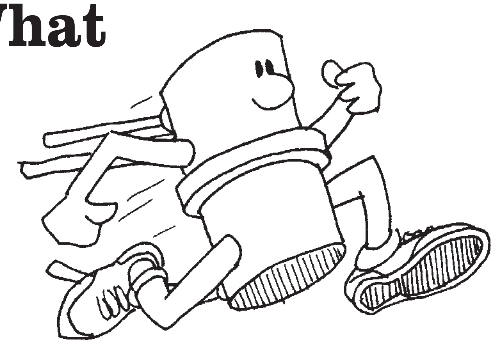
Enhanced Leak Detection in California—What We've Learned

by Randy Golding



Being involved in Enhanced Leak Detection (ELD) since 1998, I have learned some interesting things about underground storage tank systems and about leak detection in general. In fact, during the last few months of testing newly constructed UST systems in California, the lessons have come fast and have been a bit surprising.

Perhaps the most important lesson for everyone has been that petroleum storage systems can be built tight, but not without a great deal of scrutiny and effort. With more care by installers, inspectors, testers, and owners and operators, these systems can be constructed with virtually no allowance for a "significant" release of product, liquid, or vapor. This can be accomplished using a variety of currently available materials. It is the installation practices that make the biggest difference.

Traditional leak detection and inspection methods can find most of the big leaks before a system is put to use, but smaller leaks still remain. Most of these leaks are below the detection limit of traditional leak-detection methods. However, just because these leaks are small doesn't mean they don't matter. But by carefully using more sensitive testing methods during construction, UST systems can be built to a higher standard of tightness.

The cost associated with conducting very sensitive testing (e.g., ELD) of a new facility can be small compared to the long-term costs and liabilities associated with leaks, even small leaks. Soil and groundwater contamination, site remediation, and associated liabilities can quickly add up to hundreds of thousands or millions of dollars. By using state-of-the-art testing technology, a station owner can be assured of a tight facility at the time of construction. Also, at any future time, the UST owner can reliably confirm that the system remains tight.

Why Small Leaks Matter

In the 1990s, methyl, *tert*-butyl ether (MtBE) became widely used in California after the state set standards for cleaner-burning gasoline. When agencies responsible for clean water programs began looking for MtBE in soil and groundwater samples from leaking underground storage tank (LUST) sites, they started finding it with disconcerting frequency. Efforts to identify the source did not always produce a satisfactory result. The "smoking gun" remained elusive often enough that investigators grew increasingly frustrated.

A random search for MtBE at a few service stations in the Santa Clara area, where no leaks were known to be occurring, detected MtBE at 50 percent of the facilities *(Summary Report: Santa Clara Valley Water District Groundwater Vulnerability Pilot Study*, 1999). An effort was made to correlate features of the UST facilities (e.g., double-walled vs. single-walled construction) with the probability of finding MtBE. The only feature that yielded a significant correlation was the presence of a vacuum-assisted stage II vapor-recovery system, a type of vapor recovery that tends to pressurize the ullage of an UST.

These systems use a pump to return fuel vapors from the vehicle to the tank as the fuel is pumped into the vehicle. Commonly, the vapor-recovery system pumps a little more than a gallon of air and fuel vapors back to the UST for every gallon of gasoline that is dispensed. This often causes a slight pressure at the top of the tank. It appears likely that the prevalence of MtBE in the environment around USTs may be due, in part, to small vapor releases that have not previously been on the regulatory radar screen.

New Regulations

In 1999, the California legislature required some form of "enhanced leak detection" for high-risk UST facilities, including single-walled systems near public drinking-water wells. The statute required the State Water Resources Control Board (SWRCB) to define ELD and to conduct "field-based research" to determine whether current construction and testing standards were adequate to protect groundwater.

What Is ELD?

The California Code of Regulations (Title 23, Chapter 16, Article 4, Section 2544.1(a)) defines enhanced leak detection as a "test method that determines the integrity of a UST system by the introduction and external detection of a substance that is not a component of the fuel formulation stored in that UST system." The method needs to be certified by a third party as able to detect a 0.005 gallon per hour leak with a probability of detection of at least 0.95 and a probability of false alarm no greater than 0.05. Detection of both liquid and/or vapor leaks is required.

Currently, the only method available that is third-party certified to meet this requirement is the Tracer Tight method developed by Tracer Research Corporation, which is now part of Praxair Services, Inc. (Ken Wilcox Associates, October 1990; Control Strategies Engineering, May 1992).

What Did the Field-Based Research Study Show?

As part of the required field-based research, 182 UST systems were tested for tightness using a sensitive tracer method (*Underground Storage Tank System Field-Based Research Project Report*, SWRCB, May 31, 2002). Liquid releases were detected in 5 to 10 percent of the single-walled piping systems tested. These leaks were below the threshold of the most commonly used release-detection methods. Vapor releases from the tanks were detected in a little more than 60 percent of the systems tested.

This research confirmed the earlier findings: There was no correlation with releases and double-walled or single-walled systems, but there was a measurable correlation associated with facilities equipped with vacuum-assisted vapor-recovery systems. A significant number of these vapor releases emanated from fittings within containment sumps and then migrated to the backfill through defects in the seals around piping and fittings entering the sump and by sneaking under the sump lid.

Individually, on a pound-for-pound basis, vapors accounted for the largest releases observed. If the UST systems involved in the study were representative, the data suggest that a greater amount of petroleum may be released from these systems as vapors rather than as liquids.

Post-Installation Testing

In 2002, California enacted Assembly Bill 2481 into law, requiring new construction standards for UST systems. New systems were also required to demonstrate vapor and liquid tightness before being put into service. One way to demonstrate that tightness was to perform ELD (California Health and Safety Code 25290.1 (j)). The testing requirement became effective on July 1, 2003.

The installer of the first facility tested under this new requirement was not aware of the new level of sensitivity required. Before the service station was scrutinized at this new level of tightness, the UST system had already been paved over and the facility was ready to open for business.

Even though the storage system had been inspected using traditional pressure tests before it was covered, the results of the ELD test meant that some 60 percent of the newly installed piping had to be excavated and replaced because of leaks before the system could be declared tight. A number of tank-top fittings were also repaired or replaced because of leaks detected during the ELD test.

Within a short time, several other contractors experienced similar frustrations. It became clear that traditional methods of testing newly installed UST systems were not good enough. Contractors were concerned about how to know if the UST systems they were installing were tight enough to pass an ELD test before covering them up. The most reliable solution to this problem proved to be using ELD methods or other similar techniques during construction and installation.

Work Quality and Cost Adjustments

Because of the significant increase in leak-detection sensitivity, new ELD methods find smaller leaks and consequently a greater number of them. During the first few weeks of the ELD testing program for newly constructed UST systems in California, the costs associated with the test produced some sticker shock in the industry. However, contractors that have proactively adjusted their installation practices to meet these higher tightness standards have also experienced a 40 percent to 80 percent reduction in ELD costs.

Because the bar of tightness expected of UST systems has been raised, construction practices have improved, and contractors are getting better at inspecting their work at each stage of construction. A system that passes a test of equivalent sensitivity to ELD testing, previous to covering the system, will pass an ELD test after covering and paving the facility, so long as the system is not damaged while being back filled and covered with pavement.

As a result of these improvements, the cost associated with this type of testing has every opportunity to continue to decrease. As high-sensitivity leak detection matures, other testing methods are developed, and better construction practices become widespread, the price of highly sensitive leak detection will continue to fall.

Why Pressure Tests Aren't Enough

Air pressure tests are commonly used to inspect the integrity of piping before covering UST systems, but the sensitivity of this type of test is not sufficient to detect leaks on the order of 0.005 gph. It is typical to test these systems at 40 to 80 psig for 30 minutes or so, use a gauge with a scale of 0 to 100 psig, and ignore small pressure changes during the test—even up to 2 psig—because they are deemed to be insignificant and are difficult to discern with the gauges that are typically used.

For 100 feet of 2-inch piping, a change in pressure of 2 psig over a period of 30 minutes represents an air leak of 4.4 gph. If this hole were leaking liquid gasoline, the leak rate

■ continued on page 16

■ **ELD in California** *from page 15*

would be approximately 0.2 gph. A 0.2 gph leak would release 1,700 gallons, or over 10,000 pounds, of gasoline over the course of a year. Few people would argue that a release of this size is acceptable.

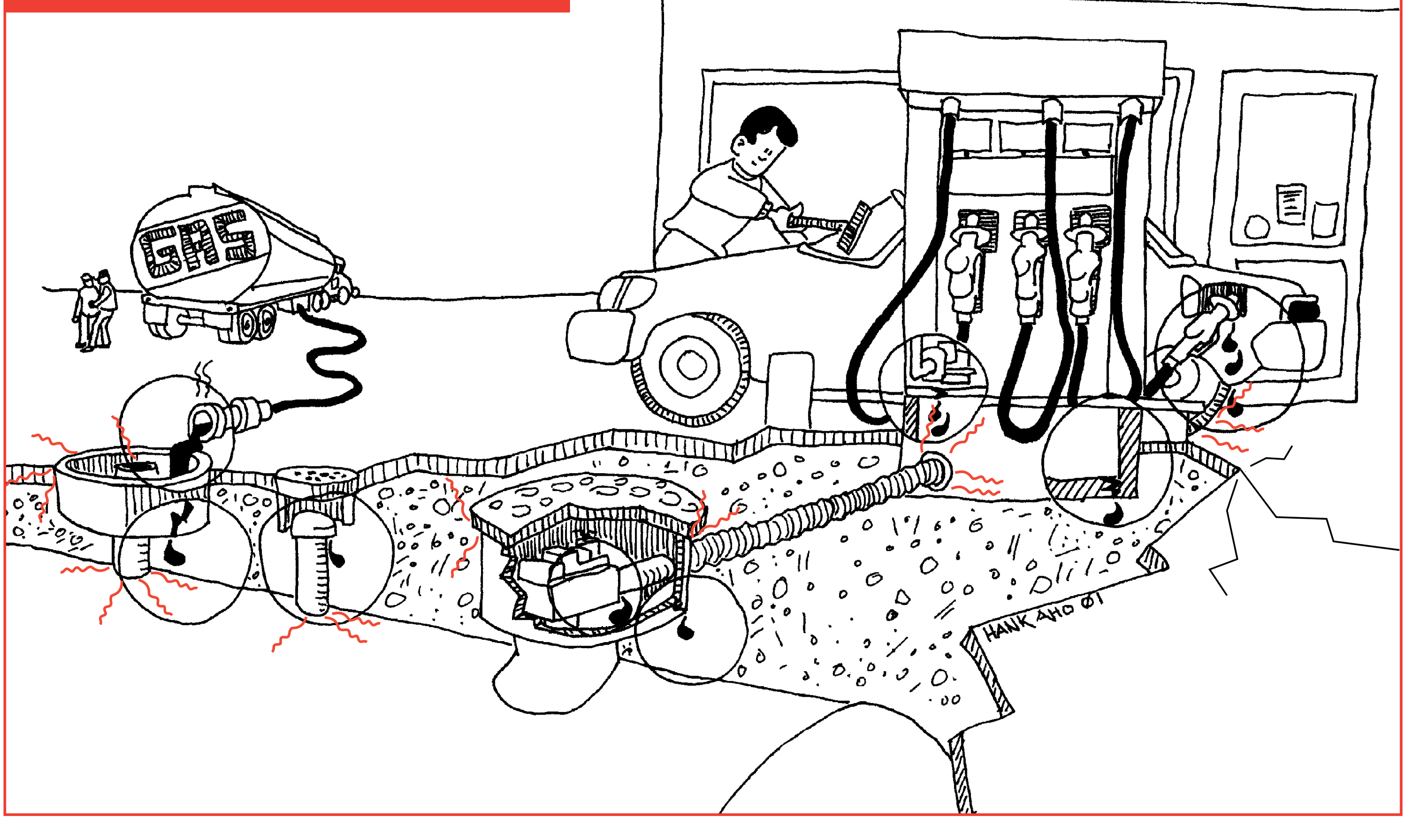
Is there any hope that a pressure test could achieve the accuracy required of an ELD test? To accomplish the 0.005 gph leak-rate sensitivity of the ELD test, a pressure test with an action threshold of 1 or 2 psig would require a minimum test period of 18 to 36 days. Few UST systems are so scrutinized and often a test of this length would be inconvenient to schedule.

Where Are the Holes in Our UST Systems?

Where have most of the leaks been found? It is probably no surprise that most of the leaks are associated with less than perfect installation practices. The following are some of the common problems that we have noted.

- Connections between spill-buckets and riser pipes seem to present a challenge for installers. Perhaps the joints are assembled from the perspective that these fittings do not need to be tight. In addition, a good number of spill-bucket drain valves present small leaks that seem to be difficult to repair after installation. Furthermore, after use, the drain valve in the fill-riser spill bucket is prone to develop vapor leaks.
- Improperly cleaned, prepared, or assembled joints are frequent sources of leaks. Assembling pipe-threaded joints without pipe dope is a sure-fire way of causing leaks. Taking a doped joint apart and reassembling the joint without cleaning and reapplying the pipe dope is unlikely to create a tight connection. A greater number of leaks are associated with T fittings than with elbows. Machine threads coupled to pipe threads do not seal. Screwing male steel-pipe threads into a threaded FRP female coupling leads to a large number of problems. Overtightened O-ring seals can be problematic.
- The use of a pipe wrench on a section of FRP piping is a risky procedure. Wrenches designed for steel pipe do ugly things to FRP pipe.
- Vapor or liquid leaks within containment sumps lead to measurable levels of vapor in the backfill in a very short time. Containment sumps are not vapor-tight. The space between the lip of the tank-top sump and the concrete form ring for the manhole cover is designed to provide a ready connection to the backfill for water drainage. Vapor leaks within the sumps commonly turn into vapor leaks in the backfill. This includes small liquid leaks in the primary piping that migrate as vapor to the sump. Another problem is that nonsealed electrical conduits do not contain vapors within the sump; they transport the vapors from the sump to unexpected places.
- Careless use of compression fittings at the tops of ATG risers leads to unnecessary vapor leaks.
- We have observed that vapors are transported through the sheath of an ATG-probe signal cable very efficiently. If there is a nick in the coating or a loose connection at the top of the probe, the slight pressure in an operating tank drives the vapors up through the sheath-

VAPOR SOURCES IN UST SYSTEMS



ing and into the electrical junction box. From there, the vapors can enter a sump or they can continue through the electrical conduit. Vapors can then be released into the soil at buried joints in the conduit or over the upper lip of the sump.

Effective Pre-Test Practices

What were some of the effective practices employed by contractors to make systems tight to the more sensitive ELD test or to facilitate needed repairs?

- Have two people carry a piece of FRP piping to reduce the possibility of bruising the pipe and fouling the ends. One person can carry a 20-foot piece of pipe, but not as carefully as two can. Gentle handling of flexible piping minimizes the chance of a leak between end connections.
- Require manufacturer-certified assemblers for each type of piping material. This also reduces the number of improperly assembled joints. Of course, certified assemblers who do not follow the manufacturer's recommendations have a lower success rate.
- Properly clean and prepare FRP joints—this is crucial. After applying the joint resin, and properly making up the joint, *do not* move the joint until the resin is cured. After assembling a few joints, the assembler needs to work on a completely different part of the system for a while to avoid moving a curing joint and thereby causing very small leaks.
- An ELD test must be conducted after every repair to document that an UST system is tight. Early identification of leaks can reduce the number of ELD retests and save much time and money. Maintaining pressure in the piping for prolonged periods before an ELD test is very helpful in identifying small leaks without the expense of a full-fledged ELD test.
- Put the system under test pressure as soon as it is assembled and leave it under pressure until it is put into service—an inexpensive but helpful precaution. It also provides a rapid indicator of any damage that might have occurred during further construction activities. The pressure inside a leak-free piping system remains stable indefinitely. Logging the gauge-registered pressure at least daily during the construction process is easy and very valuable. Adjusting the pressure periodically to compensate for repeated pressure changes is a bad sign. If the system must be recharged periodically in order to maintain pressure, there is a problem.
- Compare the pressure behavior of separate sections of the pipe at the facility. Any effect of temperature or barometric pressure on one pipe should be similar or identical to that on neighboring pipes. Effects from relaxation of the pipe materials should also be parallel.
- Digital gauges offer two important advantages: (a) it is easy to read pressure changes on the order of 0.1 psig, and (b) it is more likely that everyone will read the gauge the same. When different people read a typical dial gauge, it isn't unheard of to get readings as variable as 29, 28, and 24 psi without any movement in the gauge.
- Containment sumps or boxes are not always used at horizontal-to-vertical transitions. Vent risers, for example, may be connected to the vent pipe through a flexible connector. If that fitting needs to be tight, it is wise to make it as accessible as possible. A joint in the concrete around the area of penetration minimizes the amount of concrete that will be broken if a leak is found in this area during a final test. An even less disruptive alternative is to place these joints in containment sumps. As a general rule, minimizing the number of joints between sumps lowers the probability of a buried leak.
- The use of coarse backfill material (e.g., gravel) shortens the transport time for tracers through the soil and allows for a very fast test.

Are Newer Systems Better?

The tank-top fittings for double-walled tanks tend to look a lot like tank-top fittings for single-walled tanks. Therefore it is not surprising that vapor releases, the most prevalent form of releases from tanks, are just as likely from double-walled tanks as single-walled tanks. Though there seems to be some benefit from double-walled piping in preventing product leaks, it does not appear to me that components of newer systems are more likely to be tight than old systems. An old system that didn't leak when it was constructed could stay tight for a long time. Many very old systems have passed a Tracer Tight test. Some of these systems are more than 50 years old and in one case the tank was approximately 100 years old.

Where Do the Limits of Leak Detection Lie?

High quality, careful installation practices lead to tighter UST systems. Careful, more sensitive testing practices find more leaks and reduce the potential for unwanted and undetectable releases. Systems can be made tight to virtually any level of scrutiny if properly and carefully installed.

The good news is that virtually any level of leak-detection sensitivity that might be desired is now attainable. What size leak can reasonably be ignored? Or in other words, what leak-rate sensitivity is needed so that any leak that goes undetected really doesn't matter? Most would agree that 5,000 to 10,000 pounds per year is too much. A 0.005 gph liquid leak releases 300 pounds per year. This may also be too much.

Because gasoline is thicker than air, a 0.005-gph air leak during a post-installation test will release approximately 10 to 20 pounds of liquid gasoline per year after the system starts dispensing the product. Is this too much? A healthy discussion of how much leakage can be ignored is long overdue.

The most cost-effective leak detection occurs before a system is put into use. This is also the time to maximize the sensitivity of a tightness test. Systems that are tight from the beginning have a greater chance of staying tight for a long time. Systems that leak from the beginning allow small releases that can go undetected for a long time.

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Keeping Water Out of Mischief

The Causes and Economic Impacts of Water in Petroleum Storage Systems—and How to Prevent Them

by Wayne Geyer

Operations and maintenance procedures for water monitoring and removal have been a recommended practice for over 30 years. But despite their simplicity, the extent to which such procedures have been put to use has been inconsistent throughout the tank owner/operator community. Reasons for this lackluster attention to the details of water maintenance may include a general industry focus on tank upgrades and maintenance procedures specifically mandated by regulation or code. In other words, an attitude of "If it's not regulated, why bother?" The answer to that question has become increasingly evident.

Industry changes over the past several years have increased the risk posed by water entry and accumulation in petroleum storage systems. If water is not removed on a timely and regular basis, microbial growth may occur, resulting in potential contamination throughout the entire system, regardless of the type of storage or dispensing materials used. In short, significant and far-reaching negative impacts are possible—on the system, on the operations and profits of the facility, on the facility's customers or users, and on the environment.

The Steel Tank Institute has published a booklet entitled Water in Underground and Aboveground Storage Systems: Causes, Economic Impact on Business, and Preventive Operations and Maintenance Practices *for storage-system owners and operators which describes prudent water monitoring and removal procedures and emphasizes the importance of implementing them as part of routine storage-system operations and maintenance. The booklet also explains the relatively recent industry changes that have increased the probability of water entry and accumulation in a storage system. This article summarizes key elements of the booklet.*

An Urgent Case for Water Monitoring and Removal

Not monitoring and removing water from storage systems can lead to a number of problems, from the degradation of fuel quality and resulting effects on vehicle performance to microbial contamination and damage of the entire storage system. This pertains to all storage systems, both underground and aboveground, constructed of any material and storing nearly any product—gasoline, diesel, residential and commercial heating oils, aviation jet fuel, and others.

The entire storage system can be impacted by water, not just the storage tank. While the tank is the common collection place where chemical reactions can brew, it also serves as a central location and easy means to monitor for water in the system and treat the problem. It is crucial that owners and operators of storage systems understand that they need to begin implementing routine operations and maintenance procedures for water monitoring and that they remove any water detected, immediately.

Recent Industry Changes

Although operations and maintenance procedures for water monitoring and removal have been a recommended practice for over 30 years, the following changes within the industry have increased the risk of water entry and accumulation in the storage system and subsequent microbial growth if water is not removed.

- **The distribution infrastructure** Fuel is moving faster through the distribution/delivery infrastructure, leaving less time for water to settle out before the product moves from one step to the next in the distribution process. A shift from proprietary to shared delivery infrastructures (e.g., bulk terminals, pipelines, transports) has removed much of the control that individual companies once had over the distribution process and product.
- **Gasoline chemistry** Over the past 20 years, gasoline chemistry has undergone many changes: lead is out, additives such as MtBE and ethanol are in, and new fuels such as biodiesel are entering the market. These new/altered fuels are more susceptible to moisture accumulation, separation, and potential biodegradation, activities that are accelerated by water. Lead used to serve as a natural poison to the microbes that grow in a moist environment. In today's lead-free fuels, microbial growth can occur more readily.
- **Installation procedures** Today's tank systems have a number of connections to the tank and equipment installed to the tank (e.g., spill-box drain valves). For these reasons the possibility of water entry into the tank system when not properly maintained or installed is greater than ever. (See Figure 1 on page 19.)
- **Microbial activity** As a result of the above changes within the industry, microbial activity has been identified and found to be a much more common phenomenon than previously realized.

How Water Enters a Storage System

In addition to the possibility that water is in the delivered product, water can enter a storage system by way of damaged fill boxes or fill-cap gaskets, loose fittings or plugs, poor practices relating to spill buckets, and condensation caused by fuel temperature swings or the introduction of air through vents. Certain fuels attract moisture readily and then separate out when they are subject to temperature swings.

Preventing Potential Problems Associated with Water

Major industry groups have developed recommended operations and maintenance procedures. Basic practices include:

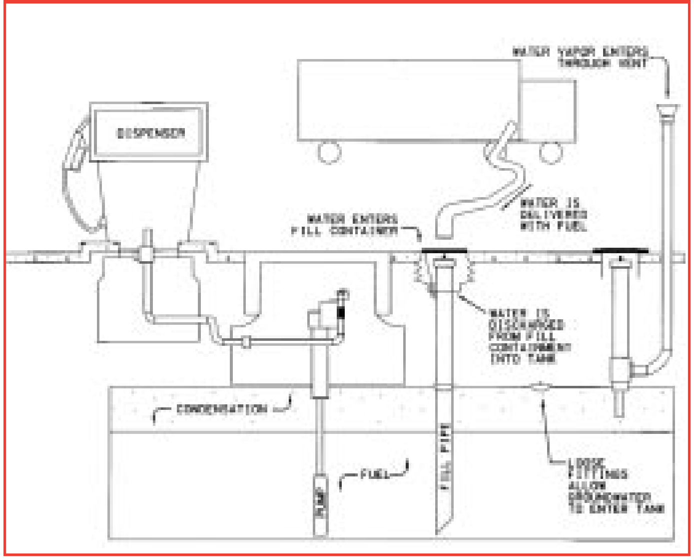
- Monitoring and checking for water with automatic-tank-gauging systems and manual gauge sticks
- Inspecting fill and vapor caps for damage and missing gaskets, replacing if necessary
- Inspecting product and spill-containment buckets and properly disposing of water if found (not draining it back into the tank)
- Auditing the fuel-delivery process and water content
- Using water-sensitive fuel filters and watching for any slow-down during fueling
- Treating storage tanks with an antimicrobial pesticide (biocide) on a regular basis
- Employing a qualified professional to periodically examine the inside of the tank, remove any water and sludge, and clean the tank

Locating Water in a Storage Tank and Removing It

The first point of contact for guidance on locating water in a petroleum storage system is the petroleum equipment or services contractor and/or the fuel supplier. Additional guidance is available from organizations such as the American Petroleum Institute (API), Petroleum Equipment Institute (PEI), American Society of Testing Materials (ASTM) International, and the National Oilheat Research Alliance (NORA).

Manual tank gauging and/or automatic tank gauging can detect water, but periodically pulling product samples from the tank is a prudent practice. Samples should be taken from the low end of the tank and, if possible, from more than one location in the tank. Hazy or waxy fuel samples indicate water. Readily available field-detection kits can be used to check for microbes and determine if the fuel meets specifications. If water is detected at any time, it must be removed by a qualified service contractor.

FIGURE 1. *Water entry points in an UST system.*



Signs of Microbial Growth

Plugged fuel filters are a common result of microbial growth. Clogged filters result from the accumulation of slime created by a thriving microorganism colony. Filter life shorter than six months is a warning signal (when flow slows to 3–5 gpm, something is amiss). Other signs include plugged fuel lines, erratic gauge readings, a rotten-egg odor, and frequent replacement of other components such as valves, rubber seals, and hoses.

Problems may also surface in vehicles that have been fueled by contaminated product, such as plugged fuel filters and unusual exhaust smoke. If water levels in a storage tank are high enough to be pumped directly into a vehicle, immediate and major problems can occur. This is of particular concern with ethanol-based fuels.

Field-detection kits can be used to verify microbial growth, but it is suggested that qualified professionals with expertise in microbial contamination control be contacted to develop a treatment plan. This may include initial tank cleaning to remove the slime and sludge, followed by treatment with a biocide.

For More Information

The publication *Water in Underground and Aboveground Storage Systems: Causes, Economic Impact on Business and Preventive Operations and Maintenance Practices* is available in print from the Steel Tank Institute *(info@steeltank.com)* or online *(www.steeltank.com/water)*. For specific information on operation and maintenance practices, contact your fuel supplier and/or a petroleum equipment or service provider. Standards and informational resources are also available from organizations such as the STI, U.S. EPA, API, PEI, ASTM, PMAA, NORA, DOE and your state or local authorities. See also *LUSTLine* #39, November 2001, "Microbes and Fuel Systems: The Overlooked Corrosion Problem," by Fred Passman. ■

Wayne Geyer is Executive Director of the Steel Tank Institute.

STI/SPFA to Combine Organizations

The Steel Tank Institute (STI) and Steel Plate Fabricators Association (SPFA) have agreed to combine organizations. The new trade group will be known as STI/SPFA and will be based in Lake Zurich, Illinois. Wayne Geyer, current executive vice president of STI, will lead the new organization. The new association will be organized with two divisions operating as STI and SPFA. SPFA members are involved in manufacturing and marketing elevated field-erected water storage tanks, pressure vessels and large-diameter steel pipe. STI members make shop-fabricated steel underground and aboveground storage tanks.

Also note that the Steel Tank Institute's *Tank Talk* publication is now an online-only publication that can be accessed at *www.steeltank.com*. ■

"I Don't Train, I Enforce!"

Or, how Bob the UST Inspector had to choose what was more important: compliance or enforcement.

by Ben Thomas

Sometimes doing something differently requires the fundamental courage to admit that what you're currently doing isn't really working. In this article, I use Bob, a fictional character, to illustrate the predicament many UST inspectors face when stuck trying to enforce tank rules while paradoxically being hamstrung with the very enforcement tools they use. In this story Bob discovers what really motivates people and by applying this wisdom, he is able to transform his UST program into a more effective one, using methods he hardly thought applicable.

Our Story Begins ...

It's early Monday morning. Bob, a state UST inspector, comes whistling into his office, only to be instantly sobered by the huge, listing pile of draft Notice of Noncompliance (NON) letters. Bob has been meaning to mail them out but he's understaffed, overworked, and, quite frankly, fed up.

Time and time again Bob works with UST operators who don't understand anything about their automatic tank gauges, don't keep their spill buckets clean, don't do their required corrosion tests, and generally don't seem to give a hoot about the rules Bob is trying to enforce. "They just don't get it," he fumes.

Overloaded, he puts off the pile another day, grabs the state rig, does a few more inspections (finds more problems, of course), and, on his way home at the end of the day, stops by his favorite bookstore. Walking down an aisle, he happens upon a trim little book called *Don't Shoot the Dog: The New Art of Teaching and Training* by Karen Pryor.

Being a dog owner, Bob is curious about the book, but as he skims through it he realizes it's not exactly about dogs, much less shooting them. (He is relieved to learn the title is only a metaphor in that "shooting the dog" is an extreme way to get it to stop barking, but there are other ways. Phew). Bob quickly concludes that the book is about training someone to do something.

The author asserts that many people don't use correct training techniques to reach a desired outcome. In fact, trainers will often blame people (or other creatures) for not doing what is being asked of them. She suggests that instead of looking at the trainee as the problem, it might well be better to focus on the trainer.

Training, she says, is not synonymous with training *effectively*, and the rules for effective training apply to more critters than just dogs; they apply to bosses, spouses, co-workers, roommates . . . even dolphins. ("And tank operators?" wonders Bob. "Nahhhh.") As Bob delves deeper into the pages of the book, he learns that there is no single method of effective training—no silver bullet—instead, there are eight of them. A good trainer uses the best method for the right situation or, even better, a combination of methods. Trainers who are frustrated with poor results are probably using the wrong method for the application. "Yeah," Bob chuckles to himself, "Like my 'they just don't get it' method."

As Bob reads on, he finds himself admitting that the concept is amusing and that it may even apply to certain situations . . . but to tank owners? He thinks about the operators who he just can't seem to get motivated. "Besides," he fumes, "I don't train, I enforce!" He buys the book, anyway, hoping he can use the techniques on his dog.

The Rude Awakening

That night Bob has a nightmare. He dreams he is wearing a black leather hood and a sleeveless tunic and pushing some hapless peasant into the stockade in the village square. He takes the prisoner, shoves him into the yoke, and secures the lock. He unfurls a scroll and cries "This man has failed to an perform an annual functionality test on an automatic line-leak detector to ensure the device can detect a 3 gallon per hour leak rate! I sentence thee to 40 lashings!"

Before the first swish-crack, Bob's alarm clock goes off. Back at the office, he sips his coffee and mulls over the dream, which has left him with an uneasy feeling. At his lunch break, and with his NONs still not mailed, Bob opens up the book and reads about the eight methods of training. To humor himself, or perhaps driven by pangs of subtle guilt, Bob jots down the methods and notes some examples of how each could apply to his universe of underground storage tanks. Still thinking hypothetically (and against his better judgment), Bob begins to venture outside the box of his day-to-day routine. After a while, with the help of author Karen Pryor, a new paradigm starts to take shape.

Bob's Eight Ways of Training Tank Operators

■ **Method 1: Shoot the dog.** Get rid of the problem behavior. "Penalize the tank operator by putting him/her out of business," notes Bob. "This gets rid of the problem of the operator not performing leak detection—no tank operator, no need to worry about leak detection. Hmmm."

■ **Method 2: Punishment.** Punish wrong behavior after the act has occurred as a "reminder." A Notice of Noncompliance letter, thinks Bob. "Aha, but issuing a penalty reprimands the operator for *not* doing leak detection. The problem is that is doesn't *make* him/her do leak detection; it only *punishes* him/her for not doing it. Hmmm."

■ **Method 3: Negative reinforcement.** An unwanted behavior is met with an undesirable response. In the book, Pryor cautions that negative reinforcement only works when the punishment is swift (i.e., nearly immediate) and relative to the "bad behavior." Otherwise, it doesn't make sense and rarely corrects the behavior. Bob notes: "Operator does not do leak detection and we publish a press release to make him look bad in the public eye." Visions of stockades dance in Bob's head. He also remembers reading about states that use "red tag" authority to shut down a facility until the violation is corrected.

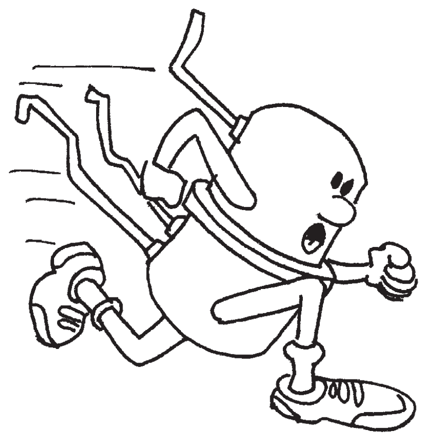
■ **Method 4: Extinction.** This is where you wait for the bad behavior to go away by itself. This works if the trainee knows what is good behavior (the rules) and what is bad behavior (the violations). Bob wonders if the mere complexity of tank rules, which can overwhelm the average operator, prevents knowing exactly what is expected. Bob can't think of an instance when ignoring the problem led the tank owner to correct it by him/herself. Bob notes: "Can't train (change behavior) if they don't know what I want beforehand." Go Bob go!

■ **Method 5: Train an incompatible behavior.** Train an alternate behavior that prevents an undesirable behavior. Bob remembers hearing once that the State of Kansas requires all operators to submit the last year's worth of leak detection records for agency review. Bob scribbles: "No leak detection reports, no state fund; no state fund, no permit; no permit, no business; no business, no money." The request for leak detection records is incompatible with not doing leak detection, because the state fund is tied into this request. "Cool," Bob muses. "Tie in technical requirements with funding incentives."

■ **Method 6: Put the behavior on cue.** Warn someone that something is going to happen. Or may happen. Bob is clicking now and writes: "Send letters to operators BEFORE I inspect them and explain that I am coming and what documents I need to review." Bob has heard about how South Carolina does this, and how it reduces the inspection time at each site, allowing for more inspections each year.

■ **Method 7: Shape the absence of the behavior.** Sometimes called Positive Reinforcement. Bob remembers hearing how in Alaska a green "atta boy" tag is issued to indicate that the operator is in compliance. At the time, Bob thought this was weird mostly because he was only familiar with red "bad boy" tags. Bob scribbles: "Offer praise when something bad is not happening (e.g., say 'Nice clean spill bucket you got there!')"

■ **Method 8: Change the motivation.** Pryor says this is the best way. Work with what motivates operators. Is someone not doing what you want? Change the motivation. Bob recently learned that the State of Washington provides "pain-free" compliance inspections for those who request one. The state does not enforce a violation on an operator if the operator initiates the call, as long as the problem is fixed. The motivation moves from "better not get caught" to "I can fix a problem without being punished if I ask for help."



The Experiment

Bob looks over his notes and decides it's time to try an experiment. He weighs his workload outlook, his chronic state of frustration, and his morbid dream and concludes he doesn't have much to lose. He tries the following.

***Ben's Warning**—The following hypothetical situation can be hazardous to initial skepticism. It involves a simplified world that is necessary to minimize bureaucratic naysaying. In order for him bring his ideas to light, Bob is granted certain authorities to make things happen fast. Before you say "no way this can happen in my state," first indulge in these generous assumptions and focus on the outcome, rather than get bogged down in the mechanics.*

- Bob goes back to his noncompliant sites and tells the operators they have 30 days to correct the problem. (Method 6: Put the behavior on cue.)
- For those who complete the work, as assigned, Bob agrees to tear up the fine. (Method 7: Shape the absence of the behavior.)
- For those who fail to complete the remedy, Bob issues them a field citation on the thirtieth day and collects a penalty. (Method 3: Negative reinforcement.) Afterward, Bob pulls their operating permit and locks their fill pipe. (Method 2: Punishment.)
- Using the proper chain of command, Bob eventually convinces the head of the state fund to require that operators submit proof of leak detection as part of the annual application process. (Method 5: Train an incompatible behavior.)
- Bob creates an amnesty program where he tells tank operators that if they call him and ask for an inspection, he will not hammer them with a "NON," as long as the UST system is not actively leaking. (Method 8: Change the motivation.)
- Bob establishes a "Tank Operator of the Month" column on his Web page to highlight a successful business person who got out of trouble by correcting a problem. (Method 7: Shape the absence of a behavior.)
- Bob changes his inspection protocol to notify operators seven to ten days before an inspection, rather than just springing on them like he used to and then being mad that they weren't more prepared. (Method 6: Put the behavior on cue.)
- Bob drafts rules that go into effect that provide a compliance tag for those tank systems that pass inspection. (Method 7: Shape the absence of a behavior.) No tag, no fuel. (Method 5: Train an incompatible behavior.)

Six months later, Bob reviews his enforcement caseload. Something, indeed, has happened. The number of NONs facilities have dropped off while the number of Significant Operational Compliance facilities have increased. Sure, he spends more time on the phone, but that's because tank operators are starting to initiate calls. Bob's boss drops by and says his federal bean count has never looked better. No longer in his state of perpetual funk, Bob is able to enjoy his job more fully. Operators are getting it.

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■ **"I Don't Train..."** *from page 21*

The Moral of the Story

A well-intended regulator of underground storage tank systems can fail to understand what motivates people. What Bob failed to understand is that he should have been trying to systematically change behavior, not catch the thief with his hand in the proverbial cookie jar. This reactive type of enforcement eventually leads to a quicksand of time and resources. Plus it doesn't really change how people do things, and, ultimately fails. Why?

Some regulators think of themselves strictly as enforcers. They think that punishing the offenders of UST regulations is the only way to make things better. According to Pryor, this would be using an exaggerated amount of Method #2, punishment. Method #2 advocates feel that a strong hand garners respect, even when doling out punishment.

Does it work? Not really. Not sure? Just look at how most states enforce the UST rules (heavy on Methods 1 and 2), then look at the national average of EPA's "significant operational compliance," and you can see we have a long way to go.

I think the trick is to not to settle on any one method but to use a blend of some or all of the methods, depending on the situation. The fun part of a regulator's job can be to decide how much of each method to use and in what amount.

As an inspector, ask yourself whether Bob's statement "I don't train, I enforce!" is in fact correct. And while Bob thought he knew what was more important, he ultimately had to decide what was more effective. If you train operators through various incentives and decrease violations, aren't you doing your job of protecting human health and the environment? If you facilitate changing behavior and get a population to perform leak detection, isn't your job a whole lot easier? And isn't that want you want? ■

Ben Thomas is former manager of the Alaska UST leak-prevention program. In that capacity, he used training methods 5, 6, 7, and 8, which helped decrease enforcement while increasing significant operational compliance. He now has his own consulting firm, Ben Thomas Associates. See www.bentanks.com.

ICC UST Operator Certification Exam Now Available

by Lynn A. Woodard

Over the past several years the same theme continues to be expressed when state regulators get together at meetings and conferences: UST operators are not sufficiently trained to know what is required by the federal regulations. In response to this concern, the International Code Council (ICC) has developed a new Operator Certification Examination designed specifically to allow operators to demonstrate that they possess the minimum required knowledge of the regulatory requirements to achieve and maintain operational compliance.

The process began in 2002, when the Board of Directors of the International Fire Code Institute (IFCI) voted to fund the development of an examination to certify UST operators. This was done at the recommendation of IFCI's UST/AST Certification Advisory Committee, which was made up of representatives of UST state regulatory agencies from around the country. You may recognize that this is the same organization that was solicited to develop and provide certification examinations for UST system installation/retrofitting, decommissioning, tank tightness testing, cathodic protection testing, and AST system installation/retrofitting.

As a result of the Board's decision, a volunteer committee was established to define the goals and objectives of the examination, define the duties of a certified operator, and develop a bank of test questions, answers, and appropriate references for the examination. During 2003, the Committee convened several times in multiday sessions to accomplish its goal.

In case I've caused confusion about ICC vs. IFCI, let me explain. During the timeframe that the operator's exam was being developed, IFCI's parent company, International Conference of Building Officials (ICBO), was merging with Building Officials and Code Administrators International, Inc. (BOCA) and Southern Building Code Congress International, Inc. (SBCCI) to create one company called the International Code Council. This officially took place on February 1, 2003. Hence, all of the examinations mentioned above are now under the auspices of the ICC.

The ICC Certified Operators Examination became available on July 1, 2003. It is administered by a company called Promissor, which has a contract with ICC. Promissor has teamed with Gateway Computers to use its locations for test centers.

To schedule a time and location for any of the examinations noted above as well as the Certified Operators Examination, contact ICC at (800) 423-6587 ext. 3419. ICC will provide applicants with a *Candidate Bulletin*, which contains a wealth of information about how the examinations are structured and the reference material from which the examination questions and answers were derived. Visit ICC's Web site at *http://www.icc-safe.org*.

If you are looking for an inexpensive way to establish an operator certification program in your state, you may want to take a look at the ICC Certified Operators Examination to satisfy a portion of that program. The hard work has been done, there is no cost to the state, it is already available in each state, test development experts have certified it, and it is defendable. Further, if your state's regulations are more stringent than the federal regulations, ICC may be willing to work with you to develop a separate state-specific examination. ■

Lynn A. Woodard, P.E., is the Supervisor of the New Hampshire Waste Management Division's UST/AST Compliance and Initial Response Section. He is also the current chairman of the ICC UST/AST Certification Advisory Committee.

An Urban Cinderella

The Transformation of a Former Petroleum-Contaminated Site in Virginia

by Barbara Howenstine

The Clarendon Centre

Across the busy Arlington, Virginia, highway you see the modern facade of an 11-story yellow brick apartment building—the Clarendon Centre. You see the tidy balconies and the polished-metal framed front door. You step into the cool, calm lobby with its black walls, taupe divans, beaux-arts crystal vases, and welcoming fireplace. You glance into the clubroom with its bar and stools, track lighting, pool table, large-screen TV, and sunny windows. You walk along the corridors with their slightly exotic olive-tinted walls and rust and taupe patterned carpeting. You glance through the door of an unfurnished apartment and note the large floor-to-ceiling windows. You go up the elevator, through the doors, and out onto the spacious, pebble-strewn balcony on the 9th floor to get a pleasant and airy panoramic view of the city and the Washington Monument in the distance. Hard to believe that just a few short years ago, this very site had been shunned by developers and deplored by nearby residents. Back then it was a petroleum-contaminated property with vacant, decades-old dilapidated buildings in a similarly blighted neighborhood.

A Collaborative Expedition

This is the story of the 1.4-acre Clarendon Triangle site in Arlington, a close suburb of Washington, D.C. Since the 1920s, the site had contained several gasoline stations, a car wash, an automobile dealership, and an office building. At least four facilities in the area had had petroleum leaks, and some plumes in the area and at the site were decades old. By the late 1980s the site was rundown, vacant, and contaminated with petroleum.

The Texas-based JPI Apartment Development, LP (JPI), became interested in the site because of its location in an area already experiencing revitalization. JPI specializes in the creation and management of luxury residential communities throughout the United States. JPI acquired the Clarendon site in 2001 and began the multi-faceted task of working with Arlington County and the Commonwealth of Virginia to clean up and redevelop the property.

JPI and its consultants, Environmental Consultants and Contractors (ECC), and lending institution First Union worked closely with the Northern Virginia Regional Office of the Virginia Department of Environmental Quality (VDEQ) to resolve environmental, regulatory, and financial issues concerning the site. Work at the site began in 2001.

Although site assessments had already been completed, ECC performed its own assessment and produced a Corrective Action Plan (CAP) to address the petroleum contamination as well as safety issues at the site. The CAP was approved by VDEQ, discharge permits were issued to handle treated excavation water, and $1.5 million from the Virginia Petroleum Storage Tank Fund was used toward the $3.5 million cost for water treatment and soil excavation. Contaminated materials were addressed to VDEQ's requirements and work at the site progressed on schedule.

By April 2002, the foundation and subsurface structure of the residential and commercial building had been completed and the environmental issues successfully resolved with VDEQ. The trendy Clarendon Centre opened its 252 residential units to residents just over a year later. Several commercial ventures occupy the first-floor retail space (14,000 sq. ft.), including a coffee shop, video rental store, dry cleaner, and restaurant. JPI sold the property to current owner and manager Equity Residential in October 2003.

Elements of Success

What contributed to the successful redevelopment of this formerly rundown and petroleum-contaminated site?

- The site was located in an urban area where job growth was occurring and projected to occur for several years in the future. Housing demand was strong.
- The site was in an urban area already undergoing extensive revitalization in the form of new or rehabilitated residential and commercial buildings.
- The site was situated close to public transportation systems, specifically metro-wide subway and bus systems. These systems allow easy access to nearby employment and commercial centers as well as the cultural attractions of the Washington, DC, area, such as museums, historic sites, arenas, and theaters.
- The site was located in a county where county officials were promoting residential and commercial redevelopment. The county wanted to turn vacant, dilapidated properties into new sources of economic activity and tax revenue. For example, the county required mixed development at the site: new residential buildings in the area were required to provide commercial activities on the first floor. This would encourage people not only to live in the area but also to spend in the area and support the local economy.
- The anti-urban sprawl movement in neighboring counties located

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■ **Urban Cinderella** *from page 23*

further from the city encouraged the redevelopment of formerly marginal properties in the county.

- The Virginia legislature had recently endorsed the concept of cleaning up and reusing brownfields properties, so the VDEQ had several procedures and programs in place to assist developers such as those at the Clarendon site. These include:
  - The VDEQ Petroleum Program's "step into the shoes" procedures that allow another party to voluntarily step into the shoes of the responsible party for a site. In Virginia, this means that at an eligible site—after proper documentation—the party taking on the responsibility for the petroleum cleanup can access the state's petroleum cleanup fund.
  - VDEQ's willingness to issue limited liability letters to the developers as well as other partners, including the lender. This provided the needed "comfort" level for the lender and partners to continue with the project. The developer had worked with VDEQ before and knew it could get the letter if it met the state's regulatory requirements.
- The developer and cleanup contractor both had experience with cleaning up and redeveloping contaminated sites with the Virginia cleanup program. "Ten years ago we would not have looked at this project; we would have run away," explains the developer. "As this program has matured in the state, there is now some certainty that with a complete CAP implementation, closure can be expected by the developer—which is imperative for a project to advance through the development process. Sites like this one require certainty that if we complete the cleanups as required, the developers, lenders, and investors can legitimately expect a closure letter. An expectation of closure will promote cooperation and allow financing to be completed."
- All parties to this project knew and respected the importance of a thorough site assessment to the project's success.

Clarendon Centre site before construction began

The Challenges

What were some of the problems this project had to deal with?

- The petroleum contamination was extensive, and so the cleanup was extensive. Remediation required the onsite cleanup and control of water in a 50-foot trench, as well as soil removal and disposal, all accomplished in a tight working space in a busy urban area. Over 32,000 cubic yards (or 49,000 tons) of soil and 1.4 million gallons of water were remediated. Soil was hauled to thermal treatment facilities in Richmond and Baltimore, where it was baked in high-temperature ovens. The physical and environmental safety of workers at the site and of surrounding neighborhoods had to be addressed in the work plan.
- Though the site assessment was considered complete, a petroleum seep from under a road and an underground storage tank were discovered during work at the site. These problems had to be addressed expeditiously for work to continue on schedule.
- Potential lenders for the project were concerned about liability and wanted documentation from state regulators before advancing funding. This is an ongoing impediment to the redevelopment of contaminated sites, even sites with the very favorable attributes of this property. As a representative of the developer said, "Lenders are the last holdout. The environmental aspect doesn't need to mean disaster." The VDEQ was ready to address this issue for this project. "We are an established program," says Randy Chapman, senior geologist for the VDEQ. "We used to do a closure letter to the tank owner—not to the bank. But with brownfields we will draft an 'aid and comfort' letter to the lender. We say, 'If you do this, the state will not look to you for liability issues.'"

Obviously, at this site, all major obstacles were successfully resolved. But beyond the issues listed above, redeveloping brownfields sites may still face an uphill battle. Chapman says an obstacle to the further use of the voluntary cleanup program in Virginia is the continued suspicion of regulators by the developers. "They still hesitate even if we stand there with checkbook in hand. It is still a hard sell."

The private participants in this project think a useful role for the federal government in the cleanup and reuse of contaminated sites is to help get consistency on how sites are handled across the country. Not all programs are as responsive as Virginia's. For more information on this project in Virginia, see the VDEQ Web site at *www.deq.state.va.us/brownfieldweb/success.html.*

Petroleum Brownfields Nationwide

The story of the Clarendon site is just one example of the efforts now underway to clean up and revitalize petroleum-contaminated properties across the country. EPA's Office of Underground Storage Tanks (OUST) is actively working to promote the cleanup and reuse of other sites like this, including the estimated 200,000 petroleum-contaminated brownfields sites nationwide, most of which are old unused gas stations.

A new law has expanded the use of EPA Brownfields funds to include petroleum-contaminated sites, opening up new resources to accomplish this work. EPA encourages public and private entities to become partners and address these sites and turn dilapidated and contaminated prop-

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New Study Raises Concerns Over the Other Fuel Oxygenates

by Kara Sergeant

With continuing concern over MtBE's impact on groundwater, it makes sense for state and federal governments to find an acceptable substitute oxygenate that will provide the necessary air quality benefits without threatening groundwater—unless, of course, the federal Clean Air Act Amendments oxygenate mandate is removed, altogether. Currently, 18 states have passed legislation banning MtBE from their gasoline. Other states may be considering such a ban and several bills, including the embattled federal Energy Bill, have proposed to ban the contaminant nationwide.

Since the market is shifting its eye toward an oxygenate replacement for MtBE, industry is also heavily invested in determining an ideal substitute. While there have been numerous studies on the environmental impacts of MtBE, we know very little about the environmental impact of other oxygenates.

A new California study, "Evaluation of the Impact of Fuel Hydrocarbons and Oxygenates on Groundwater Resources" (Shih et al., 2003) is one attempt at understanding the impact of other oxygenates. The authors examine the occurrence of fuel hydrocarbons and five oxygenates—*tert*-butyl alcohol (TBA), *tert*-amyl methyl ether (TAME), diisopropyl ether (DIPE), ethyl *tert*-butyl ether (ETBE), and MtBE—in groundwater at approximately 850 LUST sites in the greater Los Angeles region. The authors found that MtBE creates the greatest problem at LUST sites, followed by TBA and benzene.

TBA had the greatest maximum groundwater concentration among the study analytes. TBA is found as a fuel oxygenate and as a breakdown product of MtBE. TBA is also similar to MtBE in that it is highly mobile in groundwater, so finding high concentrations of MtBE along with TBA is a likely outcome. Although TBA and MtBE share many similar characteristics, states do not have a unified approach to detecting TBA.

The findings in NEIWPCC's 2003 "Survey of State Experiences with MtBE and Other Oxygenate Contamination at LUST Sites" show that only seven states currently have, or expect to have, TBA oxygenate action levels, cleanup levels, or drinking water standards, and three states were proposing levels or standards. The authors of the California study suggest that the presence of TBA needs to be confirmed at LUST sites so that specific cleanup strategies can be developed.

The authors of the California study concluded that alternative ether oxygenates (i.e., DIPE, TAME, and ETBE) were less likely to be detected in groundwater in the sites studied and when present were in lower concentrations—mostly because they are used less. However, their high solubility and low biodegradability rates suggest that these three oxygenates would pose groundwater contamination threats similar to MtBE if they were used on a larger scale.

There are limited data on the environmental behavior of these other oxygenates, due primarily to difficulties in delineating their extent in the environment, a lack of analytical procedures, and the lack of regulatory requirements. NEIWPCC's survey shows that six states regulate DIPE (two proposed), four states address TAME (one proposed), and only three states address ETBE (two proposed). It is clear that additional information is needed before states will adopt, regulate, or even analyze other fuel oxygenates.

The California study emphasizes the need for increased compliance and enforcement of underground storage tanks to prevent contamination in the first place. This is an ideal goal for those who work in the UST program, and many states are working on creative uses of limited resources to make that possible.

The California study is available at: *http://pubs.acs.org/cgi-bin/sample.cgi/esthag/2004/38/i01/pdf/es0304650.pdf* ■

Kara Sergeant is an Environmental Analyst with the New England Interstate Water Pollution Control Commission, which publishes LUSTLine. *She can be reached at* ksergeant@neiwpcc.org.

Court Says Rescission Is Not a Remedy for UST Insurance Providers

by Ellen Frye

In December 2001, during an environmental investigation conducted at a closed Zipmart gas station in Sterling, Alaska, on the Kenai Peninsula, nearly a foot of free gasoline product was found floating on the groundwater. An estimated 60,000 gallons of gasoline had leaked from the UST system. The contamination quickly spread to adjacent properties. The cleanup is expected to cost in excess of $1,000,000. But another problem surfaced when the owner of the gas station, Whittier Properties, Inc., notified the insurance provider, Zurich American Insurance Company, of the potential for claims. The problem had to do with misrepresentation.

In 1990, Whittier had two 10,000-gallon USTs at the site. During excavations to replace some pipes servicing the system, the contractor discovered some evidence of contamination at the fill pipes and beneath the dispensers. In August 1995, Whittier replaced the entire UST system with one new three-compartment 20,000-gallon tank. Again, the contractor discovered contamination, but this time it was more significant. Whittier chose to have the new tank installed without removing all the contaminated soil.

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Energy Bill Update

A new energy bill (S. 2095) introduced in the Senate earlier this month by Sen. Pete Domenici (R-NM) includes language identical to that contained in the 2003 Energy Policy Act insofar as how it amends the federal underground storage tank (UST) program. S. 2095 has a significantly lower cost than the 2003 Energy Policy Act, and it removes a provision that protected MtBE manufacturers under strict liability defective product theories, which doomed the bill last year.

Senate leaders are optimistic the Senate will approve the bill in March. However, House leaders have indicated they will not support S. 2095, so another energy conference committee would need to work out the differences between S. 2095 and H.R. 6, which is the House's energy bill. The Energy Bill still has a long way to go. The MtBE liability waiver will likely continue to plague efforts to reach agreement between the houses, as the House is expected to stand firm on including the waiver. ■

■ **ELD in California** *from page 17*

For those systems already in the ground, the best time to test is today. Now, rather than later, is the better time to turn off the leak. Sensitive UST-commissioning tests for new systems and assurance tests for operating systems make sense these days at a time when the tolerance for even small leaks is waning. ■

Randy Golding, Ph.D., is a business development project manager with Praxair Services, Inc. He spent 14 years in research and development with Tracer Research Corporation, recently acquired by Praxair Services, a subsidiary of Praxair, Inc. He received his graduate degree in chemistry from the University of Arizona and has published articles on surface chemistry, separation techniques, soil vapor survey methods, and applications of chemical tracers in leak detection. He co-authored "Underground Storage Tank System Field-Based Research Project Report" with Tom Young, Ph.D, at the University of California at Davis. Randy can be reached at (800) 394-9929 ext. 204, or at randy_golding@praxair.com

■ **Urban Cinderella** *from page 24*

erties into new housing, retail businesses, parks, public buildings, wetlands, or revitalized riverfronts that provide both environmental and economic benefits for surrounding communities.

OUST wants to hear of other efforts to clean up and reuse petroleum-contaminated properties: please send information to Steven McNeely, *mcneely.steven@epa.gov*, (703)603-7164. For information on EPA's program for cleaning up and reusing petroleum-contaminated tank sites and for more examples of other reuse projects already underway, see the EPA Web site at *www.epa.gov/oust/20 recycl.htm.* ■

Barbara Howenstine works in the EPA Office of Underground Storage Tanks. This venture was not an EPA project, but it is one example of the efforts now underway to clean up and reuse petroleum-contaminated sites across the country. The views expressed in this article do not necessarily reflect the position of the Agency. EPA does not endorse the commercial ventures mentioned in the article.

SNAPSHOTS FROM THE FIELD

Florida Worker Killed as Tank Explodes During Cutting

Pete Watson, a 33-year-old father of three, was blown into the air and killed while decommissioning a 10,000-gallon tank outside the Victory Market convenience store in Brandon, Florida, last November. Another worker was critically injured. The market had been closed, and the owner was having the tanks removed so the land could be sold or developed for other uses. The tanks had been removed from the ground and sitting on the site for several days. On the day of the accident, nine workers, including the victims, had been flushing the tanks with water and inerting them with dry ice. The workers then used an electric saw to cut large holes in one end of each tank. As Watson began cutting into the third tank, it exploded, killing Watson instantly, shooting flames into the vacated convenience store, and shaking buildings in the area and blocks away. The federal Occupational Safety and Health Administration conducted an investigation at the site and will issue a report. Speculation is that not enough dry ice was added to the third tank and that the oxygen was not measured prior to cutting the tank.

Photos courtesy of Domenic LetoBaron, FL. DEP

If you have any UST/LUST-related snapshots from the field that you would like to share with our readers, please send them to Ellen Frye c/o NEIWPCC.

■ **Court Decision** *from page 25*

A site assessment prepared by an environmental contractor in October 1995, disclosed the contamination to the Alaska Department of Conservation (ADEC). The contractor recommended that Whittier further investigate the extent of the contamination. Apparently, Whittier failed to do so and ignored ADEC's frequent correspondence urging corrective action.

Misrepresentation

In 1999, Whittier submitted an application to Zurich for a "Storage Tank System Third-Party Liability and Corrective Action Policy." In response to a question on the application concerning prior contamination at the site, Whittier's owner indicated that she was not aware of any. (The owner purportedly believed that the question asked only if leakage or contamination had occurred for the new tank that the policy would cover, not prior contamination at the site.) Relying on the owner's answers, Zurich issued the policy for an annual premium of $350. This covered any release of contamination from the new tank after December 9, 1997.

The contamination discovered in December 2001 was substantially greater than the levels found in 1995. Learning of the prior contamination at the site, Zurich denied its obligation to indemnify any third-party claims under the policy and initiated a lawsuit, demanding rescission of the policy due to Whittier's alleged misrepresentation of former contamination on the policy application. The district court granted summary judgment to Zurich, holding that Whittier made material misrepresentations and that rescission was appropriate under Alaska law. Whittier appealed.

Reversed and Remanded

On appeal, the U.S. Ninth Circuit Court of Appeals reviewed the district court's decision on the assumption that Whittier made a material misrepresentation on the Zurich application *(Zurich American Ins. Co. v. Whittier Properties Inc.)*. Based on this assumption, it focused on the district court's holding that Zurich could rescind the policy in the context of state and federal regulations governing insurance coverage for USTs. U.S. EPA regulations, which Alaska has expressly adopted in its regulations, require proof of financial responsibility (FR) for the operation of a facility with an UST and that an insurer give notice of cancellation of insurance to the UST operator prior to the cancellation. Attention to the details of cancellation are meant to alleviate the potential impact that an UST owner's inability to fund a contamination cleanup could have on the environment and innocent third parties. FR can be met with a specified amount of insurance coverage.

EPA made it clear in crafting its UST regulations that the cancellation remedy is exclusive of other, potentially inconsistent remedies. In the event of the insured's misrepresentation, the remedy would be a cancellation of the existing policy and future refusal to provide insurance. The court gave great judicial deference to EPA's interpretation of its own regulations and held that allowing rescission would render EPA's efforts to avoid periods of uninsured UST operation close to meaningless. The district court's decision regarding rescission was reversed and all remaining issues were remanded back to the district court for further consideration. Zurich may seek contract or tort damages from Whittier if warranted. ■

OUST Launches Year-Long 20th Anniversary UST Program Celebration

The U.S. EPA Office of Underground Storage Tanks (OUST) is planning activities to celebrate the 20th anniversary of the UST program and acknowledge the program's achievements as well as future challenges. See OUST's Web site (www.epa.gov/oust) for planned events and milestones. ■

Total Containment Files Bankruptcy

On March 4, Total Containment, Inc., marketers of secondary containment flexible piping systems, filed a bankruptcy case with the U.S. Bankruptcy Court, Eastern District of Pennsylvania case 04-13144. The petition can be viewed at www.paeb.uscourts.gov. ■

Georgia Woman's Hair Catches Fire at Gas Pump

According to a December 5, 2003, Associated Press report, an Albany, Georgia hair stylist was pumping gas into her car at a gas station when her hair burst into flames. Her husband, a firefighter, who happened to be with her at the time, said the fire was probably caused by static electricity from his wife's hair rubbing against her clothes. (The static electricity apparently mixed with gas fumes and ignited the fire.) While putting out the fire in his wife's hair, he saw flames coming out of the gas tank. The blaze was quenched with a fire extinguisher. The victim had to cut her hair and get her truck repaired. Her husband advised people to ground themselves before pumping gas by touching the metal of their cars. "Once you get out of your vehicle, don't get back into the vehicle until you are through,'' he said. ■

L.U.S.T.LINE Is Now Available on the Web

NEW!

Alright, okay, you win! Our readers' poll on whether you want to receive *LUSTLine* electronically or continue to get a paper copy in the mail ended in a dead heat; your votes were split right down the middle. So here's the deal for the time being. Subscribers will receive their paper issues in the mail, as usual. But now anybody can access *LUSTline* at the recently revamped New England Interstate Water Pollution Control Commission Web site: *www.neiwpcc.org/lustline.htm.* Is everybody happy?

Keep in mind, the NEIWPCC Web site is a work in progress. From now on it will provide entire issues for your reading pleasure. Previously, only cover articles were available. Past cover articles will be archived on the Web site. News updates may be available in the future.

We want to hear from you too. Let us know what you think about our stories, and let us know about stories from your neck of the woods. Enjoy!

L.U.S.T.LINE INDEX

August 1985/Bulletin #1 – October 2003/Bulletin #45

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