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Bulletin 40 March 2002

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



Tanks at Ground Zero

by Karen Gomez

On September 11, like many others, I watched with disbelief as the World Trade Center buildings collapsed. In dealing with the sheer horror of this attack and the human tragedy, I recognized that there was still a need to address the environmental aspects of this event. Within the first few hours following the tragic collapse of the World Trade Center buildings, I, like many other New York State Department

of Environmental Conservation (DEC) staff, was summoned to the DEC command post to assist in the agency's response efforts. As an engineer responsible for DEC's spill response and petroleum and chemical bulk storage programs on Long Island, I was asked to focus on these same issues as a preliminary assessment of the damage was conducted.

World Trade Center Response Petroleum Bulk Storage Tank Inspections for WTC Area Legend Inspection Zones Spill NOT Associated W/Tank identified at inspected Facility N.Y.S. Department **Environmental Conservation** Map created by DIS GIS Unit 12/05/01

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Industry Gives the Nod to S. 1850

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An Assessment Strategy

The seven buildings in the World Trade Center complex were either destroyed or partially collapsed. In addition, several other buildings adjacent to the World Trade Center suffered major structural damage. Based on the earthquake-like force of the catastrophic collapses of the buildings, we believed this destruction had the potential to cause structural damage to chemical and petroleum bulk storage tanks and systems in the vicinity of the site.

We concluded that a high priority in DEC's response effort would be to use the department's resources to identify and assess bulk storage systems to prevent further collateral damage from releases from those tanks, and in so doing, protect the health and safety of the recovery workers and the environment.

In the weeks that followed, I was given responsibility for coordinating



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the development and implementation of a plan to assess the structural integrity of the bulk storage tanks and associated systems in proximity to the World Trade Center. DEC's response was intended to prevent and alleviate immediate and future releases of hazardous substances or petroleum that could threaten the health and safety of recovery workers and the public or further impair the environment.

The World Trade Center complex had a storage capacity of more than 80,000 gallons of petroleum, and the adjacent buildings had a storage capacity of more than 170,000 gallons of petroleum.

Working with my colleagues, I developed a phased approach that prioritized inspections in areas that had received the most structural damage. The inspection areas were divided into three zones (see map on cover) within an area encompassing approximately one third of a square mile around the World Trade Center.

To assess the extent of damage within a short period of time, we established percentage goals for tank inspections in each zone to coincide with the extent of building damage in each area. The goals were as follows:

- Zone 1 The area in which buildings collapsed or suffered major structural damage—100 percent inspection.
- Zone 2 The area in which most buildings were damaged but stable—50 percent inspection.
- **Zone 3** The area in which a few buildings were damaged and stable—25 percent inspection.

This phased approach provided us with the opportunity to continuously evaluate the inspection results within each zone and adjust percentage goals for tank inspections accordingly

Utilizing the state's tank registration database and the New York City Fire Department's database, we developed a list of storage tanks within each zone to allow DEC to efficiently and accurately assess the condition of the storage tanks and associated piping. These databases were critical for developing the plan; however, we could not rely on them alone as they did not always include small unregulated tanks.

Implementation

Implementation of the plan required deploying personnel within the constraints of security and health and safety at Ground Zero. With a team of trained DEC spill responders, we commenced the tank inspections in accordance with the plan during the first week of October. The inspections focused on structural damage assessment, which included the following:

- Inspection of fill pipes, product piping, and vent pipes for damage and functionality
- Inspection of tanks for leaks, damage, or stability problems
- Inspection of electronic monitoring systems designed to register leaks and failures

When the inspector identified any damage to the tank or system, DEC advised the tank owner to make the necessary repairs and take any necessary precautions. If there was a release from the tank or system, DEC advised the tank owner to initiate a cleanup or made arrangements with the U.S. EPA to utilize one of their emergency contractors to empty the tank and initiate cleanup.

Findings

Initially, DEC inspectors made slow progress in completing the inspections, due to security, accessibility, health and safety issues, and the recovery activities at Ground Zero. By early November, however, DEC had completed inspections of 84 tanks ranging in size from 275 gallons to 20,000 gallons at 42 buildings. All of the tanks contained either fuel oil, diesel, or kerosene, which was used for heating purposes or as fuel for backup generators. There were no regulated gasoline tanks since there were no fueling facilities in this area of Manhattan.

Except for 18 underground tanks, all of the tanks were aboveground within the buildings. In Zone 1,



DEC inspector on top of a 20,000 gallon tank that was crushed by the partial collapse of a building.

except for 6 of 12 tanks in Buildings 1 and 2 of the World Trade Center, DEC inspected all of the buildings and associated tanks.

DEC inspectors identified three tanks in two buildings that were damaged as a direct result of building collapses; two buildings with three tanks with piping damage; and two buildings with eight tanks with the fill and/or vent pipes that could not be inspected because they were buried by debris-these will be tested before being put back into service. In addition, one of two chiller plants containing Freon damaged in Building 1 of the World Trade Center-the EPA made arrangements to recover the remaining Freon from these plants.

In Zone 2, DEC completed inspections of 63 percent of the tanks. DEC inspectors identified two buildings that had two tanks with piping damage. For Zone 3, based on an evaluation of Zone 2 findings (only two tanks out of a total of 34 tanks with piping damage), we concluded that further comprehensive inspections were not necessary. Instead, as DEC routinely follows up on minor spill incidents in buildings in Zone 3 (and buildings in Zone 2 that were not inspected), spill responders will be inspecting all tanks and appurtenances.

Follow Up

Except for one building that suffered minor piping damage, all of the tank and piping damage were in buildings that collapsed or suffered major structural damage. Building owners have already initiated or completed repairs of any tank or piping damage. The inspection results indicated that there were very few tanks that were damaged in Zone 2; however, as a precautionary measure, DEC contacted owners of storage tanks that it did not inspect in Zones 2 and 3 to advise them to independently inspect their tanks and piping. Tank owners were instructed to notify DEC for a follow-up inspection if they discovered piping or tank damage.

While conducting the tank inspections, DEC inspectors also checked buildings and the surrounding areas for other spills that were not associated with tanks. The inspectors discovered and followed up on hydraulic spills from elevator shafts, minor spills associated with recovery operations at Ground Zero, and a significant spill from the electric substation beneath Building 7 of the World Trade Center, which contained more than 100,000 gallons of transformer oil and dielectric fluid.

Upon Reflection

Standing at Ground Zero and looking at the immense destruction surrounding the World Trade Center complex, it seems incredible that the damage to the tanks and piping was not greater. The World Trade Center complex had a storage capacity of more than 80,000 gallons of petroleum, and the adjacent buildings had a storage capacity of more than 170,000 gallons of petroleum. However, the World Trade Center destruction damaged only three tanks with a combined storage capacity of 32,000 gallons and caused small to moderate spills from five additional tanks with piping damage. Overall, the storage tanks and their piping suffered very little damage.

I completed my assignment in November; however, spill responders from the New York City office continue to deal with spill-related matters at the recovery site. ■

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Oxygenates

When MTBE Struck Pascoag...

An Abridged Chronicle of the Impact of an MTBE Release in a Rhode Island Village

by Paula-Jean Therrien

rior to the summer of 2001 the state of Rhode Island had the good fortune of having had no public water supplies shut down due to MTBE contamination. We had been monitoring for MTBE in public water systems since the 1980s, and the results were so far, so good. Our clean slate gave us the luxury of listening sympathetically to the stories of public water supply disasters, relieved that such hardships were not ours. But that situation changed dramatically this past Labor Day, when the village of Pascoag was found to have a public water supply emergency due to contamination by MTBE.

The ensuing events have been dizzying, and I can not possibly present all the facts of this complex event from the perspectives of all involved. The experiences of those intimately involved, including numerous officials and agencies from the village, the town, the state, and, most importantly, the residents and businesses of Pascoag, would fill a book. In the interest of space, therefore, I will discuss the events of most impact to the work of the Underground Storage Tank Management Program of the Rhode Island Department of Environmental Management (DEM).

Discovery

Pascoag is one of many villages in Burrillville, a town in the rural northwest corner of the state. The village's public water was drawn from a wellfield that the Pascoag Utility District used to service over 4,000 people. Around 400,000 gallons of water per day were pumped from the wellfield. A new well (Well 3A) had been installed and put on line in the spring of 2001 to supplement an existing well (Well 3).

Quarterly sampling required by the Rhode Island Department of Health (DOH) for all new public wells had been conducted, and no contamination had been found in the May sampling. MTBE was a target compound in this quarterly monitoring. During the summer, however, a resident of Pascoag found that the water from his tap tasted bad. He had a water sample tested in late August, and elevated MTBE was reported. DOH sampling confirmed that finding and thus began a five-month nightmare for the residents and businesses of Pascoag.

Tracking Down the Source

The discovery of this drinking water emergency and the ensuing multiagency response occurred throughout the Labor Day weekend. Emergency Response personnel from the Office of Compliance and Inspection were DEM's first responders.

On Labor Day, personnel from DEM's Underground Storage Tank Management Program were called to the office to pore through DEM files to identify and review information on all registered UST facilities storing gasoline and all known LUST sites in Pascoag.

The DEM initiated an investigation that week, sampling existing monitor wells and installing additional wells with a Geoprobe in areas that the file reviews identified as potential source sites. This effort yielded enough information to narrow the list of most likely sources to two—the Burrillville Department of Public Works (DPW) and Main Street Mobil. Both sites were approximately 1,700 feet from the impacted public wells, the DPW to the northeast and the Mobil station to the southwest.

The Burrillville DPW had conducted a DEM-approved corrective action after discovery of a gasoline release in 1996. As that investigation had not included off-site bedrock wells, the DEM issued an Immediate Compliance Order (ICO) to the town of Burrillville on September 13 to install bedrock wells to determine if any contamination was migrating toward the public wellfield from the DPW. Burrillville installed the required wells and sampling results provided no indication that the DPW was the source of the contamination of the public water supply.

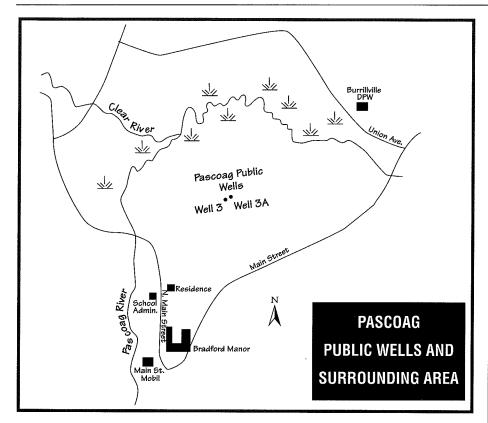
Main Street Mobil, an operating gasoline station with three 6,000-gallon gasoline USTs, became the most likely source. Free-phase product and high dissolved concentrations of gasoline constituents, including MTBE, had been found in a Geoprobe well that DEM installed in the sidewalk directly in front of the station.

An ICO was issued on September 13 to the owners and operators of the Main Street Mobil station to test the UST systems for leaks and conduct an investigation in both the overburden and bedrock. The USTs tested tight on September 19. The operators hired an environmental consultant who installed overburden wells and a recovery well on-site and recovered some product, but they did not install the required bedrock wells.

Unsatisfied with the owners' and operators' response to the ICO, on September 24, the DEM and the Rhode Island Attorney General's Office filed a complaint in the Providence County Superior Court to compel compliance with the ICO. At a hearing on September 25, the court froze the assets of the owners and operators and required the parties to exchange documentation; however, it denied the state's demand for immediate off-site and bedrock investigation activities. Instead, the court permitted the operators to perform a more limited on-site investigation and directed the parties to return to court on October 3.

Liquidation

On September 26, Pascoag residents began picketing the station. In response, the operators removed the product from the USTs, effectively



closing down all operations. Back in court on October 3, the state won a court order directing the owners and operators to begin installing off-site bedrock wells. On October 12, DEM issued a Notice of Violation (NOV) with penalties against the owner and operator for prerelease violations.

On October 23, DEM learned that the consultant had ceased work on the project and removed some remedial equipment because he was not being paid. The operators filed a motion in court asking to be relieved from the October 3 order due to an alleged financial inability to comply. The state countered with a motion to have the operators held in contempt. At a hearing on October 30 the court adjudged the operators in contempt and placed them into receivership. At the same time, the court provided DEM with full access to the property for the purpose of performing all necessary investigation and remediation from then on.

On November 2, the two operators, Potter Oil, Inc. and Medea LLC filed voluntary bankruptcy under Chapter 7 (liquidation) of the U.S. Bankruptcy Code. The principals of these corporations are members of a family that owns and operates other gasoline stations and businesses in Rhode Island under different corporate names. The financial relationship

between these various corporations and the corporations that operated the Main Street Mobil station is part of the bankruptcy investigation.

One of the gasoline stations that these principals own and operate in Warwick, Rhode Island, was the site of a release discovered in 1997 that had an impact on an adjacent neighborhood and wetland area and that required the DEM to issue formal enforcement actions to compel remedial actions. A release at another station operated by the same principals affected a number of private residential wells in Middletown, Rhode Island.

Water for Pascoag

When the contamination was discovered, the concentration of MTBE in the wellfield was around 350 to 400 parts per billion (ppb), an order of magnitude above the drinking water health advisory level of 40 ppb established by the DOH for MTBE. The DOH issued health advisories informing residents that the Pascoag water should not be used for drinking, cooking, or bathing small children. Bottled water was provided by various organizations. The DEM arranged for delivery of bottled water, first to the Pascoag Utility District for customer pickup and then to

homes. Sixty gallons per month were provided, assuming four people per household. Larger households could get another 15 gallons per month for each additional person.

Frequent sampling of the public wells by the DOH had showed a continuing rise in MTBE concentrations in the wellfield. Concentrations rose from over 600 ppb at the end of September, to 1,100 ppb by the end of October, to a high of 1,700 ppb by the end of December. The DOH issued health advisories asking residents to limit showering time, ventilate to reduce exposure to MTBE vapors, and reduce overall water use in an effort to minimize the pumping of the wells, which was drawing MTBE to the wellfield.

Beginning at the end of September, public water from Harrisville, a village just east of Pascoag, was piped into the Pascoag distribution system at a rate of 100,000 gallons a day to dilute the MTBE contamination. While this reduced the concentration of MTBE, it still remained elevated—on the order of several hundred ppb.

A carbon filter system was installed in the wellfield in mid-November, reducing MTBE concentrations from 1,200 to 1,700 ppb to under 100 ppb and in some cases to under 40 ppb. However, the health advisories issued by DOH remained in effect. Carbon filtering of the contaminated Pascoag well water was expensive, requiring frequent carbon replacement, and was only meant to be a short-term action.

The neighboring village of Harrisville provided the long-term solution. The Harrisville Fire District had been planning a new wellfield for some time. In response to the Pascoag emergency, they accelerated the permit application process, installed three wells in Eccleston field, and were ready to provide water to Pascoag by the beginning of 2002. However, a disagreement arose between Harrisville and Pascoag as to the administration of the water districts. Harrisville required that the two water districts merge before Harrisville would provide water to Pascoag. Pascoag was concerned about the degree of representation they were afforded in the merger that was proposed.

■ MTBE at Pascoag from page 5

On January 11, 2002, the court ordered that Pascoag shut down its wells and that Harrisville supply water to Pascoag. The details of the merger could be worked out later. Harrisville residents had voted to approve the proposed merger, but on January 14, the residents of Pascoag voted it down. The good news was that water was flowing from Harrisville to Pascoag. Coliform bacteria was detected during system flushing, but it quickly cleared and on January 19, the residents and businesses of Pascoag at long last had clean drinking water flowing through their taps.

Investigation and Remediation

The investigation of the area impacted by this release began immediately after discovery of the contamination in the public wells. While a consultant working for the Pascoag Utility District installed monitor wells in the wellfield, the operators' consultant and then DEM's technical contractor installed monitor wells in the area of Main Street Mobil.

It became clear that due to the presence of free-phase product onsite and off-site around the Mobil station, the DEM had to prioritize the removal of the source. DEM's investigation and remediation efforts to date have focused on the source area. Multiple monitoring wells for both overburden and bedrock have been installed. A soil vapor extraction system was successfully pilot tested and a full system has been installed on-

site and is in operation.

A total of over 1,200 gallons of product had been recovered from the site as of mid-January. A trench for the recovery of free product and contaminated groundwater was installed and in operation by the end of January. An abandoned 2,000-gallon gasoline tank containing about 500 gallons of product was discovered during installation of the recovery trench. Analysis of that product has identified it as leaded gasoline, not a source of the MTBE that contaminated the Pascoag wells. The DEM is conducting weekly gauging and sampling of monitoring wells, with analytical services provided by the EPA laboratory.

It is not yet known what caused the release or when it occurred. The single-walled tanks, which had been lined and cathodically protected prior to the 1998 deadline, tested tight in September. While we suspect it is a more recent release, it is possible that the release occurred years ago. Piping was replaced in 1994 without the required notification to and approval from the DEM. The required monitor wells were not installed. The DEM has focused resources on investigation and remediation of the released product. The tanks will be removed when funds for that work are available; however, all product has been removed from the tanks.

Indoor air issues arose in November. DEM responded to odor complaints from Bradford Manor (an elderly housing facility), from a small school administration building, and from a private residence—all downgradient of the station. Venting and sealing cracks abated the problems at the school building and the manor. An air filtration unit was necessary for the basement of the residence to reduce benzene concentrations; a consultant hired by the homeowner later added an air exchange unit.

As usual, bedrock has made the investigation challenging. Pascoag's new public well (Well 3A) was installed 9 feet into the bedrock, intersecting two large fractures. Solid casing was sealed into the bedrock, isolating the well from the overburden. The older well (Well 3), which is located 8 to 10 feet away, had been installed only to the bedrock surface. Each well was pumped at rates of up to 500 gpm.

It is not clear if the timing of the finding of MTBE contamination in the wellfield was due to a recent release or if Well 3A was pumping water from deeper in the bedrock and intercepted an older MTBE plume that Well 3 had not. Bedrock exists at and near surface in the area of the Main Street Mobil, and it has complicated the mapping of the product plume and the interpretation of dissolved contamination results. It will also certainly pose an added degree of difficulty for remedial efforts. Additional bedrock monitoring wells will be needed to fully delineate the contamination; only then can DEM determine the best remedial approach for the dissolved contaminant plume.

The Pascoag wellfield, which has been pumped at a high rate and continuously for years, has just been shut down. The effect this shutdown will have on the groundwater and the plume of contamination in this area remains to be seen. Will the water table rise to surface and flood people's yards? Will indoor air contamination in buildings over the plume become a larger problem as the water table rises? If it becomes necessary or advantageous to resume pumping of the wellfield, treatment and disposal of the water will be a significant issue.

Funding Sources

Funding for the huge costs incurred by response to an emergency of this magnitude is challenging. It became apparent early on that significant funds would not be available from the owners or the operators of Main Street Mobil. Circumstances are as follows:

- The DEM had about \$400,000 available from EPA LUST Trust funds. This money has been used to fund DEM's actions, including the investigation and remedial work conducted by DEM and its technical assistance contractors and the bottled water delivery to the residents of Pascoag.
- The application by the operators of Main Street Mobil to the UST Financial Responsibility Fund was denied because of noncompliance identified in the unresolved NOV. After the DEM became the performing party, up to \$350,000 was offered by the Fund Board to install and operate the carbon filtration system on the Pascoag wells. The Fund is also available to reimburse third-party claims by Pascoag residents and businesses that incurred expenses related to the water emergency. Additional monies will be sought from the Fund for DEM's continuing investigation and remedial action.
- DEM has submitted an USTfields grant application for up to \$100,000 to be used for work at Main Street Mobil. This includes removal of the USTs and contaminated soils and installation of additional overburden bedrock wells, both on-site and off-site.

Epilogue

The contamination of the Pascoag wellfield has been a very public issue that seriously impacts all the people who live and work in Pascoag. It has drawn constant local and statewide media attention. With such attention comes criticism. A frequent and expected criticism of agencies involved in a complex response such as this is that the time it takes to accomplish the various tasks associated with the emergency is longer than the public thinks it should take. And certainly a review of events could result in lessons for the future.

This event has heightened statewide awareness of the consequences of contamination in our public water supplies. State and local agencies are reviewing what can be done to prevent problems in the future. DEM regulations prohibit the installation of new USTs in wellhead protection areas, although this event involved a facility that existed before the regulations took effect. DEM has prioritized compliance inspections at gasoline stations in GA groundwater areas, where the groundwater must be suitable for public or private drinking water use without treatment. Communities can optimize protection of their public water supplies by controlling land development and creating buffer zones.

The incident is hardly over for many, including the DEM. The investigation and remediation of groundwater contamination in bedrock to drinking water standards is a difficult assignment and one that the DEM will be working on for some time to come.

Paula-Jean Therrien is a Principal Environmental Scientist in the Underground Storage Tank Management Program of the Office of Waste Management of the Rhode Island Department of Environmental Management. Paula-Jean acknowledges contributions from Patrick Hogan, Senior Engineer and DEM Project Manager for the Main Street Mobil LUST site, and from Brian Wagner, Esq., of the DEM Office of Legal Services. Paula can be reached at (401) 222-2797 ext. 7125 or pjtherri@dem.state.ri.us

Getting Started with UST Owner/Operator Education in Florida, California, and Oregon

Florida's Tank School

Tank School is an online training course developed for and approved by the Florida Department of Environmental Protection (DEP). It provides information designed to help owners/operators (O/Os) avoid costly UST system problems and comply with all the requirements of the Florida Storage Tank Rule. All DEP storage tank rule requirements are covered in separate AST and UST tracks. Forms, manuals, rule definitions and other helpful materials can be downloaded and printed to assist in regulatory compliance and provide valuable reference material. Tank School may also be used to reduce the cost of tank insurance premiums since insurance companies consider the positive benefits of training programs in evaluating the risk of loss to be insured.

The course can be purchased with a major credit card for \$200 and accessed any time, anywhere, for a 90-day period via the Internet. Multiple choice and true-false tests are included in the course materials. Persons successfully completing the course can print a course completion certificate. To find out more about Tank School, log onto www.fltank.learnsomething.com, or contact Bill Reeves at (850) 385-9443 or by e-mail at Br1009@aol.com.

California O/Os Will Need to Meet New Standards

California's Legislature recently adopted Senate Bill 989 (Stats. 1999, Ch. 812), requiring various parties, including UST owners and operators, to "meet minimum industry-established training standards." The legislation required the State Water Resources Control Board (SWRCB), which oversees the UST program in California, to adopt regulations implementing this requirement. UST program staff established a workgroup of industry representatives, consultants, and local regulatory agencies to develop industry-based owner/operator training standards. SWRCB staff expect to propose regulations requiring individual(s) responsible for the day-to-day operation of UST facilities to be trained in accordance with the standards developed by the workgroup. To satisfy this requirement, individuals could either pass an exam provided by an independent third-party testing organization or complete an approved training course. SWRCB staff are also working with the International Conference of Building Officials (ICBO) on their UST owner/operator certification program.

California's UST owner/operator training program is still under development. For more information, call Shahla Farahnak at (916) 341-5668 or Scott Bacon at (916) 341-5873.

Oregon Legislature Mandates Operator Training

Oregon's 2001 Legislative Assembly directed the Department of Environmental Quality (DEQ) to develop rules for a mandatory operator training program. A subcommittee comprised of DEQ UST staff and industry representatives has been working on a draft proposal since October 2001. DEQ's full Advisory Committee met on February 19, 2002, to discuss the draft proposal. The agency expects to have a public comment period in July, with the presentation of draft rules to the Environmental Quality Commission in September 2002. For additional information, contact Laurie McCulloch, Senior UST Policy Coordinator at 503-229-5769 or e-mail at mcculloch.laurie@deq.state.or.us. Information on this effort will be posted on the DEQ Web page at: http://www.deq.state.or.us/wmc/tank/USTAdvisoryCommittee.htm.

Oxygenates

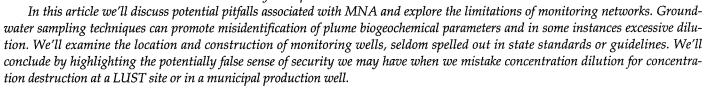
Natural Attenuation: Is Dilution the Solution?

by Joseph E. Odencrantz, Mark D. Varljen, and Richard A. Vogl

ust as it was beginning to look like we were winning the remediation battle at groundwater contamination sites, the impact of MTBE releases reared its ugly head. In the midst of our remediation battle and our MTBE discoveries, we have seen the blossoming of a management strategy for contaminated groundwater known as monitored natural attenuation, or MNA. MNA refers to the reliance on natural attenuation (see definition below) processes within the context of a controlled and monitored site cleanup approach to achieve remedial objectives.

A close examination of the application of MNA, however, reveals some potential problem areas involving the misidentification of processes that govern contaminant plume behavior. These problems are often the result of the misapplication of simulation modeling techniques and/or consideration of unrepresentative data due to outdated or inappropriate monitoring well construction and sampling approaches. Dispersion on a grander scale has been advocated at municipal production wells as one approach to diluting the problem plume.

Such problems have become especially apparent at MTBE release sites, where the use of MNA could present the danger of a potential false sense of security. We may be encouraging "walk away" site closures when active remediation should really be implemented.





The term "Natural Attenuation" (NA) has been defined as "naturally occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media" (Wiedemeier et al., 1999). This popular definition goes on to mention that the "in-situ" processes of NA include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants, meaning that natural attenuation is composed of numerous contributing factors of which biodegradation is only one.

In practice, unfortunately, the term "natural attenuation" is often used synonymously with such terms as intrinsic bioremediation, self remediation, natural restoration, passive bioremediation, or intrinsic remediation. The negative result of this is that it is increasingly common to interchange "natural attenuation" with "remediation," when in fact they are not synonymous.

Natural attenuation occurs to some degree at every site; however, depending on site conditions, there can be definite limits to its effectiveness as an interim or long-term solution because natural attenuation does not necessarily imply that contaminants are removed. Furthermore, the site-specific conditions that often limit the effectiveness of natural attenuation as a contaminant removal/ destruction process are rarely properly evaluated. It is vital that we distinguish between destructive processes and dilution. To do this it is first necessary to establish the types of biological processes that may be induced or monitored at a site.

Intrinsic or Engineered?

Hmm.

Wonder what

became of

yesterday's

smoke.

Consider a "Biologically Active Zone," or BAZ, which occurs in close proximity to the contaminant source in the presence of electron donors in the mix of available electron acceptors. Contamination that escapes the BAZ escapes biological reaction and continues to move downgradient. Perhaps this is the reason why many of our chlorinated solvents plumes are so long (miles and kilometers long). For chlorinated solvents dissolved in water, biodegradation typically occurs within a BAZ, and the limiting factor is the availability of electron donors (primary substrates) for which a zone of increased biological activity can be established. In other words, there must be some growth of bacteria in order for biodegradation to occur, and growth requires the overlap of bacteria, electron donors, and acceptors.

Biodegradation can be either intrinsic or engineered. Intrinsic biodegradation processes refer to those which occur under indigenous aquifer conditions within the contaminant plume. Contaminant plumes vary in size and shape in accordance with each constituent, as does the intrinsic biodegradation rate of each of these compounds. Oxygen is often consumed near the source of a gasoline leak by the indigenous bacteria, using benzene as an electron-donor and oxygen as an electron-acceptor. In the far-field region of the plume, indigenous oligotrophic bacteria (those which survive on trace levels of substrates) may be stimulated by some gasoline constituents, causing biodegradation to occur at slow rates.

Engineered biodegradation refers to the adding of nutrients, bacteria, electron-acceptors (e.g., oxygen, nitrate, sulfate) and perhaps other electron-donors (e.g., molasses, lactate) primarily in the near source area to develop a healthy BAZ. Flow control or a circulation system to aid in the efficiency of the BAZ sometimes accompanies this in situ biodegradation.

In examining the potential biodegradation of a compound in the field, you should rely on other lines of evidence such as tracers, microcosm studies, lack of degraders, published biodegradation pathways, comparison of movement to the other constituents in the source, and changes of mass of the compound (National Academy of Sciences, 2000).

Regardless of the type of biodegradation process that may be occurring at a site, establishing lines of evidence on a compound-by-compound basis is necessary. An examination of the spatial variability of oxidation-reduction potential and dissolved hydrogen may provide us with some idea of the potential zones of dominant biodegradation regions; however, it does not necessarily tell us if there has been biodegradation of a particular compound.

For intrinsic biodegradation processes, how do we determine if decay rates are sufficiently large to cause a change in mass or if biodegradation is occurring at all? Unfortunately, these biodegradation processes are commonly misidentified, and decay rates are, therefore, incorrectly determined.

Puff of Smoke

A recent study conducted at the Borden Aquifer, Borden Airfield, Ontario, Canada, focused on a 16-month university research project which was extended to 8 years after the initiation of the original project (Schirmer and Barker, 1998). Eight years after MTBE was instantaneously (for all practical purposes) injected into an aquifer, the researchers decided to "go find it."

Natural attenuation occurs to some degree at every site; however, depending on site conditions, there can be definite limits to its effectiveness as an interim or long-term solution because natural attenuation does not necessarily imply that contaminants are removed.

The researchers only found 3 percent of the injected mass and conthat 97 percent had biodegraded—simply because they didn't find the mass. This is analogous to trying to find all the smoke from a puff of smoke released to the outdoor air 7 hours after its release (assume dispersion in air is 10,000 times that in water; 8 years is 70,080 hours). Finding all of this smoke is clearly something that we would not expect to be possible, yet when reviewing this work, few seem to consider that perhaps the researchers simply didn't find (or couldn't quantify) the dispersed contaminant.

The work was excellent with respect to quantifying the natural attenuation of a small instantaneous amount of MTBE; however, it did not document biodegradation. There was no definitive proof (such as the presence of metabolic byproducts) presented that suggests biodegradation of MTBE occurred in groundwater. Unfortunately we are now seeing this assumption of intrinsic decay being carried forth in practice by both the consulting and regulatory communities. What was missed in the research was recognition that natural attenuation of MTBE can occur, under the right set of circumstances, in the absence of biodegradation processes.

So where do you draw the line between dispersion/dilution and biodegradation? You must first determine whether changes in concentration are changes in mass of the plume or if the plume has moved to places unknown in the aquifer.

Decay, Dispersion, and Misnomers

Monitored natural attenuation protocols (OSWER Directive 9200.4-17P, 1999) generally involve the collection of biogeochemical data from groundwater monitoring wells at sites. The data are correlated in time and space with the various chemicals of concern (COCs) to establish predominant biodegradation mechanisms.

In evaluating the size, behavior, and mass of groundwater plumes, monitoring wells are sampled by a variety of techniques at fixed locations. This protocol assumes that the monitoring wells fully delineate the plume and that there is an adequate number of wells to calculate a plume mass every time the wells are sampled (unfortunately this is not often the case in practice).

Under this assumption, though, can we really give some kind of explanation of what the plume is doing (i.e., expanding, remaining stable, or shrinking) by examining the time history of concentration of a gasoline compound at a well? Of course this depends largely on where the well is located (i.e., source proximity), how it was constructed (e.g., type, screen length), and how it was sampled (i.e., low-flow, traditional purge, or no purge). If the concentration rises and drops over a 2-year period, does this mean that the plume is shrinking, that is has moved past the well, or that there is a change in flow direction?

This question cannot be answered unless we look at the conceptual model of the site, changes in concentration at other wells, and, perhaps, changes in other biogeochemical parameters—parameters that are often overlooked. So the biodegradation is being inferred, rather than directly confirmed.

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These considerations are intuitive, and most practicing professionals routinely use standard methods and state guidelines to work through these types of evaluations. When evaluating the dominant attenuation processes, obtaining representative data from monitoring wells is a critical first step in moving onto isolating NA processes. The importance of collecting representative sampling data (as influenced by well location, construction, and sampling protocols) cannot be underestimated. This will be discussed further in later sections of this article.

Assume for the moment, however, that we have not only an adequate number of wells to fully delineate our plume but that there are only nondestructive NA processes at work (i.e., advection, dispersion, sorption, and volatilization) and we can predict them perfectly using models (another assumption that is never really achieved in practice).

Now if sorption and volatilization were minimal, the mass of the plume would remain virtually constant if we calculated it each time from the concentration in the wells. We could go back and adjust any small changes in mass by our models of sorption and volatilization. This approach has been used at a variety of research sites where several transects of multilevel monitoring wells were placed perpendicular to the groundwater flow direction. If we had the typical monitoring wells at a service station site, however, and the same exercise was performed, it would be nearly impossible to make a reasonable estimate of the plume mass with time.

Continuing with our example, consider a situation where we are faced with applying a common model, BIOSCREEN, to estimate the NA at a site. We have a well at 30 feet downgradient (near-field) and one at 300 feet downgradient (far-field). We prepare to run the model by methodically estimating all the independent variables (i.e., source concentration, conductivity/gradient, hydraulic and longitudinal dispersivity). We run the model with no first-order decay and find both wells are off significantly.

In this particular case we do not have lines of evidence of biological degradation, so we will try to use a first-order "decay" coefficient to match the results found in the field. The near-field well matches with a first-order decay rate of 0.2 years and the far-field well matches with a rate of 1.5 years.

Without getting into the details of transport modeling, it might seem reasonable that there is more decay near the source than away from the source. Using the decay coefficient in this manner assumes decay is a lumped parameter in that it is not specific to a mechanism such as biodegradation. In this case it is used to account for loss of mass in a general sense. Perhaps the loss mechanism is not necessarily decay and there is more dispersion in the system than initially estimated. We ran the model with ten times the dispersion without first-order decay and found the model output matched the data from the wells as shown in Figure 1. This suggests that perhaps first-order decay in some sites is not occurring.

So the next time you see a degradation rate or half-life presented, (a) be sure you clarify what processes it encompasses, (b) establish exactly how it was determined, (c) make certain other processes, such as dispersion, were estimated correctly, and (d) if it is a first-order biodegradation

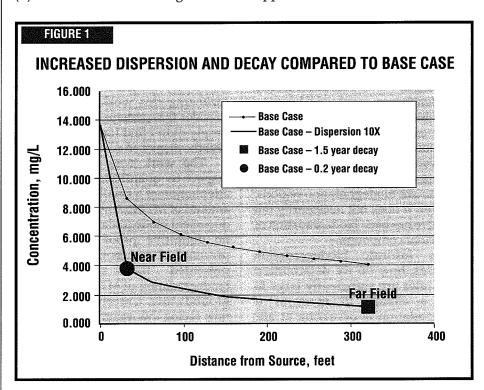
rate, examine the available lines of evidence to substantiate it.

Unfortunately, the BIOSCREEN "Help" section encourages the mixing of processes, as seen from the following passage: "Modelers using the first-order decay model typically use the first-order decay coefficient as a calibration parameter and adjust the decay coefficient until the model results match field data. With this approach, uncertainties in a number of parameters (e.g., dispersion, sorption, biodegradation) are lumped together in a single calibration parameter."

Now that we have highlighted the potential ramifications of confusing dispersion and nondestructive decay with biodegradation processes, what about mixing at a larger scale? What if we assume that all the contaminant mass leaves from a site and enters a municipal groundwater production well? What happens then? First things first: How do you estimate the mass of a contaminant leaving a site?

Mass Flux and Dilution

A recent paper by Einarson and Mackay (2001) presents a framework by which dissolved-phase mass of groundwater constituents mixes with water extracted from production wells. The mass-flux mixing approach takes the mass from a



groundwater plume and mixes it with the water from typically larger, deeper flows and formations.

The authors state: "They [the capture zones] are useful for illustrating contaminant dilution in continuously pumped supply wells." The capture zones are the regions of groundwater that are pumped into a production well as a function of time. According to the authors, when multiple plumes are heading toward a municipal well, "the larger pumping rates of many municipal supply wells may be sufficient to cause enough blending so that contaminant concentrations in extracted water remain relatively low."

Einarson and Mackay's paper seeks to establish the mass flux of contaminants leaving a site by using multilevel well fences on the downgradient side of a plume in order to provide an accurate determination of flux leaving the site. In the example in the paper, seven locations spaced 11 feet apart each contained seven vertical probes spaced 2 feet apart; the first probe was located 1.5 feet below the water table (all distances approximate for they were scaled from diagrams in the original paper).

Each of the 49 probes sampled represented 22 square feet of aquifer perpendicular to the flow direction and the entire fence a 1,078-square feet section of the contaminant plume. Although this is an extensive monitoring array, the data seem to indicate that even this elaborate monitoring approach was not adequate. The sides and bottom of the transect contained contaminant in significant concentrations, implying that only a portion of the plume was sampled.

The example yielded a mass flux of 31 grams of a compound per day after multiplying by the calculated specific discharge (Darcy Velocity of 0.64 inch/day) and adding up each mass flux from the individual probe areas. If this mass flux were to enter a municipal supply well pumping 1,000,000 gallons per day (694.4 gallons per minute), the resulting concentration after mixing would be 8.2 ug/L. The average concentration at the fence was approximately 20,000 ug/L. The net effect is lowering the concentration by approximately 2,500 times once the water is pumped from the aquifer from the municipal supply well.

What does this imply? Have we now come to rely on end-user dilution to manage contaminant plumes? Furthermore, what does this say about our sampling results if monitoring wells are sampled with high-volume, high-flow purging and sampling techniques, or if the monitoring wells are located in areas that may underestimate the dimensions of the plume?

The Sway of Sound Well Location, Construction, and Sampling

Most state standards or guidelines for implementing MNA do not address well construction and sampling procedures. Consider a LUST at a service station above a water table aquifer in a groundwater recharge area. Typical groundwater monitoring is conducted using wells with screens completed across the water (presumably to measure LNAPL, even though they are far downgradient of the LUST, and no residual hydrocarbon was noted during drilling). Common sampling shortcomings may include the use of high-flow purging, including explosive vacuum truck purging (complete evacuation), bailing, failure to measure parameters with a closed flowthrough cell, and passive or no-purge sampling.

These shortcomings can lead to an underestimation of the lateral extent of the dissolved contaminant plume (MTBE and BTEX) and misrepresentation of biogeochemical conditions (e.g., REDOX and other lines of evidence) in the following ways:

■ Wells completed across the water table. Water that is being sampled from a well completed across the water table will always have some direct contact with the atmosphere (increasing the likelihood of volatilization) through the well bore. Also, zones of artificially enhanced biodegradation (not representative of the aquifer) often occur in the immediate vicinity of I the well due to increased atmospheric contact allowed by the well. Enhanced volatilization and biodegradation can occur right at the water table (due to atmospheric contact) but not at deeper levels in the aquifer, so the sample collected from the water table may not be representative of the dissolved plume; and in recharge areas a dissolved plume will likely move vertically downward and a well at the water table may completely miss the plume. In this situation, fresh water from precipitation recharge may also reduce concentrations of dissolved constituents right at the water table.

- High-flow purging. This may cause dilution as described in the previous section. Also, volatilization losses may occur if excessive drawdown is caused, and water "cascades" into the well screen. Increased oxygenation may occur, eliminating the ability to accurately characterize REDOX conditions. If an electric pump is used, dissolved hydrogen determinations may be overestimated due to electrolysis.
- Sampling with a bailer. Volatilization losses may occur due to agitation. Mixing of altered (due to atmospheric contact) water with water being sampled is inevitable. Accurate field parameter determination and proper sampling for dissolved gases (oxygen, hydrogen, methane) is impossible.
- Failure to measure parameters with a closed flow-through cell. Both bias (high) and variability is introduced into dissolved oxygen determinations that have been collected by either pumping or decanting (from a bailer) into a cup and inserting a hand-held probe. Measurements of pH can be affected by off-gassing of CO₂.
- Passive sampling or "no-purge." These methods sample water in the well, not in the aquifer. While ambient flow may occur, and water in the well may be representative of the aquifer without purging, this must be verified by purging, because ambient flow (and hence "flushing") may occur to different degrees at different locations and may also vary seasonally at a given location. Furthermore, when passive sampling with diffusion-type samplers, the sampler itself may block any ambient flow.

In summary, we must keep in mind that many standard practices in groundwater monitoring are not giving us representative data that is

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useful for truly evaluating MNA. Solutions to this problem are to develop and enforce standards for well location, construction, and sampling protocols such that the data will be useful for the intended purpose.

When "standard" groundwater monitoring practices were first implemented years ago, no one was thinking that we would be "taking the pulse" of a site in the manner required for MNA evaluations. Our new information needs to exceed the abilities of the old practices to deliver the required information. New standards should encourage shortscreened wells in three dimensions (only screened across the water table where NAPL monitoring is required) and low-flow purging and sampling with nonelectric positive displacement pumps.

So, Do We Care?

It is all about liability and short-term versus long-term thinking. You might get approval for a "walk away" today based on some notion of NA; however, if it is not technically correct, it may be a long-term liability (for both regulators and the regulated community) regardless of current accepted technical practice. Both regulators and LUST owners are under pressure to get sites "off the list." Both also stand to suffer some negative consequences if we have to revisit these sites and implement active remediation in the future because we find out that contaminant reduction processes were not what we'd thought they were.

One might initially think that in practice it doesn't matter what is going on at a site—destruction versus dilution—as long as concentrations are reduced below a risk threshold. Maybe so, provided direct monitoring can prove this is happening. In practice, however, we are frequently closing sites and electing not to conduct active remediation, not because concentrations are already below a threshold, but rather because of some prediction that contaminant concentrations in groundwater will not exceed some risk-based threshold at some location downgradient some time in the future.

Seems to make sense. But what if for some reason (like the ones mentioned in this article) our predictions are not correct? What if we underestimate the plume mass in the first place, and we mistake concentration dilution (due to mixing or improper sampling) for concentration destruction (i.e., biodegradation)? What if we calculate a degradation rate and extrapolate that out? The model will paint a rosy picture, and we walk away from the site. In reality, those contaminants are still out there, spreading further while we sleep soundly with a false sense of security that they are being degraded.

This brings to mind a few more questions. What happens in an urban area were several of these diluted plumes commingle? What happens to the aquatic ecosystem that receives this contaminant mass discharge? We're back to a question posed by the surface water pollution community 30 years ago. Is dilution the solution to pollution? In short, we think it can be, but only in certain circum-

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If we are to comfortably embrace MNA as an alternative to active remediation, we'd better be certain that (a) if concentrations are low, there will be no cumulative affects and (b) if we are relying on degradation to remove contaminants to achieve a risk-based concentration goal, we are very confident in our assessment of biodegradation. The

only way to do this is through better groundwater monitoring and biogeochemical evaluation practices that will result in the proper recognition of the natural attenuation processes that are actually occurring at a given site, their relationship to the concentration trends observed, and the use of these findings to accurately predict concentrations into the future.

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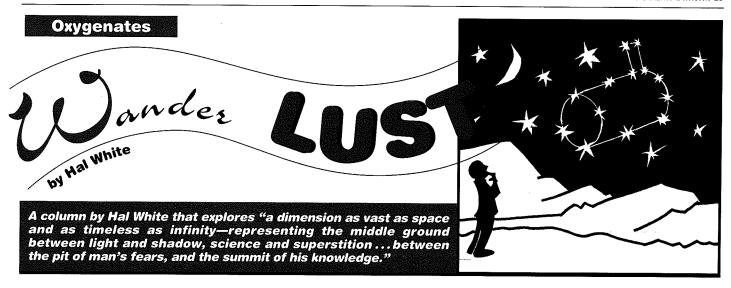
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Do Monitoring Wells Monitor Well? Part I

This article is the first of a series that will delve into the realm of site characterization. Successive decisions concerning any particular site hinge on our understanding of what lies beneath the ground's surface. With so much at stake, is it not wise to seek to improve our site characterization when possible? Of course, the answer is "Yes."

The very first thing we should seek to improve is the data that we collect. We must make it our business to continually ask ourselves and others: How well does this information support the decisions we make with respect to the site?

Our formal education and experience give us insight into how geology, hydrology, and contaminant behavior interact to determine where and at what level contaminants are likely to be found. As an aid to our understanding, we usually develop a conceptual site model. But our conceptual model must be validated by actual observations in the field, or it must be modified accordingly.

Each bit of additional information allows us the opportunity to refine our model. And it's important to realize that all the pieces of information are interrelated. For example, the decisions we make about monitoring well placement or screen length directly affect how well the other pieces of the model will ultimately fit together.

Well Begun Is Half Done...

The primary function of groundwater monitoring wells is to provide subsurface access for (a) the measurement of liquid levels and (b) the collection of liquid samples for analysis. In the UST program, the liquids that we are most concerned with are groundwater and petroleum products, whether in the nonaqueous or dissolved phase. Monitoring wells may also be used to collect gas/vapor samples and measure vertical transport properties, and they are convenient (although rarely optimally located) places to install various components of remediation systems.

Given that monitoring wells have such a wide variety of important uses, why is it that so little consideration is actually given to the question of whether the data we derive from them is of adequate quality? This question may come across as being contrary to conventional wisdom, but let's think about it. Let's begin by laying out a scenario for a "conventional" site assessment that relies on typical monitoring wells, and then we'll dig a bit deeper to uncover some shortcomings:

Scenario: We have a typical neighborhood gas station that sits on a squarish quarteracre lot at the intersection of two relatively busy streets. The station building is a one-story brick structure—an office/ storeroom occupies one-third of the building, and two garage bays occupy the other two thirds. One of the two pump islands (each with two dispensers) is in front of the station and parallel to the street; the other is parallel to the side street.

There are three large 2,000-to 10,000-gallon USTs used for fuel storage and a small tank for used oil. The entire surface area of the lot is covered with concrete or asphalt. Overhead

power and telephone lines run above the property lines parallel to both streets. Underground utilities (i.e., water, sewer, natural gas) also run parallel to the property line marking the front of the property.

Representatives from an environmental company hired by the owner/operator to conduct a site assessment arrive at the station. They visually survey the station layout, noting the painted markings on the pavement where the utility company has delineated the water, sewer, and natural gas lines, and proceed to install a monitoring well as close as possible to each of the four corners of the station property.

However, due to the locations of overhead and underground utilities, the tank field, the pump islands, the waste oil tank, and the station building,

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the locations for the monitoring wells must be shifted somewhat from the originally intended locations at the property corners. As a result, in plan, these four points outline a compressed and elongated quadrilateral, not a square.

At each location, the drill rig advances a 10- to 12-inch diameter bit in 5-foot increments and then stops to allow for undisturbed soil samples to be collected. Each sample is 18 to 24 inches in length. A geologist records the lithologic information for each sample and screens each interval with an organic vapor meter/analyzer for the presence of petroleum hydrocarbons.

Beginning with the first detection of organic vapors, soil samples are placed in labeled jars and stored on ice in a cooler. Later, the jar with the sample containing the highest reading from each borehole will be sent to a laboratory for analysis. The on-site geologist also logs cuttings between the undisturbed samples.

When the boring finally reaches the water table, it is advanced another 5 to 10 feet and then the casing and screen are installed. The casing and screen consist of a 4-inch inside diameter Schedule 40 PVC pipe with factory-threaded couplings and factory-cut slots (0.020 inch). Sufficient lengths of casing and screen are installed such that the screened portion extends 5 to 10 feet below and above the water table to allow for seasonal variation

The screened portion is backfilled with coarse (#2) sand to a level that is a foot or two above the top of the screen. On top of the sand is a bentonite seal that is 2 to 5 feet in thickness. The remaining annular seal-to-land surface is sealed with a bentonite-grout slurry. The wellhead itself is protected either with a flush-mount cover or steel surface casing. The top

of the well is fitted with a locking, watertight well cap.

Later, the newly installed well is "developed" using either pumping or surging techniques. Finally, after being allowed to recover for at least 24 hours past development, the well is ready for water level measurement and liquid sample collection.

Sounds familiar, doesn't it? With respect to the above scenario, conventional wisdom holds that the stratigraphy, water table, and groundwater flow direction are all well defined. Each boring has a continuous log plus undisturbed samples at 5-foot intervals.

Analysis of soil samples from each boring indicates only minor amounts of residual contamination near the tank field. Analysis of groundwater samples from each of the four wells indicates (we'll assume) that they are essentially free of dissolved hydrocarbons. Quarterly gauging of the water levels indicates that water table fluctuations should remain within the screened interval so that none of the wells will go dry. Since the well casings are 4-inch inside diameter, if needed they can accommodate free-product recovery (and other remediation technology) equipment.

For purposes of the following discussion, we'll assume that there is no problem with sampling or well installation techniques—this isn't a discussion of push technologies versus conventional drilling rigs, or expedited assessment versus conventional techniques. Our focus is strictly on the design and location of the monitoring wells. So what can the problem(s) possibly be?

Divining the Water Table

In Euclidean geometry, three noncolinear points in space are required to define a plane (if the points were colinear, then an infinite number of planes—all equally plausible—could be drawn through the line). By assuming that the water table is planar, the magnitude and direction of groundwater flow can be determined. The "conventional" site assessment described above employs not just three but four monitoring

wells, so the groundwater flow direction can be well defined from these data, right? Wrong!

While three points in *empty* space are adequate to define a mathematical plane, the water table isn't in empty space, and it is hardly a plane. Its position relative to a lower confining layer depends upon a number of variables that include amount and location of recharge sources, soil permeability, soil heterogeneity, and location and strength of pumping wells and other sinks.

How many wells are sufficient? That's not an easy question to answer, except to say that it's site-specific. In any case, the more wells there are, the more accurately the water table can be defined. If we accept that we're limited to just four locations on any given site, we can learn a lot more if several wells with shorter screens at different elevations are nested at each of these four locations. This is absolutely essential if we're to evaluate the presence and importance of vertical transport at a site.

Guessing Groundwater Flow Direction(s)

It is typically assumed that by default, three of the wells are downgradient and one well is upgradient-but upgradient and downgradient from what? Tank field excavations (which are backfilled with pea gravel) have a conductivity that is relatively higher than that of the surrounding soil. Rainwater runoff that flows beneath the paved surface but on top of the soil often collects in tank fields, creating a water table mound that dominates local groundwater. Radial flow from the tank field excavation (a primary source of potential groundwater contamination) virtually assures that some portion of contamination will migrate in a direction where there are no monitoring wells.

By confining the site investigation to the UST property, a very small area is used to infer the magnitude and direction of groundwater flow. This practice can lead to some predictive problems, such as water table mounding in the tank pit, affects on flow based on how much of the surrounding area is paved, and distribution of recharge-inducing features,

such as leaking storm drains or ditches.

Such effects can perturb the regional groundwater flow system. While transport of contaminants near the site may depend on these effects, off the property the regional flow may dominate and direct contaminants in a different direction.

Because the array of four wells at our typical site is usually elongated in one direction and compressed in the other, there is a high degree of uncertainty associated with our interpretation of groundwater contours. Recognizing the fact that there is a subjective element to all contouring (even that which is based on linear interpolation), strictly speaking, only those contours that lie within the region bounded by our four data points are allowed to be solid lines all other contours must be dashed to show the uncertainty associated with them.

This area is nonexistent for colinear points and very small for elongated quadrilaterals. The area bounded by four points is maximized when the data points form a square.

Figure 1 is an attempt to illustrate some of these points using linear interpolation and parallel contours for simplicity.

In the simplest case (Figure 1a), the four points are colinear with dashed vertical contours and groundwater flow (solid arrow) from left to right. But, contours as illustrated in Figure 1b or 1c (or anywhere in between), could be drawn with equal justification. The orientation of these contours differs by more than 300 degrees, and groundwater flow directions differ by nearly 180 degrees. Clearly data points away from the axis are necessary to determine which interpretation is more correct.

Finally, if the wells are oriented in a square (Figure 1d), we can see that there is a relatively large area bounded by our data points where we may be reasonably comfortable in our interpretation (i.e., where the contours are solid lines) of both the water table contours and the direction of groundwater flow. Note that simply maximizing the distance between the corners of the square at a

given site isn't a solution. This could lead to problems in detecting the location of the plume.

Postulating Potentiometric Surfaces

Our scenario assumes that the water directly beneath the site exists under unconfined conditions (which is often the case). But, in many geologic settings, layering of soil types of different permeabilities can create localized perched water zones as well as confined zones. Especially in coastal plain sediments, even thin clay layers (which may not be recognized to be continuous over the site due to the wide sample collection intervals) can create such zones.

When well screens of 10 to 20 feet are open to these different zones, the water level measured in the well is an amalgam of all of the different potentiometric surfaces of these different zones. Consequently, the measured water level may not have any correlation whatsoever with the presumed direction of groundwater flow. In addition to providing erroneous information on flow directions, such wells facilitate cross-contamination of deeper water-bearing zones.

Collecting Groundwater Samples

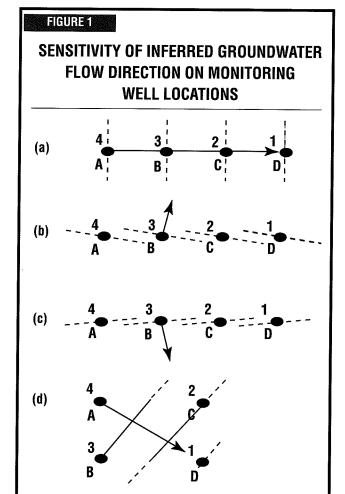
With the understanding that monitoring wells with relatively long screened intervals (10 to 20 feet) cannot be relied upon to provide accurate information about water table elevations, how can they be expected to provide accurate information on groundwater quality? They can't.

Even if the stratigraphy at a given site were purely homogeneous and isotropic (such that there are no preferential flowpaths) and each of the downgradient wells actually intersected the plume, groundwater samples withdrawn from each well would be a composite of the concentrations over the entire screened interval.

The result is always that measured concentrations are less than the true maximum. How much difference can this make? It is possible that this effect can dilute concentrations to below detection limits. But, even in this ideal case where groundwater flow to the well could be assumed to be laminar, groundwater flow into the pump (or other collection device) would be influenced by vertical location of the pump intake.

In the case where well screens are open to different water-bearing units, it is impossible to generalize what the effect might be. (To further explore the effects of in-well dilution on average borehole concentrations, visit ORD's OnSite Calculator at http://www.epa.gov/athens/learn2model/part-two/onsite/abc.htm.)

The most logical way to locate a contaminant plume would be to place sampling points along the length of the plume and to select some locations that are off the main axis of the plume. Unfortunately, the



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reality of the situation is that the location of the plume in most cases is only known through samples collected from wells. If our conventional site assessment uses wells placed arbitrarily at the property corners, they should not be expected to provide delineation of the centerline or extent of contamination. These can only be determined from a set of wells or other sampling points that transect the plume.

Aquifer Testing

Monitoring wells are essential for providing data on aquifer response to pumping stress. However, as with defining the water table or potentiometric surface, or for collecting representative samples, wells with long screened intervals may also yield erroneous information during aquifer tests. It is critical that the pumping well and the monitoring wells tap the same hydrostratigraphic unit.

With a conventional four-well arrangement, as in our scenario, aquifer test results could provide only a gross estimate of average aquifer permeability and yield. While this may be the objective of water supply investigations, it is essentially useless for determining contaminant travel time. Because contaminants migrate along preferential flow paths that generally have higher than average permeability, the "true" transport velocity of contaminants may be significantly underestimated. The result is that contaminants may arrive at potential receptors much earlier than predicted.

Installing Remediation Systems

One of the cost-savings objectives in a conventional site assessment as per our scenario is to allow for remediation equipment (especially free product recovery devices) to be installed in any of the wells, as needed. Is this really how a remediation system should be designed? The answer is a resounding "No!"

We've already established that the locations of the monitoring wells are essentially random relative to the distribution of contamination. So how is it that we can believe that their locations could possibly result in the installation of an effective (let alone optimal) remediation system?

Further, given how ineffective many of these systems are, how long most of them are operated, and how much they cost to operate and maintain over the years, how much costsavings are actually realized by a decision to arbitrarily limit the number of wells installed at a given site?

Ne'er Do Well

The preceding paragraphs are intended to illustrate some of the things that monitoring wells should not be relied on to do. So, what can we conclude about conventional monitoring wells with long screened intervals?

- Four wells are generally insufficient to provide necessary information about subsurface conditions at any given site.
- Nested wells with short screened intervals should be installed in favor of wells with long screened intervals.
- Measured water table elevations may not correlate to the same hydrostratigraphic unit from well to well.
- Concentrations of contaminants in groundwater samples may be significantly lower than the true concentration at that point.
- Results of aquifer testing (i.e., permeability, transport velocity)

- should be assumed to be best case (least conservative) because averaging gives a lower conductivity than the maximum.
- The effectiveness of remediation systems should not rely on the random location of monitoring wells.

All's Well That Ends Well...

This article turned out to be more lengthy than I originally intended, and still it doesn't address all the monitoring well issues that I'd hoped it would. Perhaps it is naïve to expect that long-entrenched behavior would be favorably altered based on a single article, no matter how convincing the argument. (That *is*, however, my hope, if not my expectation). Part II of this article will summarize monitoring well design guidance provided in 40 CFR 280. ■

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This article was written by the author in his private capacity and the conclusions and opinions drawn are solely those of the author. The article has not been subjected to U.S. EPA review and therefore does not necessarily reflect the views of the agency, and no official endorsement should be inferred.

Tank Tester Sentenced for Falsified Tests

Carolina Upgrading of South Carolina, Inc., an environmental contracting company, and its former president and owner were sentenced for conspiracy to commit mail fraud and related crimes in connection with falsified tests of USTs. The former president/owner was ordered to serve 27 months in prison and Carolina Upgrading was placed on probation for 3 years.

The president/owner directed employees of Carolina Upgrading to provide customers in South Carolina, North Carolina, Florida, Georgia, Virginia, and Tennessee with falsified test results and with invoices for those false results. Many of the over 1,500 falsified tests for which customers were billed were not performed at all. The loss from fraud suffered by these customers amounted to approximately \$750,000.

The case was investigated by EPA Region 4's Criminal Investigation Division, the South Carolina Department of Health and Environmental Control's Office of Criminal Investigations, and the North Carolina State Bureau of Investigation. It was prosecuted by the U.S. Attorney's office in Columbia, SC, and the U.S. Department of Justice. ■

Oxygenates

Is MTBE off the Hook in Europe?

A Perspective on Europe's MTBE Risk Assessment

by Patricia Ellis

n 1993, the European Union (EU) established a formal process for assessing the potential risks of chemicals to both human health and the environment. The risk assessment process for MTBE began in 1997 and was carried out in two stages. First, all known data on the health and environmental effects, along with the potential for exposure, were evaluated to determine the overall risk. The findings were then set out in a risk assessment report. Second, in areas where risks were identified, the authority recommended methods for minimizing those risks.

The risk assessment for MTBE was prepared under the leadership of the Finnish authorities in the context of the European Community (EC) Council Regulation N. 793/93 on the evaluation and control of the risks of existing substances. The Finnish Environment Institute, the National Product Control Agency for Welfare and Health, and the Finnish Institute of Occupational Health led the evaluation for the 15 member states.

In December 2001, the European Union published the overall conclusions of this risk assessment on MTBE ("COMMISSION RECOM-MENDATION of 7 November 2001 on the results of the risk evaluation and the risk reduction strategies for substances: acrylaldehyde; dimethyl sulfate; nonylphenol phenol, 4-nonyl-, branched; tert-butyl methyl ether") in the Official Journal of the European Communities. The conclusions are available at http:// europa.eu.int/eur-lex/pri/en/oj/dat/ 2001/l_319/l_31920011204en00300044 .pdf

Drafts of the complete risk assessment have been circulated through various sources. The complete risk assessment report will

eventually be published on the European Chemicals Bureau Web site: http://ecb.jrc.it/.

Report Findings

In Europe, MTBE is most commonly used as an octane booster. The maximum allowable use of MTBE is limited to 15 percent by volume in gasoline, under Directive 98/70/EC. On the average, however, the actual amount is closer to 2.5 percent by weight, but the amount varies by country and refinery.

The EU risk assessment identified a number of possible release scenarios for MTBE and its perceived risks. A strategy was proposed for limiting those risks. In terms of impact to consumers, human health, atmospheric and terrestrial ecosystems, and microorganisms in sewage treatment plants, the report stated that there are not expected to be any risks from exposure to MTBE, and no further information or testing in these areas is needed. Risk reduction measures already being applied are deemed to be sufficient.

The report found that with regard to the impact on human health, there is a need for workers to limit contact with MTBE during maintenance operations and automotive repairs because of the risk of skin irritation after repeated exposure to gasoline containing MTBE. It added, however, that there is no need for further information or testing to reduce risk to consumers, beyond the measures already being applied. In general, legislation exists for worker protection, but it was recommended that design changes might be made to fuel filters to make maintenance and repair work easier.

The assessment concluded that there is a need to limit human exposure via the environment due to concerns for the potability of drinking water with respect to taste and odor. This risk exists as a consequence of exposure arising from leaking underground s

from leaking underground storage tanks and spillage from overfilling of tanks.

To limit exposure of humans to MTBE via the environment, the following recommendations were made, aimed at protecting groundwater and drinking water:

- Existing legislation is designed to prevent releases of MTBE to the environment. Monitoring programs were recommended to provide for early detection of groundwater contamination by MTBE.
- Best available technologies are recommended for the construction and operation of underground storage and distribution systems at service stations.
- Mandatory requirements for storage facilities in groundwater recharge areas should be considered.
- Construction and operation standards for storage tanks should be standardized for all of the EU.
- Potential past releases at storage facilities should be investigated, and remediated where necessary.

The assessment concluded that there is a need for further information and/or testing with regard to potential risks to aquatic ecosystems. One concern had to do with potential releases of MTBE to surface waters from terminal storage tank-bottom waters. The report recommended that permits or rules should control MTBE-containing bottom waters of

■ MTBE in Europe from page 17

aboveground storage tanks. There are large numbers of terminal sites in the EU that store and handle gasoline, and because some of these sites do not have on-site wastewater treatment plants for the tank water, it is believed that these terminal sites are the most pronounced source of MTBE releases to surface waters. The authors discounted the threat of direct releases of gasoline to surface water from motor vehicles and recreational watercraft due to predicted low levels of contamination.

Given the large amounts of gasoline stored at service stations and terminals and the nature of the transport system, it is inevitable that some release of MTBE to the surface and subsurface environment will occur. However, because of the design of modern service stations, the committee anticipated that the risk of serious releases to soil or groundwater during normal refueling operation should be low. The highest potential risk comes from leaking underground tanks or piping, where leaks may go unnoticed for some time. Based on my review of the January 2001 draft risk analysis report, the risk of groundwater contamination due to releases at refineries or bulk storage terminals with aboveground storage facilities does not seem to have been addressed by the study.

MTBE-U.S. and EU

So with this "no worries" conclusion about the risks of MTBE in Europe, I find myself asking whether or not I think Europeans should be worried about MTBE. Let's look at some of the similarities and differences between the tank situations in the U.S. and Europe.

Other than at individual leaking tank sites, there is currently little routine monitoring for MTBE in groundwater in Europe. The limited available monitoring data show the presence of MTBE at low levels in groundwater and well samples in urban areas. But you can't know whether there is a problem if you don't start looking for it.

Few states in the U.S. were looking for MTBE until Santa Monica's wells were knocked out because of MTBE in 1996. There were problems

before then, but Santa Monica was the big wake-up call. I know of a few sites in Delaware where MTBE was first documented in the early to mid-1980s. After Santa Monica, the ostriches—oops, states—started one by one to pull their heads out of the ground. Is Europe another ostrich, slow to pull its head from the ground?

Arthur D. Little Report

A study conducted by Arthur D. Little, Ltd. (ADL) for the European Commission (2001) assesses whether groundwater in the EU faces a similar potential for widespread contamination by MTBE as has already occurred in the U.S. It also examines whether controls or obligations already present in EU member states that may or may not exist in the U.S. mitigate any such risk. Three factors were considered as part of this assessment: (a) UST construction, installation, and operation; (b) water quality regulation; and (c) MTBE monitoring programs.

Information in this report shows that requirements for the construction of UST systems in EU member states generally meet or exceed the equivalent federal or state legislation in the United States in the following four important areas:

- Specifications for tank construction. EU specs were typically either single-walled with additional containment, or doublewalled.
- Specifications for corrosion-resistant material or cathodic protection of materials prone to corrosion.
- Specifications for leak detection systems, regular monitoring of this system, and regular monitoring of tank integrity.
- Specifications for corrosion- and leak-resistant connecting pipes, and solid pavement that drains to an oil/water separator.

The study stated that strong enforcement of the UST system requirements is essential for this source-control program to be effective—ensuring that the potential for UST systems to cause groundwater contamination remains low in the future.

Of the six member states for which some groundwater monitoring and survey information were available (Denmark, Finland, France, Germany, Sweden, and the U.K.), none of the findings indicated widespread or serious groundwater contamination by MTBE on the same scale as the U.S. The authors of the study believe that, given the recent adoption of new standards for UST systems in the EU, this contamination appears to be largely either (a) historic contamination, or (b) isolated incidents where there was a recognized failure in either construction or operational standards.

Because of the significantly lower concentration of MTBE in gasoline in Europe, it is not anticipated that groundwater contamination by MTBE will increase significantly in the near future. Finland is the only EU member state using high levels of MTBE in gasoline similar to that used in oxygenated gasoline in the U.S. As requirements for the construction and operation of UST systems in Finland have only recently been introduced, data currently being collected on MTBE in groundwater will be an important indication of the effect of this usage.

The Finnish Ministry of the Environment provided a statement for submission to the U.S. EPA's Blue Ribbon Panel. The ministry does not, for the time being, consider that the use of MTBE in gasoline should be restricted because of groundwater protection in Finland. "The release of gasoline to groundwater is prohibited even if it contains no additional substances. When the pollution of groundwater by gasoline is prevented, it is not relevant whether or not the gasoline contains MTBE." (May 17, 1999, letter from Peeka Jalkanen and Tapani Suomela of the Finnish Ministry of the Environment to Jarmo Honkamaa of Fortnum Oil and Gas, for transmission to EPA's Blue Ribbon Panel.) In other words, polluting groundwater is absolutely prohibited in Finland.

The ADL report cited a study conducted between 1997 and 2000 by the Danish Oil Industry's Association for Remediation of Retail Sites. Tests were conducted at selected stations where gasoline contamination had been remediated. The stations had been in operation after 1985 (when

MTBE had first been used in gasoline blends in Denmark). Of the 479 sites, 21 percent tested positive for MTBE contamination. Of the contaminated sites, 7 percent exceeded the threshold level of 0.03 mg/L.

Denmark's Concern

The ADL report concluded that groundwater contamination by MTBE is unlikely to increase in Europe if existing standards governing the construction and operation of USTs are strongly enforced. Based on that, the Commission of the European Communities has not proposed any changes in gasoline composition with respect to MTBE content, with the exception of Denmark, which continues to express concern over the use of MTBE.

Individual member states have the right to request stricter environmental specifications in areas of particular sensitivity. The European Auto/Oil program and its associated legislation were designed to improve air quality (much like the Clean Air Act). Denmark is trying to extend this opt-out provision to cover water quality as well. The Commission has pointed out that restrictions on the sale of gasoline that complies with EU specifications could impede the correct functioning of the internal market, in much the same way that "boutique fuels" can cause supply problems in the U.S.

In the summer of 2000, the Danish media featured several stories linking the MTBE controversy with a potential threat to water supplies in Denmark, where drinking water is filtered rather than chemically treated before delivery to the consumer. Government authorities instituted an enhanced monitoring program to discover the extent of MTBE contamination, instituted a reassessment of the existing drinking water standard for MTBE, and considered a possible new tax on MTBE.

In December 2001, Denmark introduced a tax incentive scheme, whereby lower taxes are charged on gasoline distributed by service stations that meet more stringent standards of equipment and operation. This reduction in the tax is available for stations that meet a standard that will become compulsory in 2005.

Denmark is in the process of phasing out MTBE in regular unleaded gasoline. MTBE is no longer being added to 92-octane gasoline, which is suitable for most cars. High-performance cars and some older cars require 98-octane gasoline, which still contains MTBE as an octane enhancer. This gasoline is available only at selected service stations, roughly 5 percent of the stations in the country.

Denmark's requests were approved by the Council of Ministers in September 2001, but the Council noted that "leakage into groundwater does not represent a real health problem as this substance is harmful only when highly concentrated." However, it approved the measure on environmental grounds since "even minute quantities of MTBE in groundwater impart an unpleasant taste and smell ... and water containing negligible quantities of MTBE would be undrinkable."

In commenting on the Danish actions, the director-general of EFOA (European Fuel Oxygenates Association), Bruno Hery, said "EFOA supports the tax incentive scheme, which tackles the cause of possible groundwater pollution by MTBE—leaking storage tanks—rather than focusing on the product itself. We welcome Denmark's pragmatic approach to the issue, but since MTBE in groundwater is not perceived as a serious threat by other European countries, we have no plans to promote similar incentive schemes elsewhere."

Although the overall usage of MTBE in Denmark is low (0.2 percent by volume), some unleaded gasoline is imported from Fortnum Oil in Finland, which supplies unleaded gasoline with an MTBE content of 10 to 12 percent (Dottridge, 2000).

Environment Agency Report on England and Wales

Komex Europe completed a review of current MTBE usage and occurrence in groundwater in England and Wales for the Environment Agency and the Institute of Petroleum (2000). Members of the Institute of Petroleum own and operate approximately 4,500 retail filling stations and 200 oil distribution terminals in the U.K. A total of 2,069 sites have been investigated for soil and groundwater contamination, with analysis for ether oxygenates at 837 of these sites.

Of 292 sites evaluated in more detail, 179 had MTBE in soil or groundwater (61 percent), 64 had detectable MTBE in soil (22 percent), 73 had detectable MTBE in groundwater (25 percent), and 40 additional sites had MTBE in perched water (13 percent).

This report provided possible explanations as to why there were fewer problems in the U.K. than in the U.S.:

- Lower concentrations of MTBE in U.K. fuels (1/10th that of U.S. gasoline).
- Greater distance between potential fuel spill sites and drinking water wells in the U.K. A different geology and water supply infrastructure is likely to be more protective of public water supplies in the U.K. The U.K. has small numbers of deep, highyielding public supply wells. In the U.S., there are larger numbers of shallow wells that supply small communities and that are at greater risk from MTBE contamination. In addition MTBE was introduced into fuel in the U.S. in the late 1970s, 5 to 10 years before it was used in the U.K. (late 1980s).
- Greater incentive for good fuel storage due to higher fuel costs in the U.K. In the U.S., fuel is taxed as it is dispensed from the pumpleaked fuel incurs no tax. In the U.K., fuel is taxed as it leaves the refinery, ensuring that the costs incurred by retailers due to leaking fuel are much greater. This tax makes up about 75 percent of the cost of fuel and helps ensure that leaks are fixed promptly.

MTBE Concentration **Projections**

The primary reason for the addition of ether oxygenates to gasoline in Europe is to maintain the octane rating of the gasoline in the absence of lead and with reduced aromatics. Such fuel usually contains less than 5 percent ether oxygenate by weight, often as low as 1 percent by weight. Recent European fuel quality and air emissions directives, mandatory in all member states, govern the composition of gasoline in the European

■ MTBE in Europe from page 19

Union. Table 1 summarizes the maximum allowable concentrations in 95-octane gasoline.

Some major oil companies believe that the concentration of MTBE in fuel could increase with the implementation of the final part of 98/70/EC (EC 1998) in 2005. Reductions in the allowable percentage of aromatics in gasoline are required, which will necessitate the use of octane from other sources.

Based on information provided by EFOA, the ADL report predicts a temporary increase in the use of MTBE when the new specifications are required. It adds, however, that as new refining technologies are introduced to meet the tougher fuel specifications, the MTBE concentration will again drop, eventually to concentrations similar to those in gasoline prior to introduction of the 2005 specifications.

Given the high cost of adding oxygenate to gasoline blends, the extent to which MTBE is added to fuel is determined primarily by economics—where possible, petroleum refiners will use low concentrations of MTBE—unless this is overridden by policy or legislation that sets minimum oxygen or oxygenate concentrations.

Average MTBE composition in the EU countries varies from 0.2 percent by volume in Denmark to 8.5 percent by volume in Finland—1.9 percent by volume is the European Union average (Dottridge et al., 2000). The ADL report anticipates that MTBE octane requirements will settle out in the 1 to 4 percent by volume range, depending on the available octane, and will still be below the 10 to 15 percent volume by weight currently used in reformulated gasoline in the U.S.

The effects of an increase in MTBE concentration in fuel from 1 to 5 percent to 10 to 15 percent were investigated in the Komex study using a model. The model predicts that increasing the concentration of MTBE in fuel will have little effect on the total number of wells with detectable MTBE, but it forecasts a significant rise in the number of public wells that will have tastable concentrations of MTBE.

MAXIMUM ALLOWABLE CONCENTRATIONS IN EUROPEAN UNLEADED GASOLIN (95 octane).					
Component	1985	Stärting 1998) Date 2000	2005	
Lead (g/l)	0.013	0.013	0.005	0.005	
Aromatics (% v/v)		¥	42	35	
Benzene (% v/v)	5	5	1	1	
Oxygen (% m/m)			2.7	2.7	
Sulfur (mg/kg)	en e	500	150	50	

An MTBE increase from 1 to 5 percent could lead to an order of magnitude increase in the number of public water supplies with tastable concentrations of MTBE. With higher concentrations of MTBE, the MTBE in wells will remain above the taste threshold longer and impact is likely from more distant sources. The longer travel time may create a delay before the source is identified and remediated.

MTBE Not off the Hook

A December 2001 press release by White Environmental Associates expressed the opinion that, due to the findings of the European Commission risk study, the scheduled phaseout of MTBE in California gasoline now appears both unnecessary and economically risky. The press release states that MTBE has been cleared of allegations that it poses a significant risk to health or the environment.

This release fails to account for the differences in the storage and handling of gasoline in Europe, differences in geology and water supply infrastructure, and significant differences in the percentage of MTBE used in gasoline in Europe compared with the U.S. Seems to me that we may be talking apples and oranges here!

In Europe (as in the U.S.), leaking underground storage systems and spillage from overfilling tanks are the main cause of groundwater contamination (Finnish EPA, 2001). The severity of the consequences may vary greatly among countries, depending on, for example, the degree to which groundwater is used for drinking water and the condition of gasoline station USTs.

As mentioned earlier, Europe has limited monitoring data on MTBE in groundwater. ADL's recent report to the European Commission states that "little public information is available across member states regarding monitoring of groundwater contamination by MTBE." Citing unpublished information from six countries, the report concludes that "none of the findings indicated widespread or serious groundwater contamination by MTBE on the same scale as the U.S.A."

The EU risk assessment report states, however, that the "documented cases provide sufficient justification for concern that MTBE poses a risk for the aesthetic quality of drinking water from groundwater supplies. It is justified to conclude that MTBE is causing a risk for the aesthetic quality of drinking water." (Finnish EPA, 2001)

The EU risk assessment concluded that MTBE is a borderline case between non-classification as a carcinogen and Carcinogenicity Category 3. Von Krauss and Harremoës (2001) provide a good summary of the conflicting opinions as to the carcinogenicity of MTBE.

The fact is that MTBE has been shown to cause cancer in two different animal species (rats and mice). What is uncertain is whether the same mechanism that causes cancer in these animals would also cause cancer in humans. The answer may be "No." But, in fact, we don't know.

The Precautionary Principle

So, if MTBE is a chemical that causes cancer in animals, do we really want to be unnecessarily exposing human populations to it simply because we don't know for sure that it won't cause cancer? And what if by itself a tiny bit of MTBE wouldn't hurt a fly? How will that tiny bit of MTBE plus a tiny bit of some other organic chemical affect the water we drink? There is so much that we don't know.

Until the question of how mixtures affect human health can be answered beyond a shadow of a doubt, it would be imprudent to blindly assume that any chemical is harmless. If nothing else, the precautionary principle counsels us to use caution when dealing with such unknowns. Potentially carcinogenic chemicals should be assumed to be carcinogenic until they are absolutely proven not to be.

The Arthur D. Little report suggests that the new regulations and standards for USTs scheduled to take effect by 2005, along with strong enforcement, should prevent leakage. Studies in the U.S. demonstrate that even tanks in compliance with the U.S. EPA's 1998 standards can still leak.

The U.S. EPA Blue Ribbon Panel considered whether reducing MTBE to "pre-RFG" levels would eliminate the MTBE problem. The consensus was that this would not be sufficient to solve the MTBE problem. Granted, the higher levels of MTBE were definitely causing larger and more numerous problems, but problems existed even before the percentage of MTBE was increased. Unless all countries are as law-abiding as Finland, where polluting groundwater is absolutely prohibited, an increase in MTBE usage in Europe may significantly impact the groundwater!

The European Environment Agency recently issued a publication titled Late Lessons from Early Warnings: the Precautionary Principle 1896–2000. The publication is about "the gathering of information on the hazards of human economic activities and its use in taking action to better protect both the environment and the health of the species and ecosystems that are dependent on it, and then living with the consequences."

The case studies question why both early warnings and the "loud and late" warnings tend to be ignored for so long. Former EPA Assistant Administrator Bob Perciasepe said it best on the CBS 60 Min-

utes episode on MTBE that aired in January 2000. He said "Those warning bells, to the extent that they were ringing—and they were ringing...in some parts of EPA, and they were ringing in other places—were not ringing widely enough. We are clearly admitting that they weren't ringing loudly enough. We didn't yell loudly enough." Bells seem to be ringing in parts of Europe and not in others. Let us hope that the U.S.'s history of MTBE does not repeat in Europe. ■

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New UST Leak Detection Web Site Now Available

new non-EPA Web site pro-A vides valuable information on UST leak detection systems. The National Work Group on Leak **Detection Evaluations (NWGLDE)** has worked on leak detection issues for several years and has now launched its own Web site at www.nwglde.org. Users can visit this new Web site for a variety of leak detection-related information, including the most recent list of leak detection methods that have been evaluated by third parties to see if they meet EPA's performance standards. Previously. much of this information could be found on the EPA OUST Web site, but now and in the future the NWGLDE Web site will be the place to go for the latest information on leak detection evaluations and other work by NWGLDE. There will be a link on the EPA OUST Web site to this new site.

Oxygenates

Maryland Completes Study on Environmental Effects of MTBE



Maryland Task Force on the Environmental Effects of MTBE, consisting of 16 members from various government agencies, the petroleum and ethanol industries, and health related professionals, released its final report in December 2001. House Bill 823, signed by Governor Glendening on May 11, 2000, created the Task Force, charging it with the following responsibilities:

- Determine and assess the environmental and health risks associated with ground and surface water contamination from MTBE.
- Examine national and regional efforts concerning ground and surface water contamination from MTBE.
- Recommend a plan to minimize and counteract the environmental and health risks associated with ground and surface water contamination from MTBE.
- Explore alternatives to MTBE, including ethanol and oxygenated fuel, that can be used for the purpose of reformulation of gasoline to reduce air toxic emissions and pollutants that form ground level ozone.

Recommendations

The report presents an overview of the MTBE situation in the state and provides recommendations for dealing with the problem from a health and environmental standpoint. Here are some highlights:

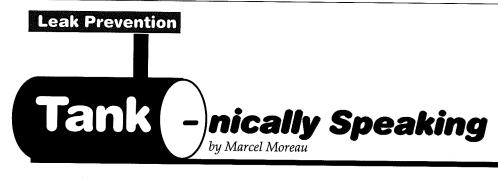
- Continue testing and assessing wells and water supply systems for MTBE and other oxygenates. Positive test results should result in a source investigation as appropriate. Specific steps include:
 - Continue to use the MTBE level of 10 parts per billion (ppb) in water samples at and above which a source investigation is conducted.

- Review U.S. EPA advisories and standards for MTBE and other oxygenates and modify state requirements as appropriate.
- Finalize a method for testing and analyzing water samples for MTBE, TBA, ETBE, and TAME contamination.
- Develop laboratory-testing methods for the determination of DIPE and Ethanol in water samples.
- Work with local health departments to expand testing of wells not currently tested in unconfined aquifers (shallow wells).
- Encourage local governments to protect drinking water sources through locally adopted siting restrictions.
- Enhance the level of inspection and enforcement of UST systems and spill prevention programs and control the escape of MTBE and other gasoline constituents through improving the technology and operation of UST systems, including the piping and distribution system. Specific steps include:
 - Establish an inspection frequency for UST systems with a once per year goal.
 - Amend regulations as necessary to prohibit petroleum deliveries to UST systems that are not properly registered and do not meet federal or state UST upgrade requirements.
 - Work with stakeholders to develop a method for the onsite display of the registration status of the UST systems at all UST facilities.
 - Work with industry and U.S. EPA to establish comprehensive certification and training programs for owners, operators, contractors, and employees who work with petroleum storage tank systems to implement procedures and processes

that would minimize leaks and groundwater contamination.

- Give careful consideration to eventually reducing or phasing out the use of MTBE in gasoline sold in the state. Work with other states and stakeholders to address MTBE issues, consistent with current discussions on energy supply.
- Implement, through public-private partnerships, expanded public outreach programs on the proper handling and disposal of gasoline. Programs should include warning the public that improper handling of petroleum products and filling of vehicle tanks and containers could lead to groundwater contamination. Require facilities dispensing gasoline to include signage informing users that the gasoline is oxygenated to reduce air pollution, and any spillage may result in contamination of water resources. Outreach efforts should also include a broad-based program targeting owners and users of private wells on measures to prevent, detect, and treat contaminated water.
- Provide adequate support to address the impact of MTBE and other oxygenates in gasoline on Maryland's water resources. Specific steps include:
 - Provide funding to health department laboratories for testing of MTBE, TBA, ETBE, TAME, and Ethanol in water samples.
 - Provide resources for a proactive drinking water sampling program.
 - Dedicate appropriate resources to enforce all existing statutes and regulations with regard to UST system integrity, maintenance, recordkeeping, and remediation.

The full report can be found at http://www.mde.state.md.us/was/pdf/mtbe_finalreport.pdf. ■



Marcel Moreau is a nationally recognized petroleum storage specialist whose column, Tank-nically Speaking, is a regular feature of LUSTLine. As always, we welcome your comments and questions. If there are technical issues that you would like to have Marcel discuss, let him know at marcel.moreau@juno.com

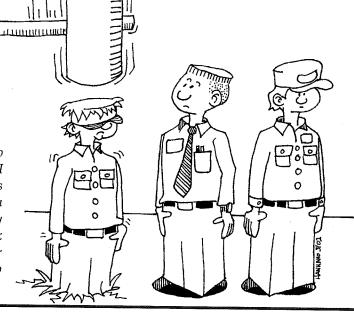
Of SQUARE PEGS and Round Tanks

OR...

What If Tank Operators Knew How to Operate Tanks?

Author's Note

This article focuses on the large majority of tank operators who have but a poor understanding of their storage tank systems. I know that there are some competent, professional tank operators out there, and I do not mean to offend them by lumping them together with tank operators who haven't a clue about what they are doing with respect to operating and maintaining their tank systems. The point of this article, however, is that there are far too few competent tank operators today, and the road we seem to be taking to address this problem is, I fear, unlikely to succeed.



Who's in Charge?

We all know the scenario: The UST inspector walks into the UST facility and asks the clerk about leak detection, overfill prevention, corrosion protection. He/she gets a blank stare.

"Where's the tank paperwork?" inquires the inspector.

"I dunno, let me check the wastebasket..." replies the attendant,

The alarm light is red. The alarm history indicates that the alarm has been active for months. The rectifier's off. There's water in the sumps, spill containers are full of crud, a broken-off gauge stick is jammed in the fill pipe, keeping the overfill device open. Sound familiar?

In May 2001, the U.S. General Accounting Office published a study of the challenges still faced by EPA's underground storage system regulatory program. One of the issues highlighted in this report is operation and maintenance. "Tank operation and maintenance problems increase the risk of contamination," states the report on page 8. "EPA and states

attribute operations and maintenance problems to insufficient training for all staff implementing tank requirements, including owners, operators, installers, removers, and inspectors," states the report on page 10. (For the full report, go to www.gao.gov and look up report GAO-01-464.)

The UST program in the U.S. depends heavily on proper operation and maintenance of leak detection, spill containment, overfill prevention, and corrosion protection systems to keep releases in check. The technologies now used almost universally to meet these varied requirements were used only sporadically as recently as a dozen years ago. Despite the complexity of some of these systems, the fact is that none of these technologies are part of the core curriculum of any high school or university in the country. So where are people who are responsible for these systems supposed to learn about them? There are a few specialized schools and seminars available, but the vast majority of people who are directly responsible for USTs today

learn "on the job." Having spoken with many of these people in seminars that I have given across the country, I can say that all too often this learning technique is woefully inadequate.

Changes Afoot?

This question of who's in charge reflects the disturbing situation more than 17 years after a national program was born and 13 years after detailed federal regulations were published. The rationale that this is a "new" program is untenable. The harsh reality is that if we keep doing things the way we've been doing them, we're going to keep getting the results we're getting.

There are moves afoot to change things. There is a bill simmering in the Senate (#1850, Chafee) that would mandate that states develop and implement a strategy for training operators of underground storage tanks. Some states (e.g., FL, CA, OR) have begun programs designed to

■ Tank-nically Speaking from page 23

increase operator knowledge. (See sidebar on page 7.) But UST operator education programs seem to be based on the overly simplistic analysis that if ignorance is the problem, then training is the solution. This approach attempts to treat the symptom but does not address the root cause of the problem. This approach disregards two fundamental facts about today's tank operator population:

- There is huge turnover in the personnel that are generally regarded as tank operators.
- For most tank operators today, keeping the storage systems up to snuff is an afterthought to the job description, if it appears on the job description at all.

Let's look at how each of these fundamental facts points to the futility of training existing tank operators as a solution to the problem.

Personnel Turnover

Personnel turnover in the convenience store industry, which represents a large portion of the motor fuel facilities in this country, is a well-known phenomenon. The convenience store industry statistics for 2001 indicate that the average turnover rate is 102 percent per year. This means that, on average, a convenience store worker keeps his job for just under a year. This is not the place to discuss the reasons for this, but I think it is safe to say that this situation is not likely to change in the fore-seeable future.

So what does this tell us about the challenge of educating tank operators? It tells us that the training effort required would be enormous because of the hundreds of thousands of people involved. It tells us that the effort will be neverending because a very large percentage of these people will be gone within a year. It tells us that employers are going to be unwilling to make any significant investment in training employees who will soon be out the door. It tells us that attempting to teach essentially temporary employ-

ees the intricacies of storage tank systems and storage tank regulations is a futile endeavor.

Job Description

And what if by some miracle tank operators did know what to do? How much time would they devote to doing it? Very few people today are hired as tank operators. The job titles typically read something like store manager, operations manager, maintenance supervisor, environmental manager, health and safety supervisor, and so on. Some of these job descriptions include items like making sure there is an adequate supply of fuel available. Some may even include items like maintaining tank paperwork. But very few of these job descriptions have tank operation and management as a prominent compo-

These job descriptions do include a multitude of other responsibilities that are typically more urgent (e.g., the cash register person didn't show up today, so I have to fill in...), more apparent (e.g., light bulbs need replacing, floor needs cleaning, toilet is overflowing...), or more likely to affect the bottom line (e.g., the cigarette rack is almost empty, the beer cooler is on the fritz, and the beer is getting warm...). How many of today's tank operators have tank compliance status as a significant component of their job performance review?

Storage systems are out of sight (buried, in fact!) and they are typically a complete mystery to the hapless operator. And we know from the generally low level of inspection and enforcement efforts (the GAO report cited above also states that 22 states do not inspect all of their tanks on a regular basis) that noncompliance with tank rules rarely has significant consequences. The end result of all this? Tank operation and management is a low priority.

I firmly believe that the class of people that are generally considered tank operators today never asked to be tank operators, will never be adequately trained to competently operate tank systems, and will never devote the time or energy to tank operation that is required. Attempting to turn today's store managers and maintenance supervisors into

professional tank managers is a hopeless task. Simply put, we are trying to jam square pegs into round holes.

Who Should Be in Charge?

Why not create a new lot of round pegs that will actually fit into the round holes—a trained class of professionals who are interested in storage tank systems and are able to demonstrate that they have adequate knowledge—and put them in charge of storage systems? Let the store managers and operations managers focus on doing what they know how to do and let storage tank operators do what they know how to do.

Are there any parallel situations? I think so.

Not so very long ago, raw sewage was discharged into the nation's waterways. There was little or nothing in the way of sewage treatment. This was eventually found to be unacceptable, and we designed sophisticated plants to treat sewage. These plants needed people to operate them, but this was not something that could be done by any Tom, Jane, or Harry off the street because it required specialized knowledge. So we created schools for sewage treatment plant operators and trained and certified a class of people to handle a vital and technically sophisticated operation.

Not so very long ago, underground storage systems were little more than steel cylinders thrown in the ground with a few pipes and a basic pump connected to them. This led to unacceptable pollution, so today's storage systems are vastly more complex and sophisticated (for reasons that are economic as well as environmental), as are the regulations governing them. Yet we still expect that people off the street will be able to successfully operate these systems. Is it any wonder that they so often fail?

I believe that what we need to create is a class of technically proficient professional tank operators who make a career out of properly managing tank systems. Managing a few storage systems at a typical facility is not a full-time occupation. A single professional tank operator, depending on the technology used at a UST

facility and the competency of the onsite personnel, should be able to manage quite a few storage facilities. This would decrease the number of people who need to be trained by a factor of 10 to 100. These people will have invested significant time and perhaps money in obtaining their qualifications, so they should, in theory at least, have significantly lower turnover rates than typical convenience store personnel. These factors should in turn significantly decrease the overall training effort required.

The Certified, Professional Tank Operator

Professional tank operators could market their services in various ways. Some could become employees of companies with many tank systems. They would have the official job description of keeping the company's tank systems properly maintained and in compliance. Some could become independent consultants hired by small tank owners to do the same job. Some could work within tank installation and maintenance firms to provide an additional service to the firm's traditional customers. Some could work with or within government agencies or the military to manage those tank populations. A small mom-and-pop tank owner who wanted to manage her own tank could be free to do so, but only if she could prove through the certification process that she was a competent tank operator.

The fundamental difference in this proposal from the usual understanding of tank operator is that the certified operator is not the person who is on site every day. The certified operator is the person who understands the characteristics of the storage systems at each facility for which he or she takes responsibility, knows what needs to be done to keep the facility in compliance, sees to it that these things get done, and maintains all of the required paperwork.

Duties of the professional operator would also include providing basic training to on-site personnel on how to operate the UST (e.g., "You have a 10,000 gallon tank but don't ever try to put more than 8,500 gallons into it.") and how to respond to alarms or other malfunctions (e.g., "If this red light comes on, call me right

away."). The presence of the professional operator can greatly reduce the level of training required for onsite personnel as well as provide a direct means of delivering very focused site-specific information to these people. This would be very efficient, effective, and economical for the employer.

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To create this class, we need only tweak existing regulations slightly to require that each regulated storage system have a "certified" tank operator and define the requirements for certification. Seed money might then be provided (and time allowed) to create the schools (perhaps within the existing vocational/technical school system, or an Internet course for those who are already well versed in tank management) to educate and certify a population of professional tank operators. The key here would be to create high enough standards and an evaluation tool (e.g., an examination) that is effective enough to reasonably ensure that only truly knowledgeable people obtain certification. The certification process must be used to raise the bar of competency, for if the certification process merely blesses the status quo, we will merely perpetuate the current situation.

Enforcement of the requirement that every tank system have a professional tank operator could be simplified by a system whereby certified tank operators would attach a tag (with their name and contact information on it) to storage systems for which they are responsible. After some fixed date, it would become illegal to deliver fuel to storage tanks that do not have a certified tank

operator tag attached to the fill pipe. If a professional tank operator ceased to be responsible for a storage system, he or she would provide reasonable notice to the tank owner and then remove the tag. The tank owner would need to find a replacement professional operator to continue to receive fuel. Any such changes in professional tank operator would need to be tracked in the state UST database.

As in the existing regulatory scheme, professional tank operators could be held liable for the regulatory shortcomings of the facilities for which they are responsible. Therefore, it would behoove a professional tank operator to drop from his client list an uncooperative owner who did not want to perform required maintenance or leak detection activities. Frequent changes in tank operator could be tracked in a state UST database and might be a signal that a facility is in need of a visit from a state inspector.

To keep professional tank operators honest, each state could organize a volunteer board consisting of industry-related people who oversee the conduct of certified tank operators. Such a board has been operating in Maine for 15 years to oversee the certified tank installer population. Complaints brought by state UST inspectors or other sources are heard before the board and the board can impose disciplinary action, including fines, suspension, or even revocation of certification. This system can respond to problems in a much more timely and efficacious manner than traditional enforcement tools.

Postscript

Of course, this program must go hand in hand with vastly upgraded UST enforcement and inspection programs. Professional tank operators will have a difficult time marketing their services to tank owners unless UST inspections are routine and deficiencies result in meaningful penalties. But think how many more inspections an inspector could conduct if someone who actually knew all the details of the storage system and could quickly produce all of the required paperwork greeted him or her at each facility. Imagine a world where violations became the exception rather than the rule...■

Leak Prevention



Overfill Spills Caused Too Often by Tampering

Cliff Manis, a Storage Tank Safety Specialist with the Illinois State Fire Marshals' Office, wrote the following thoughts in response to Ben Thomas's article, "The Missing Link in Overfill Prevention," LUSTLine Bulletin #39, November 2001:

The article's reference to "product escaping out an opening no one suspected—the loose cap of the automatic tank gauge probe" brings to mind an emergency incident I responded to several months ago. It also reminds me that it was most likely not an isolated incident nor was it an accident.

I responded on an emergency basis to a report of a small spill at a gas station as reported by the local fire department. The tanker driver reported an approximately 20-gallon spill, but the fire department stated that the spill was much larger and wanted a representative from OSFM on site

Upon arrival, I observed that the fire department had the spill pretty much under control. They had spread absorbent material and applied absorbent socks to protect a storm sewer man way located approximately 200 feet from the overfill site. Product had run down the drive and along the street gutter for a distance of approximately 200 feet. Most of the spill area was at least 8 feet wide to the point of the street gutter, where the width narrowed. The amount spilled was approximated to be in excess of 300 gallons.

The driver stated that he was at the truck when the overfill began and immediately shut down the valve. He stated that he had not measured the tank because the facility had ordered the fuel, and he assumed that the tank would hold the product. The major source of the overfill was at the point of the automatic tank gauge probe riser. Product also came out the vent pipes at a distance of approximately 25 feet from the fill pipe and elevated 12 feet.

The investigation concluded that the overfill drop-tube valve had been tampered with by jamming a measuring stick into the mechanism and breaking it off. This action completely voided the operational design of this safety device. Also, the ATG probe riser cap had been loosened to facilitate increased venting. Further investigation resulted in the discovery that the overfill valves on the remaining tanks had also been tampered with, rendering them inoperative. The ATG probe riser caps had also been loosened.

This is a situation that we encounter all too often during our inspections. Tanker delivery drivers use these methods to facilitate faster delivery drops, and I feel that everyone with the responsibility to oversee these facilities should be aware of this very dangerous procedure and take steps to prevent further occurrences.

Keep up the excellent reporting in the newsletter. It keeps me on my toes.

Ben Thomas's Response:

I agree philosophically that the responsibility of overfills should be more broadly shared. But the truth remains that the UST regulations put the burden solely on the owners and operators. Period. I think the way out of this problem is to start by letting owners and operators know it is their responsibility. By and large owners and operators do not know this because no one reminds them, and no one enforces this regulation. Until those currently accountable know the rules, there is no motive to look for options for reform. In the meanwhile, keep looking for sticks in drop tubes and pray the Biloxi incident is not repeated.

Qs & As

on

Microbes and Fuel Systems

On reading Fred Passman's article, "Microbes and Fuel Systems: The Overlooked Corrosion Problem," our UST system guru, Marcel Moreau, couldn't resist asking Fred some follow-up questions. So here are Marcel's questions and Fred's answers.

Q. Are there any case histories or known incidents of fiberglass reinforced plastic (FRP) tank failure from bacterial activity?

A. There is no published documentation of FRP UST failure due to biodeterioration. There is, however a small but significant body of literature addressing the biodegradability of composites. As I am sure you are well aware, failure analysis is a very delicate issue. Traditionally, failure analysis is fodder for litigation. My experience is that fear of litigation inhibits most impetus for all but what I call first-tier root cause analysis (RCA). My clients who do not monitor their tanks for microbial contamination have no history of microbial contamination. If a tank fails due to apparent mechanical damage, how extensively are contributory causes investigated?

The point that I was trying to make in my article was that there is sufficient evidence of FRP biodegradability to justify a risk assessment based on assumptions and historical records. Assumptions about the inertness of various materials to biodegradation have repeatedly proven incorrect. Often microbes contribute to deterioration indirectly. Their role can be overlooked, particularly when an investigation team does not include microbiological expertise.

In the U.S., several critical variables have changed in the past half-decade. These changes limit the

usefulness of historic performance data. In particular, the increased use of oxygenates and other additives has changed the nutrient profile and fuel-water phase partitioning dynamics of both water and organics. Microbial communities recovered from fuel systems today appear to be more robust than those recovered in the past (before 1995). Industry consolidation coupled with increased product demand has translated into dramatically increased throughput rates. Greater concentrations of contaminated material get transported through the distribution system. Retail USTs typically become laststage coalescers in which much of the contaminant material accumulates, further contributing to more robust microbial activity.

I do not think that FRP failure is a common occurrence. According to statistics provided by the Steel Tank Institute, neither is steel UST failure. Their quoted annual failure rate is (to me) surprisingly low. I was not able to find any one willing to share FRP tank failure statistics with me, even in confidentiality. During a 1997 conversation, one FRP tank manufacturer allowed that they had previously experienced biodeterioration problems, but (as of 1997) had modified their technology to prevent any future problems.

Would it surprise you to hear that invariably reports of resistant microbes start cropping up within a few years after each new product's introduction? My point here is that since the scientific literature demonstrates that FRP is biodegradable, I encourage members of the FRP tank fabrication industry to determine the extent to which their products are vulnerable to biodeterioration rather than take a wait and see approach.

C. I have always thought that bacterial activity required the presence of free-phase water in the bottom of the tank. While I gather from the article that this clearly exacerbates the problem, are you also saying that biofilms can exist in the total absence of free-phase water?

A. Exactly. First, most tanks don't lend themselves to accurate

measurement of free water. Many (I estimate about 60 percent) USTs that are thought to be water-free, aren't. Electronic gauging can be inaccurate, tanks may slope away from the measurement point, measurements may be taken incorrectly, or water may be pooled at a location in the tank away from the point of measurement. A hundred milliliters of water in a 10,000-gallon UST is unlikely to be detected but can harbor 10E8 to 10E10 microbes.

Also, since there is generally some free-water transported with fuel deliveries, and water can enter tanks as vapor in venting air, water can condense on tank walls and become embedded within slime accumulations on the walls. Consequently, a 10,000-gallon UST may have 10+ gallons of water entrained within slime accumulations on the shell surface.

I used to illustrate this point by drawing a parallel between a 1/8-inch column of water next to a 1-micron long bacterium and a body of water as deep as the World Trade Center was tall next to a 6-feet tall person. Although I must obviously change the metaphor, the point remains that a tank that's dry from an industrial engineering perspective is not from a microbial ecology perspective.

Q. My corrosion wisdom says that corrosion will not proceed in the absence of an electrolyte, and petroleum products are not electrolytes. In other words, are biofilms a fuel quality problem rather than a corrosion problem?

A. I've sampled and analyzed bottom water from close to 2,000 gasoline USTs since 1992. Typically bottom-water alkalinity is >1,000 ppm CaCO3; hardness is in the same range; and total dissolved solids are >1 g/L. Need I look further for electrolytes?

Q. What are the implications of all this for fuel quality/corrosion inside the automobile gas tank? Is an automobile that refuels once a month more at risk than an automobile that refuels once a week?

 In the absence of hard data, it's heard to give an unequivocal answer. There is reason to believe that automobile fuel tanks are at risk. I feel that the risk depends more on where the fuel suction line draws from the tank than from frequency of fills. If the suction is offset from the tank's bottom to prevent water and sediment transport to the fuel filter, then water and sediment are likely to accumulate in the tank. This creates an environment that encourages biomass accumulation and consequent biodeterioration. If the suction line pulls from the tank's lowest point, then the fuel filter is likely to plug more often. Water and sediment do get into automobile tanks, but the relationship between water and sediment transport and tank failure, or between fill frequency and tank failure, has not been documented.

Q. Did you know that the 2000 edition of the Petroleum Equipment Institute's RP100, Recommended Practices for Installation of Underground Liquid Storage Systems, recommends the installation of a water gauging port at the end of the tank opposite the fill pipe?

A. I've been advocating this since I performed my first gas station survey in 1992. I've never understood why the second gauging port hasn't always been recommended. So far, I've sampled at only one gas station with a sampling port by the turbine. As a diagnostician, I'm a bit conflicted. On one hand, it certainly makes it easy to get two bottom samples, pull bottoms water, and monitor changes in tank trim. However, it makes it more difficult to convince clients that they need to pull the turbine (which means taking a UST out of service until the turbine is reinstalled) so that I can look at corrosion on the adapter, turbine riser, and distribution manifold.

Fred Passman is an industrial microbial ecologist and owner of Biodeterioration Control Associates, Inc., a consulting firm dedicated to helping industry recognize and control microbial contamination in process fluid systems. He can be reached at bca-fjp@ix.netcom.com.

MESESPRI

Leak Prevention

Mississippi DEQ Seeks Input on Comprehensive UST Cathodic Protection Guidance Document

by Kevin Henderson

The Mississippi Department of Environmental Quality (MDEQ) has recently issued a draft document titled "Guidelines for the **Evaluation of Underground Storage** Tank Cathodic Protection Systems." MDEQ has released the document for public comment. It is our intent that the final version of the document will serve as straightforward and easily understandable guidance for testing cathodic protection (CP). It is also hoped that the document will serve as a model that other regulatory authorities can use in developing their own guidance. We believe that it is necessary to develop this guidance because existing industry standards/codes are woefully inadequate with regard to proper CP testing and documentation.

While we recognize that the only thing certain about CP is uncertainty, we are attempting to work out some issues with regard to CP testing that we would like to bring to your attention. We are also seeking any information you may have with regard to these issues so that we can be assured that the final version of the guidance document reflects a state-of-the-art viewpoint.

Bimetallic Couples

The first and most troubling issue has to do with "bimetallic couples" and the applicability of the 100 mV criterion. The 100 mV criterion is met if it can be shown that the structure under cathodic protection depolarizes 100 mV or more with the protective current interrupted. We have heard arguments that this polarization criterion cannot be applied to a UST system if there is a metal of a lower electropotential that is electrically continuous with the steel component of the tank system under protection. Without going into a lengthy explanation, the argument goes something like this:

If I have an older "bare steel" tank, more than likely it is electrically connected to copper through the wiring that supplies the electrical power to the pump. The electrical power system is grounded through the use of copper grounding rods and is normally also grounded to the water service lines at the facility. Since these lines are usually copper, a significant amount of copper could thus be electrically continuous with the steel components of the tank system.

Stated in simple terms, the 100 mV criterion is not applicable when the metal you are trying to protect is electrically continuous with a metal of a lower electropotential (copper). Since nearly all such "bare steel" tanks will be bonded to copper of at least some significance, the net effect will be the elimination of the 100 mV criterion.

As we believe there will be a significant number of impressed current systems that will be unable to meet the –850 mV instant off-criterion (the only other applicable criterion), this issue could have a potentially enormous impact on tank owners. Can you imagine their response when we tell them that they will have to "upgrade" their tank systems again in order to meet the regulatory requirements for corrosion protection?

Remote Earth

Another issue that has come about recently has to do with the use of "remote earth" reference cell placement. The theory of this reference cell placement is that the observed structure-to-soil potential is an average of the entire tank system under protection. Remote earth is achieved when the observed potential does not change appreciably. The Steel Tank

Institute is promoting this method of testing sti-P3 tanks for two reasons:

- It ensures that the structure-to-soil potential observed does not contain an "IR drop" because the reference electrode is within the potential gradient of an anode. An IR drop is defined as the voltage across a resistance and can be thought of as a component of a voltage measurement that causes an error.
- It is said to overcome any "shielding" that may be affecting the structure-to-soil potential observed when the reference electrode is placed directly over the tank. Shielding occurs when a structure prevents or diverts an electric current from reaching the desired location. Shielding is commonly cited when a substandard potential is observed because of the close proximity of the reference electrode to the various tank riser pipes, pump heads, product piping, and other tank appurtenances.

How Many Test Points?

A much broader CP issue has to do with the age-old question of how many test points are necessary for an evaluation of the CP system to be effective, and do they all have to "pass"? Some say that at least three test points are required over the tank (at each end and the middle). If that's the case, what if you allow the use of "remote earth" testing, which is now permitted as an alternative reference electrode placement in NACE TM0101-2001, "Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Tank Systems"? If the remote earth test point indicates adequate cathodic protection, is it then acceptable for one or

more of the local potentials to be less than -850 mV?

More fundamental to some arguments that all reference cell placements must indicate a pass is the simple fact that measurement of structure-to-soil potentials with a reference electrode is an inexact and crude technique that is fraught with difficulties. As it is entirely possible to substantially change the potential observed simply by moving the reference electrode a few inches within a manway, it then follows that you could find at least one "dead spot" on practically any UST cathodic protection system you are testing. In other

words, a substandard potential can be observed on almost any UST system if you "hunt" long enough for it.

Do You Have Some Answers?

If so please download the draft version of the Mississippi CP guidance document from our Web site (www.deq.state.ms.us) and help us produce a useful document that will allow all of us to understand the proper techniques required for an effective evaluation of UST cathodic protection systems. From the home page, click on "Underground Storage Tanks" and then look under "UST Information" for the document titled

"Guidelines for the Evaluation of Underground Storage Tank Cathodic Protection Systems."

The draft document is available for comment until June 1, 2002; the final version will be published July 1, 2002. Your help in producing the final document is needed and greatly appreciated. Please direct any comments you may have to Kevin Henderson of the Mississippi DEQ. Telephone: (601) 961-5283; e-mail: Kevin_Henderson@deq.state.ms.us; mail: Mississippi DEQ, P.O. Box 10385, Jackson, MS 39289-0385. ■

Will Congress Lay Down the Law on USTs?

A Glimpse at S. 1850, the Underground Storage Tank Compliance Act of 2001

by Ellen Frye

7ith 18 years having passed since the first federal UST regulatory program was enacted and, alas, with our way-tooclose encounters of the MTBE kind, we now have Senate Bill 1850—introduced on December 19, 2001, by Sen. Chafee (R-RI). The aim of the bill— The Underground Storage Tank Compliance Act of 2001—is to bring USTs into compliance with the requirements of Subtitle I of the Solid Waste Disposal Act and to provide sufficient resources for such compliance and cleanup. Cosponsors of the bill include Sen. Carper (D-DE), Sen. Smith (R-NH), Sen. Jeffords (I-VT), and Sen. Inhofe (R-OK). The proposed bill sets forth enhanced enforcement strategies and offers states funds and flexibility to get the job done.

The bill, if enacted as written, will present states with some challenges that could have very positive results if thought through and implemented effectively—the ultimate challenge. Hopefully the bill will provide flexibility during the transition period so that states have the opportunity to look for new, innovative ways to meet the goals of the bill, without having to settle for counterproductive

approaches designed to meet a prescribed timetable. Finally, while the bill would greatly increase the authorization levels for funds and expand the allowable use of funds, states still shudder to think of that vast and vexing gap between funds authorized and those actually appropriated. So let's take a look at the bill's main features, section by section.

■ Leaking Underground Storage Tanks

The bill gives states greater flexibility to implement the underground storage tank program. EPA would be required to distribute to the states at least 80 percent of the funds appropriated each year from the LUST Trust Fund (applies to Section 9013(2)a only). States could use these funds to pay for the reasonable costs of:

- Actions to carry out and enforce corrective actions;
- Necessary administrative costs of state assurance funds;
- Enforcement of a state program;
- State or local corrective actions; and
- Corrective action or compensation programs under a state program if there is no financially viable owner or operator of an UST.

States may also use funds to enforce state or local leak detection, prevention, and other requirements. States may not use these funds to provide financial assistance to owners and operators of tanks to comply with existing regulations governing USTs, including the requirements for upgrading existing tanks.

■ Inspection of Underground Storage Tanks

All USTs regulated under Subtitle I are to be inspected every two years. This frequency would be an immense improvement over the inspection reality in most states. In fact, many states may find this timetable for getting such an inspection program up and running problematic. A June 2000 report released by EPA estimates that the cost of these biannual inspections will be \$35 million for each of the first two years and \$20 million for every year after that. This section authorizes that level of funding to pay for this inspection requirement.

Operator Training

EPA must publish guidelines that specify methods for training operators of underground storage tanks. The guidelines must take into account existing training programs put in place by states and operators, the high turnover rate of operators, the frequent improvements in tank technology, and the nature of the businesses in which operators are engaged. (See Marcel Moreau's thoughts on this in "Tank-nically Speaking" on page 23.)

■ **S. 1850** from page 29

From the date on which the guidelines are published, the states would have two years to develop and implement a strategy for the training of UST operators that is consistent with the guidelines, is developed in cooperation with owners and operators, and takes into consideration existing operator training programs. This section allows EPA to provide an award of up to \$50,000 if a state develops and implements a state operator training strategy.

Remediation of MTBE Contamination

EPA and the states are authorized to carry out remediation of MTBE releases that present a threat to human health or welfare or to the environment. This section authorizes a one-time appropriation of \$200 million for this purpose, which will remain available until expended.

Release Prevention and Compliance

Funding (\$200 million over six years) is authorized for EPA or states to conduct inspections, issue orders, or bring actions under this subtitle. This section also requires states to submit to EPA a strategy to ensure compliance of tanks owned by state or local governments. EPA may award up to \$50,000 if a state develops and implements the strategy.

EPA and states are required to consider compliance history and operator training programs when determining both whether to issue a compliance order and the amount of the penalty.

EPA or states with an approved program would have the authority to prohibit the delivery of regulated substances to USTs that are not in compliance with a UST requirement or standard. Prior to exercising this authority, EPA must promulgate reg-

ulations that describe the circumstances under which the authority may be used and the process by which the authority will be used consistently and fairly.

EPA must require states and tribes to maintain and update data, at least annually, and make available to the public a record of USTs regulated under this subtitle. EPA would make each public record available to the public electronically.

■ Federal Facilities

EPA, in cooperation with federal agencies that own or operator USTs or that manage land on which USTs are located, would be required to review the status of compliance of those tanks within one year of enactment. Within two years of enactment, each federal agency that owns or operates USTs or that manages land on which USTs are located must develop strategies to bring its tanks into compliance with applicable law.

Field Notes

from Robert N. Renkes, Executive Vice President, Petroleum Equipment Institute

Industry Gives the Nod to S. 1850

Then Congress debated the provisions of Subtitle I of the Resource Conservation and Recovery Act Amendments of 1984, the petroleum marketing industry was quick to voice its concerns over what Congress hoped to accomplish and how they envisioned EPA regulating over 2.5 million underground tanks.

The reaction of the petroleum marketers to the Underground Storage Tank Compliance Act of 2001 is different. This time they seem very supportive of the proposed legislation and anxious to get it passed. Here is a brief summary of each trade association's reaction to S. 1850. As you can see, the regulated community is not likely to stand in the way of the measure's passage.

The Society of Independent Gasoline Marketers Association (SIGMA) is generally supportive of S. 1850 and will urge its passage. One provision that the group would like to change currently limits reimbursement of corrective action to owners and operators that do not have the financial resources "to pay the cost of a corrective action without significantly impairing the ability of the owner or operator to continue in business." SIGMA believes this form of economic relief should be available to all tank owners, without regard to their financial means to pay for the cleanup. Broadening the definition of who can be reimbursed will, in their opinion, clean up more leaks and not get the process bogged down by trying to figure out who qualifies for the reimbursement

program.

The Petroleum Marketers Association of America (PMAA) is strongly in favor of the bill as it is written. They believe the bill probably doesn't need any tweaking but were still in the process of canvassing their members to receive their input at press time.

Although the National Association of Convenience Stores (NACS) agrees with the bill in concept, in their opinion there is some language that could be changed to improve S. 1850. One of the provisions they would like to amend provides using funds "to carry out corrective actions with respect to a release of methyl tertiary butyl ether (MTBE) that presents a threat to human health or welfare or the environment." NACS prefers to use the Trust Fund money to finance "high-priority cleanups" and not just those with releases containing MTBE. NACS also would like to have some provisions governing operator training and prohibiting delivery of product clarified.

The American Petroleum Institute (API) generally supports the bill but would also support some modifications to the bill that would clarify the language and make it more effective.

The message from the marketers we talked to is simple: They are not going to stand in the way of S. 1850. In fact, we haven't heard from or read anything about anyone who is. ■

■ Tanks Under the Jurisdiction of Indian Tribes

EPA, in cooperation with Indian tribes, would be required to develop and implement a strategy within one year of enactment that prioritizes UST releases on Indian lands and take necessary corrective actions with respect to those prioritized releases. Within two years of enactment, and every two years thereafter, EPA would submit to Congress a report that summarizes the status of implementation of the UST program on Indian lands.

Authorization of Appropriations

This section provides an authorization of \$25,000,000 for each of FY2003-2007 to carry out Subtitle I (except the LUST program). It also provides an authorization for appropriation of \$100,000,000 from the LUST Trust Fund, for each of FY2003-2007 (to carry out the LUST program); \$200,000,000 to remain available until expended for the remediation of MTBE contamination: \$35,000,000 for each of FY2003-04 and \$20,000,000 for each of FY2005-07 to carry out the biannual inspections;, and \$50,000,000 for FY2003 and \$30,000,000 for each of FY2004-2008 to carry out new section 9011. ■

SNAPSHOTS FROM THE FIELD



Photo by: Dave Meyers of Hardy Environmental Services in New Castle, Delaware

Wow, what a patch job! Would you be surprised to learn that 19,000 ppm diesel-range organics were in the soil beneath this residential heating oil tank?

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.

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We welcome your comments	and suggestions on any of our articles.

New USTfields Initiative Grants to Be Announced in Late Spring

The EPA Office of Underground Storage Tanks (OUST) has received proposals for its USTfields Initiative that will provide funding for up to 40 state-local pilot partnerships and at least one tribal grant to promote innovative approaches to foster cleanup and recycling of America's gas stations and federally regulated petroleum-contaminated sites. The grants will be awarded on a competitive basis, with at least one award for every EPA region. The money must be spent at a federally regulated UST site, and the site must be eligible for LUST Trust Fund expenditures. The grant awards will be announced in late spring.

Report on Recycling America's Gas Stations Now Available

The Northeast Midwest Institute and the National Association of Local Government Environmental Professionals, in cooperation with EPA, have released a new report on EPA's USTfields Pilot Initiative, titled Recycling America's Gas Sta-

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tions: The Value and Promise of Revitalizing Petroleum-Contaminated Properties. The report provides background on the challenges of UST contamination across the nation. It profiles 20 examples of USTfield revitalization efforts in states and localities, puts forth key findings on USTfields issues, and promotes action items that could strengthen the national USTfields initiative. EPA will distribute copies of the report to states and regions. To obtain a copy of the report, contact Matthew Ward at matt.ward@spiegelmcd.com. ■

Implementation Planning Underway for New Brownfields/Petroleum Sites Legislation

Public Law 107-118, the Small Business Liability Relief and Brownfields Revitalization Act, has passed, folding petroleum-contaminated sites into the brownfields arena and authorizing up to \$50 million a year for the cleanup of petroleum sites of any type, not just federally regulated UST sites. This money can go directly to municipalities as well as states.

PL107-118 implementation workgroups have been organized to examine how this bill will expand or complement work that is already underway in the revitalization arena and to develop guidance to streamline integration.

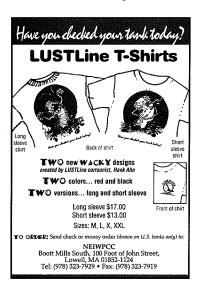
Inspector Training at Georgia Tech

As part of OUST's ongoing efforts to achieve improved compliance it awarded the Georgia Institute of Technology in Atlanta, Georgia, a cooperative agreement to develop and deliver a training course for state and tribal UST inspectors. The course, "Compliance Inspections of Underground Storage Tanks," was held on February 12-14, 2002. Corey Fischer, research engineer with the Georgia Tech Research Institute, was the course director. The main instructors for the course included: Ben Thomas, Principle, Ben Thomas Associates; Shaheer Muhanna, Georgia Environmental Protection Division; and James G. Clemenson, U.S. EPA, Region VII. A total of 62 attendees were present, representing 38 state agencies, four territories, and six tribal entities. Three EPA regional personnel audited the course.

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